INSTITUTIONAL MEMBERS

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

Arkansas College
Batesville

Arkansas Polytechnic College
Russellville

Arkansas State University
State University

College of the Ozarks
Clarksville

Harding College
Searcy

Henderson State University
Arkadelphia

Hendrix College
Conway

John Brown University
Siloam Springs

Ouachita Baptist University
Arkadelphia

Southern Arkansas University
Magnolia

University of Arkansas
Fayetteville

University of Arkansas
at Little Rock

University of Arkansas
at Monticello

University of Arkansas
at Pine Bluff

University of Central Arkansas
Conway

Westark Community College
Fort Smith

COVER PHOTO:  Head, mitochondrial collar, and portion of the flagellum of rainbow trout spermatozoon (Salmo gairdneri Richardson) viewed by scanning electron microscopy. 10,000 X.

EDITOR: J.L. WICKLIFF
Department of Botany and Bacteriology
University of Arkansas, Fayetteville, Arkansas 72701

ASSOCIATE EDITORS

James A. Scholtz
Anthropology-Sociology

Gary A. Heidt
Biological Science

Alex R. Nisbet
Chemistry

John K. Beadles
Environmental Science

Walter L. Manger
Geology

James E. Mackey
Physics

Neal D. Buffaloe
Science Education

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MINUTES OF THE SIXTIETH ANNUAL MEETING — 9-10 APRIL 1976

FIRST BUSINESS MEETING

The first business meeting of the 60th Annual Meeting of the Arkansas Academy of Science was called to order by Dr. Joe Guenter, President of the Academy, at 10:45 a.m., April 9, 1976, at the University of Arkansas at Little Rock. Dr. Guenter thanked the UALR faculty for hosting the meeting, and called on Dr. Gary Heidt, chairman of local arrangements, for an informal welcome. Dr. Heidt announced that a formal welcome would be made at the banquet and provided additional information for the meetings.

Dr. Guenter then called for reports from the officers of the Academy and from representatives of organizations sponsored by the Academy.

Secretary:

The Secretary reported that the minutes of the 59th Meeting held at Southern State College were available at the registration desk. A motion to approve the minutes was made at the second business meeting. The Secretary noted that pre-registration membership was similar to that before the 1975 Annual Meeting.

Treasurer:

Dr. W.L. Evans, Treasurer, distributed copies of the financial statement and summary for the past fiscal year.

Financial Statement
March 31, 1976

| Cash Balance in Checking Account, April 1, 1975 | $1,451.08 |
| Reserve Funds, Savings Certificate, FSLA, April 1, 1975 | 1,008.47 |
| Reserve Funds, Facebook Savings, FSLA, April 1, 1975 | 1,951.34 |
| Total Funds, April 1, 1975 | $4,411.90 |

Disbursements (April 1, 1975 through March 31, 1976)

1. Royal Printing Co., Banquet Tickets | $16.17 |
3. Patrick Lee Vaughan, Talent Search Award | 20.00 |
4. John Ju Hau Yeh, Talent Search Award | 15.00 |
5. Gregory Anthony Eaguinski, Talent Award | 10.00 |
6. Southern State College, Banquet 61342-1(14) | 356.00 |
7. Internal Revenue Service, Withholding Tax | 6.20 |
8. Univ. Arkansas, Pay, Printing | 8.10 |
9. Dr. Henry W. Robinson, Same Tags | 4.00 |
10. Southern State College, Refunds | 36.00 |
11. Donnie Williams, Travel Expenses | 100.00 |
12. Univ. Arkansas, Pay, Printing Programs | 46.10 |
13. Phillip Litho Co., PROCEEDINGS, Vol. 28 | 2,767.20 |
14. Dr. John Gilmour, Postage | 9.12 |
15. Postmaster, Box Rent, Fall Semester | 6.00 |
16. Dr. Henry W. Robinson, Postage, Newsletter | 20.00 |
17. Postmaster, Postage | 5.00 |
18. Univ. Arkansas, Pay, Printing Newsletter | 6.45 |
19. Mrs. Emily P. Tompkins, Editorial Assistant | 163.30 |

Disbursements (Continued)

20. Univ. Arkansas, Pay, Office Supplies | 7.21 |
21. Mrs. Tamara Gilmour, Pay, Postage, Mailers | 21.21 |
22. Postmaster, Box Rent, Spring Semester | 6.00 |
23. Dept. Fin. & Admin., State Tax Withheld | 3.00 |
24. Arkansas Academy of Science, 1976 Membership | 10.00 |
25. Postmaster, Envelope | 13.00 |
26. Univ. Arkansas, Pay, Stamp Pads | 2.78 |
27. Mrs. Emily P. Tompkins, Editorial Assistant | 159.40 |
28. Univ. Arkansas, Pay, Printing | 10.90 |
29. UALR, Postage | 6.95 |
Total Disbursements | $3,621.96 |

Summary

Beginning Balance, Checking and Reserve, April 1, 1975 | $4,411.09 |
Plus Total Income | $4,072.77 |
Less Expenditures | $3,621.96 |
Funds Available, March 31, 1976 | $4,961.90 |

Note: Invoice #4453 from Phillips Litho Co., dated 3/31/76, printing Vol. 20 of the PROCEEDINGS, $2,387.71, is outstanding obligation due within 30 days.

Respectfully submitted,

William L. Evans
Treasurer
Secretary's Report

After discussion of the financial statement, Dr. Evans also presented a Five Year Summary of Income and Disbursements. He noted that income was greater than expenditures and suggested the possibility of establishing a research fund with surplus monies. Dr. Evans then asked that members informally consider the suggestion so that a motion might be made at the second business meeting.

Five-Year Summary of Income and Disbursements

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Income</th>
<th>Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971-72</td>
<td>$1,785.79</td>
<td>$4,300.63</td>
</tr>
<tr>
<td>1972-73</td>
<td>$3,542.99</td>
<td>$1,343.06</td>
</tr>
<tr>
<td>1973-74</td>
<td>$3,512.25</td>
<td>$3,934.05</td>
</tr>
<tr>
<td>1974-75</td>
<td>$2,933.70</td>
<td>$2,145.81</td>
</tr>
<tr>
<td>1975-76</td>
<td>$4,072.77</td>
<td>$3,521.96</td>
</tr>
<tr>
<td>Total</td>
<td>$15,847.50</td>
<td>$15,245.51</td>
</tr>
<tr>
<td>Mean</td>
<td>$3,169.50</td>
<td>$3,049.10</td>
</tr>
</tbody>
</table>

Dr. James Wickliff, Editor, noted that copies of the 29th Proceedings were available at the registration desk. He said that editorial and publication costs had increased and stated a motion would be made at the second business meeting to increase the monies for an editorial assistant.

Dr. Wickliff then opened a discussion of proposed changes in the Editorial Board of the Proceedings. He noted that the Executive Committee had approved the proposal. After some discussion, Dr. Wickliff asked for recommendations and volunteers for the Associate Editor positions. The following changes were approved by the Executive Committee.

The Editorial Board as a functioning committee within the Academy structure will be abolished and present Editorial Board members will be relieved of further obligation in this capacity. (The present Editorial Board has been serving primarily in a policy resolving capacity.)

Proposed reorganization is as follows.

Associate Editors of the Academy will be appointed by the Executive Committee as recommended by the Editor. These Associate Editors will represents areas of scholarly interest by the Academy including the following disciplinary sections:

- Agriculture and Forestry
- Anthropology and Sociology
- Biological Science
- Chemistry
- Engineering Sciences
- Environmental Science
- Geology
- Mathematics
- Physics
- Science Education

Duties of the Associate Editors will be:

1. to arrange for persons to chair the paper presentation sessions in their respective disciplines at the annual meetings of the Academy;
2. to assist the Program Committee in organizing these paper sessions;
3. to assist the Editor in obtaining scholarly reviews of papers submitted for publication in the Proceedings of the Arkansas Academy of Science.

Associate Editors would serve a 3-year term.

Historian:

Dr. Dwight Moore, Historian, gave a detailed history of the Academy (included in this issue). Dr. Guenter gave Dr. Moore a Certificate of Appreciation for his long and devoted service to the Academy.

State Science Fair:

Professor Robert Saunders reported that the exhibits were ready and encouraged people to see them. Dr. Guenter noted that Professor Saunders was retiring and that the Academy greatly appreciated his years of service to the State Science Fair. Dr. Guenter also noted that an interested and dedicated replacement for Professor Saunders would need to be found.

Junior Academy of Science:

Professor Marie King reported that 25 papers were being given. She stated that the presentations would be interesting and invited everyone to attend the Junior Academy paper presentations. Professor King thanked all the people who had assisted her during the past year.

Collegiate Academy of Science:

Dr. John Bridgman stated that the Collegiate Academy papers would be presented this year in the Senior Academy sessions. He thanked the Academy for its support this year.

Junior Science and Humanities Symposium:

Dr. E.B. Wittlake, Director, gave the following report.

The Tenth Arkansas JSHS was conducted by the Planning Board and associate instructors at Little Rock, November 6-8, 1975, with a total of 48 teachers, 69 students, and a staff of 20. Headquarters and lecture facilities were as before. There were five guests of whom Lt. Col. Edward Downing, Executive Officer, U.S. Army Research, Durham, was most helpful; he observed and evaluated procedures as the Symposium went along. The President of the Academy brought greetings and attended part of the sessions. As the Director had asked for replacement in the future, Mr. Tom Palko, Biology Department, Arkansas Polytechnic College, was chosen by the Executive Committee at the 1975 Academy Meeting to be the next Director. Mr. Palko devoted his time to observing and evaluating the existing Symposium structure for his own future performance.
Financial support continues to be a problem. The Symposium needs a greater number of Arkansas donors from business and industry to create a broader base of contribution. The Pine Bluff Arsenal through Col. E.E. Hayes has given new backing to the total grant received from the JSHS office—$6,000 this year or $500 more than any year in the past. Dr. Morris L. Cranmer of the National Center of Toxicology continues to support us, as has the Weyerhaeuser Company through the continued interest of Mr. Tom Worth, Wood Products Manager, Mt. Pine. Mr. Tom Jenkins, long a Symposium supporter and now a Board member, has secured a promise of $100 from the Ozark Canners and Freezers Association. The Agricultural Council of Arkansas as influenced by Dr. J.B. Phillips of Fayetteville has continued its support. New donors were four associated banks of Jonesboro.

Problems of hotel management and its effect on students were noticeable. The continued use of a solid, unbroken session for student research papers proved effective. The major lectures were well taken; in at least two, those of Dr. Ann Wheistone and Dr. John Douglas, the emphasis on research method was excellent. Dr. R.R. Cohoon gave a comprehensive view of Arkansas physical geology and Dr. George Harp gave a presentation of the limnology of the bauxite lakes at Bauxite. The news media picked up the latter topic for publicity. Publicity as a whole was still not comprehensive though several sources of the media made promises, even to the point of photography of the winning students. These were:

(1) Clifford Whitmore II, Harrison High School; (2) Eugene Boyles, August High School; (3) Glenda Garner, Arkansas Senior High School, Texarkana; (4) Melody Smith, Jasper High School; (5) Karen Baker, Lake City High School; and (6) Mike Tribble, Fayetteville High School.

The Board member chosen to attend the National Symposium was Mr. Charles Price of West Memphis High School who has been active in science teacher affairs of Northeast Arkansas. Mr. Palko as incoming Director will accompany the Director at JSHS expense.

The tours were carried out very well and within the time limits. The Career Emphasis Session was weakened by the loss of Dr. J.O. Cooper, Professor of Medicine, University of Arkansas, who died in midsummer. The other four areas were well covered by their leaders.

The Director wishes to thank members of the Academy for its support of his endeavors and the Planning Board who again faithfully carried on their tasks. New Board Members in addition to Mr. Palko were: Mr. Tom Jenkins, Fayetteville; Mr. Robert Allen, Marianna; and Mr. Lloyd Martin, Trumann.

Dr. Wittlake noted that Lt. Col. Downing had written a letter praising this year's effort. Dr. Guenter followed by thanking Dr. Wittlake for his valuable contributions to the Symposium during his tenure as Director.

Science and Technology Council:

Dr. Maurice Lawson stated that no funds in support of the Council were available at present.

Newsletter:

Dr. Henry Robison, Editor, stated that he needed a representative from each school to collect information for the Newsletter. He noted that it has been difficult to gather news to date.

Unfinished Business:

Dr. Evans reported that two high school student research grants had been awarded. Last year, $40.00 was awarded to Susan Keeler of Paragould. This year, $117.00 was awarded to Eugene Boyles of Augusta High School to study wood ducks. Dr. Evans noted that each year AAAS supports this program by contributing up to $100.00. He also said that students wishing grants should contact the Academy President who will appoint a committee to evaluate the grant proposal and make grant awards.

Dr. Guenter read a letter from Dr. Francis Clayton, which stated that a new representative to AAAS (Section X) meetings would be needed. Dr. Guenter asked for a volunteer, and said if one could be found, he or she could be appointed as the Academy Representative.

Dr. Guenter announced that the Arkansas Science Teachers' Association invited all to attend a breakfast April 10.

New Business:

Dr. Guenter appointed the following committees:

Auditing: Henry Robison (Chairman), Ken Beadles, Gary Tucker.

Meeting Place: Ed Dale (Chairman), Tom Palko, Tom Clark, Ed Bacon, Jim Nichols.

Resolutions: Don England (Chairman), Art Johnson, John Bridgman.

Membership: Neal Buffaloe (Chairman), Ed Dale, Les Howick, Joanne Rife, Leon Richards, Gary Heid, John Gilmour.

Research: Tim Ku (Chairman), Howard Hodges, Carl Rutledge.

Dr. Guenter asked for any additional new business. No new business was introduced, and Dr. Guenter adjourned the meeting at 12:15 p.m.

SECOND BUSINESS MEETING

President Guenter called the second business meeting of the Arkansas Academy of Science to order April 10, 1976.

Dr. Guenter asked for a report from the Junior Academy. Professor King announced the winners for this year's competition.

Dr. Guenter asked for a report from the Collegiate Academy. Patricia Kirky of the Collegiate Academy announced that awards for physical science papers were given to Laura Ballard (1st) and Steven Latowsky (2nd) and awards for biological science papers were given to Ronald Rosan (1st), Gary Graves (2nd), and Julia Taylor (3rd). Dr. Edward Wilson led a discussion of the relationship between the Collegiate and Senior Academies. A member of the Collegiate Academy pointed out that they wished to take a more active part in their portion of the Meeting program so that they could maintain their identity. Dr. Jewel Moore stated that a faculty representative of the Collegiate Academy was a member of the Executive Committee. Dr. Gilmour added that the President of the Collegiate Academy was a nonvoting member of the Executive Committee. When the discussion concluded, Dr. Wilson stated that the Collegiate Academy had asked Dr. Guenter to be a cosponsor. Last, Dr. Wilson moved that the Senior Academy provide $175.00 for the Collegiate Academy. The motion was seconded and passed.

Dr. Guenter recognized Professor Saunders for a report on the Science Fair. He stated the Science Fair was a success. Professor Saunders noted that the four Science Fair regions have pledged $100.00 to provide electrical equipment for future Science Fairs. He announced that this year's representative to the International Science and Engineering Fair would be Glenda Garner, Arkansas High School, Texarkana, and made the following motion.
I move that $100.00 be appropriated to be applied toward the expense of sending a student and his/her sponsoring teacher to the International Science and Engineering Fair at Denver, Colorado.

The motion was seconded and passed. Dr. Guenter again noted that the Science Fair Board would be looking for a replacement for Professor Saunders and encouraged the Academy to assist.

Dr. Guenter recognized Dr. Paulissen to discuss the Science Talent Search. He announced that the state had two winners and one honorable mention this year.

Dr. Guenter then asked Dr. Paulissen to report on the biota project. Dr. Paulissen stated that eight checklists had been prepared. He encouraged the Academy members to develop more checklists and said that he hoped checklists could be displayed at the next meeting.

Dr. Guenter recognized Dr. Robison. Dr. Robison again asked for volunteers to be institutional representatives for the Academy Newsletter. Dr. Robison made the motion:

I move that up to $100.00 be set aside for the Newsletter.

The motion was seconded and passed.

Dr. Guenter then recognized the Secretary. Dr. Gilmour asked if there were any additions or corrections to the minutes of the 59th Annual Meeting published in Volume 29 of the Proceedings. Dr. Guenter noted that Robert Bustin should be changed to Roberta Bustin. Dr. Gilmour, noting the correction, made the following motion.

I move that the minutes of the 59th Annual Meeting contained in 29th Proceedings of the Arkansas Academy of Science be approved as written.

The motion was seconded and passed.

Dr. Guenter recognized Dr. Heidt. Dr. Heidt thanked everyone for attending on behalf of the University of Arkansas at Little Rock Faculty.

Dr. Guenter recognized the Editor of the Proceedings. Dr. Wickliff made the motion:

I move that the Academy allocate $400.00 for editorial assistance to include preparing the manuscript of the 1976 Proceedings for publication and for routine mailing of the issues to abstracting agencies and the like.

The motion was seconded and much discussion as to the readership of the Proceedings followed. A majority of the members expressed feelings that the Proceedings was a very valuable part of the Academy and that the readership was extensive. The motion was passed. Dr. Wickliff provided an update on the reconstitution of the Editorial Board as Associate Editors. Science Education was added to the list of disciplinary sections which would have an Associate Editor.

Dr. Guenter recognized the Treasurer. Dr. Evans made the following motion.

I move the acceptance and approval of the Treasurer’s financial statement for the period, April 1, 1975, through March 31, 1976, as submitted at the first business meeting and verified by the Auditing Committee.

The motion was seconded. Dr. Evans asked Dr. Robison to give the following report:

We the undersigned Auditing Committee have examined the financial statement of the Arkansas Academy of Science for the period April 1, 1975, through March 31, 1976, and find it complete and correct. Dr. William L. Evans, Treasurer, is to be highly commended for the excellent job in this capacity.
school teachers and students to participate in both organizations. Professor King agreed. Dr. Carl Rutledge stated that such a separation would cause some problems with respect to availability of judges and participation in both programs because of travel difficulties. Dr. Guenter encouraged the membership to contact members of the Executive Committee so that a decision could be made.

Dr. Guenter recognized Mr. Tom Palko. Mr. Palko asked if the Academy was in favor of having a banquet next year. After much discussion two informal votes were taken. The members present were evenly divided with respect to having or not having a banquet and with respect to having a speaker if a banquet were held.

Dr. Guenter then thanked the committees, the University of Arkansas at Little Rock Faculty, the Past President, and continuing officers for making his tenure as President enjoyable. He introduced the President-Elect, Dr. Jewel Moore, and passed the gavel to her. President Moore appointed the Nominating Committee of Dr. Robert Watson (Chairman), Dr. Clark McCarty, and Dr. Arthur Coffee. Dr. Moore adjourned the second business meeting.

Respectfully submitted,

John T. Gilmour, Secretary
PROGRAM
Arkansas Academy of Science

Sixtieth Annual Meeting

UNIVERSITY OF ARKANSAS
at Little Rock

Meeting concurrently with sessions of:
The Collegiate Academy of Science
The Junior Academy of Science
Arkansas State Science Fair

Friday, 9 April

SENIOR, COLLEGIATE, JUNIOR ACADEMIES -- Registration

INDUSTRIAL EXHIBITS*

SENIOR ACADEMY -- Executive Committee
SENIOR ACADEMY -- Business Meeting
JUNIOR ACADEMY -- Westinghouse Talent Search Paper Presentation

SENIOR, COLLEGIATE ACADEMIES -- Papers (Concurrent Sessions):
Physics - Mathematics
Geology
Biology I (Cytology - Biochemistry)
Biology II (Zoology)

JUNIOR ACADEMY -- Papers (Biological and Physical Sciences, Concurrent Sessions)

JUNIOR ACADEMY -- Executive Committee

PLANETARIUM SHOW

SENIOR, COLLEGIATE, JUNIOR ACADEMIES -- Banquet

Saturday, 10 April

SENIOR, COLLEGIATE ACADEMIES -- Papers (Concurrent Sessions):
Chemistry
Environmental Science
Biology III (Botany)
Biology IV (Zoology)
Anthropology

JUNIOR ACADEMY -- Business Meeting
JUNIOR ACADEMY -- Awards Presentation

COLLEGIATE ACADEMY -- Business Meeting

SENIOR, COLLEGIATE ACADEMIES -- General Business Meeting

*INDUSTRIAL EXHIBITORS:
American Optical Company
Corning Glass Company
Preiser Scientific Company
Sargent-Welch Company
Southern Biological Company
The Gene Swepston Company of Little Rock
SECTION PROGRAMS

PHYSICS AND MATHEMATICS SECTION
Chairman: Charles Harbison

*USE OF SOLAR ENERGY IN THE HOME.
G. Hook, N. Kemper, W. Friddy, J. Hancock, and T. Ngo

A NEW PROOF THAT THE DERIVATION INERTIA a (b) OF AN ELEMENT b OF V-RING R IS THE LARGEST EXPONENT S IN AN INERTIAL REPRESENTATION OF b.
Thomas F. Peter

A PROOF OF EULER'S THEOREM.
Charles Harbison

GEOLOGY SECTION
Chairman: Phil Kehler

THE CAMBRIAN-ORDOVICIAN BOUNDARY IN NORTH AMERICA: A SUGGESTED REVISION.
Raymond W. Suhm

LOWER MISSISSIPPIAN LITHOSTRATIGRAPHY, NORTHERN ARKANSAS.
Jack L. Shanks and Walter L. Manger

PATCH CORALS IN A MISSISSIPPIAN SHOALING ENVIRONMENT.
Michael W. Hansen

SEASONAL VARIATION OF DISSOLVED AND SUSPENDED CHEMICAL LOADS OF THE BUFFALO RIVER, ARKANSAS.
George H. Wagner and Kenneth F. Steele

REGIONAL CARBONATE DEPOSITION OF THE PITKIN LIMESTONE (CHESTERIAN), WASHINGTON AND CRAWFORD COUNTIES, ARKANSAS.
Robert E. Telhan

ALGAL-BRYOZOAN CARBONATE BUILDUPS WITHIN THE PITKIN LIMESTONE (MISSISSIPPIAN-CHESTERIAN), NORTHWEST ARKANSAS.
A.T. Warmath

THE ZUNI SEQUENCE IN THE SOUTHWESTERN UNITED STATES.
P.L. Kehler

BIOLOGY I SECTION (Cytology/Biochemistry)
Chairman: Hugh Johnson

HORMONE RECEPTOR SITE MATURATION IN THE SECONDARY SEX ORGANS OF IMMATURE MALE AND FEMALE RATS.
K.J. Thomas

A COMPARATIVE STUDY OF THE ESTERASE OF DROSOFLA VIRILIS AND DROSOPHILA EZONA.
Russell Webster and William C. Guest

METAPHASE CONFIGURATIONS IN DROSOPHILA. A COMPARISON OF ENDEMIC HAWAIIAN SPECIES AND NON-ENDEMIC SPECIES.
Frances E. Clayton

IODINATION OF PROTEINS WITHIN THE STOMACH OF DOGS.
Jerry R. Hershey and L. Van Middlesworth

ROLE OF GASTRIN AS RELATED TO BIOCHEMICAL PROFILE OF STOMACH MUCUS.
Roger Baker and Jerry R. Hershey

ENZYMES IN HELODERMA HORRIDIUM VENOM.
S. Murphy, D.H. Sifford, and B.D. Johnson

EFFECTS OF ESTROGEN ON UTERINE TISSUE UTILIZATION OF PYRUVATE FOR LIPID SYNTHESIS.
J.W. Harris

ELECTROPHORETIC PATTERNS OF SERUM PROTEINS IN TWO SUBSPECIES OF ODOCOILEUS VIRGINIANUS.
Greg Jackman and P.J. Garnett

BIOLOGY II SECTION (Zoology)
Chairman: Edmond Bacon

RESISTANCE TO STRESS ULCERS IN ADRENALECTOMIZED RATS.
Jerry R. Hershey

A CHECKLIST OF THE CAVE FAUNA OF ARKANSAS - PART I.
Kenneth L. Smith and V. Rick McDaniel

POPULATIONS AND MOVEMENTS OF PEROMYSCUS ON CROWLEYS RIDGE IN NORTHEASTERN ARKANSAS.
Gary W. Stephenson and V. Rick McDaniel

COMMENTS ON THE KARYOLOGY AND NATURAL HISTORY OF SYNAPTOMYS COOPERI IN ARKANSAS.
James A. Huggins and V. Rick McDaniel

THE RECENT DISTRIBUTION OF BATS IN NORTHCENTRAL AND NORTHEASTERN ARKANSAS.
David A. Saugery and V. Rick McDaniel

CHARACTERISTICS AND BEHAVIOR OF GUINEAFOWL AND DOMESTICATED CHICKEN HYBRIDS.
Earl L. Hanebrink

*THE SEASONAL OCCURRENCES OF SHOREBIRDS IN LONOKE COUNTY, ARKANSAS.
Gary R. Graves

*COMPARISON OF BICYCLING, RUNNING, AND TREADMILL WALKING FOR DEVELOPING PHYSICAL FITNESS IN COLLEGE-AGE FEMALES.
Phillip Goad, Bob Corbin, Carroll Smith, and Harry Otree

FOOD SHARING BEHAVIOR IN PRIMATES.
Charles G. Wilson

Arkansas Academy of Science Proceedings, Vol. XXX, 1976
BEHAVIORAL INTERACTIONS BETWEEN THE CALIFORNIA SEA LION (ZALOPHUS CALIFORNIANUS) AND RHESUS MACAQUE MONKEY (MACACA MULATTA) AT THE LITTLE ROCK ZOO.
Sidney Yeider and Gary Heidt

A CONTINUATION OF MOURNING DOVE STUDIES IN CLARK COUNTY, ARKANSAS, WITH EMPHASIS ON CYCLICAL BEHAVIOR PATTERNS.
Thurman Booth, Fred Burnside, Jan Burnside, and Peggy Rae Dorris

DISTRIBUTIONAL RECORDS OF AMPHIBIANS AND REPTILES IN ARKANSAS.
Edmond J. Bacon and Zane M. Anderson

CHEMISTRY SECTION
Chairman: F.L. Setliff

*THE USE OF A SHIFT REAGENT IN AN NMR STUDY OF CARVONE.
Ricky Stamps

*ARYNE INTERMEDIATES: 2,3-DEHYDROTHIOPHENE.
Michael T. Crimmins

*ISOTOPE EFFECTS IN DIFFUSION.
Stephen A. Lachowsky

*THE QUANTITATIVE EVALUATION OF LEAD-210 IN SPRING WATER.
Laura Ballard

CORRELATION ENERGY OF SMALL POLYATOMICS.
M. Fillmore Bowen and Neil S. Oslund

SYNTHESIS AND DEHYDROCHLORINATION OF 1-14C LABELED SUBSTITUTED DDT COMPOUNDS.
Scott Crook and Arthur Fry

SYNTHESIS OF p-SUBSTITUTED 1-14C-RING-LABELLED DIAZOCETOPHENONES.
Lee Netherton and Arthur Fry

STUDIES IN BALLING-ACID RATIO IN ARKANSAS GRAPES.
Camden D. Jones, Dominic T.C. Yang, and Thomas O. Whitley

QUANTITATIVE INFRARED ANALYSIS OF DIKETONES AND ANHYDRIDE IN MIXTURE.
D.T.C. Yang, F.H. Watson, and J.O. Lay

ENVIRONMENTAL SCIENCE AND SCIENCE EDUCATION SECTION
Chairman: Mel Fuller

SOIL SALINITY MEASUREMENT BY THE FOUR-PROBE TECHNIQUE.
K. Srivotai and J.T. Gilmour

THE SWIMMING ABILITY OF LARVAL AND JUVENILE GIZZARD SHAD AND THREADFIN SHAD AS RELATED TO THEIR ENTRAINMENT BY POWER WATER INTAKE SYSTEMS.
Manuel Barnes

THE EFFECT OF SOIL BUFFER CAPACITY ON THE LONGEVITY OF SOIL REACTION (pH) MODIFICATION AND THE SUBSEQUENT EFFECT ON PLANT GROWTH AND NUTRIENT UPTAKE.
P.E. Pope and R.B. Vasey

AN EXPERIMENTAL TESTING PROGRAM IN ELEMENTARY CHEMISTRY.
Billie Broach and Howard L. Hodges

PRACTICAL ILLUSTRATIONS OF GENETIC PRINCIPLES USING COAT COLORS OF CATTLE.
C.J. Brown

OUACHITA BIOLOGICAL STATION — AN OPPORTUNITY FOR FIELD BIOLOGISTS.
Richard K. Speairs, Jr.

A PLANETARIUM — WHY?
Paul C. Sharrah and Carl T. Rutledge

BIOLOGY III SECTION (Botany)
Chairman: William R. Bowen

PRIMARY PRODUCTIVITY, WATER QUALITY, AND LIMITING FACTORS IN LAKE CHICOT.
Edmond J. Bacon

THE VASCULAR PLANT FAMILY BORAGINACEAE IN ARKANSAS.
Gary Tucker

A SCANNING ELECTRON MICROSCOPE STUDY OF BRACHYSCLERIDS OF PEAR (PARUS COMMUNIS L.).
Clarence B. Sinclair

AERATION, PHOSPHORUS, AND LIME EFFECTS ON NITROGEN MINERALIZATION IN IMPERFECTLY DRAINED FOREST SOILS.
M.S. Bhangoo, D.J. Albritton, and E. Shoulders

NEW LOCALITY RECORDS FOR CLAYTONIA CAROLINIANA AND DROSERA CAPILLARIS IN ARKANSAS.
LeRoy Poff

*A PRELIMINARY STUDY OF THE ACRASIOMYCOTA NATIVE TO ARKANSAS SOILS.
Ron Rosen

TEMPORAL AND SPATIAL DISTRIBUTION OF ALGAE ON THE BUFFALO NATIONAL RIVER.
Laura Lee Rippey

AN OCULAR POINT FRAME FOR VEGETATIONAL SAMPLING.
Michael I. Johnson

RE-ESTABLISHMENT OF A PRAIRIE IN NORTHWEST ARKANSAS.
James Gibbons and Edward E. Dale, Jr.

FOREST VEGETATION OF THE BUFFALO RIVER AREA, ARKANSAS.

EVALUATION OF STAND AND SITE CHARACTERISTICS ASSOCIATED WITH SOUTHERN PINE BEETLE INFESTATIONS.
Timothy T. Ku and James M. Sweeney

A SEASONAL SYMBIOSIS INVOLVING DAMSELFLY NYMPHS AND A Euglenoid Alga.
William R. Bowen
Program

**BIOLGY IV SECTION (Zoology)**
Chairman: George Harp

**FISHES OF THE FOURCHE RIVER IN NORTHCENTRAL ARKANSAS.**
Steve M. Bounds and John K. Beadles

**A SURVEY OF THE FISHES OF CANE CREEK.**
Bruce E. Yeager and John K. Beadles

**A NEW SPECIES OF NOTROPIS (CYPRINIDAE) FROM THE MISSISSISSIPPI VALLEY.**
Henry W. Robison

**DIFFERENTIATION OF LARVAL GIZZARD SHAD, DOROSOMA CEPEDIANUM, AND THREADFIN SHAD, DOROSOMA PETENENSE, AIDED BY THE USE OF A POLARIZING FILTER.**
Manuel Barnes

**ODONATE UPDATE.**
John D. Rickett

**AN ANNOTATED LIST OF ARKANSAS COCCINELLIIDAE.**
Joan B. Chapin and E. Phil Rouse

**‘TOXICITY OF COPPER AND ZINC TO GAMBUSIA AFFINIS (POECILIIDAE).’**
Julia Louann Taylor

**‘SURVEY OF THE COLEOPTERA OF THE NORTH FORK OF CADRON CREEK.**
Chris Carnton

**‘AN EXTENDED STUDY OF THE TREMATODE FAUNA FOUND WITHIN ARKANSAS AMPHIBIANS.**
Ron Rosen

**‘FEEDING HABITS OF AMBYSTOMA TEXANUM IN CRAIGHEAD COUNTY, ARKANSAS.**
Gary Meador

**SCANNING ELECTRON MICROSCOPY OF THE RAINBOW TROUT (SALMO GAIRDNERI) SPERMATOZOOON.**
James H. Fribourgh and Bernard L. Soloff

**LAMPSILIS (PLECYPODA: UNIONIDAE), BEAUTY OF THE STREAM BENTHOS: HAVE MEN AND CORBICULA USURPED ITS FUTURE?**
Louise Russert Kraemer

**MACROBENTHOS POPULATION CHANGES IN CRYSTAL LAKE, ARKANSAS, SUBSEQUENT TO CAGE CULTURE OF FISH.**
James C. Adams, Raj V. Kilambi, William A. Wickizer, and Arthur V. Brown

**ANTHROPOLOGY SECTION**
Chairman: Timothy C. Klinger

**THE USE OF FRESHWATER MUSSEL SHELLS AS INDICATORS OF SEASONAL OCCUPATION OF ARCHEOLOGICAL SITES.**
Robert H. Ray

**TROPHY SKULLS AND LOOSE TEETH FROM THE CRENSHAW SITE (3MI6).**
Mary Lucas Powell

**THE MACHISMO SYNDROME: A RESIDENTIAL CORRELATE OF ITS EXPRESSIONS IN A SOUTH MEXICAN COMMUNITY.**
Judith M. Brueske

**THE SMITHSONIAN COLLECTIONS FROM ARKANSAS AS A RESOURCE FOR ARCHEOLOGISTS.**
Michael P. Hoffman

**IS ARCHEOLOGY REALLY ANTHROPOLOGY?**
Robert L. Brooks

**THE PROBLEM OF SITE DEFINITION IN CULTURAL RESOURCE MANAGEMENT.**
Timothy C. Klinger

**USING GLO (GOVERNMENT LAND OFFICE) LAND SURVEY NOTES IN AN ENVIRONMENTAL RECONSTRUCTION OF THE VILLAGE CREEK BASIN: A RESEARCH DESIGN.**
Ronald Wogaman

**A PRELIMINARY INVESTIGATION OF CHERT RESOURCES ALONG THE OZARK ESCARPMENT IN NORTHEAST ARKANSAS.**
Mark A. Mathis
MINUTES OF THE BUSINESS MEETING, 10 APRIL 1976

The business meeting of the Arkansas Collegiate Academy of Science was called to order by the presiding president, Patricia Alexander. The minutes of the last meeting were approved as read. The financial report was submitted by Curtis Shankle. The Collegiate Academy's account contained $172.11 which was to be refunded to the Senior Academy. Dr. Bridgman suggested that $175.00 be requested from the Senior Academy. It was so moved and passed.

The following officers were elected for 1976-77.

- President: Phillip Goad, Harding College
- President-Elect: William Casson, UAM
- Secretary: Susan Brady, Harding College
- Treasurer: Jim Hall, Harding College
- Sponsor: Dr. Edmond W. Wilson, Harding College
- Co-Sponsor: Dr. Joe Guenter, UAM

The new president, Phillip Goad, took charge and a discussion of the experimental merger of the Collegiate Academy with the Senior Academy in regard to paper presentations followed. The general opinion was that, although it was not the intention of the Executive Council to eliminate the Collegiate Academy, a certain amount of identity loss occurred. A motion was made and carried that Dr. Wilson should bring this problem to the attention of the Senior Academy in the General Business Meeting, and that Dr. Wilson should suggest that the President of the Collegiate Academy or his proxy attend the Executive Meeting of the Senior Academy. A motion was made and carried that schedules should continue to merge Academy and Collegiate Academy presentations.

Awards were made for the winning presentations at this meeting. In the Biological Science Section, the first place certificate was awarded to Ron Rosen. The second and third place certificates were awarded to Gary Graves and Julia Louann Taylor, respectively. In the Physical Science Section, the first place certificate was awarded to Laura Ballard. The second place certificate was awarded to Stephan Lachowsky. The meeting was adjourned by the new president.

Respectfully submitted,
Susan Brady
Secretary

Editor's Note: Several Collegiate Academy members distinguished themselves by presenting scholarly papers before appropriate meeting sections of the Senior Academy on 9 and 10 April 1976. Titles of papers presented by these Collegiate Academy members are identified in the preceding Section Programs by *.
Sixty Years of the Academy

DWIGHT M. MOORE

[Transcribed and edited from a report presented to the Academy at the 60th Annual Business Meeting by Dr. Moore, Academy Historian]

Here is the kind of publication that is put out now. Compare it with a copy of the first issue of the Proceedings, which came out in 1941, and for which I had the responsibility of being Editor. We had an Editorial Board of three members then.

This is the third meeting of the Academy on this campus. First was in 1946, then in 1966, and then 1976; so they seem to go on sort of 10-year jumps here. But the Academy — how many of you know just when and how the Academy was organized?

Back in 1917, at the Medical School in Little Rock, the science people (most of them doctors) got together and organized the Academy of Sciences — The Arkansas Academy of Science. I think they had more to the name at that time, but I don’t remember that now. They held one public meeting in the spring of 1917, and then do any of you remember what happened in ’17? The First World War. Now, I don’t believe many of you can remember that far back, but since then we’ve met on the campus of the Medical School in ’43, ’44, ’45 (those were the war years — the Second World War), again in ’47, ’49, and back in ’58. So we’ve met on the Medical School campus, counting the first one, seven times.

Along in the 30’s, we met at the University in Fayetteville for the first time in 1937 and, at that time, it was the idea to meet there every third year, but it didn’t work that way right then. We met again in 1940 there, but then came the war years, and so we met in Little Rock after that. In ’48 we got back to the every third year at the University in Fayetteville; in ’48, ’51, ’54, ’57, ’61 (skipped four years then), ’65, ’69, and again in ’72. So we’ve had the most meetings on the campus at Fayetteville — ten of them.

The Academy has met three times at Conway at what was ASTC (Arkansas State Teachers College). That is an interesting item. The first meeting held on a college campus in Arkansas, aside from the Medical School, was in ’34; and the President at that time was a lady from that campus, Dr. Flora Hause. She was quite active in the Academy from the time of organization. Interesting again is that our incoming President who will be installed at a meeting tomorrow is Dr. Jewel Moore, also from the same campus. We met on that campus in ’34, ’64, and ’74.

There are several other places we’ve met: three times at Jonesboro on the campus of Arkansas State College (Arkansas State University now), and then three times at Harding College at Searcy. We met only once at John Brown University in Siloam Springs, and that was in 1959. I’m not actually bragging, but that’s the only meeting since the re-organization in 1932 that I have missed. I was at the University of Saigon at that time, and couldn’t get over to the meeting.

We re-organized in 1932, and had our first public meeting in 1933, and that was at the Lafayette Hotel in Little Rock. Do any of you remember the Lafayette Hotel? It’s been gone for some time. From ’34 on, we’ve met on college campuses, except in 1950 when we met at Petit Jean State Park.

Well, that’s a little of what we’ve done in the past. Since the organization in ’17, that makes just completing about 60 years of the Academy. This is the 60th meeting.

I might explain one thing about that. From the meeting in ’17, the first meeting, our next public meeting was in ’33, and the only original member of the Academy who was attending that meeting was the permanent Secretary, Troy Lewis, who was a lawyer — a prominent attorney here in Little Rock. It was to him that I went in 1932 to get information about what had been done. He furnished that information, and he said at that time, “We’ll call this meeting at the Lafayette Hotel the 17th meeting, because it’s the 17th year since it was established first.” He said, “We’ll assume that some of the officers have gotten together once a year.” So this meeting today is, on that basis, the 60th meeting. I think that gives you a little idea of what we’ve had in the Academy in the past 60 years.
Macrobenthos Population Changes in Crystal Lake, Arkansas Subsequent to Cage Culture of Fish

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ABSTRACT

A three-year study was conducted to determine the possible effects of cage culture of fish on the environment of Crystal Lake, Arkansas. The investigation consisted of three periods: pre- (November 1971-October 1972), during- (November 1972-October 1973), and post- (November 1973-October 1974) cage culture. Numbers and biomass of benthos per square meter for pre-, during-, and post-culture periods were 1353 (10.0g), 730 (8.8g), and 1028 (4.1g), respectively. Numerically, Chaoborus sp., Chironomidae, and Oligochaeta comprised more than 97%. Chaoborus was the most numerous organism before fish culture (>68%), but dominance shifted to the Oligochaeta (>58%) after culture.

INTRODUCTION

Rapidly increasing human populations have created a severe demand for increased production of food. Fish production has been recognized for its potential importance in subsidizing the world's protein needs. The great demand for fish as a protein source has resulted in overexploitation of natural fisheries. Therefore, the yield from natural fisheries must be supplemented by fish culture.

Production of fish by culturing them in cages suspended in reservoirs is becoming a common practice in many southern states. There is some concern about the effects caged fish culture may have on these reservoirs. Metabolic products of the fish, fish feces and excreta, and substances leached from the fish food may cause significant changes in the physicochemical characteristics and normal biota of a reservoir which could hasten eutrophication.

This study was conducted in three one-year phases for comparison: (1) pre-culture from November 1971 to October 1972, (2) during-culture from November 1972 to October 1973, and (3) post-culture from November 1973 to October 1974 (Kilambi et al. 1976). This report concerns the effects of fish cage culture on the macrobenthos population of Crystal Lake, Arkansas.

STUDY AREA

Crystal Lake, Benton County, Arkansas, is owned and operated by the Arkansas Game and Fish Commission as a public fishing lake. Crystal Lake has a surface area of 24 hectares (60 acres), an average depth of 4.5 m (15 ft), and a maximum depth of 9 m (30 ft). The watershed to lake area ratio is approximately 40:1, which, with an average annual rainfall of more than 152 cm (60 in.), produces a relatively high water exchange rate.

The lake undergoes the warm monomictic type of stratification characteristic of lakes in northwest Arkansas. Stratification begins in late April and is complete by early June. Desaturation and fall turnover occurs by late November with continuous mixing of the entire water column throughout the winter and early spring.

MATERIAL AND METHODS

For sampling purposes the lake was divided into three sections, A, B, and C, representing the lower, middle, and upper regions, respectively (Fig. 1). One sampling unit was used to represent each section.

Two benthos samples were taken at each station with an Ekman dredge (231 cm³) twice a month between 0800 and 1100 hours. The contents were strained through a #30 (590 μm mesh) U.S. Standard Sieve. All material remaining in the sieve was placed in quart jars containing 5% formalin and transported to the laboratory where the organisms were separated from the detritus in white porcelain pans with the aid of an illuminated magnifying glass. Benthic organisms were identified to appropriate taxa as classified by Pennak (1953). The organisms then were preserved in 80% ethanol for future reference.

Significance of statistical tests was expressed at the 0.05 level.

RESULTS

Comparison of benthic organisms m⁻² between stations within the study periods showed no significant differences (pre-cage F₁,₉ = 0.16, during-cage F₅,₉ = 1.2, post-cage F₃,₉ = 0.32). Therefore, the data for stations within periods were combined for further analysis.

During the pre-culture phase of the study the mean annual density of the total benthic macroinvertebrates was 1353 N m⁻² with a biomass of 10.0 g m⁻². The most abundant benthic organism was larval Chaoborus sp. (F₁,₉ = 0.04). The average annual density of Chaoborus sp. was 847 N m⁻² (Fig. 2) which represented 62.6% of the total benthic community. Chironomid larvae and Oligochaeta had densities of 290 N m⁻² (21.43%) and 173 N m⁻² (12.79%), respectively (Fig. 2). The remaining portion of the benthos was composed of ceratopogonid larvae with 36 N m⁻² (2.66%; Fig. 2), mollusks (Sphaeridae, Physa sp., and Gyraulus sp.) with 5 N m⁻² (0.37%), and other taxa including Odonate nymphs (Enallagma sp. and Chromagymn sp.), dytiscid larvae, and coleopterates with 2 N m⁻² (0.15%).

During the culture phase of the study no additional taxa of benthic organisms were present in the collections. The mean annual total was 730 N m⁻² with standing crop biomass of 8.8 g m⁻². This phase showed

Figure 1. Map of Crystal Lake showing sampling stations and cage culture site.
no significantly ($F_{1,43} = 0.16$) dominant taxon; the average annual densities for Chaoborus sp., chironomid larvae, and oligochaetes were 217 N $m^{-2}$ (39.73%), 247 N $m^{-1}$ (33.84%), and 239 N $m^{-1}$ (32.74%), respectively (Fig. 2). The remainder was composed of caenorrhyncha larvae with 22 N $m^{-1}$ (3.10%; Fig. 2), mollusks with 2 N $m^{-1}$ (0.27%), and other taxa with 3 N $m^{-1}$ (0.41%).

The post-culture phase mean annual density was 1028 N $m^{-1}$ with a standing crop biomass of 4.1 g $m^{-2}$. During this phase the dominance shifted to Oligochaeta ($F_{1,2} = 0.00$) with an average annual density of 508 N $m^{-1}$ (Fig. 2) comprising 88.17% of the total benthic community. Chaoborus sp., chironomids larvae, mollusks, and other taxa had densities of 333 N $m^{-1}$ (32.39%; Fig. 2), 85 N $m^{-1}$ (8.27%; Fig. 2), 9 N $m^{-1}$ (0.88%; Fig. 2), 2 N $m^{-1}$ (0.19%), and 1 N $m^{-1}$ (0.10%), respectively.

The total density of organisms was 1353, 730, and 1028 N $m^{-1}$ in the pre-, during-, and post-culture periods, respectively. There were no significant differences in the total number of benthic organisms among the years ($F_{1,2} = 0.00$). Total biomass decreased each year; 10.0, 8.8, and 4.1 g $m^{-2}$ were found in pre-, during-, and post-culture phases, respectively.

Several statistically significant changes among the dominant taxa of benthos were observed. Chaoborus sp. was the most abundant benthic organism (61%) before fish culture ($F_{1,43} = 0.06$), no single taxon dominated the culture phase ($F_{1,2} = 0.00$), and the oligochaetes composed the bulk (>65%) of the post-culture ($F_{1,2} = 0.00$) standing crop. The number of oligochaetes increased significantly ($F_{1,2} = 0.00$) during the study, and chironomids decreased significantly ($F_{1,2} = 0.00$) from during-culture to post-culture. No significant shifts were observed either in the number of Chaoborus sp. ($F_{1,2} = 0.00$) or among the dominant taxa ($F_{1,2} = 0.00$) between culture phases. Mollusca and other taxa remained unchanged during the study.

A single specimen of Branchirha sowerby Beddard was collected on 26 June 1974 in the lower end of the lake at a depth of 9 m. This gilled oligochaete was reported from two lakes in northwest Arkansas (Causey 1953), Lake Ft. Smith and Lake Atlanta.

**DISCUSSION**

The dominant taxa of benthic organisms according to density in Crystal Lake were Culicidae (Chaoborus sp.), Chironomidae, and Oligochaeta. Throughout the study they comprised 97.23% of the benthic community. This percentage agrees with the results found in three other northwest Arkansas lakes. Tatum (1951) found that in Lake Atlanta Oligochaeta, Chironomidae, and Culicidae constituted 99.68% of the total benthos collected. In Lake Wedington, Owen (1952) reported that 97.4% of the benthic population was Oligochaeta, Chironomidae, and Culicidae. Hulsey (1956) found that in Lake Fayetteville the structure of the benthic community was 97.1% Oligochaeta, Chironomidae, and Culicidae.

Throughout the study, Mollusca and other minor taxa represented a small portion of the benthos numerically; however, because of large individual mean weight they did comprise a significant fraction of the total biomass.

During the culture period, 17,444 kg of floating fish food was fed to a fish weight of 13,185 kg of caged fish. Bottom samples from the cage site contained large quantities of fish feces composed of undigested cellulose from the fish chow. These deposits decreased appreciably through the post-culture phase, presumably as a result of decomposition and dispersal during mixis. Apparently nutrients bound in this material were released into the water and sediments. Of 13 physicochemical parameters monitored, ortho- and metaphosphate, nitrite and nitrate nitrogen, and turbidity showed significant increases during the study (Kilambi et al. 1976). This increase in nutrients produced larger annual standing crops of phytoplankton, zooplankton, and natural fish populations. The total benthos community did not increase as might have been expected. Apparently the residue resulting from fish culture was not used immediately by the macrobenthos and may have been responsible for their decrease during the study. This possibility is supported by the observation that the fish feces which accumulated were not immediately colonized by benthos. The fact that oligochaetes colonized this material at a faster rate than other taxa may account for their subsequent dominance.

Changes in the benthic community probably were caused by fish culture. However, this conclusion cannot be established definitely because there are no data covering several consecutive years in an Ozark reservoir that would establish normal fluctuations in these values for comparison. It is evident, therefore, that continuous monitoring of a reservoir for several years before and after fish culture would be necessary to record natural changes of benthos and to determine the precise effects of fish culture and the subsequent recovery rate.

**ACKNOWLEDGEMENT**

This project was supported by funds provided by the Arkansas Game and Fish Commission and the National Marine Fisheries Service through P. L. 88-309.

**LITERATURE CITED**


Distributional Records of Amphibians and Reptiles from Coastal Plain of Arkansas

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ABSTRACT

Distribution of amphibians and reptiles in the West Gulf Coastal Plain and Mississippi Alluvial Plain is not well known because extensive collecting has not been done in these areas and data in museums have not been published. New distributional records for three salamanders (Desmognathus fuscus brimleyorum, Manculus quadridigitatus, Plethodon glutinosus glutinosus), two anurans (Rana areolata circiula, Scaphiopus holbrooki holbrooki), and one snake (Lampropeltis doliata amurensis) are presented. Additional collecting will be necessary to determine the exact range and status of the secretive species.

INTRODUCTION

The herpetofauna of Arkansas is only moderately well known, and a vast amount of fieldwork is needed to define specific and subspecific ranges. The most complete description of amphibians and reptiles in Arkansas was compiled by Dowling (1957), and this work has been used to determine geographic ranges (Conant 1975) even though Dowling made no attempt to do so because of insufficient data. This report summarizes new records of amphibians and reptiles from the Gulf Coastal Plain and Mississippi Alluvial Plain. Additional collecting in these areas will be necessary to define geographic ranges, especially for the more secretive species. Additional records pending further investigation will be presented at a later date.

MATERIALS AND METHODS

Field trips were made throughout the year, but most of the collecting was conducted during late winter and spring. Several specimens, especially the rarer species, were photographed and released. After collection the animals were returned to the laboratory and frozen in water for later preparation. After thawing, they were injected with 10% formalin and pinned in a dissecting tray. Enough 10% formalin was added to cover the specimens. After fixation for 24 hours, the specimens were labeled, cataloged, and placed in 50% isopropyl alcohol or 25% soak solution for permanent storage. Voucher specimens were placed in the UAM Collection of Vertebrates. Common and scientific names are in agreement with those proposed by the Committee on Herpetological Names (1956).

CLASS AMPHIBIA

Order Caudata (Salamanders)

Distributional records for three salamanders have been found, and these species apparently are much more widespread than previously thought.

Central Dusky Salamander

Desmognathus fuscus brimleyorum Stejneger

Ouachita Co: UAM 1275-1280 (S1, T11S, R18W; S11, T11S, R18W).

Dowling (1957) considered Desmognathus fuscus brimleyorum to be statewide and data in museums have not been published. New distributional records for three salamanders (Desmognathus fuscus brimleyorum, Manculus quadridigitatus, Plethodon glutinosus glutinosus), two anurans (Rana areolata circiula, Scaphiopus holbrooki holbrooki), and one snake (Lampropeltis doliata amurensis) are presented. Additional collecting will be necessary to determine the exact range and status of the secretive species.

Dwarf Salamander

Manculus quadridigitatus (Holbrook)

Bradley Co: UAM 1259-1262, 1272-1274 (S5, T12S, R10W; S26 T13S, R9W); Calhoun Co: UM 1263-1264 (S32, T13S, R12W); Cleveland Co: UM 1267-1269 (T12S, R10W); Drew Co: UM 116-1123 (T12S, R7W; S13, T13S, R7W; S12, T12S, R17W); Nevada Co: UM 1270-1272 (S22, T11S, R20W); Ouachita Co: UAM 1126-1127, 1265-1266 (S1, T11S, R13W; S11, T11S, R18W).

The dwarf salamander previously has been reported from Lafayette and Miller Counties (Dowling 1957). This distribution was given by Conant (1975), although he reported a questionable record in southern Arkansas. The dwarf salamander is one of the most abundant and widespread salamanders in southern Arkansas. Apparently it is most abundant in Bradley County, and during a thundersstorm on 23 January 1976 more than 100 specimens were captured along the highways in less than two hours. The dwarf salamander is locally abundant in Ouachita County and has been found in upland wooded areas as well as in low swampy areas. It is also locally abundant in Drew and Cleveland Counties. Collecting trips to Ashley, Chicot, Desha, Lincoln, Union, and Dallas Counties have not yielded any specimens, but it is expected to be found in most of these areas in the near future because of similarity of habitats.

Slimy Salamander

Plethodon glutinosus glutinosus (Green)


The slimy salamander, Plethodon glutinosus glutinosus, has long been considered to be confined to the Interior Highlands, but Dowling (1957) suggested that its apparent absence in the Coastal Plain may have been due to insufficient collecting. This appears to be the case, and it is locally abundant in some areas. Eighteen specimens were collected in Bradley County and two specimens were found in adjacent Calhoun County, but the slimy salamander has not been collected in nearby counties despite many attempts. It is believed to be scattered throughout the Coastal Plain and locally abundant in only a few areas. In southern Arkansas, Plethodon glutinosus glutinosus apparently is not restricted to upland habitat, although it appears to be more common in these areas. One locality in Calhoun County was a lowing drainage valley near a small stream.

Order Anura (Frogs and Toads)

The distributions of secretive anurans such as the northern crawfish frog and spadefoot toad are difficult to determine. Consequently, these two species are probably more widespread and locally abundant than present data indicate.
Edmond J. Bacon and Zane M. Anderson

Northern Crawfish Frog
Rana areolata circulosa Rice & Davis
Bradley Co: UAM 985 (S13, T13S, R9W); Chicot Co: NELSU 16680 (T13S, R1W); Drew Co: UAM 980-984, 1249-1255 (S10, T13S, R7W; S11, T13S, R7W).
The northern crawfish frog was reported from Washington County by Dowling (1957). Byrd and Hanebrink (1974) collected four individuals in Craighead County, and Dr. Neil H. Douglas (pers. commun.) collected a single specimen in Chicot County in 1967. A single specimen was collected in Bradley County, and a large population breeds annually on the UAM campus in Drew County. It probably is present in Ashley and Desha Counties as well. Collecting in these areas has been unsuccessful.

Breeding of the northern crawfish frog in southeastern Arkansas begins in late January and is greatly dependent on temperature and precipitation. After heavy thunderstorms, males were observed moving to breeding ponds on 29 January 1976. Ambient temperature ranged from 1.7 to 14.4 C. Males called only at night for at least two weeks before the females arrived. Females were found at the ponds on 23 February 1976 and ambient temperature ranged from 0.6 to 11.1 C. Approximately 50 individuals were at the ponds by 23 February. Two individuals in amplexus were captured and taken to the laboratory. Egg masses were found in the aquarium the following day, and the eggs hatched in 3-4 days. The tadpoles were reared on a diet of boiled spinach. Calling had subsided at the ponds by 29 February. No calls were reported until 10 March after approximately 8.2 cm of rainfall, when a few individuals called during a two-day period. One individual called on 31 March after 5.0 cm of rainfall on 29 and 30 March. The height of the breeding season was during late February.

Eastern Spadefoot Toad
Scaphiopus holbrooki holbrooki (Harlan)
The eastern spadefoot toad, Scaphiopus holbrooki holbrooki, was reported by Dowling (1957) from Lawrence County. The revised distribution by Conant (1975) included only the northeastern counties of Arkansas. Eighteen specimens were found at Dermott, Arkansas, in Chicot County during late March and early April 1972. Hurter's spadefoot toad, Scaphiopus holbrooki hurteri, is present in the western part of the state, and several specimens in the UAM Collection of Vertebrates were collected at El Dorado, Arkansas, in Union County in 1964. Neither the eastern spadefoot toad nor Hurter's spadefoot toad has been collected in the areas between Chicot County and Union County. There may be a line of intergradation but it is unknown at this time.

Supporting Information

Edmond J. Bacon and Zane M. Anderson

CLASS REPTILIA
Order Squamata (Lizards and Snakes)

Louisiana Milksnake
Lampropeltis doliata amaura (Cope)
Ashley Co: UAM 178 (T17S, R5W); Bradley Co: UAM 46 (T13S, R10W); Ouachita Co: NELSU 10734 (S11, T13S, R7W).
The Louisiana milksnake, Lampropeltis doliata amaura, has been reported from scattered localities south of the Arkansas River. Dowling (1957) listed only one specimen from each of Garland, Logan, and Union Counties. Conant (1975) considered the range to be limited to southwestern Arkansas. Specimens in the UAM Collection of Vertebrates from Bradley and Ashley Counties suggest that the Louisiana milksnake is widely scattered but rare in southern Arkansas. Dr. Neil H. Douglas (pers. commun.) found a single specimen near Camden in Ouachita County. No other specimens from Arkansas are known.

ACKNOWLEDGEMENTS

The authors are grateful to the Department of Biology at the University of Arkansas for the use of space and facilities. We are indebted to the late Dr. Claud M. Ward for his contributions to the knowledge of the herpetofauna of southeastern Arkansas. Dr. Neil H. Douglas, Northeast Louisiana University, generously provided data on localities in Arkansas. We are also appreciative of distributional records and specimens collected by various individuals of the Taxonomy and Natural History of Vertebrates classes at UAM during the past few years. Special recognition is due Algie Jolly, Gale McFarland, Steve Lipton, Gary Thornton, Kenneth Loomis, Errol Barrett, and Jim McDaniel.

LITERATURE CITED


Aeration, Phosphorus, and Lime Affect Nitrogen Mineralization in Imperfectly Drained Forest Soils*

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ABSTRACT

Unamended, limed, and phosphorus-enriched Caddo, Beauregard, and Wrightsville silt loams (A. horizon) were incubated for six months at room temperature under two moisture regimes. At field capacity, unamended soils lost 0.7% of organic matter and converted 166 ppm of organic nitrogen to inorganic forms. Ninety-five percent of the converted nitrogen was present as NH$_4^+$ or NO$_3^-$. Limed and phosphorus-treated soils at field capacity lost about 1.0% of organic matter and accumulated 191 to 201 ppm of inorganic nitrogen. Submerged soils lost very little organic matter and accumulated only 24 to 28 ppm of inorganic nitrogen. There was a loss of 35 to 78 ppm of nitrogen from the submerged soils, presumably through denitrification.

INTRODUCTION

Organic matter in moderately well and less perfectly drained forest soils of the West Gulf Coastal Flatwoods contains up to 2240 kg/ha of nitrogen (USCSS 1966). How rapidly this nitrogen is mineralized profoundly affects tree growth as well as response of timber stands to nitrogen fertilization. The research reported here concerns the effects of soil aeration, phosphorus fertilization, and liming on mineralization and nitrification of organic nitrogen in three important southern pine-growing soils of the region.

Research on agricultural soils of other regions has indicated that calcium salts usually promote mineralization of soil nitrogen (Singh et al. 1969, Agarwal et al. 1971, Broadbent and Nakashima 1971) and that phosphorus may increase or decrease net mineralization depending on the soil and the level of microbial activity (Ryan et al. 1972, Ryan and Sims 1974).

Broadbent and Reyes (1971) reported that greater amounts of nitrogen were mineralized under flooded than under upland conditions. Ponnamperruma (1972) concluded that deamination of organic residues may proceed more rapidly in aerobic than in anaerobic soils, but that anaerobic soils may accumulate more inorganic nitrogen because less is immobilized by microorganisms. More recently, Stanford and Epstein (1974) found that more mineral nitrogen usually accumulated in soils having 80 to 90% of the total pore space filled with water than in wetter or dryer soils. They thought denitrification was responsible for the reduced accumulation of mineral nitrogen in wetter soils. Patrick and Tusneem (1972) described aerobic and anaerobic layers in submerged soils and showed that denitrification was the major pathway through which submerged soils lose NH$_4^+$ as well as NO$_3^-$. I)

METHODS AND MATERIALS

Soils. Three dominant virgin soils of the West Gulf Coastal Flatwoods studied were Beauregard silt loam (Plnthaqueous Paleudult, fine-silty, siliceous, thermic), Caddo silt loam (Typic Glossaqualf, fine-silty, siliceous, thermic), and Wrightsville silt loam (Typic Glossaqualf, fine, mixed, thermic). Each soil was represented by composite samples of the A horizon (0-15 cm depth) collected in midsummer from each of two locations in Rapides Parish, Louisiana. Individual composites contained 2.4 to 4.0% organic matter (Table 1).

<table>
<thead>
<tr>
<th>Layer</th>
<th>Organic Matter (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2.4-4.0</td>
</tr>
</tbody>
</table>

*Contribution from the Department of Agriculture, University of Arkansas at Pine Bluff. Published with the approval of the Dean of the Division of Agriculture and Technology and Director of Agriculture as Paper No. 4 of the Journal series. The research was partially supported by the Southern Forest Experiment Station, USDA, Forest Service.

Study Procedures. Soil from each location was mixed thoroughly while moist and divided into eight parts. Two parts were assigned at random to each of four lime-phosphorus treatments:

1. Untreated (checks).
2. Lime (CaCO$_3$) incorporated into the soil to supply 1 meq of Ca/100 g of soil.
3. Phosphorus and K$_2$HPO$_4$ incorporated at a rate of 88 ppm of P.
4. Both CaCO$_3$ and K$_2$HPO$_4$ added at the above rates.

Potassium was eliminated as a variable in the experiment by adding sufficient KCl to treatment 1 and 2 soils to compensate for the K in the phosphorus carrier in treatments 3 and 4.

After receiving the amendments, individual lots of soils were sampled for chemical analysis and further subdivided to be incubated at field capacity or submerged under one inch of water. Each plot consisted of a one-gallon plastic pot containing 2.5 kg (oven dry weight) of soil. The soils were incubated at room temperature (25-28°C) for six months and then resampled for chemical analysis.

Soil samples were analyzed by the following procedures. Organic N + NH$_4^+$ were determined by the Kjeldahl method as described by Jackson (1958). Exchangeable NH$_4^+$ was determined by a modification of the Kjeldahl method using MgO instead of NaOH to release NH$_4^+$ (Horwitz 1953). Nitrate nitrogen was determined with the procedure described by Sims and Jackson (1971). Organic matter and carbon were determined by the wet oxidation method (Jackson 1958) with Ferroin as the indicator. Exchangeable bases were replaced with 1 N HCl and determined colorimetrically by the chlorostannous-reduced molybdenophosphoric blue color method, in a hydrochloric acid system. Soil pH was measured with a glass electrode using 1:1 soil to water ratio.

Total mineralization of soil nitrogen was estimated by subtracting postincubation levels of organic nitrogen from preincubation levels in soils. Differences between pre- and postincubation levels of NH$_4^+$ and NO$_3^-$ also were computed to estimate mineralization of soil nitrogen to inorganic forms that should be available to plants. Loss in organic matter during incubation was determined by subtracting final from initial levels. Carbon to nitrogen ratios were determined by dividing organic carbon by the sum of Kjeldahl and nitrate nitrogen.

All the data were subjected to analysis of variance. In the analysis, soils comprised major plots in a randomized split plot design: fertilizer treatments were minor plots. Results for two moisture levels were analyzed individually because the data were derived from the same estimates of chemical properties before incubation.
RESULTS

On the basis of the chemical data in Table I, the similar texture of surface soils, and the lack of significant differences among soil series for organic matter decomposition and changes in soil nitrogen during incubation, the results presented here for three series were averaged.

Soil Organic Matter. During incubation at field capacity, untreated (check) soils lost 0.7% of organic matter (Table II) or about one-fourth of the amount present initially. Both lime and phosphorus fertilization significantly increased the rate of decomposition. Together they increased breakdown by 58% over the check-soil rate. Submerged soils showed no change in their organic matter content during incubation. Neither lime nor phosphorus fertilization affected breakdown significantly.

Soil Nitrogen. Organic nitrogen decreased 166 ppm in check soils and 196 to 231 ppm in the fertilized soils incubated at field capacity (Table II). Application of lime or phosphorus significantly increased mineralization, but the effects of the two nutrient supplements were not additive. The lime-phosphorus treatment accelerated mineralization of soil nitrogen one alone increased mineralization 46 ppm and phosphorus alone increased it 30 ppm. Significantly more NO-N accumulated in fertilized than in unfertilized soils incubated at field capacity. The advantage amounted to 43 ppm for the lime treatment, 33 ppm for the phosphorus treatment, and 30 ppm for the combination. A significant lime \times phosphorus interaction indicated that response to lime and phosphorus was not additive. Addition of phosphorus and lime had no significant effect on the accumulation of NH-N, which averaged only 7 ppm.

At field capacity, 5 to 19% more nitrogen had mineralized than actually was found in soils as NO-N or NH-N, indicating the presence of NO-N and some loss of nitrogen in gaseous form. The greatest loss (37 ppm) occurred in the lime plus phosphorus treatment.

Organic nitrogen altered in mineral form in submerged soils was less than half as much as that in soils incubated at field capacity. Alteration of organic nitrogen to mineral form in submerged soil ranged from 59 ppm for the check to 106 ppm for the lime plus phosphorus treatment. Both lime and phosphorus affected mineralization significantly. Levels of NO-N declined during incubation of submerged soils, indicating large N losses due to denitrification. These losses were enhanced by lime and phosphorus treatments.

Twenty-six to 30 ppm of NH-N accumulated. Phosphorus but not lime, increased significantly the amount of nitrogen mineralized to this form. The difference was unimportant, however, as it averaged only 3 ppm.

About two-thirds of the soil nitrogen that was altered in form during incubation of submerged soils was not present in the soil as NH-N. Losses were increased by the addition of either lime or phosphorus and were most severe when both were supplied. Soils given the latter treatment lost 78 ppm, in contrast to 35 ppm for check soils.

Carbon to nitrogen ratios. Carbon to total nitrogen (organic, exchangeable NH₃, and NO₃) ratios of field capacity soils narrowed 5.0 to 7.3 units during incubation. Significantly greater changes occurred in soils that were limed or fertilized with phosphorus than in check soils. There was also a significant lime \times phosphorus interaction which indicated that the responses to the two nutrients were not additive (Table II).

Incubation of submerged soils slightly increased the C/total-N ratio. Changes were significantly greater with the addition of lime and phosphorus than without. Addition of both nutrients resulted in an increase of 2.1 units. The carbon to organic nitrogen ratios narrowed less in untreated soils at field capacity and widened more in submerged soils than did overall C/N ratios. However, lime and phosphorus treatments indicated changes in the C/organic-N ratio similar to those in the overall C/N ratios. Thus, postincubation C/organic-N ratios of field capacity soils ranged from 21.4 for check soils to 20.1 for the phosphorus treated soils. Submerged soil ratios ranged from 23.3 for check to 25.1 for the lime-phosphorus treated soils.

DISCUSSION AND CONCLUSIONS

Un-treated soils incubated at field capacity showed a significant decrease in organic matter and C/N ratio and an increase in mineralization of organic nitrogen and its conversion to NO-N. Lime and phosphorus treatments further significantly increased mineralization of organic N in comparison with the check.

Submerged soils showed no change in organic matter regardless of treatments. The NH₄-N in soils showed some accumulation but no NO-N was found in soils. This lack of NO-N and the large amounts of mineralized N unaccounted for indicate that there was a great loss of N due to denitrification.

Results of this study together with those of Stanford and Epstein (1974) indicate that drainage and timely irrigation of the soils studied would be beneficial for mineralization of organic N to forms available to plants. These soils are saturated with water for prolonged periods in winter (Shoulders and McKee 1973). During summer, however, when soil temperatures favor rapid mineralization of organic nitrogen (Stanford et al. 1973), these soils intermittently develop major moisture deficits (Van Brackle 1959). Intensive control of soil moisture by drainage and irrigation may not be currently practical in the production of southern pine timber crops (Mareogaran 1973).

Lime and phosphorus were equally effective in increasing the supply of inorganic N (NH₄ and NO₃) that pine trees use. No additional advantage occurred from application of both nutrients. Because phosphorus deficiency is more likely than lime deficiency to limit pine growth in the West Gulf Region (Shoulders and McKee 1973) phosphorus fertilization appears preferable to liming to promote the release of mineral nitrogen and to reduce the amount of nitrogen fertilizer needed for maximum pine tree growth on these soils.

LITERATURE CITED


Aeration, Phosphorus, and Lime Affect Nitrogen Mineralization in Imperfectly Drained Forest Soils


<table>
<thead>
<tr>
<th>Treatment</th>
<th>Organic matter lost</th>
<th>Total mineralized organic N</th>
<th>Mineralized N unaccounted for</th>
<th>Change in C/N ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>ppm</td>
<td>ppm</td>
<td>ppm</td>
</tr>
<tr>
<td>Soil at field capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check</td>
<td>0.70 a</td>
<td>166 a</td>
<td>6 a</td>
<td>9</td>
</tr>
<tr>
<td>Lime (L)</td>
<td>0.97 b</td>
<td>212 bc</td>
<td>7 a</td>
<td>11</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>1.02 b</td>
<td>196 b</td>
<td>7 a</td>
<td>5</td>
</tr>
<tr>
<td>L + P</td>
<td>1.12 b</td>
<td>231 c</td>
<td>7 a</td>
<td>37</td>
</tr>
<tr>
<td>Submerged soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check</td>
<td>0.06 a</td>
<td>59 a</td>
<td>26 a</td>
<td>-2 a</td>
</tr>
<tr>
<td>Lime</td>
<td>0.06 a</td>
<td>86 b</td>
<td>27 a</td>
<td>-2 a</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.07 a</td>
<td>84 b</td>
<td>30 b</td>
<td>-2 a</td>
</tr>
<tr>
<td>L + P</td>
<td>0.03 a</td>
<td>106 c</td>
<td>30 b</td>
<td>-2 a</td>
</tr>
</tbody>
</table>

*Values in a column within a soil moisture treatment followed by the same letter are not significantly different at 0.05 level.

Table I. Selected Chemical Properties of Study Soils before Incubation

Table II. Changes in Organic Matter Content, Nitrogen, Fractions, and C:N Ratio During Incubation

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http://scholarworks.uark.edu/jaas/vol30/iss1/1
A Continuation of Mourning Dove Studies in Clark County, Arkansas, with Emphasis on Cyclical Behavioral Patterns

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Henderson State University, Arkadelphia, Arkansas 71923

ABSTRACT

In conjunction with the U.S. Department of Interior, Fish and Wildlife Service, the Henderson State University Biology Department has continued a study of mourning doves in Clark County, Arkansas, with emphasis on cyclical behavioral patterns. Three hundred forty-three mourning doves were banded, trapped, and caged to obtain information concerning age, sex, populations, retraps, abnormalities, migrations, trap injuries, cyclical behavioral patterns, and other factors.

INTRODUCTION

A survey was made of the mourning dove (Zenaidura macroura) population in an area two miles south of Arkadelphia between 1 May and 21 August 1975. Data concerning sex and age, retraps, cyclical patterns, trap injuries, other animals trapped, and abnormalities were recorded. Very little research has been done on cyclical behavioral patterns of mourning doves; therefore, this study emphasizes daily and seasonal cyclical patterns.

MATERIALS AND METHODS

During the 1 May to 1 July baiting period milo maize was piled and scattered at the baiting location. A blind was built to observe the birds. Weeds were cut to make the habitat suitable for feeding. According to Booth et al. (1975), a lapse of 10-20 days occurred before the first doves were lured into traps. A one-month baiting period was allowed. In the present study, a two-month baiting period was allowed and several innovations were used to accomplish immediate luring of doves into traps without a 10-20-day delay. Instead of all traps being placed on the site at once, half the traps were placed upside down at the end of the first month, and two weeks later the other half were added. One week before banding, traps were placed on stilts to enable doves to feed beneath them. Thus the doves could become accustomed to feeding under traps before actually being captured. Doves were trapped the first day after removal of stilts from the cages.

On 2 July, the 38 traps were turned right side up on top of a small pile of milo. Traps were checked 5 to 7 times a day to recover trapped doves and to prevent casualties caused by high temperatures. Each time traps were checked the worker placed both feet in front of the two funnels of the modified Kniffen Modified trap to prevent escape of birds. Doves were removed individually from the trap, placed in a holding sack, observed, banded, and released.

RESULTS AND DISCUSSION

Three hundred forty-three mourning doves were banded during the period of 2 July through 21 August 1975. One band was removed and destroyed because the dove was drenched in the rain and had to be held over longer than the designated 24-hour holding period before it could fly successfully. No mourning doves died in traps during the entire banding season, although ground temperatures at times were as high as 115°F. Frequency of trap checks accounts for lack of deaths caused by heat.

Previous studies by Keeler and Winston (1951) indicate that doves seldom eat wet milo; however, in this study doves frequently found to eat wet grain. Older than drenching of doves, the main problem created by rain was grain scattering.

Methods for aging doves followed those of Wight et al. (1967). One hundred fifty (44%) of the 343 doves banded were after-hatching-year birds (HY). One hundred eighty-eight (55%) were hatching-year birds (HY). Five birds (1%) were not aged because of uncertainties (Table I).

Of the 150 HY birds, 104 (69%) were males, 24 (16%) were females, and 22 (15%) were of unknown sex. Discrepancy of females to males may have resulted from a larger female dove kill during the hunting season according to Thomforde (1972). He stated that "banding showed that females were 143% more likely to be shot than males." In his 3-year study with 2218 doves, the sex ratio was 3.84 (79%) males to 1 (21%) females, which is in close relationship to the ratio in the present study.

Once the HY birds have molting their sixth primary, many can be sexed accurately. Of the 188 HY doves trapped, 24 were sexed on the basis of plumage maturity (8 males and 16 females).

A combination of doves banded before and during the present study were retrapped and recorded. Figure 1 indicates the number of times each bird was retrapped. Table II shows the percentage of HY, AHY, and unknowns that were caught more than once.

With respect to seasonal patterns, AHY or older birds were predominant during the first 24 days (7 June - 27 July). Young or HY birds were found predominantly during the last half of the banding season (28 July - 21 August). They appeared later apparently because the majority did not come off the nest until midseason. Waning numbers of HY birds may have been observed because of migration out of the area by unmated pairs.

Figures 2, 3, and 4 show daily patterns of HY and AHY males and females. Figure 2 shows that HY birds appeared at traps more often from 8 to 10 a.m. and from 5 to 8 p.m.; Figure 3 depicts daily patterns of males and females. Females appeared most often between 1 and 6 p.m. This behavior is believed to be related to nesting habits. According to wildlife authorities, females generally remain with their young in the early morning and evening and feed during the day. Retraps of both males and females were included in these calculations. Figures 4 and 5 show the pattern of AHY females during the first and second half of the 50-day banding period. It was observed that HY birds were numerous at the banding area on day 26, indicating they had come off the nest. Figure 4 shows overall parental care and feeding habits during the nesting period of females. Figure 5 shows females feeding throughout the day with no specific time preferred. The writers would hesitate to make a dogmatic statement concerning Figures 4 and 5 because of the small number of females involved; however, there appears to be a correlation between hatching season and daily feeding times of AHY females.

In the present study, 13 doves were recovered from a previous banding operation that had taken place in the 1974 season in the Arkadelphia area. Thomforde (1972) states that a large proportion of surviving individuals return to their natal area.

Abnormalities observed by the writers are listed in Table IV. Some of these may be the result of genetic defects, whereas others may have resulted from injury. Abnormalities were recorded because (1)
the Fish and Wildlife Service requires this information and (2) the data were collected to augment the previous study (Booth et al. 1975).

Animals other than doves were observed and trapped (Table V). Grackles had a direct effect upon numbers of doves present in feeding areas. Aggressive behavior of grackles resulted in a peck dominance over doves. Eastern cottontails got into and out of traps with difficulty because of their size, and thus moved traps to different locations. Opossums got into traps and harassed birds in an attempt to capture them. Other animals seemed to have little effect upon trapping, with the exception of grain consumption.

SUMMARY

Three hundred forty-three mourning doves were trapped, observed, and banded during the present study. Data collected are summarized in Tables I through V and Figures 1 through 5 to show age and sex, retraps during this study, cyclical patterns, injuries, abnormalities, animals caught other than doves, and returns from the 1974 banding season.

It can be concluded that the number of doves observed and banded in this study has made possible the accomplishment of two primary purposes. First, the previous study by Booth et al. (1975) is augmented. More data have been collected to substantiate previous research in the area and to add meaning to the overall study. Second, knowledge has been added to the scant record of cyclical behavioral patterns of mourning doves. Information gained from this study will prove beneficial to further dove banding research.

LITERATURE CITED


A Continuation of Mourning Dove Studies in Clark County, Arkansas

Table I. Sex and Age Data of 343 Mourning Doves Banded

<table>
<thead>
<tr>
<th>After Hatching Year</th>
<th>Hatching Year</th>
<th>Unknown Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>male</td>
<td>104</td>
<td>male</td>
</tr>
<tr>
<td>female</td>
<td>24</td>
<td>female</td>
</tr>
<tr>
<td>unknown</td>
<td>22</td>
<td>unknown</td>
</tr>
<tr>
<td>total</td>
<td>150</td>
<td>total</td>
</tr>
</tbody>
</table>

Overall total - 343

Table II. Sex and Age Data of Retrapped Doves

<table>
<thead>
<tr>
<th>Number</th>
<th>%</th>
<th>Number</th>
<th>%</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retrapped</td>
<td>Total</td>
<td>Retrapped</td>
<td>Total</td>
<td>Retrapped</td>
<td>Total</td>
</tr>
<tr>
<td>43</td>
<td>37</td>
<td>71</td>
<td>61</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Total number of birds retrapped - 116 (this is 34% of the total trapped)

Table III. Injuries to, AHY and HY Doves

<table>
<thead>
<tr>
<th>Injuries to After Hatching Year Doves</th>
<th>Injuries to Hatching Year Doves</th>
</tr>
</thead>
<tbody>
<tr>
<td>male</td>
<td>36 (34.6%) sex not figured</td>
</tr>
<tr>
<td>female</td>
<td>9 (37.5%)</td>
</tr>
<tr>
<td>unknown</td>
<td>6 (27.2%)</td>
</tr>
<tr>
<td>total injured</td>
<td>51 (34% of AHY birds)</td>
</tr>
<tr>
<td>total injured</td>
<td>59 (31% of HY birds)</td>
</tr>
</tbody>
</table>

Table IV. List of Abnormalities Noted on Mourning Doves

- 243-84164 Deformed tarsus on right leg
- 243-84166 Toenail missing on right foot
- 243-84510 Swelling on tarsus of right leg
- 243-84535 Small swelling on manus of left wing
- 243-84580 White patch found on newly molted 2nd primary of both wings
- 243-84584 Had an enlargement of the joint above the toes of the right leg
- 263-58549 Missing toenail on middle toe of right foot
- 263-588383 Upper mandible 1 cm longer than lower
- 263-58821 Feathers are missing and scabs had formed around a large wound on the breast

Table V. List of Animals Other Than Doves Trapped During Banding Season

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Number Trapped</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common grackle</td>
<td>211</td>
</tr>
<tr>
<td>Red-winged blackbird</td>
<td>11</td>
</tr>
<tr>
<td>Brown-headed cowbird</td>
<td>19</td>
</tr>
<tr>
<td>Cardinal</td>
<td>78</td>
</tr>
<tr>
<td>English sparrow</td>
<td>8</td>
</tr>
<tr>
<td>Bobwhite</td>
<td>7</td>
</tr>
<tr>
<td>Mockingbird</td>
<td>8</td>
</tr>
<tr>
<td>Eastern meadowlark</td>
<td>1</td>
</tr>
<tr>
<td>Loggerhead shrike</td>
<td>2</td>
</tr>
<tr>
<td>Lark sparrow</td>
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</tr>
<tr>
<td>Eastern cottontail</td>
<td>3</td>
</tr>
<tr>
<td>Opossum</td>
<td>1</td>
</tr>
</tbody>
</table>
Fishes of the Fourche River in Northcentral Arkansas

STEVE M. BOUNDS and JOHN K. BEADLES
Division of Biological Sciences, Arkansas State University, State University, Arkansas

ABSTRACT

A survey of the fishes of Fourche River in northcentral Arkansas was made between June 1974 and March 1976. Field collections and literature records revealed that the river system was inhabited by 94 species of fish representing 21 families. The collected fishes represent both the Ozark and the lowland faunal groups. Fourteen species of Etheostoma and four species of Percina were collected. The records of Etheostoma aspigene and Etheostoma zonatum represent extensions of the previously known ranges of these species within the state. Noturus gyninus and Etheostoma histrionicus were recorded from Black River system in Arkansas for the first time since 1894. Predominant highland species of minnows included Campostoma anomalum, Diobea nubila, Notropis boops, Notropis cornutus, chryscephaalus, Notropis telescopus, and Notropis zonatus. Predominant lowland species of minnows were Rhynoithys nuchalis, Notemigonus crysoleucas, Notropis sexamus, and Notropis venustus.

DESCRIPTION OF AREA

Fourche River is predominantly a clear, spring-fed stream originating in Ripley County, Missouri, and flowing into the Black River near Pocahontas, Arkansas, in Randolph County, approximately 40 miles from the stream's origin. Pfieffler (1971) reported 27 species from the Missouri part of the stream. With the exception of a 1953 survey conducted by the Arkansas Game and Fish Commission, no investigations of the fishes found south of the Arkansas-Missouri line are known for Fourche River. Studies were conducted in Randolph County on the Current River and Jane's Creek by Griggs and Beadles (1974) and Fowler and Harp (1974), respectively. Twenty-five floodwater-retarding structures have been proposed for the Fourche River watershed (U.S. Soil Conservation Service 1966). At the present time four have been completed. The following report includes a preliminary list of the fish fauna found in the Fourche River watershed.

INTRODUCTION

Fourche River cuts through the Salem Plateau of the Ozark Mountain physiographic province (Penneman 1938) and drains onto the Coastal Plain between the Ozark Uplands and Crowley's Ridge. The Salem Plateau in this region is composed of Gasonnade and Potosi limestone, dolomite, and sandstone of Ordovician age (Sauer 1920). The river originates approximately 16 miles northwest of Doniphan, Missouri, at an elevation of approximately 850 feet. It flows southeastward to the Arkansas-Missouri line over a substrate of gravel and limestone rock at depths of 8 to 36 inches before turning southward to Pocahontas, Arkansas. Near the state line the stream becomes wider (50 ft) and the pools range to 12 feet in depth. In Arkansas the substrate is gravel and limestone rock in the upper third of the stream, gravel and sand in the middle third, and sand and mud in the lower third. The watershed contains 298 square miles, of which 191 are in Arkansas and 107 are in Missouri. Approximately 71% of the watershed is rugged upland, 12% is rolling hill land, and 17% is bottomland (USSCS 1966). Lamonds et al. (1969) reported the flow characteristics of Fourche River above Pocahontas. On 27 July 1966 the mean discharge was 36 cubic feet per second. Discharge during annual flooding was computed at 8,600 cubic feet per second. Farming activities have caused an increase in turbidity in the Arkansas part of the stream. The average annual rainfall in Randolph County is 49.64 inches. Air temperature ranges from 121°F to -22°F (Hickmon 1941). The watershed is bounded on the east by Current River, on the north by Buffalo Creek, on the west by Eleven Point River, and on the south by Black River.

ACKNOWLEDGEMENTS

Appreciation is expressed to the graduate students at Arkansas State University, faculty members at Crowley's Ridge Academy, and especially Donald Griggs who assisted in the collection of the field data.

METHODS

Collections were taken with the following seines: 10 ft, 1/8-inch mesh; 12 ft, 1/4-inch mesh; 20 ft, 1/4-inch mesh; 30 ft, 3/16-inch mesh; and 50 ft, 1/4-inch mesh. A 45 ft, 1/4-inch mesh Gill net was used at three stations. Also, various hook and line methods were used. Specimens were preserved in 10% formalin, placed in 40% isopropyl alcohol, and stored in the Arkansas State University fish museum. Scientific names of fishes follow those of Bailey et al. (1970) except where noted.

ANNOTATED CHECKLIST OF FISHES OF FOURCHE RIVER

Petromyzontidae (Lampreys)

Ichthyomyzon castaneus Girard, Chestnut lamprey. A single specimen was collected on 6 March 1976 while it was attached to a host. A local fisherman reported a lamprey attached to a sucker in February 1976. Baker (1954) and Pfielger (1971) reported I. castaneus. Lampetra aepyptera (Abbott), and L. lamottei (Lesueur) from the Current and Eleven Points Rivers.

Acipenseridae (Sturgeons)

Scaphirhinchus platyrochus (Rafinesque). Shovelnose sturgeon. Collected in the lower part of the river.

Polyodontidae (Paddlefish)

Polyodon spathula (Walbaum). Paddlefish. Reported as present in the lower parts of the system. Probably migrates in and out of the Black River (Arkansas Game and Fish Commission 1953).

Lepisosteidae (Gars)

Lepisosteus oculatus (Winchell). Spotted gar. Rare inhabitant. Was found in a long, deep pool.
Lepisosteus osseus (Linnaeus). Longnose gar. Common inhabitant of the middle and lower parts of the system.

Lepisosteus platostomus Rafinesque. Shortnose gar. Reported as fairly abundant in the lower part of the stream (Arkansas Game and Fish Commission 1953).

Lepisosteus spatula Lacepede. Alligator gar. Reported as present in the lower part of the stream. It is an uncommon inhabitant of the Black River; however, it probably migrated in and out of the Black River (Arkansas Game and Fish Commission 1953).

Amiidae (Bowfins)

Amia calva Linnaeus. Bowfin. Abundant in the Arkansas part of the river.

Anguillidae (Freshwater Eels)

Anguilla rostrata (Lesueur). American eel. Taken on a trot line near the Arkansas-Missouri state line.

Clupeidae (Herrings)

Dorosoma cepedianum (Lesueur). Gizzard shad. Abundant and widespread in the main river channel.

Hiodontidae (Mooneyes)


Esocidae (Pikes)

Esox americanus vermiculatus Lesueur. Grass pickerel. Relatively uncommon; taken from still shallow water.

Esox niger Lesueur. Chain pickerel. Reported by the Arkansas Game and Fish Commission (1953).

Cyprinidae (Minnows and Carps)

Catostoma anomalum (Agassiz). Central stoneroller. Abundant and widespread throughout the system, particularly in shallow pools and riffles.

Catostoma otilotes Hubbs and Greene. Largescale stoneroller. Often found with the central stoneroller; fairly abundant and widespread within the system.

Cyprinus carpio Linnaeus. Carp. Common inhabitant of both shallow and deep pools, especially in the dredged ditches.

Dionda nubila (Forbes). Ozark minnow. One of the most abundant minnows. Found in the clear headwater regions near riffles.

Hybognathus nuchalis Agassiz. Silvery minnow. Common in the lower part of the system.

Hybopsis amblops (Rafinesque). Bigeye chub. This species was not collected in the writers’ study although it was reported by Pfieger (1971).

Noemis biguttatus (Kirtland). Hornyhead chub. Occasionally taken from the headwaters.


Notropis hoops Gilbert. Bigeye shiner. Abundant and widespread throughout the Ozark part of the system.

Notropis cornutus chrysocephalus (Rafinesque). Striped shiner. The writers follow R.J. Miller (1968) in considering N. chrysocephalus a subspecies of N. cornutus (Mitchill). The striped shiner was a common inhabitant of rocky pools.

Notropis galacturus (Cope). Whitetail shiner. Found throughout the system in clear pools with moderate current.

Notropis telescopus (Cope). Telescope shiner. Abundant in the higher-gradient tributary streams.

Notropis texanus (Girard). Weed shiner. Present in the lowland part of the stream.

Notropis umbratilis (Girard). Redfin shiner. Widespread throughout the system; found in both upland and lowland pools.

Notropis vaironis (Girard). Blacktail shiner. Found fairly often in the lowland reaches of the system.

Notropis volucellus (Cope). Mimic shiner. Rare inhabitant of the lowland dredged ditches.

Notropis antilus (Putnam). Bleeding shiner. Abundant in the upland reaches of the system. Taken most often over gravel substrates in fast-flowing water in or near riffles.

Ponoptes erythrogaster (Rafinesque). Southern redbelly dace. Taken occasionally in the smaller spring-fed tributary streams.

Pimephales notatus (Rafinesque). Bluntnose minnow. Common and widespread throughout the system.


Catostomidae (Suckers)

Carpio dioptus (Lesueur). Quillback. Reported by the Arkansas Game and Fish Commission (1953). Not collected during this study; however, it is a common inhabitant of the Black River system.

Catostomus commersoni (Lacepede). White sucker. Reported as fairly abundant by the Arkansas Game and Fish Commission (1953), though not collected during this study.

Emyctyphalus obtongus (Mitchill). Creek chubsucker. Commonly collected in clear pools with a gravel substrate.

Hypentelium nigricans (Lesueur). Northern hog sucker. Very common in clear shallow pools and deep riffles throughout the Ozark part of the system.

Ictiobus bubalus (Rafinesque). Smallmouth buffalo. Reported in the lower part of the river by local fishermen.

Ictiobus cyprinellus (Valenciennes). Bigmouth buffalo. Reported by the Arkansas Game and Fish Commission (1953) and local fishermen.

Ictiobus niger (Rafinesque). Black buffalo. An inhabitant of large pools.

Minytrema melanops (Rafinesque). Spotted sucker. Uncommon resident of the lowland ditches.
### Fishes of the Fourche River in Northcentral Arkansas

<table>
<thead>
<tr>
<th>Species</th>
<th>Distribution and Behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Moxostoma duquesnei</em> (Lesueur)</td>
<td>Black redhorse. Common in the shallow and deep pools of the river.</td>
</tr>
<tr>
<td><em>Ictalurus furcatus</em> (Lesueur)</td>
<td>Blue catfish. Reported by the Arkansas Game and Fish Commission (1953).</td>
</tr>
<tr>
<td><em>Ictalurus natalis</em> (Lesueur)</td>
<td>Black bullhead. Uncommon; collected in the lower reaches.</td>
</tr>
<tr>
<td><em>Ictalurus punctatus</em> (Rafinesque)</td>
<td>Channel catfish. Common in the deep pools of the river. Has been stocked occasionally in the river by Game and Fish Commission personnel.</td>
</tr>
<tr>
<td><em>Noturus exilis</em> Nelson</td>
<td>Slender madtom. Collected only at night from shallow pools just above riffles. Not common.</td>
</tr>
<tr>
<td><em>Noturus albar</em> Taylor</td>
<td>Ozark madtom. Most abundant madtom collected. Taken from riffles with a rocky substrate.</td>
</tr>
<tr>
<td><em>Noturus eleutherus</em> Jordan</td>
<td>Mountain madtom. A single specimen was collected from a riffle area with a gravel substrate and strong current.</td>
</tr>
<tr>
<td><em>Etheostoma chlorosomum</em> Storer</td>
<td>Rainbow darter. Commonly in the lower parts of the river.</td>
</tr>
<tr>
<td><em>Fundulus catesbeianus</em> Storer</td>
<td>Northern shad. Common in small clear headwater tributaries.</td>
</tr>
<tr>
<td><em>Fundulus olivaceus</em> Storer</td>
<td>Blackspotted topminnow. Common pool inhabitant throughout the system.</td>
</tr>
<tr>
<td><em>Gambusia affinis</em> Baird and Girard</td>
<td>Mosquitofish. Common in pools of lower reaches of the system.</td>
</tr>
<tr>
<td><em>Aphredoderus sayanus</em> (Williams)</td>
<td>Pirate perch. Rare. Taken from a lowland slough and Mud Creek.</td>
</tr>
<tr>
<td><em>Atherina</em> (Silversides)</td>
<td></td>
</tr>
<tr>
<td><em>Lambotus</em> (Cope)</td>
<td>Brook silverside. Common in pools throughout the system.</td>
</tr>
</tbody>
</table>

### Perciformes (Perches)

<table>
<thead>
<tr>
<th>Species</th>
<th>Distribution and Behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Perchichthyes</em> (Temperate Basses)</td>
<td></td>
</tr>
<tr>
<td><em>Morone chrysops</em> Rafinesque. White bass.</td>
<td>Reported from the lower part of the river by the Arkansas Game and Fish Commission (1953).</td>
</tr>
<tr>
<td><em>Centrarchidae</em> (Sunfishes)</td>
<td></td>
</tr>
<tr>
<td><em>Centrarchus macropterus</em> Lacepede.</td>
<td>Common and widespread.</td>
</tr>
<tr>
<td><em>Chaenobrytus gutosus</em> Cuvier.</td>
<td>Warmouth. The writers follow Miller and Robison (1973) in retaining the genus <em>Chaenobrytus</em>. Fairly common in pools of the lower part of the river.</td>
</tr>
<tr>
<td><em>Lepomis cyanellus</em> Rafinesque.</td>
<td>Common inhabitant of lowland areas with mud bottoms.</td>
</tr>
<tr>
<td><em>Micropterus dolomieu</em> Lacepede.</td>
<td>Smallmouth bass. Common in the clearer parts of the river and larger tributaries.</td>
</tr>
<tr>
<td><em>Micropterus punctulatus</em> (Rafinesque).</td>
<td>Widespread and abundant.</td>
</tr>
<tr>
<td><em>Micropterus salmoides</em> Lacepede.</td>
<td>Largemouth bass. Abundant, especially in the lower two-thirds of the system.</td>
</tr>
<tr>
<td><em>Pomoxis nigromaculatus</em> Lesueur.</td>
<td>Black crappie. Commonly found in the longer clearer pools of the upper part of the river.</td>
</tr>
</tbody>
</table>

### Etheostomidae (Pygmy Sunfishes)

<table>
<thead>
<tr>
<th>Species</th>
<th>Distribution and Behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Elasmomystus</em> (Cope)</td>
<td></td>
</tr>
<tr>
<td><em>Etheostoma aspriganum</em> (Forbes).</td>
<td>Mud darter. Collected only from the lowland ditches with a mud substrate. This is the first record of <em>E. aspriganum</em> from the Black River system in Arkansas.</td>
</tr>
<tr>
<td><em>Etheostoma blennius</em> Rafinesque.</td>
<td>Greenside darter. Abundant throughout the upper parts of the system; collected from the riffles.</td>
</tr>
<tr>
<td><em>Etheostoma caeruleum</em> Storer.</td>
<td>Rainbow darter. Very abundant in the clear riffles of the main river and tributaries.</td>
</tr>
<tr>
<td><em>Etheostoma chlorosomum</em> Hay.</td>
<td>Bluntnose darter. Inhabitant of the lower sluggish parts of the system.</td>
</tr>
</tbody>
</table>
Etheostoma euzonum (Hubbs and Black). Arkansas saddled darter. Inhabitant of deep clear riffles in the middle part of the main river.

Etheostoma flabellare Rafinesque. Fantail darter. Very abundant in the fast shallow riffles of the tributaries and river.

Etheostoma gracile (Girard). Slough darter. Inhabitant of the shallow pools of the lowland tributaries.

Etheostoma histrio Jordan and Gilbert. Harlequin darter. Three specimens were taken from a strong clear current flowing over a substrate of sand and gravel in a lowland dredged ditch. Tsai (1968) reported this to be the typical habitat of E. histrio. Before this collection only one specimen had been reported from the Black River system in Arkansas (Meek, 1894). Meristic characteristics and measurements for the three individuals are: L. 1. 53, 50,51; A. II. 8, 7, II.7; D. X-13, XI-13, IX-13; P., 14, 14, 14; P. 6, 6, 6; standard length, 53 mm, 46 mm, 44 mm; head length, 13.5 mm, 11 mm, 11 mm; body depth, 11 mm, 11 mm, 10 mm.

Etheostoma nigrum Rafinesque. Johnny darter. Common in the clear fast riffles of the upper parts of the system.

Etheostoma proeliare (Hay). Cypress darter. Specimens were collected in a lowland tributary over a substrate of sand and mud.


Etheostoma stigmataeum (Jordan). Speckled darter. Collected from a lowland ditch with clear water.

Etheostoma whipplei (Girard). Redfin darter. Inhabitant of the lowland dredged ditches. Rare.

Etheostoma zonale (Cope). Banded darter. Common in the moderate-size part of the stream in clear fast riffles.

Percina caprodes (Rafinesque). Logperch. Collected in a deep pool with a gravel substrate just above a deep riffle.

Percina maculata (Girard). Blackside darter. A single specimen was collected in a clear lowland ditch.

Percina sciara (Swain). Dusky darter. Collected in a clear lowland ditch near a submerged beaver dam.

Percina uranidea (Jordan and Gilbert). Stargazer darter. Collected in a large deep clear riffle over a substrate of gravel.

Stizostedion vitreum vitreum (Mitchell). Walleye. Though not collected in this study, local fishermen report its presence in the lower part of the river in February and March of 1976. Stizostedion canadense (Smith), the sauger, and S. v. vitreum were caught in Eleven Point, Black, and Current Rivers, respectively. Probably a winter resident of Black River which migrates to spawn.

Sciaenidae (Drums)

Aplodinotus grunniens Rafinesque. Freshwater drum. Present in the deeper pools of the river.

DISCUSSION

Fourche River flows from the Ozark uplands onto the lowland Coastal Plain. Because of its geographic situation it contains a wide variety of ecological habitats which are conducive to a great diversity of fish fauna. During this study 93 species of fish representing 20 families were reported. The fish composition was of two types, Ozarkian and lowland.

Etheostoma asprigene and Elassoma zonatum were collected from the Black River system within the state for the first time. Both were collected from a lowland ditch containing a substrate of mud and rubble, the typical habitat of both species (Miller and Wodson 1973). Noturus gyris was also taken from a lowland ditch. Meek (1894) had reported N. gyris from the Strawberry River, but Taylor (1969) questioned the validity of the identification on the basis of habitat. Robison and Beadles (1974) collected from the area but failed to produce N. gyris. One specimen of Etheostoma histrio had been reported from the Black River system within the state prior to this study (Meek 1894).

The family Percidae, particularly the genus Etheostoma, was well represented. Typical headwater species were Etheostoma flabellare, E. spectabile, E. caeruleum, and E. biennis. The main channel species included E. euzonum, E. nigrum, E. zonale, Percina caprodes, P. uranidea, and Stizostedion vitreum vitreum. Lowland species were Etheostoma asprigene, E. chlorosomum, E. histrio, E. proeliare, E. gracile, E. stigmaeum, E. whipplei, Percina maculata, and P. sciara.

Several species that were expected to inhabit the river system were not collected during this study: Notropis fumeus, N. greeni, N. maculatus, N. osarcus, N. rubellus, N. whipplei, Pimaphies vigilax, Noturus macus, Ammocrypta virus, Percina eides, and Hisoni alouides.

The Fourche River watershed is in the heart of a county that is undergoing a rapid increase in population. The number of acres of land being cleared for farming also is increasing. Undoubtedly, these two factors will influence the ichthyofauna of the watershed in the future.

LITERATURE CITED


Fishes of the Fourche River in Northcentral Arkansas


An Experimental Testing Program in Elementary Chemistry: A Preliminary Report

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Department of Chemistry, University of Arkansas at Little Rock, Little Rock, Arkansas 72204

ABSTRACT

An experimental testing program is described which utilizes questions that are partly computer composed, in addition to a section composed by the instructor, and a retesting option to the student. Results from a trial of the program for one term indicate that (1) course grades were improved, (2) the student withdrawal failure rate was unaffected, and (3) the employed students took greater advantage of the retest than did the unemployed students.

INTRODUCTION

In the fall of 1975 the authors introduced an experimental testing program at the University of Arkansas at Little Rock in the course titled, "Elementary Chemistry I." The course is designed for several categories of students: those who have had no high school chemistry; those who feel their chemistry background is weak as a result of inadequate high school preparation or an interruption of several years in their college career; those whose background in mathematics is weak; those who are pursuing professional or preprofessional careers in nursing, home economics, or agriculture; and those who need one semester of an introductory laboratory physical science course to fulfill graduation requirements. The student population in this particular class included 13 declared science majors in chemistry, physics, biology, or engineering; 32 students in health-related sciences such as nursing, premedicine, prepharmacy, medical technology, radiology technology, dental hygiene, physical therapy, and respiratory therapy; 6 students in such fields as law enforcement, psychology, sociology, and physical education; and 4 students who had not declared a major.

Experience had shown that students who have little or no confidence in their ability to succeed in chemistry, for whatever the reason, pose a challenge. It was also apparent from experience that these students were the ones who ventured timidly and reluctantly into Elementary Chemistry I. Various approaches to testing had been taken previously, and late in the fall of 1974 a grant to implement a new method of testing was applied for and received from the Donaghey Foundation through the Innovative Teaching Committee at UALR. The proposed testing program was as follows. An extensive pool of multiple choice questions would be compiled by the authors and computerized by topics; at test time multiple tests would be generated by the computer over selected topics from the pool of questions; a second section written by the instructor, including problem solving and discussion questions, would be duplicated and would complete the test packet. Students would retain the computerized part of the test and turn in only the standard answer sheet form and the duplicated part. The answer sheets would be processed by the computer and a printout of the results of the first section posted; the second section would be graded by the instructor and returned to the student. An optional discussion period would be scheduled at a time other than regular class time for questions concerning the test and the material covered on it. Shortly thereafter a three-hour period of time would be set aside to enable a student to take a retest over the same material. The three-hour period was chosen arbitrarily as a compromise between a full day for retesting which seemed highly desirable and the block of time that could be worked into the instructor's schedule.

The authors' ambition was to collect definitive data on several unanswered questions.

1. Would students achieve at a higher level in a test-retest situation than they would without the retesting?
2. Could the high percentage of withdrawals and failures that plagued this course be reduced?
3. Could some of the trauma experienced by many students when confronted by a test be reduced?
4. Was there a pattern of achievement and/or retesting of the employed versus the unemployed student?

PROCEDURE

Mechanically, it was decided to use three questions per topic from the pool of questions for the computerized part of the test. For a 20-question test this meant a subset of 60 questions from the large pool. This number was used to ensure that the questions acquired by the students would be limited and that the subset could be replaced in the pool with relative ease. Questions from the first test did not reappear on the retest or the final examination although similar ones replaced them. Students were required to turn in both sections of the retest and the computerized part was not returned to them. However, any student could obtain the computerized test for study in the instructor's office at any time after the results of the retest were posted. For both the initial test and the retest three parallel tests for the noncomputerized part were prepared and identification of the three was simplified by duplicating each test on paper of a different color (test A on blue paper, test B on yellow, and test C on white, for example). This practice seems to be common among instructors of large classes. A room for the retest period was designated and students were allowed to come in at any time during a three-hour time period to be retested. It was possible for a student to spend the entire period on the test and the 50-minute classroom limit was not observed.

The method of testing was well received by the students. The grading scale was fixed and the scores were not curved. Retesting was optional and the higher of the two scores achieved by the student was recorded. There were several problem areas. It was necessary to schedule computer time for test generation rather far in advance because the computer was new to the campus and subject to being shut down frequently. There was often a somewhat long time lag between testing and receiving test results from the computer. It was difficult at first for the students to read computer "handwriting" and to fill in the ID field on the answer sheets properly. The method of testing also is very time consuming from the instructor's standpoint. However, by the end of the semester most of these problems had smoothed out. The wide margin on the right side of each computer test was especially useful to the student and the ability to keep the computerized part of the first test seemed helpful.

RESULTS

The preliminary results of the testing were not as decisive as had been anticipated. Table I summarizes the results of the test-retesting. Column I shows a breakdown by letter grade of the total number of students who took the initial test for each of the three lecture tests given during the semester. Column II shows the number who attempted to raise their score by retesting. The percentages shown in parentheses were obtained from the numbers in Columns I and II. Column III shows the number of students attempting to raise their grades who were successful. The percentages in this column were obtained from the numbers in Columns II and III. A larger

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percentage of students had been expected to take advantage of the retest opportunity than actually participated. Numerically, the totals are about the same for all three tests. However, 49% of the students elected to retest on test 3, and the percentage of those who raised their scores was encouraging. As anticipated, the students who took the retest were predominantly in the C, D, and F range.

Statistically, 34 students, about 62%, took advantage of the retesting sometime during the semester; 19 students retested only once. 16 retested twice, and 3 students retested on all three tests. The benefits of the retesting are summarized in Table 2. Retesting on the final examination was not permitted.

One of the most striking observations about the testing results is that not even one student who withdrew from the course took advantage of the retesting program. It is especially surprising because many of these students did not withdraw until after the third test. Further study of this finding is indicated. It is of interest to note that a change from a score that would place a student, for instance, in the low “C” range without retesting but in the high “C” range by retesting would not be reflected in the “Change after 3 tests” column, but was reflected in the “Change in final grade” column where the score was averaged with those for the remaining tests of the semester.

In the final analysis 18 of the 55 students in this study who began the course, or 32.7%, were able to achieve a higher final grade through retesting than would have been possible without retesting. If this figure is based on the 40 who completed the course, the percentage rises to 45.0%.

In an effort to determine whether or not this method of testing was discriminatory to the employed student, a study was made of the retesting pattern of the employed versus the nonemployed student. The questionnaires filled out by the students attending classes during the first week of the semester were examined carefully and the findings are presented in Table III.

Contrary to what might have been expected, a substantially higher percentage of employed students participated in the retesting program than did the nonemployed students. The withdrawal rate contrast is not as dramatic but the rate is still noticeably higher for the nonemployed. Any change in the employment status of the students during the semester was not reported to the authors, but might have some bearing on the statistics. However, conclusions that can be drawn from the figures in the table are that the employed student seems to have been able to find time for retesting and that the withdrawal rate is lower for these students.

### Table I. Summary of Tests and Retests by Student Populations

<table>
<thead>
<tr>
<th>Grade</th>
<th>No. who earned this grade without retest</th>
<th>Test</th>
<th>No. attempting score rise by retest</th>
<th>Test</th>
<th>No. raising score by retest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Column I</td>
<td></td>
<td>Column II</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Column III</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade</td>
<td>1 2 3</td>
<td>1 2 3</td>
<td></td>
<td>1 2 3</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>12 3 4</td>
<td>0(0%)</td>
<td>(33%) 1(25%) 0(0%)</td>
<td>0(0%)</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>11 2 5</td>
<td>3(27%)</td>
<td>0(0%) 0(0%)</td>
<td>0(0%)</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>14 12 11</td>
<td>6(43%)</td>
<td>5(42%) 5(45%)</td>
<td>2(33%)</td>
<td>1(20%) 5(100%)</td>
</tr>
<tr>
<td>D</td>
<td>4 10 6</td>
<td>1(25%)</td>
<td>6(60%) 4(67%)</td>
<td>1(100%)</td>
<td>4(66%) 3(75%)</td>
</tr>
<tr>
<td>F</td>
<td>14 18 15</td>
<td>8(57%)</td>
<td>9(50%) 6(40%)</td>
<td>7(88%)</td>
<td>5(56%) 4(75%)</td>
</tr>
<tr>
<td>Total</td>
<td>55 45 41</td>
<td>18(33%)</td>
<td>21(47%) 20(49%)</td>
<td>10(56%)</td>
<td>10(48%) 12(60%)</td>
</tr>
</tbody>
</table>

### Table II. Testing Results

<table>
<thead>
<tr>
<th>Course grade after 3 tests</th>
<th>Students using no retesting</th>
<th>Students raising grade by retesting</th>
<th>Student not raising by retesting</th>
<th>By degree of change</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1 C A</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>1 B A</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>6 C B</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1 D B</td>
</tr>
<tr>
<td>F</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>3 D C</td>
</tr>
<tr>
<td>W</td>
<td>15</td>
<td>0</td>
<td>12</td>
<td>1 F D</td>
</tr>
<tr>
<td>Subtotals</td>
<td>29</td>
<td>13</td>
<td>12</td>
<td>55</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>13</td>
<td>18</td>
</tr>
</tbody>
</table>

### Table III. Record of Employed Versus Nonemployed Students

<table>
<thead>
<tr>
<th></th>
<th>Initial enrollment</th>
<th>Participants in retesting</th>
<th>Withdrawals</th>
<th>Completing course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employed</td>
<td>32</td>
<td>23 (71.8%)</td>
<td>8 (25.0%)</td>
<td>24 (75.0%)</td>
</tr>
<tr>
<td>Nonemployed</td>
<td>23</td>
<td>12 (52.2%)</td>
<td>7 (30.4%)</td>
<td>16 (69.6%)</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>35 (63.3%)</td>
<td>15 (27.2%)</td>
<td>40 (72.7%)</td>
</tr>
</tbody>
</table>
DISCUSSION

A comparison was made of the withdrawal-failure percentages in the fall semesters of 1973, 1974, and 1975. In the fall of 1973, the withdrawal-failure percentage for Elementary Chemistry I was 34.7%. In the same semester of 1974, it had dropped to 20.0%. This dramatic reduction is believed to be the result of an exclusive computer testing-retesting program in which the retest questions were taken from the same pool as the test questions. The authors recognized that students could easily increase their test scores by acquiring a pool of questions and memorizing the answers without understanding the material. It is believed that this held students in class but was not a desirable method of testing. The percentage rose to 38.1% in the fall semester; this increase is believed to reflect the change in the testing procedure. Certainly the 38.1% rate of fall 1975 indicates a failure to retain or even approach the low of the previous year.

Little comfort can be drawn from the fact that not one of the students who withdrew from the course elected to take even one retest. Without exception these students were unattracted to the program.

The following comments can be made concerning the questions the authors are seeking to answer.

1. A substantial number of students, 32.7% of the total beginning students and 45.0% of those who completed the course, were able to achieve a higher grade against a fixed, uncurved grading scale with the test-retest program. No attempt was made in this study to determine whether or not students gained a better understanding of the material covered except from the information gleaned from the comparison of the withdrawal-failure rates.

2. Disappointingly, the test-retest program was not as successful as the previous year's program in reducing the withdrawal-failure rate. However, it is believed to be a more valid program. Further study will be made of succeeding classes.

3. The question of the reduction of testing trauma through the test-retest program has yet to be resolved by data. It was evident from informal student response that a large number of students would have taken advantage of a retest on the final at any hour of the day or night had it been available. This indication does not constitute hard evidence, however, and a questionnaire on this topic will be administered as the study proceeds.

4. The data collected for this study show that the employed student takes advantage of the test-retest opportunity and is more successful than the nonemployed student in raising his score and grade.

Additional data will be collected and a comparison made of the achievement of two parallel classes differing only in the method of testing.
The Machismo Syndrome: A Residential Correlate of Its Expression in a Mexican Peasant Community

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ABSTRACT

The Michaelson-Goldschmidt hypothesis states that in peasant societies wherein male dominance is an ideal, matrilocally resident tends to encourage the expression of the machismo syndrome of behaviors. Recent ethnographic research in a Mexican peasant community supports the hypothesis by the finding that interpersonal violence (one measure of machismo) during a fiesta was perpetrated in every extreme instance by men who were residing matrilocally. The hypothesis thus effectively predicts. In this case, matrilocality as the variable most closely associated with the violent dimension of machismo.

INTRODUCTION

Machismo is a Spanish word that refers to excessively masculine behavior. Exactly which behaviors are considered to be masculine are defined partly by culture; but the word has come to have a more broadly applicable meaning, at least in American English. Michaelson and Goldschmidt (1971:346) define machismo as:

...aggressive masculinity which involves the demonstration of manhood through violence and fearlessness, but especially through feats of sexual conquest.

Because these authors apply the concept of machismo to a cross-cultural examination of peasant societies, they apparently intend it to carry a meaning that transcends cultural particularity.

I apply the concept of machismo, as Michaelson and Goldschmidt define it, to a series of incidents of aggressive masculine behavior that I observed during a fiesta in a rural south Mexican hamlet in 1973. My objective is to discover whether their hypothesis regarding the expression of machismo can explain why some men and not others participated in the violence observed.

THE HYPOTHESIS

Michaelson and Goldschmidt hypothesize that machismo occurs in those peasant societies that (1) have an ideology of male dominance over women, but (2) in which men do not have the means to actualize that ideology. In peasant societies land is the most valued property, so machismo is most likely to be manifested in societies in which there is an ideology of male dominance and a system of bilateral inheritance of land (i.e., women as well as men can inherit). Societies in which men alone can inherit land, or in which there is no ideology of male dominance, would be less likely to manifest machismo because there would be no major conflict between ideology and experience. Michaelson and Goldschmidt (1971) examined 46 peasant societies in culturally different parts of the world and found some confirmation of their hypothesis.

OBSERVATIONAL CONTEXT

Whereas the Michaelson-Goldschmidt study concerns differences among whole societies, my interest is to examine differences of behavior among individual men within a single community. Only one of the three behaviors associated with the machismo complex is examined here: aggressive masculine violence. Instances of this behavior were confined to a limited context (the fiesta) and were, with one exception, observable. The community in which the behavior occurred is composed of peasants, for whom inheritance of land is bilateral; there is a variety of residence choices based partly on access to land. Also the culture expresses an ideology of male dominance, although not of a very extreme sort.

Evidence of such an ideology includes the markedly differentiated socialization of boys and girls, which emphasizes active autonomy of boys and their protectiveness toward related females; the customary proscription against women and girls being alone, which implies that men would take sexual advantage of a lone female; and the public representation of the family by the husband, complemented by a wife's reluctance to embarrass her husband by public disagreement. However, the domestic solidarity of husband and wife in this community is a culturally expressed ideal, and their domestic interdependence is a socioeconomic fact. The unmarried adult status — male or female — is a difficult, undesirable, and (except for the elderly) usually temporary one. The female-headed or the matrifocal household (Gonzales 1970) is rare.

It must be noted also that violent machismo behavior occurs despite a climate of disapproval. Disruptively violent behavior within the community is neither admired nor encouraged, although (short of permanent injury) no sanctions seem to be imposed after the fact. When violence occurs it even may be officially denied as having been caused by community members. Finally, women tend to be instrumental in ending fights, an indication that such behavior is distinguishably masculine.

OBSERVATIONS OF MACHISMO

During the fiesta in 1973, I learned of four incidents of male aggression involving seven men. The first incident involved Ernesto, who was well known for his belligerence when inebriated, and for his chronic inebriation. Although he was observed trying to initiate a fight, he was unable to engage anyone.

The second incident involved a community resident, Hector, and another (unidentified) man. The fighting in this case was violent enough to disrupt all activity of an otherwise amicable celebration, and drew a crowd of people. In this incident the conflict was brought to an end when an unidentified woman struck Hector a heavy blow on the shoulder with a piece of wood. I was told later by other residents that both fighters were nonresidents, which was untrue but expressed the community fiction that they are an entirely peaceful people.

The third incident was a fight that broke out between a young man, Alejandro, and an older man, Nero, his father-in-law, both of whom had been drinking heavily. Again, a crowd gathered, and most women and children fled to a safe distance. Alejandro was said to have been the instigator and, bad enough as it was to have picked a fight with his father-in-law to whom he owed respect, he later picked a fight with his own father. Other residents who did not know I had observed the fight between Alejandro and Nero told me that neither of the belligerents were residents. Most of the crowd around the fighters were men, but foremost in the fray were Nero's wife and teenaged daughter, who finally were successful in pulling him away, and Nero's wife led him unwillingly toward home. Another man, Jaime, who evidently was inebriated, had attempted to enter the melee between Alejandro and Nero but was readily persuaded to disist by another woman.

A final case concerns Martin, who went home one evening of the fiesta and beat his wife, Marina. I have only Marina's account of this, but I observed during the day the incident that led to the violence. Both Marina and her husband were attending a dance during the fiesta, and Marina was holding their two-year-old daughter. She had been looking forward to dancing at the fiesta, but Martin would not dance with her. When an older male relative of hers invited her to dance, Marina rather unceremoniously thrust the baby into her
husband's arms and left him standing alone with an angry expression on his face. According to Marina, he was jealous of her dancing with another man, and that evening (inebriated, by her account) kicked and hit her in the stomach (knowing her to be pregnant), and "stole" some of "their" money.

DISCUSSION

According to the Michaelson-Goldschmidt hypothesis, the custom of bilateral inheritance of land is a threat to male dominance because it permits women to have control of property that might otherwise be controlled by men, and enables women to be not wholly dependent on men, particularly their husbands. Bilateral inheritance also permits flexibility of residence choice, insofar as residence is based on ownership of land, for spouses who originate in different communities. According to information I collected, the expression of machismo is related to a wife's control of land by her inheritance of it or by gift of it from her living parents, and by the degree to which the wife's access to land is economically important to the couple. The wife's control of land varies among couples in the community, and land is most likely to have been acquired through the wife if the couple is residing patrilocally — i.e., the husband and the wife have been born in different municipios (roughly analogous to townships in the United States) and after marriage they reside in the municipio where the wife was born. Patrilocal marriages are especially common in cases in which the groom has little property of his own. Thus a patrilocal marriage itself implies some economic dependence on the holdings derived from the wife or her relatives. Patrilocal residence also usually means that the wife's parents and other kin live nearby and provide various kinds of cooperative assistance to the couple; the husband, if his relatives live far away, cannot fully reciprocate such aid.

Of the marriages between spouses who have been born in different municipios (42.86% of all complete couples in the community), more than half (57.14%) are patrilocal. Patrilocal marriages also tend to be first marriages (reflecting greater permanency), are characterized by more expensive weddings and by more formal sanctions (involving both a church and a civil ceremony), and the bride in such marriages is more probably a virgin. In short, patrilocal marriages tend to be more prestigious.

Patrilocal marriages, by contrast, are 38.10% of all intermunicipal marriages (another 4.7% are neolocal), and generally carry fewer of the various criteria of prestige. Patrilocal residence is chosen over matrilocal residence by a ratio of roughly 3 to 2. Thus, though the community as a whole cannot be characterized by either a patrilocal or matrilocal residence pattern, I conclude that the first is the preferred form.

In Table 1, I have compared the men who were involved in instances of physical aggression during the fiesta with several variables that I thought might be relevant to the frustration of an ideal of male dominance. Five of the variables are related to economic concerns, and the last two refer to other possible value conflicts with male dominance. As the table shows, all the men who actually were engaged in fighting exhibit some of the traits that the Michaelson-Goldschmidt hypothesis suggests should be associated with a failure to actualize an ideal of male dominance, and which therefore should be associated with machismo. The one variable that is manifested in every case of active belligerence is matrilocal residence. By contrast, the two men who did not effectively engage in violence exhibit none of the variables.

It is also of interest that all fighting was by men who had drunk a large amount of alcohol, and who apparently were inebriated. Though Michaelson and Goldschmidt do not include drunkenness per se as a manifestation of the machismo syndrome, it might be regarded as such in some cultures and contexts. One man (a modest imbiber) told me that he did not know why certain men drank and fought so much at fiestas, but when they did they were likely to throw out their chests and exclaim to the world: "Yo soy hombre!" ("I am a man"); the machismo syndrome thus is recognized by this and probably other community members. Inebriation by itself, however, cannot explain belligerent behavior, because all men (and women to a lesser extent) are expected to drink at the fiesta, and the men who participated in the fighting were not the only ones who had drunk heavily.

CONCLUSION

Though my data do not enable me to expose the Michaelson-Goldschmidt hypothesis to conditions of possible disproof, they have had predictive success in identifying the variable most closely associated with the violent aspect of machismo: matrilocality. It is the bilateral inheritance (or gift) of land that makes matrilocal residence an economically advantageous choice for some men, but creates a situation that brings the husband into frequent and ongoing interaction with his wife's relatives, leading to indebtedness to them which he cannot easily discharge. Not being able to fulfill his role as husband, neither can he with impunity take out his frustration on his wife. In a culture that perceives men to be capable of violence and appropriately dominant, aggression toward other males provides alternative compensation.

Neither the Michaelson-Goldschmidt hypothesis nor my discussion of it exhausts the range of possible contributing causes of machismo, such as psychological development (Chodorow 1974) or socialization experiences (Stevens 1973), but I have explored some of the inherent features of the socioeconomic structure that make the manifestation of machismo likely. Though some authors have explored the causes of matrilocal residence (see Harris 1975:343-4 for a summary), perhaps one reason for matrilocal residence being less common than patrilocal residence in the community described is that the male role stresses associated with the former are perceived and avoided if possible.

Table 1. Characteristics of Belligerent Males

<table>
<thead>
<tr>
<th>Men Involved in Aggressive Behavior</th>
<th>Economic Characteristics</th>
<th>Other Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Martin</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Néron</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Hector</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Alejandro</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Jaime</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Corn land derives from wife or wife's relatives.
2. Coffee land derives from wife or wife's relatives.
3. Houseplot derives from wife or wife's relatives.
4. Wife earns some cash income.
5. Residence is matrilocal.
6. Husband is younger than wife.
7. Wife is unchaste, implied to be unchaste, was not virgin at marriage, or was married previously.

LITERATURE CITED


Metaphase Configurations in Drosophila: A comparison of Endemic Hawaiian Species and Non-Endemic Species

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ABSTRACT

The metaphase configurations of 400 strains from 63 species of Hawaiian Drosophila were determined from squash preparations of larval brain tissue or spermatogenic cells from adult testes. These karyotypes include configurations from seven species not previously described. Metaphases of 148 Hawaiian species have been recorded, including species of the "picture-wing" group, the "modified mouthpart" group, and the "bristle-foot" group. A comparison between Hawaiian species and non-endemic species was made on the basis of chromosome numbers and configurations. Among the Hawaiian species, 85.8% have retained the primitive haploid configuration of five rods and one dot compared with only 34.8% of species from the rest of the world. In only 4.7% of Hawaiian species is the chromosome number reduced from the basic haploid number of six, whereas it is reduced in 47.6% of the species from other areas. Most of the changes in chromosome size and shape among the Hawaiian species seem to be the result of added heterochromatin or chromosome fusions; no evidence of pericentric inversions has been found in modified karyotypes.

INTRODUCTION

Wheeler and Hamilton (1972) tabulated the valid species in the genus Drosophila and reported that one-fourth of a total of 1,254 described species are from the islands of Hawaii. Hardy (1974) estimated that the total fauna in the family Drosophilidae in Hawaii may consist of 750 to 800 different species. Before 1963, almost no information was available on the genetics or cytology of the Hawaiian species of Drosophila. At that time, the University of Hawaii and the University of Texas began sponsoring a research project which involved several senior investigators studying various aspects of the evolution and genetics of the Drosophilidae of Hawaii. A summary of the major accomplishments through the first few years was given in a review article by Carson et al. (1970). A symposium on the "Evolution in the Hawaiian Drosophilidae," presented at the Xth International Congress of Entomology in 1972 (see White 1974), provided background information and described achievements in such areas as cytology, mating behavior, morphology, reproductive isolation, habitat selection, and competition. The present study reports karyotype findings from 1972 to 1976, bringing the total number of metaphases described from 141 to 148 different Hawaiian species in the genus Drosophila. Prior to this report, metaphases were described by Clayton (1966, 1968, 1969, 1971), Carson et al. (1967), and Clayton et al. (1972).

MATERIALS AND METHODS

Metaphase configurations were determined from spermatogenic cells of adult males or from cells of larval brains. Tissues were stained in aceto-orcein and transferred to 50% acetic acid for squash preparation. Adults were collected from localities on Oahu, Kauai, Maui, Molokai, Lanai, and Hawaii and brought into the laboratory where females were placed singly into vials of a special high-protein medium (Wheeler and Clayton 1965) to establish "iso-female" lines. Third instar larvae from these iso-females were used for the cytological study. If larvae were not available, adult males of the species were dissected; the testes were removed and stained for examination of spermatogonia or primary spermatocytes. Species collected in the wild as larvae were maintained in the laboratory until mature enough for dissection and cytological study.

RESULTS AND DISCUSSION

Metaphase configurations were recorded from larvae of iso-female lines, from larvae collected in the wild, and from spermatogenic material of adult males. The results of the chromosome analyses are given in Table I. Included in the tabulation are configurations of 400 strains from 63 species of Hawaiian Drosophila which were analyzed during the period 1972-1976 and metaphases from seven species not previously described. Among the latter are five species undescribed at the time of the analyses, D. digossa, D. gynmophilus, D. lasioptoda, D. pilatorrns, and D. differens (Hardy and Kaneshio 1972a, b), and two species not previously analyzed cytologically, D. anomalipes (Hardy 1965) from Kauai and D. ciliiformata (Hardy 1965) from West Maui. Larval material of D. anomalipes was made available for study by Dr. H.T. Spieth, who developed a technique for raising this species in the laboratory. The metaphase configuration of D. ciliiformata was analyzed from primary spermatocyte cells of an adult male.

In Table II, a comparison is made between the metaphase configurations of species of Hawaiian Drosophila and those of species from other parts of the world. Hardy (1965) placed all Hawaiian Drosophila species into the subgenus Drosophila and the comparison therefore is based on Hawaiian species and non-endemic species belonging to this subgenus. The Hawaiian species which have been studied cytologically have been placed into groups based upon certain characteristics such as "picture-wing," "modified mouthpart," and "bristle-foot" groups. The numbers in Table II are derived from the listing of metaphase configurations by Clayton and Wheeler (1975) and from Table I.

The basic, or primitive, metaphase configuration in Drosophila consists of a haploid set of five rods and one dot. Speciation has been accompanied by modifications of this primitive karyotype, involving alteration of the number of chromosomes and/or change of chromosome size and shape. Patterson and Stone (1952) summarized the means by which such chromosome alterations could have occurred. A pericentric inversion results in a change in the shape of a metaphase chromosome if the position of the centromere is altered. Translocations result in detectable changes if there is a mutual exchange involving large segments of unequal length. A fusion results when there are two simultaneous breaks adjacent to centromeres on nonhomologous chromosomes and two long segments fuse. The centromere of this translocated chromosome is contributed by one of the long segments and the other centromeric fragment is either retained as a supernumerary chromosome or lost. In addition, the gain or loss of heterochromatic segments may account for changes in the appearance of somatic metaphase chromosomes.

The metaphase configurations listed in Table II are those which have been found among the Hawaiian species. For comparison the number of non-endemic species with similar configurations is given. Thirty-two percent of the non-endemic species have metaphase configurations not found among those Hawaiian species that have
been studied cytologically. The primitive configuration has been retained in 85.8% of the Hawaiian species but in only 34.8% of the species from other regions. In only 4.7% of the Hawaiian species is the chromosome number reduced from the basic haploid number of six, whereas it is reduced in 47.6% of the other species.

Among the Hawaiian species there has been no evidence of change in metaphase configurations resulting from pericentric inversions or translocations. The modifications may be explained by fusions, resulting in reduced numbers and V-shaped chromosomes, or by addition of heterochromatin. The latter type of change is the most common, found in both the "picture-wing" and "modified mouthpart" groups, but absent from the metaphase figures of the 17 other species examined. It can be seen from Table 2 that, within the "picture-wing" group, all species have retained the haploid number of six and modified karyotypes may be explained on the basis of heterochromatin added to dots or rods. One species, D. clytoma, apparently has heterochromatin added to every chromosome in the set, which results in five V-shaped and one J-shaped chromosome. This configuration has not been described previously for any other Drosophila species. The karyotypes of six species within the "modified mouthpart" group have been altered from the primitive by fusions, the resultant configurations having one V-shaped chromosome (3R, 2V, 1D) or two V-shaped chromosomes (1R, 2V, 1D).

As is apparent in Table II, most of the species examined cytologically have been members of the "picture-wing" group. A chromosome phylogeny based on inversion differences was developed by Carson (Clayton et al. 1972) for 96 species of this species group. On the basis of this phylogeny, it appears that metaphase chromosome modifications of the species were distinct events rather than a type of speciation in which closely related species share chromosomal changes through a common ancestor. The situation seems to be different among the non-endemic Drosophila species. Stone (1962) discussed metaphase relationships among approximately 300 species that had been analyzed cytologically. Considering groups in which related species may share a common ancestral chromosome modification, he estimated that there have been 32 pericentric inversions, three translocations, 58 fusions, and 38 cases of added heterochromatin. Therefore, the percentages in Table II are probably too high for non-endemic species because no attempt was made to consider common ancestral configurations. A comparison of data on Hawaiian karyotypes with Stone's estimates reveals the conservative trend within the Hawaiian species. According to Stone, heterochromatin addition had occurred in approximately 12.5% of the species. Among the Hawaiian species this addition has been observed in 9.5%. Chromosome fusions have been found in 4.7% of the Hawaiian Drosophila compared with 19.3% of non-endemic species. These observations must be considered preliminary because the number of species available for cytological studies has been very limited except in the "picture-wing" group. Analysis of chromosome relationships among the different groups of the Hawaiian species can be expanded as additional species are cultured and studied in the laboratories.

ACKNOWLEDGEMENT

This work has been supported in part by National Science Foundation Grants 27586 and 29288 to the University of Hawaii and by a grant to the author from the University of Arkansas Graduate School.

LITERATURE CITED


Table I. Karyotypes of Hawaiian Drosophilidae, 1972-1975

<table>
<thead>
<tr>
<th>Species (Metaphase)</th>
<th>Locality and Collection No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>adiastola (5R, 1D)</td>
<td>Puu Kukui, W. Maui (Q30G9)</td>
</tr>
<tr>
<td>Waikamoi, Maui (Q30S5, S4)</td>
<td></td>
</tr>
<tr>
<td>Hanaula, W. Maui (R10M10, R82B5, B7, B8, B9)</td>
<td></td>
</tr>
<tr>
<td>Waikolu Valley, Maui (R2G2)</td>
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</tr>
<tr>
<td>aglaia (5R, 1D)</td>
<td>Puu Kaua, Oahu (P72G4)</td>
</tr>
<tr>
<td>*anatrimes (5R, 1D)</td>
<td>Kokee, Kauai (T4B8)</td>
</tr>
<tr>
<td>*assita (5R, 1D)</td>
<td>Near Moaniauhea, Hawaii (Q65F4)</td>
</tr>
<tr>
<td>Moaniauhea, Hawaii (R4B11, B13, B14)</td>
<td></td>
</tr>
<tr>
<td>*baliopenta (5R, 1D)</td>
<td>Manawainui Gulch, W. Maui (F34B1, G16)</td>
</tr>
<tr>
<td>S. of Hanaliiolilo, Molokai (R83B9)</td>
<td></td>
</tr>
<tr>
<td>*bostrycha (5R, 1D)</td>
<td>S. of Hanaliiolilo, Molokai (R83B14)</td>
</tr>
<tr>
<td>Mapulehu Gulch, Molokai (Q86G2)</td>
<td></td>
</tr>
<tr>
<td>*ciffermina (5R, 1D)</td>
<td>Puu Kukui, W. Maui (Q30B4)</td>
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<tr>
<td>claytoniae (5R, 1D)</td>
<td>Olaa Forest Reserve, Hawaii (P105G8)</td>
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<td>Laupahoehoe Forest Reserve, Hawaii (Q57S10)</td>
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<td>*conspeciosa (5R, 1D)</td>
<td>Olaa Forest Reserve, Hawaii (Q49G3)</td>
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<td>discreta (5R, 1D)</td>
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<td>*fasciculatae (5R, 1D)</td>
<td>Waikamoi, Maui (R9M6)</td>
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<td>*flexipes (5R, 1D)</td>
<td>Wailuku Gulch, Oahu (Q24O3, Q4)</td>
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<td>*formella (5R, 1D)</td>
<td>Pauahi, Kona, Hawaii (Q17T4, F5, G6, J2)</td>
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<td>Near Moaniauhea, Hawaii (R5S23)</td>
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<td>*gradata (5R, 1D)</td>
<td>Mokuleia Rd. to Kaena Pt., Oahu (P9S1G1, G2)</td>
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<tr>
<td>Near Pali Lookout, Oahu (Q26R2)</td>
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<td>*grimshawi (5R, 1D)</td>
<td>Kawela Gulch, Molokai (Q7Q14, Q15, Q81G28, G29, G30, G31)</td>
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<td>Near Kawela Gulch, Molokai (Q8QS5)</td>
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<td>*gymnophalirius (5R, 1D)</td>
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<td>*hawaiigansis (5R, 1D)</td>
<td>Kilauea Forest Reserve, Hawaii (P104G1)</td>
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<td>Puuwaawaaw Summit, Hawaii (Q6Q1)</td>
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<td>Puuwaawaaw Summit, Hawaii (Q7S0Q1)</td>
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<td>Laupahoehoe Forest Reserve, Hawaii (Q57SM5)</td>
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<td>*hypermarginalis (5R, 1D)</td>
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<td>*hyperopta (5R, 1D)</td>
<td>Puu Kukui, W. Maui (Q30G9)</td>
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<td>*hydranthe (5R, 1D)</td>
<td>Puu Kaua, Oahu (P72G4)</td>
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<td>*hydranvera (5R, 1D)</td>
<td>Kokee, Kauai (T4B8)</td>
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<tr>
<td>*indescens (5R, 1D)</td>
<td>Near Moaniauhea, Hawaii (Q65F10, Q6GQ7)</td>
</tr>
<tr>
<td>Kea District, Hawaii (R1G1)</td>
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<tr>
<td>*pictocernis (5R, 1D)</td>
<td>Manawainui Gulch, W. Maui (Q23B1, B4, B7, B8, B9, G1, G2, G3, G4, G5)</td>
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<td>Hanaula, W. Maui (R10B31, B14, B15, B16, B17)</td>
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<tr>
<td>*planthopper (5R, 1D)</td>
<td>Near Moaniauhea, Hawaii (R5S32)</td>
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<tr>
<td>*pugilator (5R, 1D)</td>
<td>Near Moaniauhea, Hawaii (R5S32)</td>
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<tr>
<td>*recticula (5R, 1D)</td>
<td>Kahuilahua Gulch, Kauai (Q37B a)</td>
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<tr>
<td>Kahuilahua Gulch, Kauai (Q37B a)</td>
<td></td>
</tr>
<tr>
<td>*setsis (5R, 1D)</td>
<td>Olaa Forest Reserve, Hawaii (P105G2, G5)</td>
</tr>
<tr>
<td>Kipuka 9, Saddle Rd., Hawaii (Q15G3)</td>
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<td>Laupahoehoe, Hawaii (Q57S11)</td>
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<td>Hanaula, W. Maui (R81B2, B3)</td>
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<td>Mt. Kahili, Kauai (Q78B2, B3)</td>
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<td>Waiuli Forest, Maui (R22G 1(1), T13, B 1(4))</td>
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<td>Waialua, Maui (Q81B, B4, B5, D2, D4)</td>
<td></td>
</tr>
<tr>
<td>Kauholena Gulch, Lanai (Q2Q2 Q 1(3))</td>
<td></td>
</tr>
<tr>
<td>paenehamifera (5R, 1D)</td>
<td>Trail to Puu Kukui, W. Maui (Q30G9)</td>
</tr>
<tr>
<td>pacipuncta (5R, 1D)</td>
<td>Olaa Forest Reserve, Hawaii (P105G4, G6, G7, MSC)</td>
</tr>
<tr>
<td>peniculipes (5R, 1D)</td>
<td>Hanaula, W. Maui (R10B31, B14, B15, B16, B17)</td>
</tr>
<tr>
<td>pictocernis (5R, 1D)</td>
<td>Kahuilahua Valley, Kauai (Q76B a 1(2), Q76B b 1(3))</td>
</tr>
<tr>
<td>planthopper (5R, 1D)</td>
<td>Waikamoi, Maui (R3B2)</td>
</tr>
<tr>
<td>Hanaula, W. Maui (R9B3)</td>
<td></td>
</tr>
<tr>
<td>primaeva (5R, 1D)</td>
<td>Mt. Kahili, Kauai (Q78B4, B5, B6)</td>
</tr>
<tr>
<td>*psilostylis (5R, 1D)</td>
<td>Near Moaniauhea, Hawaii (R5B3)</td>
</tr>
<tr>
<td>recticula (5R, 1D)</td>
<td>Kahuilahua Gulch, Kauai (Q37B a)</td>
</tr>
<tr>
<td>Kahuilahua Gulch, Kauai (Q37B a)</td>
<td></td>
</tr>
<tr>
<td>*setsis (5R, 1D)</td>
<td>Olaa Forest Reserve, Hawaii (P105G2, G5)</td>
</tr>
<tr>
<td>*setsis (5R, 1D)</td>
<td>Kipuka 9, Saddle Rd., Hawaii (Q15G3)</td>
</tr>
<tr>
<td>Laupahoehoe, Hawaii (Q57S11)</td>
<td></td>
</tr>
<tr>
<td>Hanaula, W. Maui (R10B13, B14, B15, B16, B17)</td>
<td></td>
</tr>
<tr>
<td>Hanaula, W. Maui (R81B2, B3)</td>
<td></td>
</tr>
<tr>
<td>*Paumalae, Hawaii (R35G1, Q2, Q3)</td>
<td></td>
</tr>
<tr>
<td>Kipuka at 4140, Hawaii (Q58M1, M2, M3, Q70Q1, M1, M2, M3, M4, M6)</td>
<td></td>
</tr>
<tr>
<td>*Moaniauhea, Hawaii (Q46B1, B2, B3, M1, R4B3, B4, B5, B6, B7, B8, B10, Q6Q2)</td>
<td></td>
</tr>
<tr>
<td>Kipuka at 4140, Hawaii (Q58M1, M2, M3, Q70Q1, M1, M2, M3, M4, M6)</td>
<td></td>
</tr>
<tr>
<td>*Moaniauhea, Hawaii (Q46B1, B2, B3, M1, R4B3, B4, B5, B6, B7, B8, B10, Q6Q2)</td>
<td></td>
</tr>
</tbody>
</table>
Table II. Comparison of Metaphase Configurations of Hawaiian Drosophila and Non-Endemic Species Belonging to the Subgenus Drosophila

<table>
<thead>
<tr>
<th>Species Endemic to Hawaii</th>
<th>Total</th>
<th>%</th>
<th>Non-endemic Species*</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;picture-wing&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;modified mouthpart&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;bristle foot&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Primitive:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5R, 1D</td>
<td>92</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Fusion:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3R, 1V, 1D</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>1R, 2V, 1D</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Added heterochromatin:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6R e</td>
<td>6</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5R, 1V</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5V, 1J</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4R, 1V, 1D</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4R, 1J, 1D</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4R, 1J, 1D</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>total</strong></td>
<td>101</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

*Numbers taken from tabulation of species in Clayton and Wheeler (1975) and Clayton (this publication).

**Metaphase for this species reported here for first time.**

**Metaphase determination from adult male.**

1. One rod longer, not double-length.
2. Two rods longer, not double-length.
3. Two rods half-length.
4. Large dots.
5. Very small dots.
Dietary Fat-Carbohydrate Combinations: Their Effects on Lipid Metabolism in Estrogen-Treated Rats

BEVERLY A. CLEVIDENCE
Department of Home Economics,
University of Arkansas, Fayetteville, Arkansas 72701

ABSTRACT

Female rats 4 weeks old were fed diets including beef tallow or safflower oil in combination with sucrose or rice starch. At 8 weeks of age, half the rats were orally administered 2 μg of estrogen (mestranol) in 5 μl of safflower oil and half were fed the vehicle only. After 10 to 14 days of estrogen treatment, rats were fasted and exsanguinated. Alterations were found in weight gain, liver weights, and levels of various lipids in plasma and liver. Most lipid levels were influenced by an interaction of mestranol with one of the dietary factors. No changes were observed in blood clotting activity as measured by prothrombin time and levels of plasma fibrinogen.

INTRODUCTION

Oral contraceptives (OCs) are known to elevate plasma lipids and to increase thromboembolism in women (Mann et al. 1975). It is possible that certain dietary histories predispose women to thrombosis. Estrogens from OCs may act synergistically with certain dietary patterns. Plasma and liver lipids and blood clotting activity in rats are known to be influenced by the interaction of OCs with dietary fat (Tabacchi and Kirksey 1973). Plasma and liver lipids are known to be influenced by type of carbohydrate fed with various fats (Carroll and Bright 1965). The purpose of this investigation was to study liver and plasma lipid levels and blood clotting activity of young female rats treated with estrogen and fed diets of varied fat-carbohydrate composition.

MATERIALS AND METHODS

The experiment was designed as a 2 × 2 × 2 factorial with 5 or 6 rats to each of 8 treatment combinations. Experimental variables were the type of dietary fat, beef tallow (BT) or safflower oil (SO); the type of dietary carbohydrate, sucrose (S) or rice starch (RS); and estrogen treatment, with mestranol (+ M) or without mestranol (-M).

At 4 weeks of age, female rats of the Sprague-Dawley strain were assigned at random to treatment groups. In a temperature-controlled room, rats were housed individually in wire-bottomed cages where they had free access to water and ration (Table I). At 8 weeks of age, half the rats fed each of the 4 diets were orally administered 2 μg of mestranol, a common estrogen in OCs, in 5 μl of safflower oil and half were fed the vehicle only. This quantity of mestranol is approximately the minimum dosage of estrogen used in combination with a progestin to prevent conception in rats (Aftergood and Alfin-Slater 1971). In proportion to body weight, this dosage in rats is approximately 10 times the quantity of estrogen taken by women who use OCs.

After 10 to 14 days of estrogen treatment, rats were fasted for 4 hours, anesthetized with sodium pentobarbital, and exsanguinated from the abdominal aorta. Liver and plasma were assayed for lipid content. Triglyceride was assayed by the method of Mendez et al. (1975). The method of Zlatkis et al. (1953) was used to determine cholesterol. Phospholipids were hydrolyzed by the method of Youngberg and Youngberg (1930), and the inorganic phosphorus thus released was determined by the method of Fiske and Subbarow (1925). Plasma coagulation properties were measured by prothrombin time (Faulkner and King 1970) and level of plasma fibrinogen (Ratoff and Menzie 1964). Data were examined by analysis of variance in a completely random design. Significance was determined by F-values.

RESULTS AND DISCUSSION

Mestranol depressed weight gain by 46% (Table II). Rats treated with mestranol not only ate less ration than did their counterparts, but also used food consumed less efficiently for weight gain. Rats fed SO had heavier livers in relation to body weight than did those fed BT. Relative liver weights of rats treated with mestranol were greater because of lower body weights. Values for liver lipids were stated per 100 mg of liver protein in order to make comparisons unaffected by liver or body weights.

Total liver lipids and liver triglycerides were altered by an interaction of the carbohydrate and estrogen factors (Fig. 1a, b). Without mestranol, liver lipid was greater when the dietary carbohydrate was RS rather than S. However, when the treatment included mestranol, RS was unable to elevate total liver lipids and triglycerides.

It is not clear why, in the absence of mestranol, RS but not S elevated liver lipids. Carroll and Bright (1965), who fed low carbohydrate-high fat diets, found that accumulation of liver lipids in male rats was dependent on both the type of carbohydrate and the type of fat fed. In that study, liver lipid was decreased when rats were fed fructose with corn oil rather than glucose with corn oil, or either carbohydrate with hydrogenated coconut oil.

The fate of RS in the presence of mestranol is unknown. Cortisol, which increases gluconeogenesis and inhibits fatty acid synthesis in the liver, is known to be elevated in plasma of rats treated with mestranol (Renaud 1970). Perhaps glucose from RS undergoes gluconeogenesis in the absence of mestranol but is utilized by cells or converted to glycogen in the presence of mestranol.

Liver cholesterol was elevated by SO and by the interaction of SO with RS, regardless of whether or not mestranol was administered (Fig. 1c). Plasma cholesterol was depressed by mestranol, an action independent of the type of fat or carbohydrate fed (Table III). Thus, the elevation of liver cholesterol and the depression of plasma cholesterol were unrelated and not the result of transfer from plasma to liver.

 Plasma phospholipids were elevated by BT over SO, and depressed by the interaction of SO with mestranol. Although mestranol had no influence on plasma phospholipids when the dietary fat was BT, phospholipids were greatly decreased by mestranol when SO was fed (Fig. 1d). Aftergood and Alfin-Slater (1971) reported that plasma phospholipids were decreased in female rats fed a stock diet and treated with an OC.

 Plasma cholesterol and cholesterol phospholipids of rats were depressed in this experiment by mestranol or by an interaction that included mestranol. Yet these lipids commonly are elevated in the plasma of women who take OCs. In contrast, plasma triglycerides seem to be elevated in both women and rats by most OCs and by estrogen. Although plasma triglycerides were not measured in this study, it is suspected that this lipid was elevated by mestranol (Kekki and Nikkila 1971, Tabacchi and Kirksey 1973, Kudzma et al. 1975).

The liver of an estrogen-fed animal is likely to be overburdened with fatty acids because estrogen elevates plasma cortisol levels and
cortisol mobilizes fatty acids from adipose tissue. The liver, which cannot use fatty acids for gluconeogenesis, may incorporate them into triglycerides and transfer them to the blood as lipoproteins. No difference in blood clotting activity among treatments was found as measured by prothrombin time or level of plasma fibrinogen. Tabacchi and Kirksey (1973) reported that OCs containing mestranol elevated levels of plasma fibrinogen in 7-month-old female rats when the diet included coconut oil or cholesterol. Negative results of the present experiment may have been due to the youth of the rats tested.

The results of this study indicate that young female rats undergo changes in liver and plasma lipids in response to the type of dietary fat or carbohydrate, and that these changes can be modified by administration of mestranol. Yet certain blood clotting factors do not appear to be altered either by mestranol or by dietary fat or carbohydrate.

Table I. Composition of Diets

<table>
<thead>
<tr>
<th>Component</th>
<th>g/100 g diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin-free casein&lt;sup&gt;1&lt;/sup&gt;</td>
<td>19.6</td>
</tr>
<tr>
<td>DL-Methionine&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0.4</td>
</tr>
<tr>
<td>Salts, R. H.&lt;sup&gt;2&lt;/sup&gt;</td>
<td>5.0</td>
</tr>
<tr>
<td>Vitamin Mixture&lt;sup&gt;3&lt;/sup&gt;</td>
<td>0.3</td>
</tr>
<tr>
<td>Choline Chloride</td>
<td>0.2</td>
</tr>
<tr>
<td>Fat&lt;sup&gt;4&lt;/sup&gt;</td>
<td>20.0</td>
</tr>
<tr>
<td>Carbohydrate&lt;sup&gt;5&lt;/sup&gt;</td>
<td>30.0</td>
</tr>
<tr>
<td>Alphacel&lt;sup&gt;1&lt;/sup&gt;</td>
<td>24.5</td>
</tr>
</tbody>
</table>

<sup>1</sup>ICN Pharmaceuticals, Inc., Cleveland, CH.


<sup>3</sup>mg/100 g of ration: thiamine HCl, 0.8; pyridoxine, 0.4; Ca pantothenate, 4.0; niacin, 5.0; inositol, 20.0; folic acid, 0.4; vitamin B<sub>12</sub> (triturated 3000 μg per g), 1.33; biotin, 0.02; vitamin A powder (20,000 IU per g), 10.0; calciferol (850,000 IU per g), 0.18; DL-α-tocopherol powder (250 IU per g), 30.0; menadione, 0.38; riboflavin, 0.6; and sucrose, 176.89.

<sup>4</sup>Beef tallow or safflower oil.

<sup>5</sup>Sucrose or rice starch.

Figure 1. Interaction means of liver and plasma lipids. RS = rice starch. S = sucrose. -M = without mestranol, +M = with mestranol. SO = safflower oil. BT = beef tallow.

LITERATURE CITED


Table II. Weight Gain, Food Intake, and Food Efficiency Ratio During Period of Mestranol Treatment

<table>
<thead>
<tr>
<th>Weight gain (g)</th>
<th>Food intake (g)</th>
<th>PER&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat</td>
<td>BT&lt;sup&gt;1&lt;/sup&gt;</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>SO</td>
<td>10</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>S</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>RS</td>
<td>11</td>
</tr>
<tr>
<td>Estrogen</td>
<td>-M</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>+M</td>
<td>7</td>
</tr>
</tbody>
</table>

<sup>1</sup>BT = beef tallow. SO = safflower oil. S = sucrose. RS = rice starch. -M = without mestranol, +M = with mestranol.

<sup>2</sup>Food efficiency ratio = g weight gain/100 g food intake.
Dietary Fat-Carbohydrate Combinations


Table III. Composition of Liver and Plasma Lipids

<table>
<thead>
<tr>
<th>Liver lipids</th>
<th>Total Lipid</th>
<th>Triglyceride</th>
<th>Cholesterol</th>
<th>Plasma lipids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/100 mg liver protein</td>
<td>mg/100 ml plasma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BT</td>
<td>24.67</td>
<td>6.80</td>
<td>2.29</td>
<td>95.1</td>
</tr>
<tr>
<td>SO</td>
<td>26.41</td>
<td>5.29</td>
<td>3.13</td>
<td>89.9</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>22.78</td>
<td>4.55</td>
<td>2.45</td>
<td>94.0</td>
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<tr>
<td>RS</td>
<td>28.45</td>
<td>7.70</td>
<td>2.95</td>
<td>91.0</td>
</tr>
<tr>
<td>Estrogen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-M</td>
<td>27.47</td>
<td>7.43</td>
<td>2.72</td>
<td>102.4</td>
</tr>
<tr>
<td>+M</td>
<td>23.68</td>
<td>4.75</td>
<td>2.67</td>
<td>83.1</td>
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</tbody>
</table>

Significant F values

(P < 0.005) CHO, Est, CHO, Est, Fat, CHO, Est Fat X CHO Fat X Est

(P < 0.05) CHO X Est CHO X Est Fat X CHO Fat X Est

1 BT = beef tallow, SO = safflower oil, S = sucrose, RS = rice starch, -M = without mestranol, +M = with mestranol.
Influence of Dietary Fats and Carbohydrates on Lipid Metabolism in Male and Female Rats

MARJORIE ELLEN FITCH
Department of Home Economics, University of Arkansas, Fayetteville, Arkansas 72701

ABSTRACT
Effects of dietary fats and carbohydrates on lipid metabolism in rats were studied. Male and female 4-week-old rats were divided into 8 groups and fed 4 fat-carbohydrate combinations (beef tallow or safflower oil, each with either sucrose or rice starch). After 4 weeks, animals were killed by exsanguination through the abdominal aorta and livers were removed. Plasma and liver cholesterol and phospholipids were determined quantitatively and qualitatively. Liver moisture, protein, and lipid and the fatty acid composition of the total liver lipid were determined quantitatively. Variations in growth, food efficiency, and lipid metabolism, particularly as manifested by the fatty acid composition of the liver lipid, were apparent between males and females and among groups of each sex as a result of dietary treatment.

INTRODUCTION
Several studies have shown that metabolic responses of male weanling rats to the type of dietary carbohydrate are in part dependent upon the type of dietary fat (Carroll 1963). Other investigators have reported that males and females differ in their response to dietary carbohydrate (Macdonald 1972), and this response can be modified by the type of fat in the diet. The purpose of this experiment was to determine the effects of certain dietary fats and carbohydrates on various metabolic functions in male and female rats.

MATERIALS AND METHODS
Twenty male and 20 female 4-week-old rats of the Sprague-Dawley strain were divided into 8 groups (4 of males and 4 of females). The initial average body weights of the males and females were 72 grams and 100 grams, respectively. Rats were fed nutritionally adequate diets containing one of four dietary fat-carbohydrate combinations. The carbohydrate was either sucrose or rice starch and the fat was either beef tallow or safflower oil. After 4 weeks, animals were killed by exsanguination through the abdominal aorta and the liver and plasma were retained for assay.

Criteria for determining the metabolic responses of male and female rats to the diets were levels of plasma cholesterol and phospholipid, total lipid, cholesterol, phospholipid, and protein in the liver. Also, the fatty acid composition of the liver lipid was determined. Data were examined by analysis of variance.

RESULTS AND DISCUSSION
Weight gain was significantly greater in males than in females. This difference seems to have been due to the greater food consumption and food efficiency ratio of the male rats. Rats fed sucrose had a slight depression in growth in comparison with those fed rice starch. Accumulated data show that males had higher levels of plasma cholesterol and phospholipid than did females. Contrary to the findings of others (Macdonald 1972), plasma cholesterol was not significantly affected by the type of fat or carbohydrate in the diet. The qualitative responses of plasma phospholipids to the type of dietary fat and carbohydrate were the same in both sexes. Rice starch and safflower oil were associated with a depression in plasma phospholipids.

Regardless of the dietary treatment, males had higher relative liver weights (g liver/100 g body weight) than did females (Table I). The beef tallow—rice starch diet produced lower relative liver weights than did the other diets.

On the basis of absolute amounts (mg/100 mg liver nitrogen), the amount of liver lipid was greater in females fed the safflower oil—rice starch diet than in females fed any of the other diets, but this amount was less than that found in males fed the safflower oil—rice starch diet (Table II). The absolute amount of liver cholesterol and phospholipid increased when rice starch rather than sucrose was the dietary carbohydrate. The cholesterol in the liver lipid was quantitatively higher in males than in females. Also, liver cholesterol was higher in rats fed safflower oil than in those fed beef tallow. On the basis of absolute values, liver phospholipids apparently were more resistant to dietary change than liver cholesterol.

Comparison of the fatty acid composition (Table III) of the liver lipids of rats fed beef tallow with that of rats fed safflower oil reflects the differences in the fatty acid composition of the two dietary fats. Lipids from rats fed beef tallow contained higher proportions of saturated and monounsaturated fatty acids and lower proportions of polyunsaturated fatty acids than did those from rats fed safflower oil. However, both the type of carbohydrate and the sex of the animal exerted significant influences on the fatty acid composition of the liver lipid, which were superimposed on the basic effect of the fat source.

In females, sucrose increased the percentage of stearic (18:0), arachidonic (20:4), and the third fatty acid eluted after arachidonic acid in comparison with rice starch. Also, these fatty acids were more concentrated in the liver lipid of females than in that of males. The percentages of palmitic (16:0), oleic (18:1), and linoleic (18:2) acids were greater in males than in females. Female rats had less palmitic (16:0) and more stearic (18:0) acid than did male rats. Therefore, there appears to be a significant sex difference in the elongation of palmitic acid to stearic acid, and this finding agrees with the work of other investigators (Pudelkewicz et al. 1968).

In this experiment, both males and females fed the safflower oil—rice starch diet had higher percentages of linoleic acid (18:2) and greater accumulation of lipid in the liver than did other dietary groups. However, females on this diet had less linoleic acid and less lipid accumulation in the liver than did males. Female rats seem to have a greater capacity not only for the elongation of palmitic to stearic acid, but also for the conversion of linoleic acid to long-chain polyunsaturated fatty acids.

Carroll and Williams (1971) found severely fatty livers and proportionally large amounts of linoleic acid in males rats fed a polyunsaturated fat (corn oil). They suggested that the ingestion of large amounts of linoleic acid could be detrimental. However, this harmful effect may be reduced if fructose (or sucrose) is included in the diet.

From the findings of this experiment, the mechanisms by which the differences in lipid metabolism between the sexes occur cannot be explained. Yet there are differences in the plasma and liver lipid response of males and females to the type of dietary fat and carbohydrate. It is evident that without consideration of the sex of the individual the evaluation of dietary treatments of such metabolic disorders as hyperlipemia would be incomplete.

LITERATURE CITED


*Graduate Assistant in Nutrition Research.
Table I. Means by Analysis of Variance for Relative Liver Weight and Major Liver Components of Male and Female Rats Fed Different Dietary Fat-Carbohydrate Combinations

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>g liver/100 g body weight</th>
<th>% protein of liver</th>
<th>mg protein/100 g body weight</th>
<th>% moisture of liver</th>
<th>% lipid of liver</th>
<th>mg liver lipid/100 mg liver N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat (F)1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BT</td>
<td>3.82</td>
<td>16.1b</td>
<td>611b</td>
<td>70.8a</td>
<td>5.25a</td>
<td>205a</td>
</tr>
<tr>
<td>SO</td>
<td>3.93</td>
<td>16.7</td>
<td>652</td>
<td>69.7</td>
<td>6.36</td>
<td>241</td>
</tr>
<tr>
<td>Carbohydrate (C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SUC</td>
<td>3.99b</td>
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<td>70.6b</td>
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<td>195a</td>
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<tr>
<td>RS</td>
<td>3.76</td>
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<td>653</td>
<td>69.9</td>
<td>5.55</td>
<td>251</td>
</tr>
<tr>
<td>Sex (S)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>4.51a</td>
<td>15.4a</td>
<td>638</td>
<td>69.4a</td>
<td>5.99</td>
<td>243a</td>
</tr>
<tr>
<td>Female</td>
<td>3.60</td>
<td>17.4</td>
<td>625</td>
<td>71.1</td>
<td>5.63</td>
<td>203</td>
</tr>
<tr>
<td>Interactions</td>
<td>F × Cb</td>
<td></td>
<td>F × Sb</td>
<td>F × Cb</td>
<td>F × Sb</td>
<td>F × C × Sb</td>
</tr>
</tbody>
</table>

1 Abbreviations: F = Fat, C = Carbohydrate, S = Sex, BT = Beef Tallow, SO = Safflower Oil, SUC = Sucrose, RS = Rice Starch, M = Male, F = Female.

Table II. Means by Analysis of Variance for Composition of Total Liver Lipid of Male and Female Rats Fed Different Dietary Fat-Carbohydrate Combinations

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>% cholesterol</th>
<th>mg cholesterol/100 g liver N</th>
<th>% phospholipid</th>
<th>mg phospholipid/100 mg liver N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat (F)1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BT</td>
<td>7.68a</td>
<td>15.6a</td>
<td>38.8a</td>
<td>79.0</td>
</tr>
<tr>
<td>SO</td>
<td>10.87</td>
<td>26.5</td>
<td>32.8</td>
<td>75.6</td>
</tr>
<tr>
<td>Carbohydrate (C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUC</td>
<td>8.93a</td>
<td>17.4a</td>
<td>37.9b</td>
<td>72.4b</td>
</tr>
<tr>
<td>RS</td>
<td>9.62</td>
<td>24.7</td>
<td>33.8</td>
<td>76.9</td>
</tr>
<tr>
<td>Sex (S)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>9.25</td>
<td>23.3a</td>
<td>33.0a</td>
<td>77.7</td>
</tr>
<tr>
<td>Female</td>
<td>9.30</td>
<td>18.9</td>
<td>38.7</td>
<td>76.9</td>
</tr>
<tr>
<td>Interactions</td>
<td>F × Cb</td>
<td></td>
<td>F × Sb</td>
<td>F × C × Sb</td>
</tr>
</tbody>
</table>

1 Abbreviations: F = Fat, C = Carbohydrate, S = Sex, BT = Beef Tallow, SO = Safflower Oil, SUC = Sucrose, RS = Rice Starch, M = Male, F = Female.

Table III. Means by Analysis of Variance for Fatty Acid Composition of Total Liver Lipid of Male and Female Rats Fed Different Dietary Fat-Carbohydrate Combinations

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>16:0</th>
<th>16:1</th>
<th>18:0</th>
<th>18:1</th>
<th>18:2</th>
<th>18:3</th>
<th>Unidentified</th>
<th>20:4</th>
<th>2nd &gt; 20:4</th>
<th>3rd &gt; 20:4</th>
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</thead>
<tbody>
<tr>
<td>Fat (F)1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BT</td>
<td>19.7a</td>
<td>4.90a</td>
<td>17.1a</td>
<td>35.0b</td>
<td>7.3a</td>
<td>tr</td>
<td>tr</td>
<td>13.4a</td>
<td>tr</td>
<td>tr</td>
</tr>
<tr>
<td>SO</td>
<td>14.1</td>
<td>2.01</td>
<td>12.5</td>
<td>10.7</td>
<td>35.7</td>
<td>2.07</td>
<td>1.13b</td>
<td>17.0</td>
<td>1.60b</td>
<td>2.86b</td>
</tr>
<tr>
<td>Carbohydrate (C)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUC</td>
<td>17.2</td>
<td>3.82a</td>
<td>15.9a</td>
<td>22.7</td>
<td>19.5a</td>
<td>2.77</td>
<td>0.97</td>
<td>15.3</td>
<td>1.46</td>
<td>3.21b</td>
</tr>
<tr>
<td>RS</td>
<td>16.7</td>
<td>3.09</td>
<td>13.8</td>
<td>23.0</td>
<td>23.6</td>
<td>2.98</td>
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<td>15.0</td>
<td>1.67</td>
<td>2.42</td>
</tr>
<tr>
<td>Sex (S)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>17.9a</td>
<td>3.80a</td>
<td>12.4a</td>
<td>23.4</td>
<td>23.6a</td>
<td>2.88</td>
<td>1.35a</td>
<td>13.9a</td>
<td>1.70</td>
<td>2.64a</td>
</tr>
<tr>
<td>Female</td>
<td>16.0</td>
<td>3.21</td>
<td>17.3</td>
<td>22.3</td>
<td>19.5</td>
<td>2.87</td>
<td>0.73</td>
<td>16.4</td>
<td>1.43</td>
<td>3.19a</td>
</tr>
<tr>
<td>Interactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Abbreviations: F = Fat, C = Carbohydrate, S = Sex, BT = Beef Tallow, SO = Safflower Oil, SUC = Sucrose, RS = Rice Starch, M = Male, F = Female.

2 Unidentified peak between 18:3 and 20:4.

a, b, x Level of significance: a = P ≤ 0.005, b = P ≤ 0.05, x = P ≤ 0.10.
Scanning Electron Microscopy of the Rainbow Trout (Salmo gairdneri Richardson) Spermatozoon

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ABSTRACT

The scanning electron microscope was used to determine the morphology of the rainbow trout (Salmo gairdneri Richardson) spermatozoon. The spermatozoon is approximately 32 μm long and consists of a head, mitochondrial collar, and flagellum. The head is elongated and somewhat flattened. It has an antero-posterior length of 3.1 μm and a maximum diameter of 1.6 to 2.2 μm. Mean antero-posterior length of the mitochondrial collar is 0.8 μm. The collar encircles the flagellum but is separated from it. The flagellum ranges in length from 26 to 31 μm and is divided into a principal piece and end piece. Cytoplasmic vesicles commonly are found in the anterior region of the flagellum.

INTRODUCTION

Scanning electron microscopy is a relatively new technique that yields three-dimensional views of objects at high magnifications by bombarding the specimen with a moving beam of electrons. Although highest magnification is less than that obtained by transmission electron microscopy, the three-dimensional representations of specimens make scanning electron microscopy a valuable adjunct to studies of the morphology of biological specimens.

The scanning electron microscope has been used to study human, hamster, bull, rabbit, ram, monkey, boar, and turkey spermatozoa (see, for example, Dott 1969, Fujita et al. 1969, Gould et al. 1971, Zaneveld et al. 1971, Hafes and Kanagawa 1973, Yauuda and Tanimura 1974, Marquez and Ogasawara 1975). However, a review of the literature has failed to disclose scanning electron microscope studies of fish sperm cells. The purpose of this report is to describe the morphology of the rainbow trout (Salmo gairdneri Richardson) spermatozoon as revealed by the scanning electron microscope (SEM) and to coordinate the results with transmission electron microscope (TEM) findings.

METHODS AND MATERIALS

Milt was collected by stripping ripe rainbow trout. Care was taken to avoid contaminating the specimens with water, urine, or feces. Specimens were fixed in 4% glutaraldehyde in Millonig's phosphate buffer for 8 hours, then centrifuged, and the sediment was stored in 5% collidine buffer (pH 7.38) until further processing was performed.

For SEM studies, smears were made on microscope slide fragments that had been coated with a 0.5% gelatin solution and allowed to dry. The smears were dehydrated in an ethanol series, then processed through absolute ethanol-amyl acetate solutions containing increasing concentrations of amyl acetate, and finally were rinsed twice with 100% amyl acetate. Samples were flooded with amyl acetate to prevent air drying and were transferred to a critical-point drying apparatus where they were dried with carbon dioxide. The dried specimens were coated with carbon and 60-40 gold palladium and were examined on a Cambridge Stereoscan 600 at accelerating voltages of 15 and 25 kV.

For TEM studies, testes from ripe males were excised, diced into blocks of about 1 mm³, then fixed in glutaraldehyde and stored as described above. Specimens were postfixed in 2% osmium tetroxide, dehydrated rapidly in a graded methanol series with extended soaking in absolute methanol, and embedded routinely in epoxy resin. Thin sections were cut with a diamond knife on a Porter-Blum MT-2 ultramicrotome and supported on naked 300 mesh copper grids. These were stained sequentially with potassium permanganate, uranyl acetate, and lead citrate (Soloff 1973), and were examined with a Hitachi model HU-11B electron microscope at an accelerating voltage of 75 kV.

RESULTS

The spermatozoon of rainbow trout is approximately 32 μm long. It has a head and flagellum with no clearly differentiated neck or midpiece (Fig. 1). The head is somewhat elongated and appears to be flattened on the substrate. In some sperm cells, a mitochondrial collar or lobe can be identified near the posterior region of the head (Fig. 2). The mean antero-posterior length of the head is 3.1 μm measured from its anterior tip to the ridge demarcating the mitochondrial collar. Maximum diameter of the head ranges from 1.6 to 2.2 μm. Mean antero-posterior length of the mitochondrial collar is 0.8 μm. The collar encircles the flagellum and is separated from it by the cytoplasmic canal (Fig. 3). Some observations of sperm positioned at unusual angles introduce the possibility that the collar may not encircle the flagellum completely. Analysis of both SEM and TEM samples failed to show the collar or lobe of an acrosome.

The flagellum ranges in length from 26 to 31 μm and is divided into a principal piece and end piece (Fig. 1). The flagellum diameter appears to be constant throughout the principal piece, but narrows sharply at the transition to the end piece. One or more cytoplasmic vesicles are observed commonly at the anterior region of the flagellum (Figs. 1, 3).

TEM studies (Fig. 4) confirm the presence of mitochondria in the collar. The head is composed of a dense, coarse, granular material and is covered by a nuclear envelope. Separation of the mitochondrial collar from the flagellum by the cytoplasmic canal is evident in sectioned material.

DISCUSSION

Using the transmission electron microscope, Billard (1969) studied the sperm ultrastructure of various species of fishes including rainbow trout (Salmo gairdneri) and brown trout Salmo trutta fario (Linnaeus). Our observations conform with his and integrate the surface morphology of the sperm cells with their ultrastructure. Our head measurements are slightly greater than those reported by Billard but the difference may be that his represent average measurements made on both species. The dimensions of rainbow trout spermatozoa are in general agreement with those reported for other species of Salmonidae (see Ginzburg 1972 for a summary of these investigations).

The apparent absence of an acrosome agrees with TEM findings reported for carp (Fujimura et al. 1956), guppy (Porto and Folleinius 1960), middshipmen (Stanley 1965), goldfish (Fribourgh et al. 1970), and channel catfish (Jaspers 1972). It has been suggested that the absence of an acrosome may be related to the presence of a micropore in the eggs of teleost fishes.

Morphology of the mitochondrial collar, as revealed by TEM, supports deductions made from TEM studies (Billard 1969, Nicander...
1969, Stanley 1969, Fribourgh et al. 1970, Jaspers 1972). It has been suggested that the morphology of the collar (also called cytoplasmic collar or lobe) may be associated with fertilization. Low collars are present if fertilization is external and high collars are found in viviparous species (Porte and Follenius 1960, Dadone and Narbaitz 1967, Stanley 1969). Separation of the flagellum from the mitochondrial collar by a cytoplasmic canal has been reported for other species with external fertilization and compares with the structure of mammalian spermatozoids (Billard 1969, Nicander 1969, Fribourgh et al. 1970, Jaspers 1972).

Our study shows the presence of cytoplasmic vesicles in the anterior region of the flagellum. This finding agrees with TEM findings in rainbow and brown trout (Billard 1969). A discussion of the proposed nature and relationships of this structure is given by Ginzburg (1972).

Demonstration of a well-defined end piece in rainbow trout agrees with observations reported for lake trout (Ginzburg 1972). Tails of the spermatozoids of some fishes gradually thin toward the end (carp, guppy) in contrast to the flagella of bream sperm that remain the same diameter to the tip (Ginzburg 1972).

Figure 1. Scanning electron micrograph of rainbow trout spermatozoon that shows the head (H) and attached flagellum which is composed of a long principal piece (P) and a short end piece (E). Cytoplasmic vesicles (V) appear commonly in the anterior region of the flagellum. 3,000 X. (Index line = 3 μm.)

Figure 2. Scanning electron micrograph of rainbow trout spermatozoon head (H) lying at an angle that encourages identification of the mitochondrial collar (M). 10,000 X. (Index line = 1 μm.)

Figure 3. This scanning electron micrograph illustrates the cytoplasmic canal (C) that penetrates the mitochondrial collar (M). A cytoplasmic vesicle (V) is attached to the flagellum. 12,000 X. (Index line = 1 μm.)

Figure 4. This transmission electron micrograph demonstrates the relationship between the flagellum (F), cytoplasmic canal (C), and the mitochondrial complement (*) of the collar. The sectioned head (H) reveals the chromat in arranged in blocks that are composed of fibrillar material. 20,000 X. (Index line = 1 μm.)

ACKNOWLEDGEMENT

The writers thank the U.S. Fish and Wildlife Service, Fish Control Laboratory, LaCrosse, Wisconsin, for collecting, fixing, and storing the specimens.

LITERATURE CITED


Scanning Electron Microscopy of the Rainbow Trout


Characteristics and Behavior of Guineafowl and Domesticated Chicken Hybrids

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Division of Biological Science, Arkansas State University, State University, Arkansas 72467

ABSTRACT

The description, behavior, and morphologic measurements are presented for two hybrid crosses of domesticated chicken and guineafowl. The ease at which gallinaceous birds hybridize might warrant a closer look at the classification system. Possibly the number of families in the superfamily Phasianioidea should be reduced as some other researchers suggest.

INTRODUCTION

Hybridization occurs at the species, genus, and family levels among domesticated birds. In gallinaceous birds it has occurred among species of different families (Hanebrink 1973a, b). Isolating mechanisms, however, normally keep these crosses to a minimum.

The purpose of this report is to describe the characteristics of crosses between guineafowl and domesticated chickens. Ghigi (1900), Heinroth and Heinroth (1955), and others reported such crosses. The Heinroth's (1955) stated that both peacocks and domestic cocks are known to mate successfully with guineafowl hens, but the offspring show no sexual behavior because their sex glands hardly develop at all. Such hybrids are sometimes mentally abnormal and are always undistinguished in color; instead of being the sum of their two parents they are an unseemly mosaic of both. The breeding dress of the peacock and the elegant spotting of the guineafowl are the results of factors inherited from two birds of the same species: because the hybrids get only one dose of inheritance for either species, the characteristics of each parental type tend to be diluted. Recently Hanebrink (1973a, b) published reports on a cross between guineafowl and peafowl. Reports have been written on various hybrids of gallinaceous species. Some of these crosses have been induced artificially by artificial insemination. Domesticated chicken-quail hybrids (Gallus gallus x Coturnix coturnix japonica) were produced successfully by Mitsumoto and Nishida (1958) and by Wilcox and Clark (1961). Several crosses have been attempted between domesticated turkeys (Meleagris gallopavo) and domesticated chickens (Warren and Scott 1935). Published reports of turkey-chicken crosses indicate that only a limited number of fertile eggs were obtained and few advanced embryos (Ogorodii 1935, Quinn et al. 1937, Asmundson and Lorenz 1957). Olson (1960) reported successful hatching of chicken-turkey hybrids; he found a total of 302 embryos (14.2%) among 2,132 eggs incubated. One-hundred twenty of these embryos had attained an age at which down color established hybridization. Twenty-three hybrids hatched. It is evident from Olson's study that under certain conditions, spermatogonia from Dark Cornish and Rhode Island males are capable of fertilizing turkey eggs. An early account by Edwards (1761) reported a cross between a turkey and pheasant.

Crosses between peafowl and guineafowl have been reported by Serebrovsky (1929), Ghigi (1900), Taibel (1955), Heinroth and Heinroth (1955), Mayball (1961), and Hanebrink (1973a, b).

From crosses of turkeys and domesticated chickens, Olson (1960) reported all males. Wilcox and Clark (1961) gave no sex ratios among their artificial-insemination crosses of the Coturnix quail and domesticated chicken. Haldane (1922) concluded that in the F₁ offspring of a cross between two animals' species, one sex is absent, rare, or sterile. That sex is always the heterogametic sex. In birds the heterogametic sex is the female whereas in mammals it is the male. An increased percentage of males has been found in the F₁ generation in interhybrid crosses among gallinaceous birds. Ghigi (1936) reported only males in crosses between domestic fowl and guineafowl and guineafowl and peafowl. From color markings the hybrid guineafowl x peafowl cross reported by Hanebrink (1973a, b) was thought to be a female, although no eggs were laid and no autopsy was performed. This hybrid is living and associates itself with other peafowl. According to Cole and Hollander (1950), a cross of a male pigeon with a female dove produces offspring which are all males, and these are sterile when mated to pigeons. When this hybrid is mated to a dove of the parental species, however, it occasionally produces a three-fourths dove. Such offspring are all males and sterile. A male dove mated with a female pigeon produces both male and female offspring of which all the females are barren.

DESCRIPTION OF DOMESTICATED CHICKEN—GUINEAFOWL HYBRIDS

Chicken-guineafowl hybrids (Figs. 1, 2) were hatched from guineafowl. According to Cole and Hollander (1950), a cross of a male pigeon with a female dove produces offspring which are all males, and these are sterile when mated to pigeons. When this hybrid is mated to a dove of the parental species, however, it occasionally produces a three-fourths dove. Such offspring are all males and sterile. A male dove mated with a female pigeon produces both male and female offspring of which all the females are barren.

Figure 1. Hybrid of White Leghorn and White Guineafowl.

Figure 2. Hybrid of Buff Cochin and White Guineafowl.
eggs under natural barnyard conditions. In this situation two female white guineas were enclosed in a pen with several breeds of domesticated chickens. No male guineafowl were included in the enclosure. From a total of 30 guineafowl eggs, only one hatched; it produced the white hybrid (Fig. 1). The eggs were incubated by a domesticated duck and one of the female white guineafowl. All the other eggs from these two settings either were infertile or at least no development of embryos occurred to the hatching point. The buff hybrid (Fig. 2) hatched from a total of 12 eggs. Four of these eggs were fertile to the point of the eggs being piped. Two actually hatched from this setting but one chick died the first day. Both the buff and white hybrids (Figs. 1, 2) were reared with baby chicks and are now more than two years old. During the spring of 1974 copulation between the female white guineafowl and the two domesticated roosters was observed several times by David Remagen (pers. commun.) who is the owner of the hybrids. Morphologic measurements for the two female white guineafowl were practically identical. It was not known whether the hybrids came from one female guineafowl or both, but the father of the pure white hybrid had to be the White Leghorn rooster as there was no feathering on the tarsus and the color was pure white. The father of the buff hybrid had feathering on the tarsus which is characteristic of the Buff Cochin rooster. The hybrid was also buff, even though the female guineafowl was white. Neither hybrid shows any visible sex characteristics in its behavior, and they fare equally well with chickens and guineas but usually associate with each other. They feed and roost with both chickens and guineafowl but are seldom included in a flock of either chickens or guineas in their normal routine.

The hybrid from the female white guineafowl and male White Leghorn is solid white and is generally intermediate (Table 1) in the characteristics between the parents in morphologic measurements but actually is smaller in stature than either parent. This hybrid has bright orange legs which are guinealike but weak. The bird is wobbly as it walks. This cross has specific guineafowl traits with the tail elevated somewhat like that of the chicken. Waddles are vestigial and the face has sparse feathering, a characteristic of the guineafowl. There is no helmet like that of the guineafowl nor is there a comb like that of the domesticated chicken. There is a small round tubercle near the base of the upper bill which is characteristic of neither the chicken nor the guineafowl.

<table>
<thead>
<tr>
<th>Characters in cm</th>
<th>White Guinea</th>
<th>Hybrid White</th>
<th>White Leghorn</th>
<th>Hybrid Buff</th>
<th>Buff Cochin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culmen</td>
<td>3.5</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Tarsus</td>
<td>8.0</td>
<td>8.0</td>
<td>10.0</td>
<td>9.5</td>
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</tr>
<tr>
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<td>4.3</td>
<td>5.0</td>
<td>5.5</td>
<td>6.2</td>
<td>5.3</td>
</tr>
<tr>
<td>Middle Toe with Nail</td>
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<td>6.0</td>
<td>6.5</td>
<td>7.5</td>
<td>6.0</td>
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<tr>
<td>Bend of Wing (length outward from bend)</td>
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<td>10.16</td>
<td>12.70</td>
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<td>14.00</td>
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<tr>
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<td>30.48</td>
<td>35.60</td>
<td>33.02</td>
<td>40.60</td>
</tr>
</tbody>
</table>

SOCIAL BEHAVIOR OF THE HYBRIDS

Even though the guineafowl-domesticated chicken hybrids were reared with baby chickens they prefer to remain to themselves. They both show no visible sex characteristics and are calm under normal conditions. However, they are extremely nervous when caught and are easily frightened when cornered in contrast to either parent. Their voice is somewhat guinealike although different. They never use their voice unless frightened. Peafowl-guineafowl hybrids associate more with other peafowl than with guineafowl. The guineafowl-domesticated chicken hybrids seem to have no preference but associate with each other. These hybrids are similar to guineafowl in their agonistic behavior as they are very hostile toward domesticated chickens while feeding which is a characteristic of guineafowl.

CONCLUSIONS

Crosses between domesticated chickens and guineafowl have been reported as well as a large number of crosses among other members of the superfamily Phasianoidae. The cross reported here represents species in different families of the superfamily Phasianidae and the guineafowl in the family Numididae. Most published accounts mention the hybrids but give little description of the behavior or morphologic measurements. This report includes descriptions of the behavior and morphologic characters of such a cross. Though game breeders do not advocate interhybrid crosses, these crosses do occur both naturally and under artificial conditions. Sarvella (1969) mentions that these crosses can be valuable research tools. Cytological and biochemical (serum protein) studies of intergeneric and interfamilial crosses help to advance the understanding of evolutionary trends which lead to classification systems. Also, they can make it possible to devise techniques for transferring genes from wild birds to domestic ones. The ease with which gallinaceous birds seem to hybridize suggests a closer look at the classification system. Possibly the number of families in the superfamily Phasianoidae should be reduced as suggested by Yamashina (1952) and Mainardi (1959).

ACKNOWLEDGEMENTS

The writer is most grateful for the cooperation of David Remagen in permitting the hybrids to be studied. Photographic work was done by Dr. Harvey Barton, Associate Professor of Zoology, and Dr. James Hutchison, Professor of Botany, Arkansas State University.
Characteristics and Behavior of Guineafowl and Domesticated Chicken Hybrids

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YAMASHINA, Y. 1952. La Kromosomo 14:536 (cited from Mainardi).
Effect of Estrogen and/or Supplemental Substrates on Uterine Utilization of Pyruvate for Lipid Synthesis

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ABSTRACT

Precursor incorporation into uterine lipids was examined \textit{in vitro} after estradiol-17\beta administration in immature female rats. The effect of adding supplemental substrates, glucose or gluconate, to the incubation medium on the labeling pattern of pyruvate-3-\textsuperscript{14}C into uterine lipids was studied. Presence of supplemental substrate in the medium enhanced the incorporation of pyruvate into uterine lipids after two hours of \textit{in vivo} estrogen treatment. It is suggested that estrogen's acceleration of pyruvate incorporation into lipid may be due to a concomitant effect on glucose metabolism.

INTRODUCTION

The growth and differentiation of the rat uterus after estrogen treatment is accompanied by many physiological and biochemical changes. With physiological doses of estrogen the uterus of the immature or ovarietomized rat changes from an atrophic organ to a rapidly growing one. Estrogen facilitates the entrance of substrate materials and ions into the uterus with as little as two hours of treatment (Smith 1967, Smith and Stultz 1971).

The works of Aizawa and Mueller (1961) showed that increased lipid synthesis is one of the earliest and most dramatic responses in the uterus treated with estrogen. Measurements of incorporation of various labeled compounds into uterine lipid after estrogen treatment have been used to evaluate the stimulation of lipid synthesis in uteri of immature or ovarietomized rats.

This investigation was undertaken to examine the effect of estradiol-17\beta on pyruvate-3-\textsuperscript{14}C incorporation into uterine lipids and the relationship of this process to other aspects of uterine carbohydrate metabolism.

MATERIALS AND METHODS

Immature (21-23 day old) female Holtzman rats were injected intraperitoneally with either 5 \mu g of estradiol-17\beta dissolved in 5 ml of 0.15 M NaCl or with 5 ml of 0.15 M NaCl alone (controls). Animals were decapitated at the end of each specified time period (1-16 hr) after injection. Uteri were removed and trimmed of fat and connective tissue.

Whole uteri were incubated \textit{in vitro} at 37°C in a shaking water bath, after gassing with a mixture of 95 \% O\textsubscript{2} and 5 \% CO\textsubscript{2}. Incorporation of pyruvate-3-\textsuperscript{14}C (10-20 \muCi/ml, New England Nuclear) was carried out in Robinson's medium. After incubation, flasks were placed on ice, then the uteri were removed and washed twice in cold saline solution.

Washed uteri were placed in 3 ml of 5 \% TCA in centrifuge tubes. Each tube contained from two to six pooled whole uteri. The contents of each tube was homogenized in a glass Duall homogenizer. Total lipids were extracted by sequential centrifugation with 100 \% ethanol, chloroform:ethanol (2:1), and anhydrous ether (twice). The washes (5 ml each) were collected and allowed to evaporate in a stream of air for 6-12 hours. Total lipid fractions were transferred in ether to scintillation vials and allowed to evaporate prior to the addition of fluid for counting. For lipid separation into phospholipid and neutral lipids, 0.5 ml of chloroform:absolute methanol (1:1) was added, then the extracts were flushed with nitrogen and stored overnight at -20°C for use in thin-layer chromatography (TLC) experiments. TLC experiments were carried out by the procedure of Freeman and West (1966). Liquid scintillation counting procedures were done in a Beckman LS 100 counter.

RESULTS

The data in Table I show the effects of length of estrogen treatment on pyruvate metabolism. Pyruvate incorporation into lipid increased significantly at all time periods. Tables II and III show the effect of estrogen on stimulating the incorporation of pyruvate-3-\textsuperscript{14}C into uterine lipid when exogenous glucose or gluconate, respectively, was present in the incubation medium. Neither substrate alone was effective in elevating pyruvate incorporation into lipid. However, \textit{in vivo} estrogen treatment in combination with \textit{in vitro} glucose or gluconate in the medium gave significant results.

Total lipids extracted from each uterus were analyzed by TLC. The percentage of total lipid radioactivity appearing in phospholipid and neutral lipid fractions is given in Table IV. The data for controls (0 hr) and two-hour estrogen pretreatment show an approximate 1:1 ratio, but by six hours there was an apparent increase in the proportion of labeling of neutral lipids.

Table V presents data showing the effects of glucose and gluconate on pyruvate labeling of uterine phospholipid and neutral lipid fractions after estrogen treatment. After two hours of hormone treatment neither estrogen nor added substrate had significantly altered the labeling pattern of neutral or phospholipid fractions. However, after six hours of hormone treatment, the phospholipid fraction showed a 10\% decrease under all conditions, whereas the neutral lipids showed more than a 10\% increase under all conditions.

DISCUSSION

Information obtained from these studies demonstrates that \textit{in vivo} estrogen treatment in immature rats stimulates subsequent \textit{in vitro} incorporation of pyruvate-3-\textsuperscript{14}C into uterine lipids. As suggested by earlier work, the time course of the estrogen effect on lipid synthesis begins as early as two hours and continued through the longest time studied (16 hr).

The addition of supplemental substrates, glucose or gluconate, to the incubation medium tended to enhance the incorporation of pyruvate into uterine lipids after two hours of estrogen pretreatment. The combined effects of the nutrient substrates with estrogen in the immature rat uterus caused elevations above control of 137\% for glucose and 161\% for gluconate. These findings suggest that carbohydrate substrate availability for lipid synthesis is associated with the effect of estrogen on uterine tissue.

TLC analysis of total uterine lipids showed equal stimulation of pyruvate into neutral and phospholipids after two hours of estrogen treatment. These findings are interpreted to mean that the estrogen effect responsible for the increases observed occurs in the metabolism of pyruvate at a step common to all classes of lipids. Although such an effect might implicate acetyl-CoA carboxylase activity, other workers have shown that the activity of this enzyme is not affected by estrogen. An increase in acetyl-CoA pool size is also unlikely because of the differential effect of estrogen on pyruvate oxidation to CO\textsubscript{2} and its incorporation into lipids.

Because pyruvate utilization for lipid synthesis is influenced under \textit{in vitro} conditions by the presence of exogenous sugars, it is evident that the metabolism in uterine tissue is complex. Estrogen alterations in uterine glucose metabolism are known to occur early enough in the hormone's action on the uterus to be capable of causing changes in lipid synthesis secondarily (Smith 1967). It is suggested that estrogen's acceleration of pyruvate incorporation could be due to a
concomitant effect on glucose metabolism. The reported estrogen-induced increases in glycolysis and oxidative glucose metabolism are probably sufficient to supply the increased amounts of substrates, energy, and reducing equivalents necessary to stimulate lipogenesis generally.

LITERATURE CITED

Table I. Time Course of the Estrogen Effect on Uterine Metabolism of Pyruvate-3-14C

<table>
<thead>
<tr>
<th>Estradiol-17-β treatment in vivo (hr)</th>
<th>14CO2 as % of control</th>
<th>14C-lipid as % of control</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>2</td>
<td>96.3±3.5(40)</td>
<td>132.8±6.0**(27)</td>
</tr>
<tr>
<td>4</td>
<td>88.0±3.8**(8)</td>
<td>181.8±27.0**(6)</td>
</tr>
<tr>
<td>8</td>
<td>82.2±7.8**(8)</td>
<td>277.0±46.0**(6)</td>
</tr>
<tr>
<td>12</td>
<td>84.2±2.5**(7)</td>
<td>538.0±66.0**(4)</td>
</tr>
<tr>
<td>16</td>
<td>81.5±3.4**(7)</td>
<td>364.0±39.0**(4)</td>
</tr>
</tbody>
</table>

* indicates significance at p < 0.05; ** p < 0.01.

Immature rat uteri were incubated for one hour in Robinson's medium containing 0.125 μCi/ml of pyruvate-3-14C. 14CO2 and lipids were collected as described in methods section. Data are expressed as percentage deviation ± SEM from control where control is considered 100%. Typical values for control uteri are 10,278 cpm/uterus and lipid 580 cpm/uterus. Values in parentheses indicate the number of determinations.

Table II. Effect of Estrogen and/or Exogenous Glucose on Incorporation of Pyruvate-3-14C into Uterine Lipid

<table>
<thead>
<tr>
<th>Treatment or condition</th>
<th>14C-lipid cpm as % of control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>100</td>
</tr>
<tr>
<td>Glucose (5 mM)</td>
<td>112.4±16.0</td>
</tr>
<tr>
<td>Estrogen (2 hr)</td>
<td>116.2±10.0</td>
</tr>
<tr>
<td>Estrogen (2 hr) + Glucose Added (5 mM)</td>
<td>137.15±12.0*</td>
</tr>
<tr>
<td></td>
<td>(117.23±10.0)</td>
</tr>
</tbody>
</table>

* indicates significance at p < 0.01. Δ = % change compared with estrogen alone.

Immature rat uteri were incubated for one hour in Robinson's medium containing 0.125 μCi/ml of pyruvate-3-14C, prepared with or without glucose. Lipids were extracted as described in methods section. Typical 14C-lipid value for control uteri is 582 cpm/uterus. Values are the result of nine determinations.

Table III. Effect of Estrogen and/or Exogenous Gluconate on Incorporation of Pyruvate-3-14C into Uterine Lipid

<table>
<thead>
<tr>
<th>Treatment or condition</th>
<th>14C-lipid cpm as % of control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>100</td>
</tr>
<tr>
<td>Gluconate (5 mM)</td>
<td>109.5±13.0</td>
</tr>
<tr>
<td>Estrogen (2 hr)</td>
<td>151.8±11.3*</td>
</tr>
<tr>
<td>Estrogen (2 hr) + Gluconate added (5 mM)</td>
<td>161.1±18.2*</td>
</tr>
<tr>
<td></td>
<td>(109.7±9.0)</td>
</tr>
</tbody>
</table>

* indicates significance at p < 0.01. Δ = % change compared with estrogen alone.

Immature rat uteri were incubated for one hour in Robinson's medium containing 0.125 μCi/ml of pyruvate-3-14C, prepared with or without gluconate. Data are expressed as % of control ± SEM. Typical lipid control value is 318 cpm/uterus. Values are the result of 10 determinations.

Table IV. Effects of Estrogen on Pyruvate Labeling of Phospholipid and Neutral Lipids Recovered in Total Uterine Lipids

| Estradiol-17-β treatment in vivo (hr) | % of total lipid radioactivity Phospholipid Neutral lipid |
|--------------------------------------|---------------------------------|-----------------|
| 0                                    | 46.5(6)                         | 53.5(6)         |
| 2                                    | 49.0(4)                         | 51.0(4)         |
| 6                                    | 35.8(2)                         | 64.2(2)         |

Immature rat uteri were incubated for one hour in Robinson's medium containing 0.50 μCi/ml of pyruvate-3-14C. Data are expressed as % fraction recovered (phospholipid fraction cpm or neutral lipid fraction cpm/total lipid cpm recovered x 100). Radioactivity measurement and lipid extraction were as described in methods section. Typical control values are 367 cpm/uterus (phospholipid) and 393 cpm/uterus (neutral lipid). Values in parentheses indicate the number of determinations.
### Table V. Effect of Estrogen and Added Glucose or Gluconate on Pyruvate Labeling of Uterine Phospholipids and Neutral Lipids

<table>
<thead>
<tr>
<th>Substrate added to medium</th>
<th>Estrogen treatment in vivo (hrs)</th>
<th>0</th>
<th>2</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Phospholipid (% of total lipid radioactivity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>46.5 (6)</td>
<td>49.0 (4)</td>
<td>35.8 (2)</td>
<td></td>
</tr>
<tr>
<td>Glucose (5 mM)</td>
<td>47.4 (6)</td>
<td>48.8 (4)</td>
<td>31.0 (2)</td>
<td></td>
</tr>
<tr>
<td>Gluconate (5 mM)</td>
<td>41.2 (6)</td>
<td>46.3 (4)</td>
<td>30.0 (2)</td>
<td></td>
</tr>
<tr>
<td>Neutral lipid (% of total lipid radioactivity)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>53.5 (6)</td>
<td>51.0 (4)</td>
<td>64.2 (2)</td>
<td></td>
</tr>
<tr>
<td>Glucose (5 mM)</td>
<td>52.6 (6)</td>
<td>51.2 (4)</td>
<td>69.0 (2)</td>
<td></td>
</tr>
<tr>
<td>Gluconate (5 mM)</td>
<td>58.8 (6)</td>
<td>53.7 (4)</td>
<td>70.0 (2)</td>
<td></td>
</tr>
</tbody>
</table>

Immature rat uteri were incubated for one hour in Robinson's medium containing 0.5 μCi/ml of pyruvate-3-¹⁴C plus added substrate where indicated. Phospholipids and neutral lipids were separated and radioactivity measured as described in methods section. Data are expressed as in Table IV. Values in parentheses indicate number of determinations.
Electrophoretic Patterns of Serum Proteins in Two Subspecies of Odocoileus virginianus

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ABSTRACT

Cellulose acetate electrophoresis revealed six monomorphic forms of serum protein in natural populations of two subspecies of white-tailed deer, Odocoileus virginianus virginianus from Arkansas and Odocoileus virginianus macroura from Tennessee. The fixed pattern of serum proteins in the two populations indicates a lack of genetic variation in the loci controlling these proteins.

However, electrophoresis revealed different hemoglobin phenotypes in the two subspecies. This finding indicates that further study is needed to determine whether or not there are genetic differences in the hemoglobin forms.

INTRODUCTION

Two subspecies of white-tailed deer, Odocoileus virginianus virginianus and Odocoileus virginianus macroura, are present in Arkansas and Tennessee, respectively (Hall and Kelso 1959). The range of O. v. macroura includes Missouri, Arkansas, eastern Kansas and Oklahoma, northern Louisiana, and a small area of northeastern Texas. The range of O. v. virginianus includes virtually all of Tennessee, Kentucky, the inland areas of Mississippi, Alabama, Georgia, South Carolina, North Carolina, Virginia, and most of West Virginia. The zone of contact between the two subspecies is the Mississippi River.

Electrophoretic analysis of serum proteins has been used as a valid method of determining genetic variation between natural populations of various mammals (Zimmerman 1975, Kilpatrick and Zimmerman 1976, Selander and Yang 1969). The purpose of this study was to analyze the serum proteins of O. v. macroura from Arkansas and O. v. virginianus from Tennessee to assess the levels of genetic similarity between the two subspecies.

MATERIALS AND METHODS

Samples of blood were collected from deer shot by hunters which were brought to Wattensaw Wildlife Management Station, Prairie County, Arkansas, and the Natches Trace Wildlife Management Area, Dyer County, Tennessee, during the respective hunting seasons. Samples were taken from 25 deer selected from 160 tagged at Natches Trace and 23 selected from approximately 200 tagged at Wattensaw. Selection was based on the time of death and the condition of the deer. Most samples were taken from deer killed within one hour of their arrival for tagging. Approximately 10 cc of blood was collected from the pleural cavity of each deer. Care was taken to collect clear serum; however, in most cases hemoglobin contamination could not be avoided. A sample of blood also was collected from a live deer at the Little Rock Zoo to be used as a control. Samples were placed in glass vials, stored on ice, and transported to the laboratory where the serum was separated by centrifugation, frozen, and stored until electrophoretic analysis.

Serum proteins were separated on cellulose acetate membranes by use of Shandon Electrophoresis Apparatus Model U77. A minimum of two runs was made of each sample. After an application of 2.5 μl of serum on a 10-cm cellulose acetate strip, the samples were subjected to electrophoresis in barbital buffer, pH 8.6 and ionic strength 0.075, for 2 hr at 175 v with a mean current of 2.5 ma per strip. At the conclusion of the run, strips were transferred to 5% trichloroacetic acid fixing solution, then to Amido 10B staining solution for 10 min. Strips were washed in methyl alcohol until the last wash remained colorless. Visual inspection was carried out on each strip.

RESULTS

Electrophoretic analysis revealed six bands of serum protein which appeared to be monomorphic with no detectable differences in occurrence or intensity between the two populations. No sexual variation was detected. For two bands of hemoglobin, variation of occurrence between the two subspecies was detected. Migrating toward the anode, the fastest component, albumin, was followed by alpha globulin, hemoglobin A, hemoglobin A1, alpha, globulin, beta, and beta globulin, and gamma globulin (Fig. 1).

All samples clearly indicated the presence of four serum proteins including albumin, alpha, beta, and gamma globulins. Because of the light staining of alpha globulin, this band was not always detectable. Gamma globulin, which moved only a slight distance from the origin, stained lightly and also was difficult to detect.

Visual analysis of the electrophoretic strips indicated that the concentration of each component of the serum was consistent for all deer. Bartlett (1963) observed that the optical density of proteins stained with Amido Black 10B increased linearly with increasing concentration of dye and that albumin and globulins have equal affinity for the stain on a percentage basis.

After electrophoretic separation the hemoglobin bands were visible before staining and thus could be easily identified. After staining, two forms of hemoglobin designated HbA and HbA1 were observed. HbA migrated approximately midway between alpha and alpha globulins: HbA migrated slightly faster than alpha globulin.

Of 23 samples of blood from O. v. macroura, two showed both hemo-
DISCUSSION

The Mississippi River does not provide complete geographic isolation for the two populations because residents and officials of state agencies have reported deer crossing low-water areas of the river. Furthermore, Lowery (1974) in reporting on white-tailed deer in Louisiana stated that transplantation of deer has resulted in a genetic conglomerate of hybrids among several natural geographic races. Attempts to obtain stocking information on populations of deer in the two states were unsuccessful because of lack of accurate records maintained in the states.

Analysis of the serum proteins showed no detectable differences in the occurrence, electrophoretic migration, or intensity of staining either among individuals of a population or between the subspecies. The consistent pattern of serum proteins in the two populations indicates a lack of genetic variation in the loci controlling these proteins.

This study was intended as an analysis of only the serum proteins; however, because of hemolysis of blood before collection, hemoglobin was detected in samples of blood from both populations. *O. v. virginianus* was characterized by the presence of HbA; and the absence of HbB. The characterization of hemoglobin in *O. v. macroura* was more difficult as both HbA and HbB were found rarely in the samples. No visible difference in hemoglobin contamination was observable in the samples of serum; however, the consistent HbB absence and HbA presence of the Tennessee deer was not observable in samples from Arkansas deer. This study indicates the presence of polymorphic forms of hemoglobin within the two populations. Further study of isolated hemoglobin from the subspecies is desirable to determine whether or not there is geographic variation in hemoglobin forms.

ACKNOWLEDGEMENT

The authors acknowledge the assistance of the Arkansas Game and Fish Commission and Tennessee Wildlife Resources Agency in their cooperation for the procurement of samples of blood.

LITERATURE CITED


Composition of Arkansas Grapes During Maturation

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ABSTRACT
Changes in organic acid and glucose content during maturation and ripening of grapes grown in Arkansas in 1973 are shown for four French hybrid varieties, S5279, S10878, SV23-657, and S13033, and for four rotundifolia varieties, Scuppernong, Tarheel, Fry, and Magoon. In all varieties the concentrations of malates and tartrates were highest in the early stages of berry growth after véraison. During ripening the titratable acidity decreased and Balling and pH measurements increased. Although varieties reached maturity on different dates, changes in parameters followed similar curves typical for grapes of the species but occurring over a short period (Johnson and Nagel 1976, Winkler 1970). Rotundifolia varieties showed unacceptable Balling-acid ratios as well as irregular maturation progress in the study period.

HISTORY AND BACKGROUND
Viniviticultural, also called the winegrowing industry, may have an important future in Arkansas. Thousands of hillside acres, now semiproductive, could produce valuable crops of grapes. The most discouraging aspect for the investor is the almost complete lack of technical information on desirable locations and the best grape varieties to plant.

European nations have been selecting locations and varieties for hundreds of years (Continuescu 1971). In California, New York, Ohio, Michigan, and Washington sufficient data have been accumulated to define risks and prospects (Carter 1974). The UALR Department of Chemistry undertook preliminary investigations in 1971 using the procedures and techniques developed by the University of California at Davis (Amerine 1967).

Grapes were obtained from the University of Arkansas Experiment Station Fruit Substation in Clarksville to accumulate data on ripening patterns in Arkansas grapes. Wine was made each year from several of the varieties obtained to gain experience in winemaking with local grapes.

Ripening phenomena usually are recorded in terms of sugar and acid content, commonly expressed as ratios of Balling to acid (Joslyn and Amerine 1964). Balling is a hydrometer scale representing soluble solids in grape juice as percentage fructose and total acidity expressed as percentage tartaric acid. If total acid, 95% is tartaric and malic. Many other acids account for the remaining 5%. pH was recorded after the first year. A pH of less than 4 is desirable to inhibit the growth of spoilage organisms in the medium, whereas more than 1% total acids may produce wines too acid to drink (Amerine 1967).

Studies reported here were undertaken when it appeared from previous experience that grapes grown in Arkansas do not mature as they do in other states (Amerine and Joslyn 1970, Johnson and Nagel 1976).

The balance between glucose and titratable acid content of mature grapes, or Balling-acid ratio, depends greatly on the variety and climate in which it matures. Taste-panel evaluations of experimental and commercially produced wines in Arkansas indicate a potential for varietal wine production of excellent quality. However, several varieties considered adaptable to Arkansas may in fact show wide fluctuations in Balling-acid ratio from year to year and may not perform as well as in other locations. The varieties of grapes used in this study were selected from varieties known to be grown in commercial quantities within the state.

MATERIALS AND METHOD
Sample preparation. Grape berry samples were collected from varietal plantings of the University of Arkansas Agricultural Experiment Station Fruit Substation near Clarksville. Approximately 500 g of each variety were collected at one-week intervals during the 1973 season. Clusters were taken from several vines in different locations in the case of French hybrid varieties. Rotundifolia vines were shaken according to commercial harvesting practice and all fruit which fell was collected. The berries were macerated in a blender for one minute to produce a homogeneous sample. The sample was centrifuged to remove particulate matter and 100 ml of clear juice was placed in a 125-ml flask, labeled, and stored at approximately 0°C until analyzed.

Measurement. The pH of the sample was determined by means of a Beckman pH meter calibrated to ambient temperature and range 1 to 4. Titratable acidity was measured on 5-ml samples of juice diluted with 50 ml of deionized water. The samples were titrated by use of phenolphthalein indicator to the end point with 0.1N NaOH. Titratable acidity was expressed as tartaric acid in g/100 g of grapes (Amerine 1967). Soluble solids were measured by Abbe refractometer. Balling at 20°C was read from tables.

RESULTS AND CONCLUSIONS
Total titratable acid diminished (Figs. 2, 5) and glucose increased in all samples analyzed (Figs. 1, 4). French hybrid varieties reached acceptable balance or Balling-acid ratios between 20 and 40 with Balling 19 or more (Winkler 1970). Rotundifolia varieties did not. The relatively small change in Balling-acid ratios of the latter during the sampling period may indicate that flowering and berry set were prolonged either because of environmental conditions, as characteristic of the varieties, or a combination of both (Avramov 1972, Calo 1972, Minarik 1971). In South Carolina where there are large acreages of Scuppernong, the berries are harvested by hand several times, each berry selected for maturity (Hearing 1971). Shaking may produce a uniform mix of ripe and immature berries over an extended period. The pH remained at low levels for rotundifolia varieties (Fig. 6) but rose to unacceptable levels for S5279 and S13033 (Fig. 3).

These data are indicative of characteristics of grapes grown in Arkansas. The information may provide a basis for the selection of varieties best suited to this environment.

ACKNOWLEDGEMENT
This research was partially funded by a University of Arkansas at Little Rock Faculty Research Grant.

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http://scholarworks.uark.edu/jaas/vol30/iss1/1

52 Arkansas Academy of Science Proceedings, Vol. XXX, 1976
Cameron Jones, Dominic T. C. Yang, and Thomas O. Whitley


Figures 4-6. Changes in composition of four rotundifolia grape varieties during September - October 1973. • Scuppernong, ▲ Fry, O Tarheel, ▲ Magoon.
The Problem of Site Definition in Cultural Resource Management

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ABSTRACT

The strategies employed by the Cache River Archeological Project, the Little Black Watershed Project, and the 1976 Village Creek Archeological Project with regard to site definition are compared and assessed. It is argued that both the Cache and Little Black Projects used unnecessarily restrictive definitions of cultural resources. The more liberal approach of the Village Creek Project enables both the archeological community and governmental agencies to interpret and assess better the significance and general extent of the archeological context of the cultural resource base.

INTRODUCTION

Several researchers involved in cultural resource management (Price et al. 1975, Raab 1975, Raab and Klinger 1976, Schiffer and House 1975) have argued recently that problems of interpretation and assessment of significance of archeological resources are related directly to the theoretical and methodological framework within which these resources are viewed (i.e., research design). Site interpretability and significance, in other words, are variables construed in the eyes of the beholder.

A comparison is made of a basic methodological aspect of three major research programs involving regional assessments of cultural resources in separate areas of northeast Arkansas and southeast Missouri (Fig. 1). The focus of this discussion is on the problem of site definition and how this affects subsequent interpretations and evaluations of resource significance. The research programs reviewed include (1) the Cache River Archeological Project, an Arkansas Archeological Survey program sponsored by the U.S. Army Corps of Engineers during 1973 and 1974 (Schiffer and House 1975); (2) the Little Black Watershed Project, conducted by the Southeast Missouri Archeological Research Facility of the University of Missouri during 1975 and sponsored by the U.S. Soil Conservation Service (Price et al. 1975); and (3) the 1976 Village Creek Archeological Project also conducted by the Survey and sponsored by the U.S. Soil Conservation Service (Klinger 1976).

THE PROBLEM OF SITE DEFINITION

It seems curious that archeologists should hold as widely varied concepts of such a basic analytical unit as the site as are illustrated in the examples outlined in Table I. The crucial question at this juncture is what configuration of variables must be present for a cultural resource to be recognized.

In the Cache Project, for example, the definition of an archeological site was "any area with observable evidence of past cultural behavior" (House and Schiffer 1975:47). When this notion was operationalized in the case of prehistoric sites, however, areas were recorded and found eligible for possible future analysis only if they yielded "a double hand-full of cultural material" (House and Schiffer 1975:48). In addition, historic sites were mapped only if they produced clear evidence of an occupation predating 1860 (House and Schiffer 1975:47). The relationship between a double hand-full of artifacts and past human behavior was not the subject of one of House and Schiffer's more explicit discussions in the Cache volume.

In the Little Black Watershed investigations, the minimal criterion for assigning a site number to an area was that it contain at least "3 or more specimens of prehistoric cultural material such as potsherds, or chert and quartzite flakes" (Price et al. 1975:79). In contrast to the Cache practice, historic sites within the Little Black basin were recorded if they predated 1900, although post-1900 sites representing important or poorly documented activities (e.g., mining, moonshining) also were noted when identified.

The definition of cultural resources in the Cache and Little Black projects, then, rested on seemingly tenuous criteria involving a double hand-full of artifacts and sites predating 1860, or areas containing the "magic number" of three pieces of cultural material and, in most cases, predating 1900.

The 1976 Village Creek Project took a more expansive approach to defining cultural resources than either of the other two projects. The
TIMOTHY C. KLINGER

same definition of a site as used in the Cache Project was employed in the Village Creek investigations. The "double hand-full" criterion, however, was not involved in the latter study. Thus, any discrete spatial loci exhibiting evidence of past cultural behavior, whether it be a single sherd or flake, was deemed a site. In the case of historic resources, any set of cultural remains that could be considered to be in archaeological context (Schiffer 1972) was, by definition, mapped and processed as an archaeological site regardless of age.

DISCUSSION

The disparity in strategies of site definition exhibited in Table I is not unique to the Western Lowlands of Arkansas and Missouri or to the Lower Mississippi Valley. The problem of site definition has confronted many researchers in a variety of cultural and ecological settings. Site definition as such is not unlike any other variable, in that it is derived from and intimately associated with the overall theoretical and methodological framework or research design. In cultural resource management, however, no matter what the research design may entail, one must be capable of assessing the total resource base, not just a portion of it. (This not to suggest that all archeological sites can be recorded, for there is a portion of the archeological record which falls below the current threshold of visibility: however, one must be in a position to make an adequate assessment of those resources which are visible.)

Thomas (1975:62) adopted a strategy involving analytical units that are even more basic than the traditional site for use in his Great Basin Reese River Ecological Project. This approach is characterized by use of "the cultural item (the artifact, feature, manuport, individual flake, or whatever) as the minimal unit" of analysis rather than the site (1975:62).

This non-site archeology (a poor choice of label by Thomas for it implies that a single cultural item cannot, by itself, fulfill a more traditional site definition) is essentially the strategy used in the 1976 Village Creek Project. Allowing the criteria for a resource to expand beyond traditional limits has literally exposed a vast portion of archeological record that previously was ignored or labeled insignificant and/or uninterpretable.

A particularly telling point in this regard is the Cache Project's operational definition of archeological sites in comparison with that used in Village Creek. Both projects involved an intensive and well-designed sample survey of analogous areas of the Western Lowlands in northeast Arkansas (Fig. 1). To complement the efforts of the Cache investigators, it was decided to continue to the west the already completed Cache Transect 1 with the Village Creek Transect 107. Both of the cross-basin strips were ¼ mile wide and were in the central part of Township 15N. House (1975:153) reported an overall site density of 11.3 sites/mi² for the Cache Transect (Table I). This density contrasts sharply with the 30.7 sites/mi² found in the transect extension across the Village Creek Basin.

Differential use of the two basins both prehistorically and historically may account for some of the observed variability. Differences in approach to site definition, however, probably account for most of it.

Although there are no strictly analogous data for the Little Black investigations, a review of the site descriptions (Price et al. 1975:78-111) confirms that small scatters were recorded and designated as cultural resources. Overall site densities for this area also would exceed significantly those projected for the Cache.

A conservative view of cultural resources such as that used in the Cache Project not only tends to mislead government agencies as to the nature and extent of the archeological record but also severely limits the resultant data base with regard to its potential to inform about total cultural systems as they operated in the past.

The question remains as to what effect conservative or liberal approaches to the archeological record have on the ability to assess and interpret cultural resources. Although this is difficult to answer, one readily apparent ramification of the conservative view is that at least 50% of the resource base must immediately be disregarded, half of the total settlement system (63% in the case of the Cache/Village Creek dichotomy). By recording the small sites and isolated items, in contrast, one builds a valuable body of regionally derived data from which potentially significant patterns may emerge. This far-reaching problem affects both the archeological community and those governmental agencies responsible for the protection of cultural resources.

CONCLUSION

An unnecessarily restrictive view of the archeological record can be detrimental in several respects. Three major research projects were evaluated in terms of their approach to defining cultural resources. The most conservative of these, the Cache Project, employed what now can be judged as a totally unacceptable strategy of resource definition. Although the Little Black criteria were much more liberal, the 1900 restriction on historic sites and the three-artifact qualification on prehistoric sites are still thought to be much more repressive. The liberal approach used in the Village Creek Project should serve as a model for future investigations charged with assessing cultural resources from a regional perspective. The notion of cultural resource management implies responsibility for the total resource base, not an arbitrarily defined portion of it.

LITERATURE CITED


Table I. Methodological Comparison of Three Recent Archeological Research Programs Conducted in Northeast Arkansas and Southeast Missouri

<table>
<thead>
<tr>
<th>Project</th>
<th>Site Definition</th>
<th>Site Definition</th>
<th>Comparative Site Densities</th>
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<tbody>
<tr>
<td>Cache River Archeological Project</td>
<td>Prehistoric</td>
<td>Historic</td>
<td>11.3 sites/mi²</td>
</tr>
<tr>
<td>(Schiffer and House 1975)</td>
<td>double</td>
<td>pre-1800</td>
<td></td>
</tr>
<tr>
<td></td>
<td>hand-full</td>
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<tr>
<td></td>
<td>of artifacts</td>
<td></td>
<td>not reported</td>
</tr>
<tr>
<td>Little Black Watershed Project</td>
<td>at least 3</td>
<td></td>
<td>30.7 sites/mi²</td>
</tr>
<tr>
<td>(Price and Price et al. 1975)</td>
<td>artifacts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Village Creek Archeological Project</td>
<td>single</td>
<td>archeological</td>
<td></td>
</tr>
<tr>
<td>(Klinger 1976, in preparation)</td>
<td>artifacts</td>
<td>context</td>
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<tr>
<td></td>
<td></td>
<td>historic</td>
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<tr>
<td></td>
<td></td>
<td>sites</td>
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<td></td>
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<td>regardless</td>
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<td></td>
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<td>of period</td>
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</tbody>
</table>
The Problem of Site Definition in Cultural Resource Management


Cave Fauna of Arkansas: Selected Invertebrate Taxa

V. RICK Mc DANIEL and KENNETH L. SMITH
Division of Biological Science, Arkansas State University,
State University, Arkansas 72467

ABSTRACT
This report is the first in a series of reports describing the fauna of Arkansas caves. Included are notes accumulated during the past four years on nematomorphs, amphipods, isopods, diplopods, decapods, and a variety of insect taxa. In addition to recorded records of distribution, the ecological status of each species (as a cavernicolous) is described as troglobitic, troglophilic, trogloxenic, or accidental. Several of the included species are reported for the first time from Arkansas.

INTRODUCTION
The Ozark region of Arkansas contains hundreds and possibly even thousands of limestone caves, almost all of which harbor various forms of life. Although large numbers of both invertebrate and vertebrate organisms have been encountered in these caves, relatively few scientific efforts have been made to document or in any way study the cavernicolous fauna of Arkansas. The most readily available defers studies extensively covering aspects of the fauna associated with Arkansas caves included a small series of papers on cave-dwelling salamanders (Bishop 1944; Smith 1960, 1964, 1968; Brandon 1962, 1966; Brandon and Black 1970), some inspecific comments on the fauna of all Ozark caves (Hubricht 1950), a paper on records of bats in Arkansas (Sealander and Miller 1941), a description of a new troglobitic crayfish (Hobbs and Bedinger 1964), the Environmental Impact Statement for Blanchard Springs Caverns (U.S. Forest Service 1973), and a thesis listing major invertebrate groups and vertebrate species present in Blanchard Springs Caverns (Grove 1974). In addition, various species have been mentioned as present in Arkansas (Nicholson 1960; Holsinger 1967, 1972; Fleming 1972), but there is no comprehensive list of species in Arkansas caves. This report is the first in a series of reports documenting the presence and distribution of organisms inhabiting the caves of Arkansas. The list is not complete for the species covered, but is intended to provide an initial basis upon which other investigations can be instituted.

METHODS
During the past four years, the caves of northcentral Arkansas have been searched extensively for forms of life. Collection has been minimal and has been for the purpose of identification only. All forms collected by the writers are represented by voucher specimens in the collection of Cavernicolous Materials at Arkansas State University or in the collections of other recognized taxonomists. Species and localities reported herein are the results of the writers' collection efforts unless otherwise indicated.

Included for each species in this list are the probable ecological position of the species in the cave environment, all Arkansas cave records assembled by the writers to date, and a comment concerning the status, collection, or life history of the species. The convention of contemporary biologists is followed in use of the terms "troglobitic," "troglophilic," "trogloxenic," and "accidental" to describe the probable ecological position of animals found in the cave environment (Barr 1963). Although widely used, these terms are relevant only to an organism in the cave environment. Troglobites are obligate cavernicolous unable to exist in epigean environments, and normally show marked adaption to the cave environment (e.g., absence of pigments and eyes, and hypertrophy of other sensory modalities). Troglophilic species are commonly found in caves, but exist equally well in suitable epigean environments. Trogloxenes may be common in caves, but must periodically leave the cave for completion of their life cycles (e.g., bats and cave crickets). Accidental species normally do not live in caves, but have fallen, washed, or wandered into a cave. Accidentally survive long in the cave environment.

ACKNOWLEDGEMENTS
Several individuals made important contributions to this survey during the past four years. In particular, assistance in collecting specimens was provided by H. Baber, G. Gardner, J. Rockwell, R. Rockwell, J. Rooker, D. Saugey, O. Wood, and B. Yeager. We especially acknowledge and appreciate the contributions of each of the following systematists in identification of specimens: H.E. Barton, insects; T.E. Bowman, isopods; G.W. Byers, diplopods; N.B. Causey, millipedes; K. Christiansen, collemboles; T.L. Erwin, podurids; O.S. Flint, trichopterans; R.H. Foote, insects; R.J. Gagne, mycetophilids and other dipterans; G.L. Harp, aquatic arthropods; J.L. Herring, hemipterans; J.R. Holsinger, amphipods; G.A. Schultz, nematodes; D.R. Smith, hymenopterans; F.C. Thompson, dixids; B. Tucker, collemboles; R.D. White, chrysomelids; W.W. Wirch, and other phorids; D.L. Wray, podurids. We are grateful to the U.S. Forest Service personnel at Blanchard Springs Caverns for allowing us to use their copy of the Environmental Impact Statement for the cavern. Finally, we thank Mary Smith for critically reading this manuscript.

ANNOTATED LIST OF ARKANSAS CAVE FAUNA

PHYLUM ASCHELMINTHES
Class Nematomorpha
Order Gordioidea

Undetermined species, trogloxene. Izard Co.: Clay Cave; Stone Co.: Ennis Cave. Adults were taken from shallow stream pools in the twilight zone of these caves. Larval gordin worm are internal parasites of many insects, including the abundant cave crickets, Centophilus sp.

PHYLUM ARTHROPODA
Class Crustacea
Order Amphipoda
Family Gammaridae

Bairdus mexicanus (Forbes), troglophilic. Central Arkansas. According to Holsinger (1972) this is a common interstitial species.

Crangonyx forbesi (Hubricht and Mackin), troglophilic. Ozark region of Arkansas. Hubricht (1950) reports this species is found in caves throughout the Ozarks. Holsinger (1972) indicates this may actually be an undetermined species closely related to C. forbesi.

Crangonyx obliquus (Hubricht and Mackin), troglophilic. Johnson Co. In Arkansas, this species has been found only in springs, but Nicholas (1960) considers it a cave inhabitant of the Eastern United States.

Gammus minus (Say), trogloxene. Izard Co.: Needles Cave. Found throughout Needle Caves, these epigean amphipods are...
extremely abundant in the stream flowing from the mouth of this cave.

*Gammarus pseudolimnaeus* Bousfield, troglobite. Specific locality in Arkansas unknown. Although it is not definitely recorded from Arkansas caves, Nicholas (1960) considered this species a cave inhabitant.

Stygonecestes alabamensis alabamensis (Stout), troglobite. Benton Co.; seep; Boone Co.; seep; Izard Co.; Bergren Cave, Clay Cave, Needles Cave; Jackson Co.; spring; Logan Co.; seep; Newton Co.; seep; Searcy Co.; seep; Stone Co.; Allison Cave, Blanchard Springs Caverns. This species is common in Arkansas (Holsinger 1967), and usually is found in drip pools; however, two specimens were taken from the stream in Needles Cave.


Stygonecestes ozarkensis Holsinger, troglobite. Benton Co.; Cave Springs Cave, Danford Cave. Specimens have been found in streams far from the entrances of these caves (Holsinger 1967).

Order Isopoda

Family Asellidae

*Asellus ancyclus* Fleming, troglobite. Boone Co.; Brewer Cave. Fleming (1972) reported this species from the mud of a stream floor.

*Asellus antrocinus* (Creaser), troglobite. Independence Co.; Cushman Cave, Dodd Cave; Izard Co.; Needles Cave; Searcy Co.; Hurricane Cave; Stone Co.; Rowland Cave. Aspects of the life history of this apparently abundant organism are being studied by K.L. Smith. *Asellus nickajackensis* is a synonym of *A. antrocinus* (Steeves 1966).

*Asellus brevicauda* Forbes, troglobite. Specific locality in Arkansas unknown. Nicholas (1960) reported this species from Arkansas, but gave no locations.

*Asellus dimorphus* (Mackin and Hubricht), troglobite. Searcy Co.; Jackson Co. Little is known of this species (Fleming 1972; Mackin and Hubricht 1940).

*Asellus oculata* (Mackin and Hubricht), troglobite. Polk Co.; Rich Mtn. This species has been collected from several springs and may be present in caves.

*Asellus situlactylus* (Mackin and Hubricht), troglobite. Benton Co.; Big Spring at Bella Vista, Cave Spring Cave. This species was reported by Fleming (1972), but little is known of its life history.

*Asellus tridentatus* (Hungerford), troglobite. Lawrence Co. This species was taken from a deep cistern near Imboden (Fleming 1972).

*Lirurus* n. sp., troglobite. Independence Co.; Foshee Cave; Stone Co.; Hell Creek Cave. This unpigmented and minutely eyed isopod is very different from the only other cave species of this genus, *L. usdalagun* (T.E. Bowman, pers. comm.). Specimens have been taken from the bottom of rocks in the ripples of these caves. The writers found these isopods to be abundant in these two caves.

Family Trichoniscidae

*Miktoniscus* sp., troglobite. Izard Co.: Clay Cave. The poorly known oniscoids are relics of a once widely distributed group (Vandel 1964). A single specimen was taken about 1000 ft from the entrance on a sand bank littered with stream debris.

Family Ligiidae

*Ligidium etrodi* etrodi (Packard), troglobene. Stone Co.: Blanchard Springs Caverns. One of the few native terrestrial isopods of North America. Prefers moist conditions, but generally avoids areas subject to flooding (Hatchett 1947). *Ligidium longicaudatum* Stroller is a junior synonym of this species (Schultz 1970).

Order Decapoda

Family Astacidae

*Camarus zophonastes* Hobbs and Bedinger, troglobite. Stone Co.: Hell Creek Cave. This recently described crayfish is known only from the type locality (Hobbs and Bedinger 1964).

*Oreonecestes* sp., troglobene. Independence Co.; Cushman Cave; Izard Co.; Needles Cave. A common epigean form that often enters the twilight zone of caves.

Class Diplopoda

Order Cambalida

Family Cambalidae

*Cambala* (minor) Bollman, troglobipe. Stone Co.: Roaring Ear Cave. The writers' single specimen was in the post-molt stage, making specific identification difficult. This species is frequently found in caves.

Order Chordeumididae

Family Conotylidae

*Scoterpes* dundrus Loomis, troglobite. Carroll Co.; Newton Co. According to Causey (pers. comm.), this is one of two species present in caves along the White River.

*Scoterpes* n. sp., troglobite. Independence Co.; Cushman Cave, Dodd Cave; Izard Co.; Bergren Cave, Clay Cave, Donovan Cave, Needles Cave; Stone Co.; Blanchard Springs Caverns, Hell Creek Cave. In northcentral Arkansas this appears to be the most abundant troglobitic millipede. This species is very similar to *S. martini* and is being described by Causey.

*Trichopetalum uncum* Cook and Collins, trogliophile. Sharp Co.; Center Cave. A trogliophile with well developed ocelli.

Family Cleidogonidiidae

*Pseudotrematia* pinetorum. Undetermined. Stone Co.: Blanchard Springs Caverns. The writers are unfamiliar with this species, but it was listed in the Environmental Impact Statement for Blanchard Springs Caverns and therefore is included in this list.

Order Platychetida

Family Andrognotidae

*Brachycyte* lecontei Wood, trogliophile. Sharp Co.; Center Cave #2. One specimen was taken from the twilight zone.

Order Polydesmida

Family Euryuridae

*Anturus* eviser (Bollman), trogliophile. Independence Co.; Cushman Cave, Dodd Cave; Izard Co.; Clay Cave; Stone Co.; Roaring Ear Cave. This common epigean form is often found in large numbers associated with bat guano deposits.
Cave Fauna of Arkansas: Selected Invertebrate Taxa

<table>
<thead>
<tr>
<th>Family Polydesmidae</th>
<th>Order Coleoptera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loomis, troglobite.</td>
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<tr>
<td>Independence Co.:</td>
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<tr>
<td>Cushman Cave; Izard</td>
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<tr>
<td>Co.: Clay Cave. This</td>
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<tr>
<td>small millipede usually</td>
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<tr>
<td>is associated with</td>
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<tr>
<td><em>Scolioptera</em>. These</td>
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<tr>
<td>records are the first</td>
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<td>for Arkansas.</td>
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<tr>
<td><em>Pseudopolydesmus</em></td>
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<tr>
<td><em>Pseudopolydesmus pinetorum</em> (Bollman), troglobite. Izard Co.:</td>
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</tr>
<tr>
<td>Clay Cave: Sharp Co.: Center Cave. Center Cave #2. Although</td>
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<tr>
<td>normally an epigean species, this millipede is present in</td>
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<tr>
<td>the twilight zone of caves.</td>
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<tr>
<td>Order Spirobolida</td>
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<tr>
<td><em>Narceus americanus</em> (Beauvois), accidental. Independence Co.:</td>
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<tr>
<td>Cushman Cave. This large epigean millipede was found in the</td>
<td></td>
</tr>
<tr>
<td>twilight zone of this cave, where it apparently had strayed.</td>
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<tr>
<td>Class Insecta</td>
<td></td>
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<tr>
<td>Order Collembola</td>
<td></td>
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<tr>
<td><em>Pseudosinella argenta</em> Folsom, troglobite. Independence Co.: Dodd</td>
<td></td>
</tr>
<tr>
<td>Cave: Izard Co.: Clay Cave; Stone Co.: Allison Cave. Specimens</td>
<td></td>
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<tr>
<td>were taken from the surface of water far from the entrances</td>
<td></td>
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<tr>
<td>of these caves.</td>
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<tr>
<td><em>Pseudosinella dubia</em> Christiansen, troglobite. Washington Co.: Devils</td>
<td></td>
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<tr>
<td>Den Cave, Devils Den Kitchen Cave, Granny Dean Cave. Not</td>
<td></td>
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<tr>
<td>collected by the writers, but reported by Christiansen (1960).</td>
<td></td>
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<tr>
<td><em>Sineilla barri</em> Christiansen, troglobite. Izard Co.: Needles Cave.</td>
<td></td>
</tr>
<tr>
<td>Taken off the surface of standing water.</td>
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</tr>
<tr>
<td>Family Isotomidae</td>
<td></td>
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<tr>
<td><em>Folsomia candida</em> Willem, troglobite. Izard Co.: Needles Cave.</td>
<td></td>
</tr>
<tr>
<td>Taken off the surface of standing water.</td>
<td></td>
</tr>
<tr>
<td>Family Poduridae</td>
<td></td>
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<tr>
<td><em>Neanura bareri</em> Handschin, troglobite. Izard Co.: Clay Cave.</td>
<td></td>
</tr>
<tr>
<td>Taken off a sand bank beside standing water.</td>
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<tr>
<td>Family Smintthuridae</td>
<td></td>
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<tr>
<td><em>Arrhopalites clarus</em>, troglozene. Newton Co.: Boxley Cave. Taken in</td>
<td></td>
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<tr>
<td>the twilight zone.</td>
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<tr>
<td><em>Arrhopalites pygmaeus</em> (Wankel), troglozene. Izard Co.: Clay Cave.</td>
<td></td>
</tr>
<tr>
<td>Taken from flood debris near a small stream.</td>
<td></td>
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<tr>
<td><em>Plecosthrix</em> sp. Borner, accidental. Izard Co.: Clay Cave. Not a</td>
<td></td>
</tr>
<tr>
<td>cave form, probably wandered in. Young specimen.</td>
<td></td>
</tr>
<tr>
<td>Order Ephemeroptera</td>
<td></td>
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<tr>
<td>Family Heptageniidae</td>
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<tr>
<td><em>Stenonea tripunctata</em> (Banks), accidental. Izard Co.: Needles</td>
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<tr>
<td>Cave. A nymph was taken from the underside of a stream stone</td>
<td></td>
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<tr>
<td>in the twilight zone.</td>
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<tr>
<td>Order Hemiptera</td>
<td></td>
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<tr>
<td>Family Coreidae</td>
<td></td>
</tr>
<tr>
<td>Undetermined species, accidental (?). Stone Co.: Roasting Ear Cave.</td>
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<tr>
<td>A single nymph was taken from a wet wall about 400 ft from</td>
<td></td>
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<tr>
<td>the entrance.</td>
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<tr>
<td>Family Gerridae</td>
<td></td>
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<tr>
<td><em>Gerris remigis</em> Say, troglozene. Izard Co.: Needles Cave. This species</td>
<td></td>
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<tr>
<td>was taken from the pool area of a stream flowing from the</td>
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<tr>
<td>entrance. Taken from the twilight zone.</td>
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<tr>
<td>Order Coleoptera</td>
<td></td>
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<tr>
<td>Family Hydrophilidae</td>
<td></td>
</tr>
<tr>
<td><em>Tropisternus mexicanus mexicanus</em> LaPorte, accidental (?). Izard</td>
<td></td>
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<tr>
<td>Co.: Needles Cave. Taken from a stream pool in the twilight</td>
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<tr>
<td>zone.</td>
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<tr>
<td>Family Leptodiridae</td>
<td></td>
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<tr>
<td><em>Ptomaphagus caverntica</em> (Schwarz), troglobite. Stone Co.: Blanchard</td>
<td></td>
</tr>
<tr>
<td>Springs Caverns. Not collected by the writers, but listed in</td>
<td></td>
</tr>
<tr>
<td>the Environmental Impact Statement.</td>
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<tr>
<td>Family Hydroptilidae</td>
<td></td>
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<tr>
<td><em>Psephidionus</em> sp. Gistel, troglozene. Stone Co.: Blanchard Springs</td>
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<tr>
<td>Caverns. Not collected by the writers, but listed in the</td>
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<tr>
<td>Environmental Impact Statement.</td>
<td></td>
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<tr>
<td>Order Trichoptera</td>
<td></td>
</tr>
<tr>
<td>Family Hydroptilidae</td>
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</tr>
<tr>
<td><em>Ochroiricha spinosa</em> (Ross), troglozene. Izard Co.: Needles Cave.</td>
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<tr>
<td>Great numbers of pupae were found attached to riffle substrate</td>
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<tr>
<td>in the stream flowing from the entrance of this cave.</td>
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</tr>
<tr>
<td>Order Diptera</td>
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<tr>
<td>Family Ceratopogonidae</td>
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<tr>
<td><em>Dasyhelea</em> sp. Kieffer, troglozene. Independence Co.: Dodd Cave.</td>
<td></td>
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<tr>
<td>Taken from the twilight zone.</td>
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<tr>
<td>Family Dixidae</td>
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<tr>
<td><em>Disa</em> sp. Meigen, troglozene. Izard Co.: Needles Cave. Large</td>
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<tr>
<td>numbers of larvae were found attached to the riffle substrate</td>
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<tr>
<td>in the stream flowing from the entrance.</td>
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<tr>
<td>Family Helomyzidae</td>
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<tr>
<td><em>Ameobaiaia sackeni</em> Garrett, troglobite. Stone Co.: Blanchard</td>
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<tr>
<td>Springs Caverns. Not collected by the writers, but listed in</td>
<td></td>
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<tr>
<td>the Environmental Impact Statement.</td>
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<tr>
<td><em>Scoliocentra</em> sp. Loew, troglobite. Independence Co.: Cushman</td>
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<tr>
<td>Cave. Taken from the twilight zone.</td>
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<tr>
<td>Family Mycetophilidae</td>
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</tbody>
</table>

Arkansas Academy of Science Proceedings, Vol. XXX, 1976 59
Exochia sp. Winnertz, troglodene. Izard Co.: Clay Cave. Taken from the twilight zone.

Exochiopsis sp., troglodene. Sharp Co.: Center Cave. Taken from the twilight zone.

Neuratelia sp. Rondani, troglodene. Izard Co.: Needles Cave. Taken near an opening to the surface.

Family Phoridae

Megaselia cavernicola (Brues), troglodile. Independence Co.: Dodd Cave. This species should be common in Arkansas caves.

Family Sciaridae

Bradydia sp. Winnertz, troglodene. Independence Co.: Dodd Cave; Izard Co.: Clay Cave. Appears to be locally common.

Family Tipulidae

Limonia stulta (Ostensacken), troglodene. Sharp Co.: Center Cave. Taken from the twilight zone.

Tipula algonquin Alexander, troglodene. Stone Co.: Roasting Ear Cave. Taken from the twilight zone.

Order Hymenoptera

Family Formicidae

Camponotus sayi Emery, accidental. Stone Co.: Allison Cave. Several specimens were taken from a limb floating in a pool about 500 ft into the cave. They had either washed or had been carried into the cave.

LITERATURE CITED


Enzymes in *Heloderma horridum* Venom

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**ABSTRACT**

A mixture of venom and saliva from the lizard *Heloderma horridum* was analyzed for esterase, phosphomonoesterase, phosphodiesterase, 5'-nucleotidase, and protease activities. Hydrolysis of N-benzoyl-L-arginine ethyl ester occurred at a pH optimum between pH 8.6 and 9.1 with a maximum activity of 452 units per mg per min. Hydrolysis of p-toluenesulfonyl-L-arginine methyl ester occurred at a pH optimum between pH 8.1 and 8.5 with a maximum of only 36 units per mg per min. One mg of the venom mixture liberated 9.3 \( \mu M \) of p-nitrophenol from p-nitrophenyl phosphate per minute at an optimum pH between 8.2 and 8.3. Over a wide range of pH, only low phosphodiesterase and 5'-nucleotidase activities were observed. A trace of caesinolytic activity occurred at pH 9.0.

**INTRODUCTION**

*Heloderma suspectum* and *Heloderma horridum* of Mexico and Southwestern U.S.A. are the only known poisonous lizards (Stybilia and Kornalik 1967). In both lizards, Mebs (1968) reported that the venom secretion is diluted with saliva. This venom-saliva mixture is very toxic and has phospholipase A, hyaluronidase, esterase, and kinin-releasing properties (Mebs and Raudonat 1967, Mebs 1968, 1972).

This report concerns the esterase, phosphomonoesterase, phosphodiesterase, 5'-nucleotidase, and protease activities in the venom-saliva mixture of *H. horridum*.

**MATERIALS AND METHODS**

The lyophilized *H. horridum* venom-saliva mixture was a gift from Dr. H.L. Stahnke, Director, Poisonous Animals Research Laboratory at Arizona State University. The BAEE (N-benzoyl-L-arginine ethyl ester), TAME (p-toluenesulfonyl-L-arginine methyl ester), 5'-adenylic acid, and bis-p-nitrophenyl phosphate sodium salt were purchased from Sigma Chemical Co.; disodium p-nitrophenyl phosphate from Nutritional Biochemicals Corp.; Tris-hydroxymethylammonium chloride, glycine, ammonium molybdate, hydroquinone, sodium sulfite, magnesium chloride, and trichloroacetic acid (TCA) from Fisher Scientific Co.; sodium hydrogen sulfite from J.T. Baker Chemical Co.; magnesium sulfate from Mallinckrodt Chemical Works; and the casein from ICN Pharmaceuticals, Inc.

All enzyme assays described herein were performed with 1.0 mg per ml stock solutions of the lyophilized venom-saliva mixture. At this concentration, linear rates of substrate hydrolysis were obtained by measuring absorbance changes with a Beckman Acta C III spectrophotometer. After determination of concentration of stock solution for use in the assays, buffer solutions over a wide pH range were prepared for determining the pH optimum of an enzyme activity. The factors used by Sulkowski et al. (1963) and Richards et al. (1965) for converting enzyme activities measured at 37C to values at 25C were followed.

Esterase activities were assayed at 25C by use of Tris-HCl buffers. Solutions of 0.87 \( \times 10^{-3} \) M TAME (p-toluenesulfonyl-L-arginine methyl ester) and 0.25 \( \times 10^{-3} \) M BAEE (N-benzoyl-L-arginine ethyl ester) served as substrates (Schwert and Takenaka 1955, Tu et al. 1965). The control cuvette contained 3.0 ml of substrate solution and the test cuvette contained 2.9 ml of substrate solution to which 0.1 ml of venom dissolved in H2O was added and mixed. Then absorbance increases at 247 nm for TAME or at 233 nm for BAEE were recorded at 30-sec intervals for up to 10 min. Activity is expressed as:

\[
\frac{\Delta A_{233} \text{min}^{-1} \times 1000}{\text{Units/mg}} = \frac{\text{mg of venom}}{\text{substrate hydrolyzed/min}}
\]

A factor of 0.70 was used to convert results obtained at 37C to 25C.

For determination of phosphomonoesterase the procedure described by Richards et al. (1965) was used. The reaction mixture of 1.0 ml of 0.1 M Tris-HCl buffers, 1.2 ml of 0.001 M disodium p-nitrophenyl phosphate, 0.3 ml of 0.01 M MgCl2, and 0.5 ml of diluted venom was incubated at 37C for 30 min. Absorbance was measured at 400 nm. The blank contained all components except the venom. Specific activity was calculated as:

\[
\frac{\mu M \text{ of substrate hydrolyzed/min}}{\text{mg of venom}}
\]

A factor of 0.25 was used to convert results at 37C to 25C.

Protease activity was determined by using casein as substrate (Kunitz 1974, Rick 1965). The casein solutions were prepared by heating 1 gm of casein in 100 ml of buffer at 100C for 15 min. After cooling, H2O was added to bring the solution back to 100 ml. One ml of venom solution was incubated with 1.0 ml of prewarmed substrate. After 20 min incubation at 37C, 3.0 ml of 5% TCA was added. After 30 min at room temperature, the solutions were centrifuged for

Arkansas Academy of Science Proceedings, Vol. XXX, 1976 61
20 min at 3000 to 4000 g and the absorbance of the supernatants was determined at 280 nm. The blank was prepared by adding 3.0 ml of TCA to 1.0 ml of substrate solution followed by 1.0 ml of venom solution. A protease unit (PU) is defined as the amount of venom which under the conditions (20 min, 35C, final incubation mixture of 2 ml, final volume after TCA of 5 ml) liberates TCA-soluble products, so that at 280 nm the absorbance increases by 1.00 in 1 min.

**Specific activity** = \[
\text{Abs. in 20 min} = \frac{\text{mg of venom/ml} \times 20}{\text{activity}}
\]

![Figure 1. H. horridum venom arginine ester hydrolase activity with BAEE and TAME as substrates at various pH values of Tris*HCl (0.0667 M) buffer, 25C. Activities were calculated by methods described in text.](image)

![Figure 2. H. horridum venom phosphomonoesterase activity at various pH values. Activity is defined as the number of *µ*M of p-nitrophenol liberated from p-nitrophenyl phosphate per min per mg of venom at 25C.](image)

![Figure 3. A comparison of H. horridum venom phosphodiesterase and 5'-nucleotidase activities at various pH values. Activity is defined as the number of *µ*M of phosphate liberated from the substrate per min per mg of venom at 25C.](image)

**RESULTS AND DISCUSSION**

Esterase, phosphomonoesterase, phosphodiesterase, 5'-nucleotidase, and protease activities were present in the venom-saliva mixture from the lizard *H. horridum*. Results plotted in Figure 1 show that hydrolysis of BAEE by *H. horridum* venom occurred at a pH optimum between 8.6 and 9.1 with a maximum activity of 452 units per mg per min. Hydrolysis of TAME occurred at a pH optimum between 8.1 and 8.5 with a maximum activity of only 36 units per mg per min (Fig. 1).

*H. suspectum* venom also hydrolyzes BAEE in preference to TAME (Tu et al. 1965, Tu and Murdock 1967, Mebs 1972). Mebs (1972) reported a pH optimum between 8.5 and 9.0 for BAEE and TAME hydrolysis by *H. suspectum* venom. Using snake venoms, Tu et al. (1965) reported that Crotalidae venoms have relatively high activities with BAEE and TAME substrates and that Viperidae venoms hydrolyze BAEE more rapidly than TAME. Neither BAEE nor TAME was hydrolyzed by Elapidae venoms.

One mg of *H. horridum* venom-saliva mixture liberated 9.3 *µ*M of p-nitrophenol from p-nitrophenyl phosphate per minute at an optimum pH between 8.2 and 8.3 (Fig. 2). Although phosphomonoesterase has been observed in a variety of snake venoms (Gulland and Jackson 1938, Richards et al. 1965) no report to the writers' knowledge has shown its presence in Heloderma venoms.

*H. horridum* phosphodiesterase and 5'-nucleotidase activities were low over a wide range of pH (Fig. 3). Phosphodiesterase activity is present also in *H. suspectum* venom (Styblova and Kornalik 1967) and in all snake venoms tested (Russell 1972). 5'-nucleotidase is also common to most venoms (Russell 1972).

The *H. horridum* venom-saliva mixture had a trace of caseinolytic activity (PU = 0.0015/min) at pH 9.0. Higher protease activity was observed in *H. suspectum* venom (Styblova and Kornalik 1967, Mebs, 1972). Proteinases are also present in Crotalidae and Viperidae snake venoms although there is little or no protease activity in Elapidae and Hydrophiidae snake venoms (Russell 1972).

**LITERATURE CITED**


Enzymes in *Heloderma horridum* Venom


STYBLOVA, Z. and F. KORNALIK. 1967. Enzymatic properties of *Heloderma suspectum* venom. Toxicon. 5:139-140.


The Study of Ultraviolet-Induced Chromatid and Chromosome Aberrations as a Function of Dose in G1 Phase Vertebrate Tissue Cultures

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ABSTRACT

G. phase A8 Xenopus laevis (toad) and V79B Cricetulus griseus (hamster) tissue cultures were used to observe the frequency of ultraviolet-induced chromosomal aberrations as a function of dose. When cultures are irradiated with ultraviolet light, visible aberrations are virtually absent until a threshold of approximately 80 ergs mm\(^{-2}\) is reached. Aberrations then occur as a nonlinear function of dose. Chromatid aberrations are by far the most prevalent until doses in excess of 1 ergs mm\(^{-2}\) are administered, at which point chromsome aberrations become common.

INTRODUCTION

The study of ultraviolet light (UV)-induced chromosomal aberrations in eukaryotic cells has been limited in comparison with that of the induction of chromosomal aberrations by ionizing radiation. The frequency of chromosomal aberrations in G1 vertebrate cells induced by ionizing radiation has been observed to be a logarithmic function of the dose administered. These aberrations are basically of the chromosome type, which can be subdivided into deletions, resulting from single breaks, and exchanges, resulting from multiple breaks and rejoining (Evans 1967). Humphrey et al. (1963) studied aberration production in hamster cells by a single dose of UV (100 ergs mm\(^{-2}\) - 254 nm) in the DNA-sensitive absorption range. Log phase cells in monolayers were irradiated and samples were collected for chromosome analysis when they reached the first mitosis after exposure. To determine whether the cells in a given collection sample were in the G1, S, or G2 phase of the cell cycle during exposure, the monolayers were flash labelled with tritiated thymidine before UV was administered. Somewhat surprisingly, Humphrey's group found that a high frequency of chromatid aberrations was produced in the G1 cells, but the frequency of chromosome aberrations observed in these same G1 cells was not significantly above the control level. Chu (1965) carried out a detailed study of aberration production in hamster cells, using 265 nm in the DNA absorption range and 280 nm in the protein absorption range. These studies with 265 nm were carried out in essentially the same manner as the work by Humphrey et al. (1963). Chu found, however, that doses such as 50, 100, and 200 ergs mm\(^{-2}\) produced a significant frequency of both chromatid and chromosome aberrations in G1 cells. He also concluded that UV-induced aberration frequencies increased with increasing dose, as was the case with ionizing radiations. Both of these studies were complicated by the complex "mixing" of cells after UV exposure of log phase cultures, because of the fact that cells in different phases of the cell cycle during a given exposure are delayed by different time intervals in their progression toward mitosis. Griggs and Bender (1973), working with synchronous cultures of A8 Xenopus and V79B hamster cells, observed that a dose of 120 ergs mm\(^{-2}\) (254 nm) induced damage in G1 cells which was expressed as chromatid aberrations in exposed cells that reached the first mitosis after exposure. A significant frequency of chromatid aberrations was not observed. By a rather detailed study of aberration frequencies as a function of UV dose (254 nm) over an extended dose range, using synchronous cultures of cells to circumvent the problem of cell mixing, the writers hoped to elucidate the mechanism of aberration production by UV in G1 cells and to aid in the resolution of the apparent conflict mentioned above.

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MATERIALS AND METHODS

The A8 amphibian cell line is maintained in monolayer cultures at approximately 24C in glass tissue culture bottles and plastic tissue culture flasks in F12 medium. F12A medium consists of powdered F-12 medium (Grand Islands Biological Company) supplemented with fetal calf serum. Penicillin and streptomycin are added to aid in controlling contamination, and the pH is controlled with N-2-hydroxy ethylpiperazine-N'2' ethane sulfonic acid (HEPES) and sodium bicarbonate (Griggs and Bender 1972). The V79B Chinese hamster cell line is maintained in monolayer cultures at 37C in F10 medium. This medium consists of F-10 powdered medium (Grand Islands Biological Company) supplemented with fetal calf serum. Penicillin and streptomycin are added to help control contamination, and the pH is controlled with sodium bicarbonate and carbon dioxide after titration with sodium hydroxide. Both types of media are sterilized by filtration.

Routine cultivation is achieved in the A8 cell line by vigorous shaking of the culture to produce a suspension of cells. The V79B cells, however, being more firmly attached to the surface of the container, are treated with a trypsin-versene solution to produce cell suspensions.

The UV source consisted of a single 15W germicidal lamp (Sylvania G15 T8). The lamp was suspended 60 cm above the floor of the radiation chamber, a glass enclosure with a plastic front containing entry ports (to permit the use of hands and for placing items within the chamber). Thin sheets of plastic were placed between the lamp and the radiation area to decrease the UV dose rate to the point at which relatively accurate dosages could be obtained by varying the exposure time. The exposure time was controlled by manually exposing the cells while recording the elapsed time. The modified dose rate, approximately 4 ergs mm\(^{-2}\) sec\(^{-1}\), was checked periodically with a Westinghouse WL 755 phototube designed to read intensity at 254 nm.

Each culture for irradiation was prepared and irradiated as follows. The stock culture bottle was shaken lightly and the medium changed to remove dead cells and start the synchronization of the culture for G1 cells. Cells were collected from the stock culture by similar "shake-offs" every 30 minutes, to remove only those cells that had just come through mitosis. Then 2 ml of each resulting cell suspension was deposited carefully in the center of a 10-cm petri plate so as to form a large drop. Within approximately two hours at room temperature the cells had settled to the bottom and attached to the surface, with no cells more than 2 cm from the center of the plate and with essentially no touching or overlap; thus exposure was uniform without interference from the shadow cast by the sides of the petri plate. Once the cells had attached to the plate, the medium was removed, the cells were irradiated for a specific length of time according to the desired dose, and fresh medium was gently reapplied.
Troy V. Orr and H. Gaston Griggs

All A8 irradiations were done under red light to avoid photoreactivation, and the irradiated cultures were transferred immediately to a light-proof container. Irradiated cultures were incubated at 24°C in these covered glass containers, which kept the humidity near 100%, until the cultures were ready for fixing. Colcemid, to a final concentration of 10^-4 M, was added after the appropriate incubation period, and 24 hours later the cells were fixed on glass slides with 3:1 methanol-acetic acid and stained with crystal violet. Chromosome spreads were scored by conventional methods (Wolff 1961). Spreads containing a normal complement of chromosomes (36 for A8 cells and 22 for V79B cells) were examined for chromatid terminal deletions, isochromatid breaks, chromatic exchanges, chromosome terminal deletions, interstitial deletions, and chromosome exchanges (rings and dicentrics).

The monolayers of V79B G0 cells were treated throughout the experiments in essentially the same manner as the A8 cells with the following exception. All cultures were maintained at 37°C in glass containers and irradiated cultures were fixed approximately 15 hours after treatment with colcemid to a final concentration of 4 x 10^-4 M.

RESULTS AND DISCUSSION

Extensive mitotic index determinations not only provided a guideline for appropriate incubation periods, but also yielded informative data for doses between 0 and 120 ergs mm^-2 (Fig. 1). A marked increase in the time required for the cells to reach mitosis after irradiation was observed through the 60 erg point, beyond which the required time became more consistent. A similar pattern was noted in the effect of the radiation dose on the optimum mitotic index (Fig. 2); there was a relatively sudden decrease in the fraction of cells reaching mitosis, again through the 60 erg point. These determinations have an important bearing on the validity of data concerning chromatic aberrations at doses below 200 ergs mm^-2 (Griggs and Bender 1973). Figures 1, 2, and 4 and Table I show only data for the A8 cell line to maintain clarity, but similar data were observed for the V79B mammalian line. Griggs and Bender (1972) reported that the surviving fraction for A8 cells varied logarithmically with dose, which also seems true of the writers' mitotic index data between 0 and 60 ergs mm^-2.

When aberration frequencies are plotted as a function of dose, no clear increase in aberration frequency is observed until doses exceed 60 ergs mm^-2, beyond which the curves sharply rise (Fig. 3). This rise is first noticed in the V79B cells at the 75 erg point, and appears in the A8 cells at about the 90 erg point (Fig. 3, and Table I). This event occurs after the aforementioned observed effect of UV radiation on mitotic index. These data suggest that some threshold radiation value must be exceeded before aberrations appear, and thus imply that an "accumulation of UV-induced events" leads to aberrations. This effect is not observed in aberration production with ionizing radiation, and has not been observed before in studies reported on UV-induced aberration production, probably because no one has studied doses below 50 ergs mm^-2 for damage induced by wavelengths in the DNA-sensitive absorption range. Separate compilation of the chromatic and chromosome aberration frequencies showed that chromosome aberrations became noticeably more prevalent at 200 ergs mm^-2 than at any lower dose administered (Fig. 4). The fact that relatively low frequency of chromosome aberrations was noticed in the controls and at low radiation levels suggests a threshold radiation value for chromosome aberrations at a higher dose level than the threshold for chromatic aberrations.

The data are somewhat similar to Chu's (1965) findings at higher doses, but are more in accord with the data presented by Humphrey et al. (1963) for doses of about 100 ergs mm^-2. Consideration of the long and complicated division delays (more than 70 hours in some cases) reported by Chu suggests that he may have scored many cells at the second mitosis after exposure instead of the first. For example, irradiation of a given G1 cell might result in damage which would appear in a cell scored at the first division as a chromatic terminal deletion. However, if this cell were capable of moving through a second cell cycle, the damage would appear at the second mitosis as a terminal chromosome deletion. Such an effect could significantly bias results in such a manner as to overestimate chromosome...
The Study of Ultraviolet-Induced Chromatid and Chromosome Aberrations

aberration frequencies and underestimate chromatid aberration frequencies. Use of synchronous cultures minimized this problem in the writers' study.

LITERATURE CITED


Table I. Aberration Distribution for A8 Cells at Low Doses

<table>
<thead>
<tr>
<th>Dose ergs mm(^{-2})</th>
<th>Number cells scored</th>
<th>Chromatid aberrations</th>
<th>Chromosome aberrations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Terminal deletions</td>
<td>Interstitial breaks</td>
</tr>
<tr>
<td>0</td>
<td>200</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>400</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>300</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>310</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>40</td>
<td>500</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>50</td>
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<td>400</td>
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<td>6</td>
<td>0</td>
</tr>
<tr>
<td>90</td>
<td>400</td>
<td>11</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 4. Aberration frequencies of the A8 cell line over an extended dose range, with aberrations separated into chromatid and chromosome types. Average number of cells scored was 425.
Effect of Soil Buffer Capacity on Soil Reaction (pH) Modification and Subsequent Effects on Growth and Nutrient Uptake of Platanus occidentalis L. Seedlings

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ABSTRACT

The buffer capacity of a soil is a significant factor in determining the longevity of soil reaction (pH) adjustments by aluminum sulfate, Al\(_2\)(SO\(_4\))\(_3\), or calcium carbonate, CaCO\(_3\). After 12 weeks the modified pH values of the highly buffered Emory silt loam had changed substantially toward the original pH value of 7.6. Modified pH values for the Groseclose silt loam soil remained essentially unchanged under the same conditions. These differences in soil response to modified soil pH are related to the differences in the percentage of vermiculite-chlorite and chlorite in the clay fractions of the two soils.

The longevity of soil pH modification is related to total sycamore seedling dry weight and nutrient uptake. Though these components were significantly affected for plants grown in a Groseclose soil, the lack of significant response differences, except at the extremely low pH adjustment (5.21), in the Emory soil suggests a rapid change in modified soil pH toward the original soil pH value.

The condition of the seedlings coupled with total dry weight accumulation and foliar nutrient content eliminates acid toxicity as a factor affecting growth and nutrient uptake.

Plants grown in the Groseclose soil at pH 4.31 could be the exception.

INTRODUCTION

Most published reports concerning soil pH modification have described the time of effectiveness as the length of time required to produce the initial desired pH change after amendment application (Peech 1941, Coleman et al. 1958, Hall and Barker 1971). However, only meager data have been presented to describe the longevity of soil reaction modification (Coleman et al. 1958, Hutcheson and Freeman 1965). Those data which are available are concerned primarily with the effects of liming (Lund 1970, Reeve and Summer 1970, White et al. 1970, Hall and Baker 1971) and supply little information about the period of time that "effective" soil acidification can be expected to be maintained after applications of acidifying materials.

The amount of an amendment required to raise or lower soil pH to the desired value is dependent on the resistance of that soil to changes in pH, i.e., buffer capacity (Buckman and Brady 1967). Other factors being equal, the buffer capacity is highly correlated with cation exchange capacity (CEC) (Buckman and Brady 1967). Both the CEC and the buffer capacity of a soil are affected by changes in soil pH (de Villiers and Jackson 1967a), amount of organic matter (Hallsworth and Wilkinson 1958), clay content (McLean and Owen 1969), and type of clay (de Villiers and Jackson 1967b). Percentage base saturation is linked to the degree of buffering (Peech 1941) and where extremes in base saturation are found at high and low pH values, the buffer capacity of a soil is at its lowest (Mehlich 1941, Peech 1941). Previous investigations on the effect of soil type and soil reaction demonstrated that the dry matter accumulation of sycamore seedlings (Platanus occidentalis L.) was affected significantly by adjustments to soil pH for a Groseclose soil but not for an Emory soil (Pope 1973). The lack of significant growth differences of sycamore seedlings for adjusted pH levels of the Emory soil apparently was related to a substantial change in the adjusted pH values toward the original pH of the soil. The purpose of this report is to explain the possible causes for the change in the adjusted pH values in the Emory soil and to relate these facts to the growth response of sycamore seedlings.

MATERIALS AND METHODS

The soils used in this study were the A. horizon of an Emory silt loam derived from a colluvial limestone with an original pH of 7.6 and the Ap horizon of a Groseclose silt loam derived from alluvial deposition and having an original pH of 6.2 (Obenshain et al. 1966). Chemical and mechanical analyses were conducted by the Soils Testing Laboratory, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Identification of clay minerals was achieved by the techniques of differential thermal analysis (DTA) (Mackenzie 1957) and X-ray diffraction (Brown 1961, Rich 1969). The soils were fertilized to an equivalent of 1000 lbs/acre of 10-10-10 commercial fertilizer and the soil pH was adjusted to either 4.25, 5.50, 6.75, or 8.00 by the addition of Al\(_2\)(SO\(_4\))\(_3\) or CaCO\(_3\) as determined from a standard curve for each soil type. The standard curves for the Groseclose and Emory soils were derived from the procedures for soil pH adjustment described by Rich and Obenshain (1955) and Hutcheson and Freeman (1965). The soil pH was determined after equilibration and after plant harvest by using a 1:1 ratio of soil to water. The initial pH was within ± 0.1 pH unit of the desired value.

Sycamore seed was collected in mid-April after overwintering on the tree. After germination and the development of the first two true leaves, the seedlings were transplanted into 6-in. (20-cm) pots containing the fertilized and pH adjusted soil media. After 12 weeks of growth, the plants were harvested and the total dry weight of the plant determined by oven drying at 80°C to a constant weight. The foliage was analyzed for percentage nitrogen, phosphorus, and potassium. Nitrogen was determined by the semi-micro Kjeldahl technique, phosphorus by the ammonium-molybdate vanadate method, and potassium by use of a flame photometer.

The experimental design was composed of 2 soil types, 4 pH treatments, and 24 replications of 192 seedlings. Within a replication the seedlings were located in a randomized complete block design. The dependent variables were analyzed by an analysis of variance for the independent variables replication, soil type, soil pH, and all possible interactions. Variation about the mean values was examined by use of Duncan's Multiple Range Test.
RESULTS

Chemical, mechanical, and mineralogical data for the Groseclose and Emory soils are reported in Table I. With regard to the chemical characteristics, the Emory soil has a higher pH value (7.58 vs. 6.15), greater exchangeable calcium (11.49 vs. 2.82 milli-equivalents, MEQ) and magnesium (3.41 vs. 0.66 MEQ), greater total exchangeable cations (17.42 vs. 10.09 MEQ), and a greater percentage base saturation (88.69 vs. 39.84%). The values for the exchangeable cations, hydrogen (H) and aluminum (Al), are substantially greater in the acid Groseclose soil.

The mechanical analyses show that the A horizon of Emory soil contains 20% more sand, 24% less silt, and 4% more clay than the Ap horizon of the Groseclose soil.

The mineralogical data indicate higher percentages of vermiculite-chlorite and chlorite clay minerals in the Emory soil and a higher percentage of vermiculite in the Groseclose soil.

The standard curves for soil acidification and liming (Fig. 1) indicate that at the extremes in soil pH (below 5.0 and above 7.6) the Groseclose soil exhibited a larger change in pH than did the Emory soil when equivalent amounts of CaCO₃ or Al₂(SO₄)₃ were added. The ability of the Emory soil to resist such pH changes suggests it has a higher buffer capacity than the Groseclose soil in accordance with Peaich (1941).

There were pronounced differences between the initial and final adjusted soil pH values for the two soils (Table II). For the Emory soil the final pH approached the original pH of the soil. However, the magnitude of difference decreased as the initial adjusted pH approached the original soil pH. In contrast, for the Groseclose soil, the differences in initial and final pH values were very small.

Plant dry weight and the percentage of foliar ash, nitrogen (N), phosphorus (P), and potassium (K) were affected significantly by the final soil pH value for a given soil type (Table III). Plant dry weight was affected markedly by the adjusted pH levels in the Groseclose soil. Plant dry weight increased from 0.49 grams at a pH of 4.31 to 8.91 grams at a pH of 6.67 and then declined to 7.72 grams at a pH of 7.97. There were no significant differences in dry weight among plants grown on the Emory soil adjusted to different pH values.

Reduced growth rate normally is accompanied by an increase in percentage ash and in elemental levels if the plant is not subjected to elemental deficiency.

The percentage ash declined to a constant level for all plants grown at adjusted soil pH values greater than 4.31 in the Groseclose soil. This trend is reversed for the Emory soil. Percentage ash was greatest for plants grown at a pH of 7.93 and declined to a constant level for all plants grown at lower pH values.

For the Groseclose soil, the percentage of foliar N and K respectively decreased from a maximum of 3.61 and 2.73 to a minimum of 3.00 and 1.81 as the adjusted soil pH increased. Soil pH had little effect on the percentage of N and K for plants grown on the Emory soil. For the Groseclose soil, the concentration of foliar P increased from a minimum of 0.32% at pH 4.31 to a maximum of 0.46% at pH 6.67, then declined to 0.38% at a soil pH of 7.97. The foliar concentrations of P were unaffected by the adjusted soil pH of the Emory soil except at a pH of 6.13.

DISCUSSION

For the Emory soil, plant dry weight was not significantly different over the range of adjusted soil pH levels because of the substantial pH shift back toward the original pH. After adjustment, Hutcheson and Freeman (1965) reported a rapid change in soil pH toward the initial pH for both limed and acidified plots of a Burgin soil which has properties approximating those of the Emory soil. Hutcheson and Freeman concluded that such pH changes occurred within 6 weeks of initial equilibration and were caused by the strong buffer capacity of the soil. The similar soil characteristics of the Burgin and the Emory soils plus the 12-week duration of this study suggest that the same explanation may apply to the Emory soil. The differences in pH response between the Emory and Groseclose soil can be explained in terms of the differences in buffer capacity at the extreme adjusted levels of soil pH.

Obenshain et al. (1966) concluded that in CEC the two soil types are not substantially different (18.7 for the Emory and 18.3 for the Groseclose). The differences in the buffering ability of soil cannot be explained solely by differences in CEC but rather by the variables which are important in the makeup of the soil CEC (Buckman and Brady 1967), namely organic matter and clay (Hallasworth and Wilkinson 1958, McLean and Owen 1969). Generally, the Emory soil has a higher percentage of organic matter and clay than does the Groseclose. These facts alone would suggest a higher buffer capacity for the Emory soil; however, on the basis of the CEC of the soil the buffer capacity should not differ significantly. de Villiers and Jackson (1967b) demonstrated that chloritized 2:1 layer silicates having an initial high soil pH retained a large increment of the CEC as long as the soil pH was not reduced below 5.0. Release of the initially blocked isomorphous and interlayer subtitutional negative charge by deprotonation of the positive hydroxyalumina in clays is the indicated mechanism. Pionke and Corey (1967) found results similar to those of de Villiers and Jackson (1967b) but with organic matter. The mechanism of CEC retention and subsequent soil pH increase may be operating in the Emory soil.

The buffer capacity is related not only to clay and organic matter but also to percentage base saturation and type of clay. The higher percentage base saturation in the Emory soil under natural conditions indicates that a larger number of cations can be fixed in the interlayers of the clay minerals (Rich 1964). When soil pH is lowered with Al₂(SO₄)₃, the surface exchangeable cations are replaced by Al(OH)ₓ polymers but the fixed cations are still present in the interlayers (Rich 1964). The type of clay present will determine the rapidity with which these interlayer cations can be replaced by H⁺ (Rich 1964). The higher natural pH of the Emory soil suggests it has a higher percentage base saturation. It is generally reported that the percentage of 2:1 clay is higher in the Emory soil (Obenshain et al. 1966).
Effect of Soil Buffer Capacity on Soil Reaction (pH) Modification

The facts suggest that a larger number of cations are trapped in the clay interlayers and are released at low soil pH.

When cations are replaced from the interlayers, they may deprotonate Al(OH)₃ polymers in clays or organic matter or replace them altogether and increase the pH of the soil solution. From the data presented by Obenshain et al. (1966) and on the basis of the results of this study, it appears that the Emory soil is capable of overriding changes in pH.

After the changes in the adjusted pH values, the nutrients available for plant uptake were not appreciably different over the pH range for the Emory soil. In the Groseclose soil, where adjusted soil pH did not change significantly with time, the ranges in available nutrients, as reflected in foliar concentrations, were much wider and resulted in significant differences in plant dry weights with changes in soil pH. Although no chemical analyses were made for foliar content of aluminum (Al) or manganese (Mn), the general appearance of the seedlings coupled with the growth rates and foliar nutrient contents practically eliminates "acid toxicity" as a factor affecting growth and nutrient uptake. Plants grown in the Groseclose soil at pH 4.31 could be the possible exception.

CONCLUSIONS

The study findings support the idea that the buffer capacity of a soil cannot be explained solely by its CEC. Other factors such as percentage base saturation, organic matter, clay content, and types of clay must also be considered. The buffer capacity of a soil is responsible for the substantial changes in adjusted soil pH values toward the initial pH, and frequent soil pH checks should be made in studies where plant growth is measured in response to adjusted soil pH. These results raise doubts about the conclusions drawn from earlier studies (Kipps 1947, Vlamis 1953) where plant response to adjusted soil pH was investigated and final soil pH was not measured.

LITERATURE CITED


Table I. Chemical, Mechanical, and Mineralogical Analysis for the A Horizons of a Groseclose and an Emory Soil

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>pH</th>
<th>Organic Matter(%)</th>
<th>Exchangeable Cations (Milli equivalents/100 grams soil)</th>
<th>Base Saturation %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ca</td>
<td>Mg</td>
</tr>
<tr>
<td>Groseclose(sl)</td>
<td>6.15</td>
<td>2.30</td>
<td>2.82</td>
<td>0.66</td>
</tr>
<tr>
<td>Emory(sl)</td>
<td>7.58</td>
<td>2.15</td>
<td>11.49</td>
<td>3.41</td>
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</tbody>
</table>

MECHANICAL ANALYSIS

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Sand</th>
<th>Silt</th>
<th>Clay</th>
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<tr>
<td>Groseclose(sl)</td>
<td>17.8</td>
<td>64.2</td>
<td>18.0</td>
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<tr>
<td>Emory(sl)</td>
<td>37.4</td>
<td>40.6</td>
<td>22.0</td>
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MINERALOGICAL DATA

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>C.E.C</th>
<th>Montmorillonite</th>
<th>Vermiculite</th>
<th>Vermiculite-chlorite</th>
<th>Chlorite</th>
<th>Kaolinite and/or Halloysite</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Groseclose(sl)</td>
<td>18.3</td>
<td>8</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>15</td>
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<tr>
<td>Emory(sl)</td>
<td>18.7</td>
<td>10</td>
<td>10</td>
<td>13</td>
<td>20</td>
<td>15</td>
</tr>
</tbody>
</table>

*CEC expressed as me/100 grams of soil. Determination made by the Soil Testing Laboratory, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.
Table II. Predicted, Mean Initial, and Final pH after 12 Weeks for a Groseclose and an Emory Soil Whose pH was Adjusted with CaCO₃ or Al₂(SO₄)₃.

<table>
<thead>
<tr>
<th>Predicted Soil pH</th>
<th>Groseclose Soil Means for Adjusted pH Values</th>
<th>Emory Soil Means for Adjusted pH Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Final</td>
</tr>
<tr>
<td>4.25</td>
<td>4.28</td>
<td>4.31</td>
</tr>
<tr>
<td>5.50</td>
<td>5.47</td>
<td>5.50</td>
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<tr>
<td>6.75</td>
<td>6.75</td>
<td>6.67</td>
</tr>
<tr>
<td>8.00</td>
<td>8.01</td>
<td>7.97</td>
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Table III. Effect of Soil Type and Final Soil pH on Dry Weight and Percentage of Foliar Ash, Nitrogen, Phosphorus, and Potassium of Sycamore Seedlings after 12 Weeks

<table>
<thead>
<tr>
<th>Variables</th>
<th>Groseclose Soil</th>
<th>Emory Soil</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Final</td>
</tr>
<tr>
<td>Final soil pH</td>
<td>4.31 a</td>
<td>5.50 b</td>
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<tr>
<td>% Ash</td>
<td>13.86 a</td>
<td>11.7</td>
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<tr>
<td>% N</td>
<td>3.61 a</td>
<td>3.41 a</td>
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<tr>
<td>% P</td>
<td>.32 a</td>
<td>.36 ab</td>
</tr>
<tr>
<td>% K</td>
<td>2.73 a</td>
<td>2.40 a</td>
</tr>
<tr>
<td>Plant Dry Weight (g)</td>
<td>0.49 a</td>
<td>3.00 b</td>
</tr>
</tbody>
</table>

*Row values for a variable, over the pH range and within a soil type, not followed by the same letter were significantly different at 0.01 for Duncan's Multiple Range Test.*

70

Arkansas Academy of Science Proceedings, Vol. XXX, 1976
Freshwater Mussel Shells as Indicators of Seasonal Occupation of Archeological Sites: Review of the Method

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ABSTRACT

Seasonal occupation of sites and utilization of resources by aborigines is a subject of growing importance to prehistoric archeologists; however, relatively few satisfactory techniques are available for making the necessary determinations. Recent research in New Zealand has indicated the potential value of bivalve mollusks in subsistence-settlement pattern studies. A method for seasonal dating of prehistoric sites involving growth ring analysis of freshwater mussel shells and the potential application of this method in Ozark archeology are discussed.

INTRODUCTION

Because of the increasing concern in recent decades for explanation of the processes underlying cultural development and interaction, there has been a shift from research on individual sites and artifacts to studies involving whole areas and the various relationships among sites and their environments. Such studies necessarily pertain to the spatial and living arrangements of groups of people over a period of time. This new dimension in archeology has been appropriately labeled "settlement archeology" and has been the subject of much discussion during the past decade (Chang 1968, Trigger 1967, Willey 1968). However, the reconstruction of the settlement patterns of prehistoric hunters and gatherers has posed a particular problem to archeologists because such groups periodically shift their residences to exploit resources more efficiently. Such shifts have been documented ethnographically as well as archeologically (Schoolcraft 1854, Stewart 1983, Swanton 1946, Thomas 1973, Winter 1974).

To assess adequately the subsistence-settlement system of any given prehistoric group, one must determine the variety of site types, their functions, and, most notably for the purposes of this discussion, the duration and season of their occupation. Faunal analysis has been one of the more useful archeological tools for determining seasonal shifts in residence patterns, although few specialized techniques are available which can offer reasonably accurate reconstructions. The purpose of this paper is to introduce the fundamentals and potential archeological applicability of one technique which involves analysis of freshwater mussel shells excavated from prehistoric sites. Also, its particular relevance to Ozark archeology is discussed briefly. Research is being conducted by the author toward the testing of this method at an Ozark bluff shelter; it is hoped that more concrete results soon will be available.

METHOD OF ANALYSIS

The basic objective of the method is to ascertain by growth ring analysis the season of death of freshwater mussels gathered by prehistoric peoples and thus the season of the mussels' use. Before the actual analytical procedures are described, a brief discussion of mussel shell structure and growth is provided as a basis for understanding the procedures.

Structure of Mussel Shells. The shell of a freshwater mussel has two parts, a left and a right valve, held together by ligament. Each valve is composed of three layers of secreted material: the periostacum or external covering which protects the underlying portions of the shell from damage and erosion; the thin middle or prismatic layer composed of vertical prisms of calcium carbonate; and the relatively thick nacreous (mother-of-pearl) or inner layer which consists of a large series of thin calcium carbonate sheets or plates that lie upon each other and are parallel with the surface of the shell (Murray and Leonard 1962, Parmalee 1967, Pennek 1953). Growth of the shell is accomplished by the secretion of shell substance on the three layers by cells near the margin of an organ called the mantle. The primary function of the mantle, along with sensation and respiration, is secretion of shell material for growth.

Upon any change or fluctuation in environmental conditions (for instance, the drastic drop in air temperature during winter), the margin of the mantle withdraws within the shell to such an extent as to sever its formerly uninterrupted growth connection with the margin of the shell. When growth resumes after such an interruption, there is essentially a doubling up or overlapping of the outer two shell layers (i.e., the periostracum and prismatic layer). In other words, growth does not begin again exactly where it left off, but at a slight distance from that point. This phenomenon is manifested by a dark band or ring. Although any relatively severe disturbance of the organism (e.g., handling of the mussel by humans) can cause such an interruption of the growth process, interruption rings corresponding to the season of winter differ from those corresponding to more singular disturbances; the former show several repetitions or duplications close together and the latter do not. Thus, winter bands in shells tend to appear darker and broader (Chamberlain 1930, Coker et al. 1920, LeFevre and Curtis 1910). The technique to be outlined is an attempt to recognize these winter recession or interruption rings so that the approximate season of death of the organism can be ascertained.

Sampling Considerations. Though a technique based on recognition of winter recession rings in mussel shells would be most valuable for extracting seasonal data from archeological sites, it would be adequate only for determining whether or not a site was occupied at a particular time during the year. It would leave unanswered the question of whether the site also was occupied at other times of the year. For a more thorough picture of the subsistence-settlement patterns of sites, all other forms of evidence, faunal and otherwise, should be considered in conjunction with the data provided by this and other techniques.

In addition, for more accurate pertinent seasonal data, several "indicator" species to be used for the procedure should be determined on the basis of environmental and habitat data of the various species. These species not only should have been easily accessible to the prehistoric Indians, populations, but also should have been within a class that prefer more insulated environments so that external ecological influences would have been minimized (Murray and Leonard 1962). Obviously, a compromise must be reached between these two seemingly opposing characteristics.

Preparation and Analysis of Samples. The technique is based essentially on work done in New Zealand with saltwater bivalves by Coutts and others (1970, 1971). The basic preparatory procedure is summarized in Kummel and Raup (1965). The valve to be analyzed is cross-sectioned through the umbo axis (i.e., the axis of maximum shell diameter from the hinge) with a diamond-bladed saw, and one half is mounted in plaster of paris to secure it. The cross-section then is sanded and polished by use of a lapidary wheel. Next it is etched with a 5% dilute solution of hydrochloric acid to remove impurities and prepare the surface. This step is followed by the application, drying, and removal of a liquid acetate peel. The removed peel is stained if necessary to bring out details and is secured to a slide so that it can be photomicrographed. The resultant photograph is used to obtain an estimation of the approximate date of death of the specimen by measuring the distances from the margin of the shell to...
the last winter growth interruption ring. Measurement obviously must be taken of the distances between all of the annual rings of a given species so that the time gap between the laying down of the last winter ring and the death of the organism can be approximated. However, it is first necessary to determine whether there is any consistent metrical relationship between the consecutive winter rings of a given shell, for as the organism increases in age, its growth decreases and the distances between rings tend to lessen. There are indications from the results obtained in New Zealand and from the Chamberlain study that it would be feasible to distinguish metrically between consecutive rings. This step would necessarily be accomplished for each species by correlating the measurements taken from a sample of modern-day mussels with similar measurements taken from excavated specimens of the same species (Coutts 1971). It might also be possible to observe daily growth rings within the cross-section and thus increase the accuracy of the technique, but such rings could be determined only by microscopic examination. The results obtained from the analysis of each specimen are compared with those of others in order to calculate an approximate season or time of mussel collecting by the inhabitants of the site in question.

POTENTIAL USE IN OZARK ARCHEOLOGY

Such a method would be of great value for Ozark archeology because relatively little is known about the subsistence-settlement patterns of the prehistoric inhabitants of this region, as is indicated in the cultural synthesizes of the region (McGimsey 1963, Scholtz 1969, Wolfman 1974). This lack is due partly to the overemphasis during past decades on excavation of bluff shelters and partly to the difficulties of locating open sites in this region. There is even general disagreement as to the nature and length of occupation of the bluff shelters themselves (Cleland 1965, Freeman 1960). More precise methods for determining occupation duration and season would be instrumental in defining site types and site functions. This information in turn would expand knowledge so that more reliable predictions of site locations might be made for the region.

The significance of the method might be said to go beyond Ozark prehistory and even subsistence-settlement pattern studies in that it is another indication that archeology is continually expanding its scope by adapting and refining techniques of other disciplines for the study of prehistory. The understanding of the behavioral processes involved in the interaction of cultural systems with each other and their environments depends upon the understanding of the nature of the interaction in question (in this case, the subsistence-settlement system of a prehistoric population). Therefore, one of archeology's major goals today should be to develop and refine such analytical techniques so as to interpret more precisely the nature and workings of prehistoric cultural systems.

LITERATURE CITED


An Update of Arkansas Odonata (Anisoptera)

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ABSTRACT

Seventy-five species of dragonflies have been reported in Arkansas. The present study provides 43 species; records of the other 32 are drawn from the literature and personal communication with individuals. A new species, Gomphus ozarkensis, described from western Arkansas in 1975 on the basis of minimal data emphasizes the need for extensive work in this area. Opportunities to collect and identify additional species are discussed.

INTRODUCTION

When Needham and Westfall's Manual of Dragonflies of North America was published in 1955, only 12 species were included from Arkansas, but Bick (1959) mentions 16 species from the literature that were unreported in the Manual. Little work from water was performed in compiling and reporting a complete list of odonates. George Harp studied the group in northeast Arkansas, Jim Houston published a brief report in 1970 of those found in Franklin County, and Minter J. Westfall, Jr., has several records of dragonflies from Arkansas. He recently published a description of a new species, Gomphus coyneri, from western Arkansas on the basis of a minimal amount of material (1975). There is real need for more complete and updated keys for all aquatic insects, especially immature forms, and little is known about the natural history of many species.

An aquatic organism, in the context of this report, is any one whose life cycle is spent partly or entirely in or on water. Some make small contributions to the ecosystem, others large. Dragonfly nymphs are predators of a variety of aquatic insects and even small fish. They in turn are eaten by larger fish and perhaps by larger predatory insects such as diving beetles and giant water bugs. Therefore their contributions should not be minimized and cannot be ignored.

Several organisms have been studied in relation to their tolerance or intolerance of changing conditions. Although dragonfly nymphs are found in many different habitats, they have limited tolerance to pollution and therefore might be studied as an indicator of water quality.

METHODS

Aerial adults of many species were collected with a standard entomology net. Much patience and care are required to obtain a representative sample of adults because they have an uncanny ability to dodge the net regardless of how hard it is swung. Therefore, it is necessary to record as auxiliary data the species of adults seen but perhaps not actually captured.

Nymphs were captured with a three-sixteenths-inch mesh dip net or fish seine. Some were found in aquatic vegetation, others in mud, sand, or detritus on the bottom. Riffle-kicking (disturbing the substrate and letting the current carry specimens into a waiting net) yielded a surprising variety. A Surber sampler was used sparingly.

Aerial adults were killed in a jar containing ethyl acetate and dried, whereas specimens in the water were preserved in 70% ethyl alcohol. All were returned to the laboratory where positive identifications were made to the extent possible with present keys. Needham and Westfall's (1955) is the most complete key, containing characters for all adults and most nymphs. Usinger (1956) provides a key to widespread genera and California species. Edmundson's (1959) and Pennak's (1953) keys also were used, but neither goes beyond genus. Some of these keys apparently are built upon Wright and Peterson's (1944), which is still one of the best.

Dragonflies were collected at 27 sites in 16 counties, mostly in central Arkansas (Table I). All collections were made in the months April through October because adult specimens become rather scarce during the months and water temperatures tend to dampen ardor. Habitat types included all gradations from swift streams with clean, rocky bottoms to lakes with silty bottoms to swamps.

RESULTS AND DISCUSSION

Several taxa are represented by nymphs only, others by adults only. Rarely were both nymphs and adults of the same species collected at the same locality and time. The explanation of this phenomenon is that many species of insects (aquatic and terrestrial) undergo large periodic emergences, for example, cicadas (White and Lloyd 1975) and mayflies (Ross 1965). Moreover, it is known that within a family or genus, each species has a characteristic time of emergence (Usinger 1956). At a certain time, dependent on water temperature, directness of sunlight, and perhaps other factors, all or nearly all of the immature forms become adults. The staggered emergence of species, especially those closely related, apparently enhances reproductive isolation.

Thirty-four species were collected in this study, six additional species are catalogued in the UALR entomology collection, and three more (Anax junius, Libellula luctuosa, and L. pulchella) were observed in Saline, Conway, and Lonoke counties, respectively. These three are distinctive and easily recognized by sight. Therefore a total of 43 species of dragonflies are listed herein (Table II).

Needham and Westfall's (1955) listed six species not in this report. Bick (1959) listed 38 species, 22 of which had not been reported from Arkansas at the time. Eight species he listed were neither collected in this study nor listed by Needham and Westfall (1955). George Harp (pers. comm.) has records of 40 species representing five families (six families if Macromidae is valid) collected mostly in northeastern Arkansas. Eleven of his species were neither collected in this study nor listed previously. Jim Houston (1970) listed 27 species representing four families from Franklin County, six of which are not listed in previous works. Because many nymphs are poorly characterized and others are unknown, identifications are commonly subject to error. If all taxonomic efforts are to be correct, at least 75 species of dragonflies are known to be present recently in Arkansas. Minter J. Westfall, Jr. (pers. comm.) has records of additional species from Arkansas besides the new Gomphus ozarkensis.

Higher taxonomy of Anisoptera is basically agreed upon, although some entomologists (Borrero et al. 1976) have given family status to two subfamilies of Libellulidae, Macromiinae and Cordulinae. Of the families represented, Libellulidae is by far the most diverse, but Gomphidae presents the most difficult taxonomic problems. These problems are intensified by inadequate nymph records and descriptions.

Bick's (1959) report is based on specimens taken from eight counties in the western part of the state, and Houston's (1970) work was done nearby (Franklin County). Harp's (pers. comm.) work was mainly in the northeast corner. With the exception of those in Columbia County, the Anisoptera of the southeastern third of the state are virtually unknown. There are other scattered counties where few or no collections have been made. Within recent months two additional species have been identified, but data on them were not ready for this report. It is entirely possible at least a third of the more than 330 North American species of dragonflies are present in Arkansas.

ACKNOWLEDGEMENT

Financial aid for this project was provided by a UALR Faculty Research Grant.
LITERATURE CITED


Table I. Collecting Localities for Dragonflies, 1974-75

<table>
<thead>
<tr>
<th>County</th>
<th>Name</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>1. Arkansas</td>
<td>Cox Cypress Lake</td>
<td>T 55 R 6 W 2</td>
</tr>
<tr>
<td>2. Arkansas</td>
<td>Bayou LaGrue</td>
<td>T 4 S R 3 W 25</td>
</tr>
<tr>
<td>3. Clark</td>
<td>Caddo River</td>
<td>T 55 R 22 W 2</td>
</tr>
<tr>
<td>4. Conway</td>
<td>E. Fk. Point Remove Creek</td>
<td>T 7 N R 16 W 8</td>
</tr>
<tr>
<td>5. Conway</td>
<td>Lake Overcup</td>
<td>T 7 N R 16 W 30</td>
</tr>
<tr>
<td>6. Faulkner</td>
<td>Buffalo Fork Lake</td>
<td>T 6 N R 14 W 26</td>
</tr>
<tr>
<td>7. Faulkner</td>
<td>Lake Conway</td>
<td>T 4 N R 13 W 19</td>
</tr>
<tr>
<td>8. Grant</td>
<td>Hurricane Creek</td>
<td>T 3 S R 13 W 25</td>
</tr>
<tr>
<td>9. Madison</td>
<td>Kings River</td>
<td>T 16 N R 24 W 28</td>
</tr>
<tr>
<td>10. Marion</td>
<td>Crooked Creek</td>
<td>T 8 N R 16 W 9</td>
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<tr>
<td>11. Montgomery</td>
<td>Ouachita River</td>
<td>T 1 S R 25 W 32</td>
</tr>
<tr>
<td>12. Newton</td>
<td>Buffalo River</td>
<td>T 16 N R 20 W 7</td>
</tr>
<tr>
<td>13. Perry</td>
<td>Farm pond</td>
<td>T 5 N R 19 W 28</td>
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<tr>
<td>14. Pulaski</td>
<td>Big Piney Creek</td>
<td>T 10 N R 20 W 6</td>
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<tr>
<td>15. Pulaski</td>
<td>Boyle Park Pond</td>
<td>T 1 N R 13 W 12</td>
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<td>16. Pulaski</td>
<td>Little Maunelle River</td>
<td>T 2 N R 15 W 30</td>
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<td>17. Pulaski</td>
<td>Coleman Creek</td>
<td>T 1 N R 12 W 18</td>
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<td>18. Pulaski</td>
<td>Broadmoor Lake</td>
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<td>19. Pulaski</td>
<td>Hindman Park Pond</td>
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<td>20. Pulaski</td>
<td>Lakewood Creek No. 1</td>
<td>T 2 N R 12 W 24</td>
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<td>21. Saline</td>
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<td>Alum Fork Saline River</td>
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<td>23. Saline</td>
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<td>24. Saline</td>
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<td>25. Washington</td>
<td>White River</td>
<td>T 15 N R 20 W 20</td>
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<td>26. Woodruff</td>
<td>Black Swamp</td>
<td>T 6 N R 3 W 15</td>
</tr>
<tr>
<td>27. Yell</td>
<td>Petit Jean River</td>
<td>T 5 N R 21 W 23</td>
</tr>
</tbody>
</table>

Table II. Taxonomic List of Species of Dragonfly Nymphs (N) and Adults (A) Collected in Arkansas, 1974-75 (numbers refer to exact locality, Table I)

Odonata

Anisoptera

Aeshnidae

Aeshna constricta (UALR collection)

Anax junius A-28 (sight record)

Basiaeschna janae A-15, 32

Boyaria vinosa A-22

Epiaeschna heros N-28, 33; A-31

Nasiaeschna penicillata A-25

Gomphidae

Dromogomphus armatus N-19

Dromogomphus spinosus A-4, 34

Dromogomphus splendens N-30; A-18

Gomphus brevis N-15

Gomphus descriptus A-34

Gomphus submedianus N-27

Gomphus villosipes N-2

Hagenius brevicostatus N-14, 15, 16, 22; A-28

Lanthus athabascae N-3, 13, 29

Ophiogomphus rupesstrensis N-14

Libellulidae

Cannacria gravida (UALR collection)

Culithemis elis A-31

Erythemis simplicicollis N-25; A-5, 6, 7, 10, 18

Libellula cyanea (UALR collection)

Libellula favea A-29

Libellula incesta A-1, 5, 6, 30

Libellula fucunda A-5 (sight record)

Libellula pulchella A-5 (sight record)

Libellula vibrans A-18, 28

Libellula sp. N-20, 24, 25

Miathyra marcella N-6

Pachydiplax longipennis N-1, 30; A-5, 6, 7

Pantala flavescens N-23; A-1, 2, 10, 18

Pantala hymenaea A-23

Perithemis tenera N-22, 24; A-6, 18

Plathemis lydia N-20; A-18

Symetrum ambiguum (UALR collection)

Symetrum vicinum A-23

Tetragonura corollae (UALR collection)

Tetragonura cyanura N-1; A-13

Tramea lacera A-23

Tramea onusta (UALR collection)

Macromiidae

Didymops transversa A-13

Macromia ilionensia N-4, 14, 29, 32

Macromia taeniostata A-2

Macromia sp. N-34
A Preliminary Checklist of Arkansas Acrasieae

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A study of the distribution of the Acrasiomycota in Arkansas was conducted which included identification and culturing. The Acrasiomycota species were collected from soil, dung, and leafmold during January 1976. Sampling sites included a mesic forest type predominated by white oak (Quercus alba) and mockernut hickory (Carya tomentosa) in Van Buren County (T9N R12W NW NW27) and a dry forest type characterized by shortleaf pine (Pinus echinata), black hickory (Carya texana), and white oak in Pulaski County (T1N R12W center 32). Isolation of the Acrasieae was accomplished by the methods established by Raper and Cavender (1965a).

Nine species of cellular slime molds were recovered from Arkansas soils. Five of these Acrasieae are reported to be universal in habitat, Dictyostelium mucoroides, D. purpureum, D. polycephalum, Polysphondylium pallidum, and P. violaceum inhabiting tropical, temperate, and Asian forests (Cavender 1976, Bonner 1967). The other four species isolated, Guttulinopsis, D. minutum, D. lacteum, and Acrasis, may have a restricted range.

In their study of Acrasieae distribution in the eastern forests of North America, Raper and Cavender (1965b) sampled the soil of the oak-hickory forest at Rich Mountain Gap, Arkansas. Of the nine species recovered in the present study, D. polycephalum, Acrasis, and Guttulinopsis were undetected by Raper and Cavender in Arkansas.

LITERATURE CITED


*Ron Rosen is a member of the Arkansas Collegiate Academy of Science and his paper has been sponsored by G.T. Clark, Hendrix College.
A Checklist of the Coccinellidae of Arkansas**

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ABSTRACT

A checklist of 49 species of Coccinellidae in Arkansas is updated by the inclusion of species from the reference collection of the University of Arkansas and the collection in the Louisiana State University. This list extends the range of eight species. Distribution, ecological data if known, and references for their identification are included.

INTRODUCTION

Catalogues of the Coccinellidae list only the more common ones found within the boundaries of Arkansas. This list updates such lists and extends the known range of eight species (indicated by asterisk). Voucher specimens are in the collections of the University of Arkansas and Louisiana State University and are identified by Chapin (1974) and Wingo (1952).

The list consists of 49 species and includes distribution by county and ecological information if known.

FAMILY COCCINELLADE

SUBFAMILY STICHOLOTINAE

TRIBE SERANGIINI

*Delphastus punctus* (LeConte). Sevier County; on crimson clover.

TRIBE STICHOLOTINAE

*Microwesia microsia* (LeConte). Ashley, Johnson, and Washington Counties; on pine.

SUBFAMILY SCYMNNAE

TRIBE STETHORINI

*Stethorus punctum* (LeConte). Johnson and Washington Counties; on pecan.

TRIBE SCYMNNINI

*Scymnus* (*Scymnus*) *indianensis* Weise. Crawford County; on soybeans.

*Scymnus* (*Scymnus*) *apicanus* Chapin. Conway, Drew, Mississippi, and Washington Counties; numerous on ironweed; sometimes on Johnson grass and cotton.

*Scymnus* (*Scymnus*) *parcanus* Chapin. Ashley, Conway, Crawford, Lee, and Washington Counties; on bitterweed; sometimes on corn and cotton.

*Scymnus* (*Pullus*) *rubricaudus* LeConte. Mississippi County; in malaise trap from cotton-alfalfa strip crop.

*Scymnus* (*Pullus*) *fraternalis* LeConte. Mississippi County; in malaise trap from cotton-alfalfa strip crop.

*Scymnus* (*Pullus*) *bicuspidatus* Mulsant. Calhoun, Chicot, Conway, Crawford, Desha, Hempstead, Lincoln, Mississippi, and Washington Counties; numerous on crops of alfalfa, corn, cotton, pecan, and sweet potatoes.

*Scymnus* (*Pullus*) *cervicollis* Mulsant. Franklin, Johnson, St. Francis, and Washington Counties; on pecan.


*Scymnus* (*Pullus*) *socr* LeConte. Desha County; on cotton.

*Scymnus* (*Pullus*) *uncus* Wingo. Mississippi County; in a malaise trap in cotton.

*Scymnus* (*Pullus*) *compar* Casey. Franklin County; on pecan.

*Scymnus* (*Nephus*) *intrusus* Horn. Bradley and Crawford Counties; on crimson clover.

*Scymnus* (*Diomus*) *amabilis* LeConte. Washington County.

*Scymnus* (*Diomus*) *terminatus* Say. Arkansas, Benton, Conway, Crawford, Cross, Desha, Hempstead, Lee, Little River, Lonoke, Mississippi, Pulaski, Saline, Washington, and Yell Counties; on cotton, soybeans, sweet potatoes, and wheat.

*Scymnus* (*Nephus*) *zimmernannii zimmernannii* Crotch. Johnson County; on apple.

TRIBE HYPERASPINI

*Hyperaspis pinorum* Casey. Ashley County; on pine.

*Hyperaspis rivularis* Dobzhansky, Washington County.

*Hyperaspis bigeminata* (Randall). Desha and Washington Counties; on *Porynya sp.*, in malaise traps in cotton, cotton-sorghum strips, and on oats.

*Hyperaspis fimbriolata* Melsheimer. Washington, White, and Yell Counties; on wheat.

*Hyperaspis undulata* (Say). Desha, Mississippi Counties; in malaise traps in cotton and cotton-sorghum strips.
The Coccinellidae of Arkansas, Clark, Conway, Crawford, Desha, Franklin, Jefferson, Lincoln, Lonoke, Madison, Mississippi, Sevier, Washington, White, and Yell Counties.

**SUBFAMILY CHILOCORINAE**

**TRIBE CHILOCORINI**

Axion tripustulatum (DeGeer). Lee, Pulaski, Sebastian, and Washington Counties; on oak.

Chiocorus stigma (Say). Benton, Crittenden, Desha, Franklin, Johnson, Poinsett, Van Buren, and Washington Counties; on pecan.

Esochomus marginipennis (LeConte). Clark, Crawford, Faulkner, Franklin, Grant, Jackson, Johnson, Lafayette, Little River, Logan (LSUC), Mississippi, Pulaski, Sevier, and Washington Counties.

**SUBFAMILY CHilocorinae**

**TRIBE COCCINELLINI**


Hippodamia tredecimpunctata tibialis (Say). Conway, Mississippi, Pope, and Pulaski Counties; in light traps.

Hippodamia parenthesis (Say). Craighead, Mississippi, and Washington Counties; on alfalfa.

Hippodamia quindecimmaculata Mulsant. Conway County; on alfalfa.


Neoharmonia venusta venusta (Melsheimer). Desha, Hempstead, Little River, and Washington Counties; on cottonwood.


Cycloneda sanguinea (Linnaeus). Jefferson and Desha Counties.


Adalia bipunctata (Linnaeus). Jefferson (LSUC), Mississippi, Washington, and Yell Counties; on bark lice on spruce.

Mulantina picta (Randall). Calhoun County; on pine.

Anatis quindecimmaculata (Olivier). Desha, Johnson, Mississippi, and Washington Counties.

Neomyzia obtonguttata pullata (Say). Conway, Crawford, Desha, Drew, Grant, Johnson, Lee, Lincoln, Logan (LSUC), Mississippi, Polk, Pulaski, and Washington Counties. A long series in the LSUC was collected at catalpa nectaries in the town of Magazine, Arkansas.

**TRIBE PSYLLOBORINI**

Psyllobora vigintimaculata (Say). Benton, Conway, Desha, Lafayette, Madison, Mississippi, Washington, and Yell Counties and LSUC.

*Psyllobora renifera* Casey. Mississippi and Washington Counties.

**SUBFAMILY EPILACHINAE**

*Epilachna boreralis* (Fabricius). Baxter, Mississippi, and Washington Counties.


**LITERATURE CITED**


Lower Mississippian Lithostratigraphy, Northern Arkansas

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ABSTRACT

Lower Mississippian lithostratigraphic units in northern Arkansas are (ascending order) the Bachelor, St. Joe, and Boone Formations. These formations disconformably overlie Middle Ordovician to Upper Devonian strata and are overlain disconformably by Meramecian or Chesterian strata.

The Bachelor Formation is generally a thin (less than 0.3 m), persistent, orthoquartzitic sandstone with common to abundant phosphatic pebbles overlain by a green silty shale. In northwestern Arkansas, the Bachelor Formation commonly lacks sandstone. The Bachelor Formation has been confused previously with the Sylamore (Upper Devonian) and older sandstone units.

Although commonly regarded as a member of the Boone Formation, the St. Joe Limestone should be raised to formation rank in accordance with the earlier proposal of Cline (1934). The St. Joe Limestone in northwestern Arkansas can be subdivided into (ascending order) the Compton, Northview, and Pierson Members which are recognized as formations in Missouri. In the type region, northcentral Arkansas, subdivision of the St. Joe is precluded by lack of the shaly Northview Member. A marked color change from gray to red from northwestern to northcentral Arkansas is accompanied by a general increase in the allochemical constituents. The St. Joe-Boone boundary is taken to be at the first persistent chert. This contact generally coincides with a thin calcareous shale unit and a marked decrease in carbonate grain size.

INTRODUCTION

Lower Mississippian (Kinderhookian-Osagean) strata of northern Arkansas are predominantly limestone with variable development of chert. This entire sequence, which may be more than 110 m thick, traditionally is referred to the Boone Formation and the basal chert-free part is recognized as the St. Joe Member (Stroud et al. 1969).

Recent investigations of Lower Mississippian strata (Thompson and Fellows 1970; McFarland 1973a, b; Shanks 1976) support earlier suggestions (Cline 1934) that this interval be subdivided further. This report presents a preliminary proposal for a more detailed lithostratigraphic framework for Lower Mississippian strata in northern Arkansas.

LITHOSTRATIGRAPHY

Lower Mississippian lithostratigraphic units in northern Arkansas are (ascending order) the Bachelor, St. Joe, and Boone Formations. The formations disconformably overlie Middle Ordovician to Upper Devonian strata and are overlain disconformably by Meramecian or Chesterian strata.

Bachelor Formation. The Bachelor Formation was proposed by Mehl (1960) for a thin (generally less than 0.3 m), quartzose sandstone at the base of the Kinderhookian Series in central Missouri. Lateral equivalents of this unit had been recognized previously in southern Missouri (Moore 1928), northeastern Oklahoma (Laudon 1939), and northern Arkansas (Purdue and Miser 1916). However, they appear to have been included within the St. Joe Limestone or confused with older units, particularly the Sylamore Sandstone (Upper Devonian). Thompson and Fellows (1970) divided the Bachelor informally into a basal quartzose sandstone overlain by a green, silty shale and applied the name to all basal Mississippian terrigenous strata in southwestern Missouri, northern Arkansas, and northeastern Oklahoma.

The Bachelor Formation has been recognized at more than 35 localities across northern Arkansas (Fig. 1A). In northwest Arkansas, the Bachelor is predominately a green, silty shale, particularly where it overlies the Upper Devonian Sylamore Shoale. Maximum thickness of the Bachelor in this area is approximately 1.2 m, but generally it is less than 0.3 m (McFarland 1973b). In northcentral Arkansas, medium-grained, orthoquartzitic sandstone predominates Bachelor exposures, reflecting the change from Chattanooga Shoale to older quartz-bearing strata (Fig. 1A). Commonly the sandstone is conglomerate bearing abundant, black, rounded phosphatic pebbles and cobbles. These pebbles are commonly oolithic in texture, and the writers interpret them to be reworked, phosphate-replaced fragments of Ordovician carbonate rocks.

The Bachelor Formation is entirely of Mississippian age on the basis of conodonts recovered from all localities. The formation in places contains a reworked Upper Devonian assemblage. Conodonts from the Bachelor Formation can be assigned to the Siphonodella duplicata zone of the type Mississippian (Collinson et al. 1971). The fact that this conodont zone is well above the base of the type Mississippian indicates later initiation of Mississippian deposition in Arkansas than in the type region. The Bachelor forms an obvious disconformity with subjacent strata at most localities in northern Arkansas. However, where the Bachelor overlies the Chattanooga Shoale, structural relationships have not been resolved completely because of the lack of fauna in the uppermost Chattanooga strata. This problem is complicated further by localities where the Bachelor may directly overlie the Sylamore Sandstone, which is reported to span the Devonian-Mississippian boundary (Freeman and Schumacher 1969).

St. Joe Limestone. The name “St. Joe” was used by Hopkins (1893) for the chert-free lower part of the Boone Formation in northern Arkansas. However, Hopkins did not formally propose or describe the unit. Girton (1915) formalized the St. Joe as a member of the Boone Formation, citing a railroad cut near St. Joe, Searcy County, Arkansas, as the presumed type section. Cline (1934) elevated the St. Joe to formal rank in Arkansas and included all its lateral equivalents and the basal shale (= Bachelor) as members. This proposal has not been widely accepted. Present usage in Arkansas recognizes the St. Joe as the basal and only member subdivision of the Boone Formation (Stroud et al. 1969).

Before 1944, the name “St. Joe” was used to designate a formation in Missouri (Branson 1944). Since that time it has been used occasionally as a group name (Clark and Beveridge 1952). However, the present lithostratigraphic framework in Missouri subdivides equivalent strata into (ascending order) the Compton, Northview, and Pierson Formations of the Chouteau Group (Howe and Koenig 1961).

In northeastern Oklahoma, “St. Joe” has been retained as a group name encompassing the equivalent Missouri formation names (Huffman et al. 1966).

The St. Joe Limestone has been recognized widely throughout

78

Arkansas Academy of Science Proceedings, Vol. XXX, 1976

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northern Arkansas; it is distinguished as a mappable unit on the Geologic Map of Arkansas (1929). In northwestern Arkansas, the St. Joe Limestone is generally a light gray, mud-supported, erinozoan-bryozoan calcilutite. Allochemical constituents average 34%, decreasing from an average of 44% in the basal rocks to 29% at the top of the St. Joe (McFarland 1975b). Thickness in this area ranges from 4.9 to 13.0 m (Fig. 1B). The St. Joe carbonate succession is interrupted by a thin, persistent, green, calcareous siltstone in the lower half of the section. This siltstone can be traced continuously into the Northview Formation of Missouri (Thompson and Fellows 1970). The carbonate section above the Bachelor Formation and below the Northview is a continuation of the Compton Formation from Missouri into northwestern Arkansas. The section between the Northview and Boone correlates with the Pierson Formation of Missouri. Lithologically, the Compton and Pierson intervals cannot be distinguished except by reference to the intervening Northview terrigenous rocks (McFarland 1975b).

The name "St. Joe" has priority over all equivalent Missouri lithostratigraphic names for the carbonate succession above the Bachelor and below the Boone in northern Arkansas. The writers advocate adoption of Cline's (1934) proposal for recognition of the St. Joe as a formation separate from the Boone. In northwestern

Figure 1. Isopachous maps of the Bachelor (A) and St. Joe (B) Formations, northern Arkansas and southwestern Missouri (data from Thompson and Fellows 1970, McFarland 1975b, and Shanks 1976).

Figure 2. Correlation of selected sections of lower Mississippian strata in northern Arkansas (data from Thompson and Fellows 1970, McFarland 1975b, and Shanks 1976).
Lower Mississippian Lithostratigraphy, Northern Arkansas

Arkansas, the St. Joe should be subdivided further by recognition of the Compton, Northview, and Pierson Formations of Missouri as members in Arkansas (McFarland 1975a; Fig. 2).

The St. Joe Limestone can be traced continuously from northwestern Arkansas into its type region in northcentral Arkansas (Fig. 2). In the type region, the St. Joe is generally a red, unsorted, grain-supported crinoid-bryozoan calcarenite. Allochemical constituents average 94%, although mud-supported lithologic types are present, most commonly in the upper 3 m of the section (Shanks 1976). The fact that the terrigenous rocks of the Northview Member do not reach the type region precludes subdivision into members (Fig. 2). Thickness of the St. Joe in northcentral Arkansas is variable, ranging from a minimum of 0.6 m to more than 30 m (Fig. 1B). Maximum thicknesses form a series of lobate ridges oriented northwest-southeast extending across northern Arkansas (Fig. 1B).

The red color is a distinctive feature of the St. Joe in northcentral Arkansas. The color is an indication of the oxidation state of the iron oxide associated with the carbonate rocks and is not a surficial feature. However, the origin of the iron and the conditions for its oxidation are not known. In addition, there does not appear to be a significant difference in iron concentration between St. Joe Limestone units of northwestern and northcentral Arkansas (Wagner et al. 1975). Correlation of measured sections demonstrates an interfingering of gray and red carbonate rocks (Fig. 2). Allochemical constituents increase from northwestern Arkansas into the type region (Shanks 1976).

Although the St. Joe Limestone has been regarded traditionally as chert-free, detailed study (McFarland 1975b, Shanks 1976) has shown that this is not the case. Thin, discontinuous beds and nodular zones of red, varicolored, and gray chert are present in both the lower and upper parts of the St. Joe Limestone (=Compton and Pierson Members or equivalent horizons) in northwestern and northcentral Arkansas (McFarland 1975b, Shanks 1976). Color and lack of both persistence and abundance of chert seem to be reliable criteria for differentiating St. Joe and Boone chert-bearing horizons.

The St. Joe Limestone spans the Kinderhookian-Osagean boundary on the basis of associated conodonts (Thompson and Fellows 1970). Deposition of the St. Joe followed that of the Bachelor without apparent break (Thompson and Fellows 1970). The Kinderhookian-Osagean boundary is approximately 0.3 m above the Northview-Pierson Member contact in northwestern Arkansas (McFarland 1975b). In northcentral Arkansas, this boundary is in the lower quarter of the section (Thompson and Fellows 1970). Initiation of "Boone-type" chert formation, which provides a basis for lithostratigraphic recognition, appears to be markedly diachronous in southern Missouri and northern Arkansas (Thompson and Fellows 1970).

Boone Formation. The name "Boone" was introduced simultaneously by Banner (1891), Simonds (1891), and Penrose (1891) for a cherty-limestone sequence typically exposed in Boone County, Arkansas. This formation is one of the most distinctive and easily mapped units in the Boston Mountains. Unfortunately, complete exposures are few and only the basal contact has been examined in detail for the present study. The St. Joe-Boone contact is taken to be at the first persistent chert. This chert is dark colored, usually gray, and develops an irregular, anomosing pattern of replacement (McFarland 1975b, Shanks 1976). This "Boone-type" chert is in marked contrast to the thin, nonpersistent chert in the upper St. Joe Limestone. Placement of the St. Joe-Boone boundary at this level is supported by the common presence of a thin calcareous shale unit separating St. Joe and Boone carbonate rocks. The lowest carbonate rocks of the Boone Formation are extremely micritic and usually contain less than 10% allochemical constituents in contrast to approximately twice the allochemical percentage and blocky spar shown by the St. Joe Limestone (Shanks 1976).

CONCLUSIONS

Lower Mississippian lithostratigraphic units in northern Arkansas are the Bachelor, St. Joe, and Boone Formations. Although commonly regarded as a member of the Boone Formation, the St. Joe Limestone should be raised to formation rank as proposed by Clark (1934). The basal terrigenous unit included in the St. Joe by Cline (1934) is the Bachelor Formation of Missouri. In northwestern Arkansas, the St. Joe Limestone should be subdivided further into the (ascending order) Compton, Northview, and Pierson Members. In northcentral Arkansas, the St. Joe is undifferentiated because of the absence of the Northview Member. The contact of the St. Joe Limestone and overlying Boone Formation is drawn at the first persistent chert. This boundary coincides with the presence of a thin calcareous shale unit and a marked decrease in carbonate grain size.

ACKNOWLEDGEMENTS

Shanks thanks Norman F. Williams, State Geologist, for financial support of the field investigations leading to this report. This report draws heavily on a Master's thesis completed by John D. McFarland III (1975) and supervised by Manger, McFarland's field work also was supported by the Arkansas Geological Commission and is gratefully acknowledged.

LITERATURE CITED


*References cited in text but not listed can be found in Thompson and Fellows (1970).
A Scanning Electron Microscope Study of Brachysclereids of Pear (*Pyrus communis* L.)

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**ABSTRACT**

The external surfaces of pear sclereids commonly are illustrated as covered with apertures. This SEM investigation of the surface features has shown the surface to have few or no apertures. When the primary wall layer was removed the typical ramiform canal system was obvious. This observation confirms the often-ignored fact that the pit apertures of the secondary wall are not continuous with the primary wall. Hence, they do not show on the surfaces of the intact cell.

**INTRODUCTION**

The pulp of pear (*Pyrus communis* L.) long has been used in botany and general biology laboratory courses as a source of sclereids for student observation. These sclereids generally are classified in the literature as brachysclereids. The term "brachysclereids," as first designated by Tschirch (1889, p. 301-302), has continued to be recognized by many anatomists including Esau (1965), Cutter (1969), Foster (1949), Fahn (1974), and Eames and MacDaniels (1947). Authors such as Rao (1957) suggested that modifications to this classification system would be advisable to bring it up to date. Singly occurring sclereids have been termed "idioblasts" and they pose numerous problems in plant development (Foster 1955).

Descriptions of these sclereids or "stone cells" are very uniform in the literature (Cutter 1969, Eames and MacDaniels 1947, Esau 1961, 1965, Fahn 1974). Anatomical descriptions denote the sclereids as short, compact, isodiametric cells with extremely thick laminated walls, often with ramiform canal-like cavities in the secondary wall. Eames and MacDaniels (1947) indicated that two or even several pits fused to form one structure which had only one aperture in each cell. Ledbetter and Porter (1970) produced a TEM illustration of the laminated cell walls and the restricted lacuna of the pear sclereid. Parameswaran (1973) illustrated the same thing in sclereids of various tree bark. Sterling (1954) presented a description of pear sclereid development. All data indicate these descriptions of the sclereids to be accurate.

Illustrations of several authors (Cutter 1969, Eames and MacDaniels 1947, Esau 1961, 1965, Fahn 1974) made by use of light, polarized, and/or nonpolarized microscopy show the ramiform pit structure. However, in these illustrations cells also are shown with surface views bearing small circular areas labeled as pits. Thus, either correctly or incorrectly, the impression is given that the exterior faces of the sclereid cells are covered with obvious apertures. Such observations in some cases are transferred to general botany texts without correction (for example, Weier et al. 1974). Observations of sclereids with the scanning electron microscope help clarify the external appearance and pit structure of these cells.

**METHODS AND MATERIALS**

A pear fruit was cut into half-inch pieces, placed into a blender with FAA fixative (Jensen 1962), and homogenized for 10 minutes. The homogenate was mixed with a large volume of FAA and allowed to stand overnight. A large number of sclereids settled to the bottom of the container, and thus unwanted material could be decanted away. The sclereids were dehydrated in an ethyl alcohol series to absolute alcohol. Some of the sclereids were placed on a small section of glass slide which was glued to an SEM stub. Another slide was placed on top of it, and pressure was applied carefully to break up some of the larger masses of sclereids. The specimens were air dried in a dessicator, coated with approximately 50 Å carbon, and coated with about 200 Å of 60% gold - 40% palladium in a vacuum evaporator. The stubs were examined and photographed in a Cambridge S-600 microscope.


Ouachita Biological Station

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A biological station has been established in the Big Fork Civil Township of Polk County, Arkansas, encompassing 300 acres. The area is in the Caddo Mountains of the Ouachita Province of the Paleozoic area. Topographically the area consists of steep, rocky mountain slopes forming narrow ridges running east-west, separated by narrow floodplains. Soils, developed in mixed material from alternate beds of shale, sandstone, and novaculite, are dry to droughty and have moderate erosion potential. The natural vegetation is predominantly oak-hickory on ridgetops and north slopes, and shortleaf pine on south slopes. Oak, beech, gums, sycamore, and wild cherry grow along drainages and near the base of north slopes.

Facilities include a 20 by 30 ft cinder-block building on a concrete slab which provides floor space for a laboratory, a food preparation area, a dining area, and a 200 sq ft dormitory. Two restrooms are included, one with shower. Electricity, propane gas, and water are available. Because the tap water is untreated spring water which will not pass Public Health Standards, drinking water must be brought in by all visitors. A floored attic of about 600 sq ft affords additional sleeping area for persons with sleeping bags or air mattresses.

It is hoped that the Ouachita Biological Station will serve as a center for in-depth study of the biota and ecology of the Ouachita Mountains of Arkansas and Oklahoma and, ultimately, compilation and synthesis of such findings.

Visiting biologists are welcomed and encouraged to use the facilities. Usage will be restricted to research or teaching. It is planned to grant use permits to full-time research or teaching staff members (including graduate students) of institutions of higher learning, or recognized private or public agencies and organizations. Undergraduate student usage will be restricted to groups accompanied by a full-time research or teaching staff member.
Soil Salinity Measurement by the
Four-Electrode Probe Technique*

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ABSTRACT

The four-electrode probe method was tested on a Crowley silt loam soil in which salt type, salt content, and water content were varied. Theory associated with this technique of assessing soil salinity was verified. Equations were developed which quantified the relationships between soil electrical conductivity obtained by the four-electrode probe technique \( (EC) \), saturation extract \( (EC_s) \), and 0–2 soil to water extract \( (EC_w) \).

INTRODUCTION

Historically, the presence of salt in soil has been detected by laboratory analysis of soil samples obtained from the field. A saturation (U.S. Salinity Laboratory Staff 1954) or 0–2 \( (w/v) \) (Jackson 1958) soil to water extract has been made and tested for electrical conductivity (EC). Though such procedures have provided much useful information, they require a large time investment if extensive and/or intensive evaluations of soil salinity are desired. A portable in situ method for measuring soil salinity, the four-electrode probe method, has been developed which overcomes these problems (Shea and Luthin 1961, Rhoades and Ingvalson 1971, Gupta and Hanks 1972, Rhoades 1975).

The objectives of this study were (1) to verify the usefulness of the four-electrode probe method, (2) to evaluate mathematical relationships associated with the four-electrode probe method, and (3) to provide calibration data which will allow use of the four-electrode probe method on Crowley silt loam soil.

METHODS AND MATERIALS

Crowley silt loam soil was obtained from the Rice Branch Experiment Station, Arkansas County, Arkansas. The soil was air-dried and ground to pass through a 20 mesh sieve. Reagent grade NaCl, NaSO₄, or CaCl₂ salts were mixed thoroughly with 5000 g of soil to give estimated EC, \( (EC) \) of the saturation extract \( (EC_s) \), and 0–12 \( (w/v) \) soil to water extract \( (EC_w) \) of approximately 0.08 to 0.26 mmhos/cm. Known solution EC relationships (U.S. Salinity Laboratory Staff 1954) were used in association with a calculated soil porosity (50%) to make these computations.

The soil was placed in a plastic box which could be sealed. The soil depth was about 9 cm. Distilled water was added to give a desired gravimetric soil water content \( (\Theta) \), the lid was placed on the container, and the soil-water mixture was allowed to equilibrate. The EC of the soil was measured by the four-electrode probe technique and the sequence was repeated at a higher water content. Water contents considered were 15, 20, 25, 30, 35, and 45 \% (flooded soil) percent by weight. The EC, \( (EC) \), and ECₐ, \( (EC_s) \) (Jackson 1958) were measured over the entire soil depth after the \( EC_w \) by the four-electrode probe method had been determined at 45\% soil water content and the soil had been allowed to dry to 38\% soil water content (saturation).

The four-electrode probe instrument which includes a current source and resistance meter has been described by Rhoades and Ingvalson (1971). Four stainless steel electrodes were mounted in a linear array in Plexiglas to create a probe with an electrode spacing of 7.50 cm and electrode depth of 1.56 cm. The depth to which the electrodes measure salinity is equal to the electrode spacing (Rhoades 1975). The electrode probe was calibrated by placing it in a series of solutions of known salinity and measuring resistance. Equation 1 describes the relationship between the measured resistance, \( R \) (ohms), the apparent electrical conductivity (mmhos/cm), \( EC_w \), and the cell constant, \( k \) (mmhos*ohm/cm).

\[
(1) \quad EC_w = k \times f / R
\]

where:

- \( f \) is the temperature correction factor from Rhoades (1975) which is used to convert all EC, to standard temperature (25°C). The value of \( k \) for the 7.50-cm probe was 74 mmhos*ohms/cm. The value of \( f \) was unity as these experiments were conducted at 25°C.

- \( k \) and additional probe calibration techniques are given by Shea and Luthin (1961) and Rhoades (1975).

RESULTS AND DISCUSSION

To verify the usefulness of the four-electrode probe technique, EC data were compared with EC, values at different water contents by linear correlation analysis. This relationship was evaluated for the probe with a 7.5-cm spacing which detected salinity to a depth comparable to the soil depth sampled for EC,. Table 1 shows the relationships obtained for the various gravimetric water contents. Correlation coefficients were highly significant at each of the water contents, and slope and intercept values increased as water content increased. The standard error of the estimate for EC, ranged from 0.08 to 0.26 mmhos/cm. Intercept values \( (EC_w = 0) \) approximate the electrical conductivity due to ions associated with colloidal surfaces in soil. Van Olphen (1963) has stated that for most soil colloids, this surface conductance should increase as bulk soil solution salt concentration decreases. Because salt concentration decreased with increases in water content, the intercept data agreed well with theory. The increases in slope water content increased were largely a result of the effect of the pore size and tortuosity of this soil upon the bulk soil solution assuming that the EC of colloidal surfaces was much smaller than the EC of the bulk soil solution. At small water contents the bulk soil solution resides in small, tortuous pores, whereas at large water contents the bulk soil solution occupies larger, less tortuous pores. Larger, less tortuous pores are less restrictive to the mobility of ions (Van Olphen 1963) and so slope values would be expected to increase as water content increases, even though actual bulk soil solution concentration decreases.

Rhoades (1975) proposed the equation shown below which quantifies the interrelationship between EC, EC, (EC of the bulk soil solution), E, (EC of colloidal surfaces), and \( \Theta \) (gravimetric water content).

\[
(2) \quad EC_w = EC_0 \times \Theta \times T + EC_0
\]

where:

- \( T \) is a transmission coefficient which varies with pore size and tortuosity and is linearly related to \( A \) by \( A \times \Theta + B \).

Substituting \( A \times \Theta + B \) for \( T \) in equation 2 and using data from all treatments over all \( \Theta \) allowed determination of the constants \( A \) and \( B \) by statistical methods where:

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K. Sriyotai and J. T. Gilmour

The multiple correlation coefficient (0.977, d.f. = 214) for equation 3 was highly significant and values of the constants A and B were 2.58 and 0.16, respectively. The value found for EC over all treatments was 0.13 mmhos/cm, whereas the standard error of the estimate for EC calculated from equation 3 ranged from 0.17 to 0.26 mmhos/cm. These results compare well with those reported by Rhoades (1975). And, the influence of T and 0 on the part of equation 2 (EC = 0 + T) associated with EC of the bulk soil solution supports the contention that the EC as reflected by EC increases as water content (0) increases. Similarly, the supposition that EC is much smaller than EC as EC increases was verified. Thus, the four-electrode probe method appears to describe adequately soil salinity over a range of salt and water contents for the Crowley silt loam soil.

To compare EC, EC, and EC, the linear correlation between EC and EC was evaluated and yielded the following relationship:

\[ EC = EC_{0} \times \Theta \times A + EC_{0} \times \Theta \times B + EC_{0}. \]

The correlation coefficient was highly significant (0.945, d.f. = 34) with slope and intercept values equal to 0.24 and 0.04, respectively. The use of equation 4 and data from Table I provides calibration data for the Crowley silt loam soil which allow computation of EC, or EC, from EC, data. Such data are necessary in comparing EC data obtained by the four-electrode probe technique with data obtained by more traditional methods. It should be noted that the EC, by the method of Jackson (1958) differs from the EC, currently used in routine soil testing procedures in Arkansas.

**Table I: Relationship Between EC, and EC, (EC = Slope*EC, + Intercept) for Amended and Control Crowley Silt Loam Soils at Various Water Contents**

<table>
<thead>
<tr>
<th>Water Content (%)</th>
<th>Slope</th>
<th>Intercept</th>
<th>r (34 d.f.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>0.056</td>
<td>0.048</td>
<td>0.918**</td>
</tr>
<tr>
<td>20</td>
<td>0.141</td>
<td>0.051</td>
<td>0.954**</td>
</tr>
<tr>
<td>25</td>
<td>0.183</td>
<td>0.144</td>
<td>0.956**</td>
</tr>
<tr>
<td>30</td>
<td>0.238</td>
<td>0.143</td>
<td>0.970**</td>
</tr>
<tr>
<td>35</td>
<td>0.278</td>
<td>0.228</td>
<td>0.979**</td>
</tr>
<tr>
<td>45</td>
<td>0.329</td>
<td>0.407</td>
<td>0.981**</td>
</tr>
</tbody>
</table>

**Significant at the 99% level of confidence.**

**LITERATURE CITED**


U.S. Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkaline soils. USDA Handbook 60. 160 pp.

1974 Nonflood-Stage Chemical Loads of the Buffalo River, Arkansas

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ABSTRACT

Dissolved Ca, Mg, Na, K, Fe, Mn, and Zn loads of the Buffalo River generally show trends along the river attributable to changes in geology and vary with the season because of evaporation and dilution by rain. Suspended material element loads show neither seasonal trends nor trends along the river. The Fe load for the river is predominantly in the suspended material, the Mn load is divided approximately evenly between dissolved and suspended material, and Ca, Mg, Na, K, and Zn are predominantly in the dissolved load.

METHODS

Water samples were collected in March, May, June, August, and December 1974 and in March 1975 from seven stations (Steele et al. 1975) spanning 110 miles of the Buffalo River in northcentral Arkansas. For each collection the river was clear and in a nonflood condition. Atomic absorption spectrophotometric analyses were made for major elements (Ca, Mg, Na, and K) and minor elements (Fe, Mn, Zn) on the dissolved (<0.45 μm) and the suspended (>0.45 μm) material. Approximately 500 ml of river water was filtered through a 0.45 μm filter. The filter containing the suspended material was treated with 2 ml of concentrated HCl overnight and the extractant was diluted to 25 ml before analysis. The analyses are expressed in terms of milligrams or micrograms per liter of water filtered. Data for the minus 95 mesh fraction of bottom sediments indicate that approximately 70% of each of the elements is obtained by acid treatment (Steele and Wagner 1975). The major elements were analyzed directly by the methods of the Perkin-Elmer Handbook (1970). The minor elements also were determined directly on extracts of suspended samples, but for the dissolved material were determined by an organic extraction method modified from that of Nix and Goodwin (1970).

DISSOLVED MATERIAL

Water concentrations of elements along the Buffalo River (Fig. 1) generally reflect the geology. Calcium and Mg increase in concentration downstream where limestone and dolostone are present. Because of the presence of shale (clay) in the upstream region which tends to scavenge Na and K from the water and because of the presence of feldspar in sandstone downstream, the trend for Na and K is a slight increase in concentration downstream. A trend of decreasing Fe concentration downstream is observed because a major source of Fe is the shale in the upper part of the drainage basin, and the dissolved Fe is diluted and precipitated downstream. It is possible that colloidal iron may have passed through the 0.45 μm filter and that the iron trend represents the settling (removal) of colloidal iron downstream. Manganese concentrations are low and relatively constant (4-9 ppb). Zinc concentration is variable and may be related to zinc mineralization in the area. These relationships are essentially those reported by Nix (1973, 1975) for detailed (about 50 samples) study of the river in late spring in 1973 and 1974. This observation confirms that the seven stations can be used to represent the river. Differences between the present data and Nix's 1974 sodium and potassium trends can be attributed to different flow rates at collection time and/or the fact that Nix analyzed unfiltered water samples. The maximum concentrations of major ions during the late summer (Fig. 2) correlate with low flow and high temperature of the river (Fig. 3). This correlation can be explained as the result of concentration of the elements by evapotranspiration during periods of least rainfall and the lack of dilution by rain. Iron and Zn variations are irregular (Fig. 2); there is no correlation with flow, temperature, dissolved oxygen, or pH. The Mn concentration of the river water is uniform (Fig. 2) and apparently not affected appreciably by the aforementioned factors.

CONPARISON OF DISSOLVED AND SUSPENDED LOAD

The load of elements in the suspended sediments is low in comparison with their dissolved loads except in the case of Fe. As expected, the Fe content increases with river flow rate. The other element values show no systematic variation with river miles or season. Elemental load ratios of dissolved material to suspended material show no seasonal patterns or trends with river miles. Table I shows that the Fe load for the Buffalo River is predominantly in the suspended material, the Mn load is divided approximately evenly between dissolved and suspended material, and Ca, Mg, Na, K, and Zn are predominantly in the dissolved load.
Table I. Ratios of Dissolved Load to Acid Extractable Suspended Load

<table>
<thead>
<tr>
<th></th>
<th>Ca</th>
<th>Mg</th>
<th>Fe</th>
<th>Mn</th>
<th>Zn</th>
<th>Na</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>250-750</td>
<td>0.6-1.5</td>
<td>0.5-1.7</td>
<td>3.5-100</td>
<td>21-560</td>
<td>30-846</td>
<td></td>
</tr>
</tbody>
</table>

ACKNOWLEDGEMENT

This study was supported in part by funds provided by the National Park Service and the Office of Water Resources, U.S. Department of the Interior, as authorized under the Water Resources Research Act 1964, Public Law 88-379, and administered through the Water Resources Research Institute of Arkansas.

LITERATURE CITED


Regional Carbonate Deposition of the Pitkin Limestone (Chesterian): Washington and Crawford Counties, Arkansas

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ABSTRACT

The Pitkin Limestone overlies black shale of the Fayetteville Formation and is the youngest Mississippian unit in the Paleozoic succession of northwest Arkansas. Five major facies have been delineated within the formation by a petrographic examination of samples collected from 17 measured sections: (1) oolith facies, (2) bioclastic facies, (3) nodular limestone-shale facies, (4) mudstone facies, and (5) lime mud mound facies. The distribution of these facies in the Pitkin Formation suggests that Fayetteville terrigenous sedimentation was succeeded by the deposition of widespread oolith shoals and skeletal blanket sand bodies across the northern Arkansas structural platform. Sparse accumulations of lime mud formed in quiet protected areas within the coalescing carbonate complex. Increasing water depth and decreasing turbulence as Pitkin sedimentation proceeded allowed the establishment of brachiopods and blue-green algal communities. The entrapment and stabilization of carbonate mud by these organisms promoted mound development and growth. Scattered oolith shoals formed adjacent to the growing mounds in more turbulent water. Mound development was terminated in shallower water by extensive oolith and by the appearance of extensive skeletal sand accumulations in more turbulent water as regression was initiated.

INTRODUCTION

The Pitkin Limestone, the youngest Mississippian (Chesterian) unit exposed in northwest Arkansas, crops out along the northern escarpment of the Boston Mountains from Batesville, Arkansas, to Muskogee, Oklahoma. Stratigraphically the Pitkin conformably overlies the Fayetteville Formation and is unconformably overlain by the Cane Hill Member of the Hale Formation (Morrowan). In Washington County the unit crops out along a narrow northeast-southwest-trending belt from Fayetteville to Evansville, Arkansas (Fig. 1). Seventeen stratigraphic sections of Pitkin Limestone were measured throughout the study area to delineate lithofacies within the formation and to determine their regional geometry. Lithofacies determinations involved both field observations and thin-section examination. Five major facies were delineated within the formation: (1) oolith facies, (2) bioclastic facies, (3) nodular limestone-shale facies, (4) mudstone facies, and (5) lime mud mound facies (Fig. 2).

LITHOFACIES

Oolitic units are usually thick to massive-bedded packstone and grainstone ranging in thickness from four inches to 11 feet. The beds commonly show a blocky weathering pattern. These oolitic strata are present without restriction in the measured sections, but are most common in the lower one-third of the formation and in the intermould areas. Oolith sand initially accumulated in shoal areas across the platform and eventually coalesced to produce blanket sand beds. These beds grade into both bioclastic and mudstone units. Bioclastic units for the most part are thick to massive-bedded, although thinner beds also are present. They are composed of wackestone, packstone, and grainstone. The beds commonly have horizontal partings which impart a gneissic appearance to the units; they closely resemble the lumpy, gauged mound units. Most of the constituents of these beds are crinoids, brachiopods, and brachiopods. Crinoids appear to be the most dominant particle. Near the lime mud mounds brachiopods are dominant. Bioclastic beds grade laterally into all of the other lithofacies.

Nodular limestone-shale units range from six inches to eight feet in thickness. They range from lenticular beds to limestone nodules embedded in a shale matrix. The beds are composed of oncoidlith-intraclast mudstone and bioclastic wackestone and mudstone. The shale ranges from abundant partings to thin beds or stringers. This facies may be the flank facies of the lime mud mounds and may form a transition zone between the mounds and the intermound areas. Some of the material actually may have been derived from the lime mud mounds as a result of wave erosion. These strata grade laterally into mounds and also into bioclastic intermound strata.

Lime mudstone units range from thin to thick-bedded and are commonly in the lower 10 feet of the formation. A few shale stringers are associated with these beds. They appear dense and show conchoidal fracture on fresh surfaces. They contain very few fossils.

The lime mud mounds are massive and have a gnarled or lumpy appearance. They are usually lenticular. The mound core is composed of boundstone containing spar-filled voids and possibly stromatolites (Heckel 1972). Mound development is very localized in the area and generally is confined to the top one-half or one-third of the formation. The mound core grades laterally into nodular limestone-shale beds or into bioclastic and oolitic beds.

DEPOSITIONAL HISTORY

Chesterian seas apparently encroached across northwest Arkansas from the southeast (Fig. 3). A decrease in Fayetteville terrigenous sedimentation was succeeded by Pitkin carbonate deposition. Examination of the Fayetteville-Pitkin contact indicates that sedimentation was continuous across the boundary. Oolith shoals with associated spillover lobes migrated across the platform as Pitkin sedimentation commenced. Coalescing oolitic and skeletal blanket sand bodies were deposited adjacent to the shoals in this initial phase of Pitkin sedimentation. Subsidence of the platform and possibly eustatic oscillations of sea level provided the mechanism for abrupt facies changes. Throughout most of the deposition of Pitkin Limestone, sedimentation probably equaled subsidence. Differential subsidence as a result of compaction of Fayetteville Shale formed deeper or more protected areas across the platform in which a middle phase of Pitkin deposition occurred. These areas allowed the deposition of mudstone and nodular limestone-shale. It was in these areas that mound growth commenced. Fistuliporid and fenestrae bryozoans as well as Girvanella established themselves on the small mud mounds. Crinoids probably attached to the flanks of the mounds, thus holding the mud together. Early inorganic cementation also may have caused diagenetic lithification of the mound (Heckel 1974). Mound growth flourished during the final phase of Pitkin sedimentation in which more turbulent conditions prevailed. Mound growth increased because of better circulation patterns and moderate current and wave activity which stimulated faunal growth and carbonate mud production, possibly by green algae. The mounds were self-perpetuating features because the communities of organisms trapped their own skeletal debris and the mud that they produced. Bioclastic and oolitic sands also formed in broad intermound areas and eventually coalesced to form extensive blanket sand bodies during the final phase of Pitkin sedimentation. At the end of Pitkin deposition, regression eventually was initiated, causing subaerial exposure and erosion of Pitkin and possibly post-Pitkin strata.
LITERATURE CITED


ACKNOWLEDGEMENTS

Appreciation is extended to the American Association of Petroleum Geologists for monies provided for this study from the Hugh D. Miser Memorial Fund. Appreciation also is extended to D. Zachry, W. Manger, K.C. Jackson, and P.H. Heckel who helped criticize and provide ideas for this study by lengthy discussions and visits to Pitkin Limestone outcrops.

Figure 1. Location of study area in northwest Arkansas.

Figure 2. Lithofacies cross-section of the Pitkin Formation (from Tehan 1976). Vertical scale: 1 inch = 50 feet.

Figure 3. Isopachous map of the Pitkin Formation (from Tehan 1976).
Hormone Receptor Site Maturation in the Secondary Sex Organs of Immature Male and Female Rats

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ABSTRACT

The effect of a combined dose of pregnant mares' serum (PMS) and human chorionic gonadotropin (HCG) on male and female rats 2-25 days old was studied. Groups of animals were given injections for three days, then sacrificed on the fourth day. All injections were begun on the 2nd, 7th, 12th, 17th, and 22nd day of life. Ovaries, uterus, seminal vesicles (SV), and ventral prostate (VP) were removed, dissected free of fat, and weighed. Because uterine weight increased earlier than either SV or VP weight, the ability of the uterus to respond to exogenous estradiol and of the SV and VP to respond to exogenous testosterone was examined. The injection schedule, age groups, and day of sacrifice were the same as above. The uterine response to estrogen was found to appear earlier than the VP-SV response to testosterone. The observations suggest that the receptor sites for estrogen may mature earlier than the receptor sites for testosterone.

INTRODUCTION

McQueen-Williams (1935) and Stein (1935) reported that peak ovarian weight response to a preparation of follicle stimulating hormone (FSH) and/or pregnant mares' serum (PMS) occurs at the end of the third week of life in the rat, rather than at some time during or after sexual maturity. Additional evidence that the ovaries undergo a period of increased responsiveness to gonadotropins was produced by Cole (1937), who observed both superovulation and superfecundation after injecting 22-day-old female rats with PMS. Cole believed that a response of any nature to gonadotropins does not occur with any consistency in females younger than 21-22 days of age. Greep (1961) concluded that ovaries in rats are refractory to exogenous gonadotropins until the 15th day of life.

It generally has been accepted that HCG will augment the action of either PMS or FSH on the ovary (Bates and Schooley 1942). Steelman and Pobly (1953) showed that combining HCG with small doses of PFSH produced a marked and linear increase in ovarian weight. FSH alone in the same dose failed to elicit a significant weight response. These findings indicate that HCG makes intact ovaries of immature female rats extremely sensitive to exogenous FSH. This study, however, was conducted on 21-22-day-old rats, and no attempt was made to evaluate the effect of such an augmented gonadotropin stimulus on the ovaries of younger animals. Neither was the effect of combined gonadotropins on immature male sex organs (SV or VP) investigated.

The purpose of the present study was to investigate the effect of a combined dose of exogenous gonadotropins (PMS and HCG) on the ovaries, uterus, VP, and SV in rats that had not reached the 22nd day of life. An increase in uterine weight was considered the result of gonadotrophin-mediated ovarian estrogen production and secretion; increased VP and SV weight was considered the result of gonadotrophin-mediated testosterone production and secretion by the testes (Korenchovsky 1930, Sawin 1969, Velardo 1959). After delineation of these response patterns, estrogen and testosterone alone were administered exogenously to groups of rats younger than 22 days of age. Both studies were designed to show a graphic illustration of hormone receptor site maturation and resultant secondary sex organ response.

MATERIALS AND METHODS

Newborn Sprague-Dawley (Charles-River) rats were divided into five groups and each group was given injections of gonadotropins beginning on the 2nd, 7th, 12th, and 22nd day of life. The day of birth was considered to be day one. Each animal was given a total dose of five International Units (IU) of PMS (Nutritional Biochemicals) and 20 IU of HCG (Nutritional Biochemicals) dissolved in distilled water. Subcutaneous injections of the combined gonadotropins (0.1 ml) were given three times a day for three days. Control rats were injected concurrently with distilled water. On the fourth day (72 hours after the first injection) the animals were sacrificed by concussion; the organs were removed and trimmed free of excess tissue, and weighed to the nearest one-tenth of a milligram on a Rollier-Smith torsion balance. The autopsies, therefore, were performed on the 5th, 10th, 15th, 20th, and 25th days of life. Actual organ weights were converted to mg of organ weight per 100 g of body weight (relative weight).

With the same age groups, injection schedule, and day of sacrifice, a total dose of three µg of 17-alpha estradiol (Nutritional Biochemicals) and 1500 µg of testosterone (Philadelphia Amoule Laboratories) was given to females and males, respectively. The solvent for each was distilled water; control groups received injections of the solvent. Organs were trimmed, weighed to the nearest 0.1 mg, and converted to relative weight.

STATISTICS

The Student's t-test was used to compare mean organ relative weights of treated groups with mean organ relative weights of corresponding control groups. Calculations were based on n = 12 animals per group.

RESULTS

Rats injected with gonadotropins on days 22-24 showed a highly significant (p < 0.01) increase in ovarian weight (Fig. 1). This difference was also significant on the 15th and the 20th days (both p < 0.01), but the weights failed to vary from control weights on the 5th and 10th days.

Uterine weight increased rapidly between the 10th and 15th days of life (Fig. 1), and an increase was noted in both controls and in animals treated with gonadotropins. However, gonadotropin-treated animals had significantly higher relative weights on the 15th day than controls (p < 0.01).

In males, combining gonadotropins resulted in a gradual increase in the relative weights of both SV and VP which became significant by the 15th day of life (p < 0.01); the gain increased with the age of the rat (Fig. 1).

When female rats were given a total dose of 3 µg of 17-alpha estradiol over a three-day period, the uterus increased markedly in relative weight (Fig. 1). This increase was particularly noteworthy during the 5th through the 10th days of life. A large dose of 17-alpha estradiol (25 µg) elicited virtually the same response as did 3 µg. Such a response was unobtainable in the SV and VP by administering 1500 µg testosterone (Fig. 1).
DISCUSSION

The findings indicate that the ovaries can be stimulated by combined exogenous gonadotropins to begin secreting estrogen shortly after the 10th day of life. This conclusion was reached because of the observed weight increase of the uterus which typifies this organ's unique response to estrogen. The binding of estrogen and resultant protein synthesis have been considered to be mediated by specific receptors in the nuclei of steroid target cells (Jensen and Jacobson 1962, Jensen and DeSombre 1972, O'Malley and Means 1974). These workers used both 17-beta estradiol and ultracentrifugation separation techniques to demonstrate both estradiol organ specificity and nuclear concentration. Toft and Gorski (1966) showed that the binding can be disrupted by proteolytic enzymes, a finding which suggests that the receptors are protein in nature. More recent studies have shown that these proteins also have binding specificity for entities other than estrogens, i.e. DNA (Yamamoto 1974a, b).

The results also suggest that the hormone receptor mechanism for estrogen in the uterus undergoes early maturation, enabling exogenous estrogen to induce significant uterine weight gain at four days of age. When combined gonadotropins (PMS and HCG) were given, the initial weight increase occurred later (after 10 days), suggesting this to be the age at which the ovaries can release estrogen upon sufficient gonadotropin stimulation.

The SV and VP response indicates an absence of both testicular response to gonadotropins and secretion of testosterone until after the 10th day of life. Unlike the uterine response to estrogens, neither of these organs responds to exogenous testosterone until after the 10th day of life.

Presumably, the maturation process involves the receptor sites, although other biochemical entities (cyclic AMP, Sutherland et al 1965) should not be overlooked. Other studies to detect production of steroids within the cell could supply additional pertinent information. Histochemistry, for example, could be used to illustrate intracellular synthesis of steroids and to point out any age discrepancies in this process. Use of such an approach could provide a method for both extending and further clarifying the present findings.

ACKNOWLEDGEMENT

The author expresses sincere appreciation to Dr. William L. Money, University of Arkansas, for his advice and personal interest in the project.

LITERATURE CITED


Hormone Receptor Site Maturation in Male and Female Rats


Algal-Bryozoan Carbonate Buildups Within the Pitkin Limestone (Mississippian-Chesterian), Northwest Arkansas

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ABSTRACT

More than 14 bioheral buildups have been recognized within the Pitkin Limestone (Mississippian-Chesterian) in eastern Washington and western Madison Counties, northwest Arkansas. These buildups resemble previously described algal mounds in upper Pennsylvanian strata of the Midcontinent region, but differ in their faunal and floral constituents.

The mounds are composed of calcilutite with variable amounts of spar and fossil allochemical grains. Associated flanking facies consist of mixed biosparite near the core, grading outward into oosparite. A few zones of shaly, poorly washed biomicrite containing rounded clasts bearing Archimedes fragments are interbedded with the flanking mixed biosparite facies. These clasts appear to be fragments of the mound facies, and suggest that the lithified mounds were attacked by wave activity.

The mounds developed from the entrapment of carbonate mud by cyanophylic algae (blue-green) and cryptostomous bryozoans. The mounds and flank facies appear to have originated in an area of relatively great turbulence, as indicated by oolite development, and thus were restricted in lateral expansion. Coincidence of lateral expansion of the mounds with deposition of an extensive mixed biosparite facies and an absence of oosparite development suggests less turbulent conditions.

INTRODUCTION

More than 14 lime mud mounds have been found in eastern Washington and western Madison Counties, northwest Arkansas (Fig. 1). This report describes the general lithic character and facies relationship of a particularly large group of closely spaced mounds in the NE ¼, NW ¼, Sec. 34, T15N, R28W near Durham, Arkansas. The largest single mound in this group (Fig. 2) has a lateral exposed width of 315 feet (95.7 meters) and a vertical dimension of 60 feet (18.2 meters). Examination of the Pitkin isopachous map indicates that mound deposition did not produce anomalous thicknesses of carbonate sedimentation (Fig. 1).

PETROGRAPHY

The mound cores at all 14 locations are similar megascopically. The core can be identified by its distinctive humpy and ropy weathered appearance, which contrasts with the smoother bedding surfaces of the other lithofacies of the Pitkin Limestone. Microscopically, according to R.L. Folk's classification, the mound core is a dark-gray, sparse biomicrite, with irregular spar-filled voids and rare allochemical debris (20% or less). Microscopic examination indicates that bryozoans are the dominant allochemical constituent, and crinoids, bivalves, foraminifers, sponges, and oncolitic algae are also present.

The mounds show a marked variation in the abundance and diversity of the fauna in the lower five feet in comparison with the fauna found within the upper part. Sponges, brachiopods, spar-filled voids, and an abundance of fenestellid bryozoans characterize the lower part. Shale pods commonly are present here, and appear to be restricted to the lowest five feet of the mounds. The upper part of the mound core contains a limited abundance (10% or less) and diversity of allochemical debris. The typical mound rock is dark-gray fossiliferous micrite with minor fenestellid bryozoan fragments and spar-filled voids. The mound core facies is remarkably uniform both within and among Pitkin mounds. The only departures from the dense fossiliferous micrite are rare pockets of crinoid fragments surrounded by mud and spar.

Five facies, recognized megascopically, are associated with the mound: oolitic calcarenite facies, mixed bioclastic-ooolitic calcarenite, crinoid bioclastic calcarenite, alternating shale and mixed bioclastic calcarenite, and a talus calcirudite. The oolitic calcarenite facies is typically massive, light-gray, well-sorted oosparite. A massive light-gray mixed calcarenite averaging 60% fragmental crinoids, brachiopods, and bryozoans and 40% ooliths characterizes the mixed bioclastic-ooolitic facies. Characterizing the crinoid bioclastic facies is massive, medium-gray, poorly sorted crinoid. Calcereous thinned bedded shale and irregular beds of light-gray mixed calcarenite compose the alternating shale and mixed bioclastic facies. The talus facies consists of irregular medium-gray calcirudite, with abundant large calcilutite clasts bearing eroded Archimedes fragments.

DEPOSITIONAL HISTORY

The lime mud composing the mounds probably was produced by chlorophylic (green) algae in a fashion similar to that by which recent lime mud was produced in Florida Bay (Stockman et al. 1967). Initial growth of algae began in the alternating shale and mixed biosparite...
facies (Fig. 2). Cyanophytic (blue-green) algae acted as entrappers of the lime mud, producing a coherent, positive structure. In addition to cyanophytic algae, fenestellid bryozoans may have served to bind the lime mud, but this relationship is unclear.

After initial formation, the mound was in an area of relatively great turbulence as indicated by the development of abundant ooliths (Fig. 2). The turbulence restricted the lateral expansion of the mound by erosion of its margins. A talus facies containing modules bearing Archimedes fragments interbedded with the flanking mixed bioclastic-oolitic facies suggests that the mounds were capable of being eroded. Conditions of decreased turbulence allowed lateral mound expansion. Such conditions possibly were produced by vigorous crinoid growth, which acted as a baffle to wave energy, or to a slight increase in water depth. This interpretation is supported by coincidence of lateral expansion of the mounds with deposition of a thick mixed bioclastic facies (Fig. 2). Oolitic rock is not present at horizons of maximum lateral expansion (Fig. 2).

Many of the mounds were terminated by the development of oolitic shoals at the crest. This termination may be the result of the mound's inability to persist in great turbulence which would inhibit algal growth and cause erosion of the positive portions of the mounds.

Figure 2. Lithofacies of organic mud mounds in NE¼, NW¼, Sec. 34, T15N, R28W. Vertical scale 1″ = 32″; horizontal scale 1″ = 84″.
Food Sharing Behavior in Primates: Another Species Added

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ABSTRACT

Observations of food sharing behavior in golden lion marmosets are reported and three categories of food sharing behavior are proposed for primates: passive, active, and overt.

INTRODUCTION

Food sharing generally is assumed to be voluntary; involuntary food sharing perhaps is categorized better in terms of aggression. Capuchin monkeys in food deprivation experiments have been observed to "hand" food through the bars to one another, and Markowitz (1973) reported gibbons and diana monkeys sharing food tokens and cooperating in bar press situations. However intriguing these sharing situations may be, they cannot be categorized as normal even within the realm of captive behavior studies. Although chimpanzees (Goodall 1965, Reynolds and Reynolds 1965; Van Lawick-Goodall 1971; Teleki 1973), spider monkeys (Dare 1974), and olive baboons (Harding and Strum 1976) have been observed in the wild to share food, most observations of food sharing have been made in captive species: chimpanzee (Nissen and Crawford 1930, Mason 1970), gorilla (Schaller 1963), douc langur (Kavanagh 1972), gibbon (Berkson and Schusterman 1964), and tree shrew (Hasler and Sorenson 1974). To this relatively short list of "normal situation" food sharers may be added the golden lion marmoset (Leontopithecus rosalia). The importance of food sharing behavior in marmosets is understood better with a brief description of their social organization.

The typical marmoset social structure can be described as a parental family unit consisting of an adult bonded pair and their immature offspring of perhaps more than one litter. This parental family unit is rare in nonhuman primates and is known only in gibbons and marmosets. What comprises the pair bond in parental family units is not completely understood. Eisenberg et al. (1972) describe a pair bond as grooming, huddling, and other nonsocial behaviors performed on a daily basis. The father in a marmoset family typically takes the offspring from the female for seven to ten days after parturition (carries them about four weeks), returning them to the mother only for nursing. This type of nonhuman primate parental care in which the male is actively involved is unique to marmosets (Eisenberg et al. 1972).

The diet of marmosets in the wild consists mostly of insects, smaller vertebrates, eggs, foliage, fruits, and nuts (Izawa 1975). The agility required to secure proper amounts of food is obvious. A pregnant female would be at a distinct disadvantage. During a study on the social and reproductive behavior of golden lion marmosets at the Oklahoma City Zoo, marmosets were observed to not feed continuously at the feeding dish but instead to take a piece of food in their mouth or on one hand and carry it a short distance before eating. Consequently feeding time is very active with frequent trips to the feeding station because small pieces of food are either taken by other marmosets, eaten, or dropped to the ground.

The writer proposes that food sharing behavior in primates can be divided into three categories.

1. Passive food sharing is when one animal allows another to take (share) food without resistance even though the sharing is not solicited.

2. Active food sharing has the added facet of the sharer apparently actively seeking association with another individual ("sharee") although the food is not actively offered or presented (given or handed) to the individual.

3. Overt food sharing involves active sharing with the overt or active donation or carrying of the food to another individual. This is the highest level of food sharing behavior, correlating with at least the beginnings of advanced social contact systems similar to those of early man.

PASSIVE FOOD SHARING

Passive food sharing was observed on nearly a daily basis in all adult pairs. The same food item frequently was transferred or shared between the pair several times before being completely consumed or discarded.

A single female offspring born to a pair on 25 March 1974 was 34 days old when first observed to eat solid food. In 17 hours of observation during the next 26 days, the offspring was observed to take food from the father 32 times and from the mother only 6 times. In view of the high degree of male interaction in the rearing of offspring, this disproportionate difference is not surprising, although on one occasion the mother was observed to take food from her offspring. Additional observations of another adult pair and their twin female offspring indicated similar food sharing patterns with occasional passive food sharing between the offspring.

ACTIVE FOOD SHARING

During the introduction of a new male and female, by use of a 10-ft-cage divided by a wire partition (one animal in each half), the male was observed to retrieve a food item from the floor and carry it to the wire divider. The female reached through the wire divider and took the food item. No resistance on the male's part was noted, nor assistance other than carrying the food item to the female. This behavior would clearly be a case of "active food sharing" and adds further support to the importance of food sharing behavior in the establishment and maintenance of the pair bond in marmosets.

OVERT FOOD SHARING

Behavior changes were noted in an adult pair of wild-born marmosets during the course of the female's pregnancy. As parturition approached, the female became less active, spending much time resting in the nest box entrance or basking under an ultraviolet light. The female went to the food dish with decreasing regularity. The male was observed on several occasions to put food directly in front of the female as she rested at the nest box entrance, a gesture the writer interprets as overt food sharing. After giving birth, the mother resumed normal feeding activities. Adult pairs with offspring passively shared food more frequently than adult pairs without offspring.

LITERATURE CITED


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Semiquantitative Infrared Analysis of Diketones and Anhydrides in a Reaction Mixture

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ABSTRACT

The ozonolysis of a hydroxymethylene ketone yields a mixture of diketone and anhydride. Treatment of hydroxymethylene camphor with ozone affords, in addition to the expected camphor quinone, a surprisingly large amount of camphoric anhydride (56%) via Baeyer-Villager reaction. Use of infrared absorption to analyze the relative amounts of camphor quinone and camphoric anhydride in a reaction mixture was studied by comparing peak heights of their carbonyl stretching bands.

INTRODUCTION

It has been shown (Yang and Pelletier 1968) that oxidative ozonolysis of the hydroxymethylene ketone (I) shown in Figure 1 yields a dicarboxylic acid. The synthesis involved treatment with ozone, peroxide, and base. If the peroxide and base treatments are omitted, straight ozonolysis yields the diketone (II) and anhydride (III) shown in Figure 1. That the dicarboxylic acid is not a precursor to the anhydride via dehydration was demonstrated by ozonation of the hydroxymethylene ketone in acetic acid-ethyl acetate solvent, yielding the mixture of anhydride and diketone. Other solvents (such as methylene chloride) also lead to mixtures, but with lesser amounts of the anhydride. It was concluded that anhydride formation resulted from a Baeyer-Villager type oxidation of the diketone by a peracid generated during ozonolysis. Nonetheless, the yield of the seven-membered ring anhydride is surprisingly large.

Because of the extremely small amount of the starting hydroxymethylene compound, attention was directed toward analogous camphor compounds. Figure 2 shows several synthesis routes starting with camphor. The diketone, camphor quinone, can be made in high yield by treating camphor with selenium dioxide. Treatment of camphor with sodium and ethyl formate yields hydroxymethylene camphor. It has been shown that ozonolysis, followed by treatment with peroxide then base, produces camphoric acid in high yield. In fact, seven dicarboxylic acids have been synthesized by this method (Yang 1976).

Future synthesis attempts will be to make seven- and eight-membered ring anhydrides by the route demonstrated in Figure 2. Addition of a peracid should encourage the Baeyer-Villager mechanism and cede high yields. Seven- and eight-membered ring anhydrides cannot be made by standard dehydration of straight chain dicarboxylic acids.

METHODS AND MATERIALS

Efforts to date have been directed toward use of infrared spectra to analyze the relative amounts of diketone and anhydride in the reaction mixture which results from straight ozonolysis of hydroxymethylene ketones without successive treatment with peroxide and base or with peracid. The infrared spectrum of the reaction mixture resulting from ozonation of compound I (Figure 1) was measured with a Perkin-Elmer Infracord spectrophotometer. All spectra were scanned in the region 4-7 microns to reveal carbonyl stretching frequencies of diketones and anhydrides.

Samples of dl-camphoric anhydride and dl-camphor quinone were secured from Aldrich Chemical Company. Potassium bromide pellets of each were measured on a Perkin-Elmer Model 21 infrared spectrophotometer. The instrument resolution at 6.5 microns is quoted by the manufacturer to be 17 cm^{-1}. Mixtures of known mole ratios of the two compounds also were measured in KBr discs. Mixtures were made so that the smallest quantities weighed were approximately 10 milligrams which allowed three significant figures in the masses. Pellets made from these mixtures were 0.12 grams total mass, more than 99% of which was KBr. Mixing was done in vials on a mechanical shaker; pellets were pressed at 20,000 pounds per square inch for five minutes and their spectra determined immediately. Peak heights were estimated by the tangent baseline method (cf. Conley 1966) for the semiquantitative determinations.

RESULTS AND DISCUSSION

Figure 1 shows a tracing of the spectrum obtained for the reaction mixture containing diketone II and anhydride III. The band at 1800 cm^{-1} is due to anhydride, that at 1730 cm^{-1} to diketone. The remaining doublet members from each species overlap and merge into the band at 1760 cm^{-1}. The peak height ratio for diketone/anhydride was found to be 2.8/1. To verify that the

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97 Arkansas Academy of Science Proceedings, Vol. XXX, 1976
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D.T.C. Yang, F.H. Watson, Jr., J.O. Lay and R. Getty

Figure 2. Synthesis routes of camphor derivatives.

Figure 3. Infrared spectra of camphoric anhydride, camphor quinone, and 1:1 mixture.
anhydride does not result from ozonolysis of the diketone, the mixture was recovered from the disc, subjected to excess ozone, and repressed into a KBr pellet. After over-ozonization, the peak ratio was found to be 2.7/1, which confirmed that the diketone is stable to excess ozone and lent credence to the Baeyer-Villiger mechanism for anhydride formation.

Shown in Figure 3, a and b, are the infrared spectra of camphoric anhydride and camphor quinone, respectively. A shoulder is observed on the red side of the camphor quinone band, but is not resolved as a distinct peak. Figure 3c shows the two bands superposed and reveals major overlap. The spectrum of a 1:1 mole ratio mixture of the two compounds is shown in Figure 3d. Such major overlap negated the possibility of using peak areas for analysis of the mixture. In fact, some doubt arose as to whether a ratio of the 5.5-micron camphoric anhydride peak height to the height of a peak due to overlapping bands would be useful for semiquantitative analysis. The peak ratios, however, did yield the smooth working curve shown in Figure 4.

As a check on the reliability of the peak ratios, four different pellets of mixtures with 0.60 mole fraction camphoric anhydride were made and their spectra obtained. Resultant ratios were 0.752, 0.746, 0.763, and 0.737, yielding an average value of 0.750 with standard deviation of 0.011. This finding indicates that mole fractions can be obtained to two significant figures from the working curve.

Analysis of the reaction mixture revealed it to have $X_{\text{camphoric anhydride}} = 0.53$, corresponding to 56% camphoric anhydride by mass. The identities of the two species were verified by chromatographic separation and elemental analysis of each.

**ACKNOWLEDGEMENTS**

Thanks are due Dr. Maynard Hall at the Graduate Institute of Technology, Department of Chemistry, for his assistance and for allowing use of the Perkin-Elmer Model 21 instrument. This research was funded in part by a U.A.L.R. Faculty Research Grant.

**LITERATURE CITED**


![Figure 4. Ratio of peak intensities versus mole fraction camphoric anhydride.](image)
Fishes of the Cane Creek Watershed in Southeast Missouri and Northeast Arkansas

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ABSTRACT

A survey of the fishes of Cane Creek in southeast Missouri and northeast Arkansas was made between 25 August 1974 and 16 July 1975. Field collections, literature records, fisherman reports, and museum specimens showed the fishes of Cane Creek to be composed of 90 species distributed among 20 families. Records of Lampetra aepyptera (Abbott), Hiodon alaskoides (Rafinesque), Etheostoma histrio Jordan and Gilbert, and Percina uranidea (Jordan and Gilbert) were either the first records of these species in this stream or reaffirmed their presence.

The fish collected were common to the Ozark, Ozark-lowland, lowland, and wide-ranging faunal groups of Pfieger (1971). The Ozark faunal group was restricted primarily by topography and the confluence of Ten Mile Creek with Cane Creek. The lowland faunal group was influenced by fish migrating between Cane Creek and Black River. Channelization of lower Cane Creek in 1907 and 1908 undoubtedly influenced the immigration and emigration of fishes from Black River.

INTRODUCTION

Cane Creek is a medium-size stream originating from numerous small springs and surface runoff. The watershed is unusual in that it consists of an Ozark region and a distinct lowland region. In the Ozark region the substrate is composed of rock and gravel and pools are separated by swift rocky riffles, whereas in the lowland region the substrate is clay, silt, and sand and pools are intermittent. Farming activities have caused an increase in turbidity in the lower part of the stream.

Beginning in southeastern Carter County, Missouri, Cane Creek flows southwest 68 miles to its confluence with the Black River, 8.5 miles northeast of Corning in Clay County, Arkansas. Ten Mile Creek, the only major tributary of Cane Creek, originates approximately one-half mile south of Cane Creek and flows parallel with it 29 miles to its confluence at a point due west of Poplar Bluff, Missouri. Other named tributaries are Goose and Proctor Creeks and Fletcher Branch.

No complete study of Cane Creek is known, although Pfieger (1971) reported two sites sampled between 1905 and 1945 and two sampled between 1946 and 1962 which yielded a list of 63 species. Similar studies have been conducted on the Black River and its tributaries by Black (1940), Funk et al. (1953), Funk and Campbell (1953), Martin and Campbell (1953), and Green and Beadles (1974).

The following report is based primarily upon collections made by Pfieger (1971) and the writers. All specimens taken by the writers are housed at Arkansas State University.

DESCRIPTION

Cane Creek begins at an elevation of 890 ft and drops to an elevation of 360 ft where it joins Ten Mile Creek, covering a distance of 30 miles. As the stream leaves the Ozark escarpment near Harviell, Missouri, it drops to an elevation of 315 ft in a total distance of 55 miles to produce a stream gradient of 10 ft/mile. In the lowland region the stream covers 13 miles and drops only 25 ft to an elevation of 290 ft for a stream gradient of 2.3 ft/mile (U.S. Forest Service 1964). Cane Creek originates in southeastern Carter County, Missouri, where it cuts through rocks of the Ordovician System of the Ozark Highland Physiographic Province (Fenneman 1938). Major geologic formations are the Roubidoux, composed of sandstones, chert, and fine-grained dolomite, and the Gasconade, composed of coarsely crystalline cherty dolomite with a basal sandstone (Missouri Geological Survey 1961). The creek enters the northwest corner of Butler County, Missouri, where it turns south and runs along the western edge of the county. At a point due west of Poplar Bluff it joins Ten Mile Creek, its only major tributary. From this point, because there is little change in elevation, the stream flow slows and Cane Creek begins to assume the appearance of a lowland stream.

Channelization of the last 9 miles of the stream has left a 12-mile segment of the stream, known locally as Old Cane Creek, cut off from the rest of the system. Vegetation has taken over much of this area, leaving shallow pools with no current. However, during spring floods, fish are able to move in and out of this area. Channelization was done in 1907-1908 as a result of local complaints of annual flooding. No dredging has been done since the original work, except for minor repair of the flood levees. At the present time no major changes of the stream are planned, although flooding still occurs one to three times annually.

Although no major source of pollution for the entire system is known, several factors combine to keep the water of the lowland region turbid. In the Ozark region livestock are allowed free access to the stream and produce a source of organic fertilizer. Several land owners conduct gravel mining operations which increase the silt content of the stream. Other factors are indiscriminate removal of trees along the shore, and poor agricultural practices which allow silt and fertilizer to empty into the stream.

PURPOSE

The purpose of this study was to determine the qualitative variations of fishes in the Cane Creek watershed. Because the stream is divided into an Ozark region and a lowland region, it was thought that differences between the fish populations of the two parts might be observed. Finally the study sought to determine a preference for pool or riffle habitats by some species.

METHODS

Eight sampling stations were established within Cane Creek watershed. Two sites were on lower Cane Creek, three on Ten Mile Creek, and three on the Ozark region of Cane Creek, where access was available between 25 August 1974 and 16 July 1975. Because most of the lowland region is not suitable for seineing year round, 30 supplemental samples were made by various methods.
Most specimens were collected with a 30 x 6-ft seine with 1/4-in. mesh or a 12 x 4-ft seine with 3/16-in. mesh. Several specimens were taken at night with a pig. An electrofishing sample was conducted at eight at the confluence of Canoe Creek and Black River.

All specimens were fixed in 10% formalin for 3 to 7 days, then washed, identified, and preserved in 40% isopropanol. Identification of fishes was made from keys by Buchanan (1973), Cross (1967), Miller and Robison (1973), Moore (1968), Pfieger (1968), and Taylor (1969). Genera and species are arranged alphabetically within each family in accordance with the scheme proposed by Greenwood et al. (1966). Scientific and common names of fishes follow those of Bailey et al. (1970) except where noted.

ACKNOWLEDGEMENTS

Dr. George A. Moore, Professor Emeritus, Oklahoma State University, kindly made verification of certain darters and cyprinids. Drs. George L. Harp, V.R. McDaniel, and Dewey H. Sifford verified certain darters and cyprinids, read the manuscript, and served on the thesis committee, respectively. Several high school students from Neelyville, Missouri, and graduate students from Arkansas State University aided in the collection of fishes.

ANNOTATED CHECKLIST OF FISHES
OF CANE CREEK WATERSHED

Petromyzontidae (Lampreys)

Ichthyomyzon castaneus Girard. Chestnut lamprey.
Common inhabitant of the lower Ozark region and the lowland region.

Lampetra aeryptera (Abbott). Least brook lamprey. Collected from shallow riffles of the Ozark region during late winter and early spring. One specimen was taken in a pool in 4 ft of water from inside a log. This is the first record of Lampetra aeryptera in the Black River system; however, Harp and Matthews (1975) reported this fish in Arkansas in the upper part of the White River system.

Polyodontidae (Paddlefishes)

Polyodon spathulatus (Walbaum). Paddlefish. Although not represented in the writers’ collections, this species has been reported by local fishermen. One report is as recent as October 1975.

Leptosomatidae (Gars)


Leptosoma oculus (Linnaeus). Longnose gar. Rare inhabitant of the lowland region, taken only from the channeled part. However, collecting it was extremely difficult in the lowland region of Canoe Creek.

Amiidae (Bowfins)

Amia calva Linnaeus. Bowfin. Common inhabitant of the sluggish backwaters of the lowland region and Old Canoe Creek.

Anguillidae (Freshwater Eels)

Anguilla rostrata (Lesueur). American eel. Not collected, but local fishermen report taking this species on trot lines and by gigging.

Clupeidae (Herrings)

Dorosoma cepedianum (Lesueur). Gizzard shad. Abundant throughout the medium to large parts of the stream.

Hiodontidae (Mooneyes)

Hiodon alousides (Rafinesque). Goldeye. Collected in the channeled part of the stream, over sandy bottom. This is the first record of this species in the Black River system.

Hiodon tergitus Lesueur. Mooneye. Taken only at the mouth of the stream by electrofishing. Most likely an occasional visitor from the Black River.

Esox americanus vermiculatus Lesueur. Grass pickerel. Relatively common throughout the system, taken from shallow water in or near vegetation.

Esox niger Lesueur. Chain pickerel. Inhabitant of deeper pools, often near surface or submerged vegetation.

Cyprinidae (Minnows)

Camptonotus anomalous pulmilus (Agassiz). Central stoneroller. Present throughout the watershed, from the headwaters to the lowland. Most often taken in moderate to swift current over rock and gravel bottom.

Camptonotus olgolepis Hubbs and Greene. Largescale stoneroller. Abundant throughout the Ozark region. Commonly taken over rock and gravel bottom in moderate to swift current. One of the most abundant cyprinids in the system. The writers concur with Pfieger (1971) in recognizing C. olgolepis and C. anomalus as distinct species.

Cyprinus carpio Linnaeus. Carp. Fairly common inhabitant of shallow and deep pools, often near submerged logs and trees.

Dionda nubila (Forbes). Ozark minnow. One of the most common cyprinids of the Ozark region, generally inhabiting clear water over gravel bottom with moderate to swift current.

Hybognathus molarus Agassiz. Silvery minnow. Collected in both the Ozark and lowland regions; however this species seems to be distributed throughout the watershed.

Hybopsis ambloplites (Rafinesque). Bigeye chub. Inhabitant of clear water, often present in moderate to swift current over gravel or sand. It was last reported by Pfieger (1971).

Nocomis biguttalus (Kirtland). Hornyhead chub. Rare inhabitant of clear water in the upland region. Collected only from shallow riffles.


Notropis annis Hubbs and Greene. Pallid shiner. An inhabitant of lowland streams. Pfieger (1971) reported this species was last collected in Canoe Creek prior to 1945.

Notropis athecoides (Rafinesque). Emerald shiner. Common inhabitant of the lower region of the stream, most often collected from sandy-bottomed pools.

Arkansas Academy of Science Proceedings, Vol. XXX, 1976
Fishes of the Cane Creek Watershed in Southeast Missouri and Northeast Arkansas

*Notropis boops* Gilbert. Bighorn shiner. Collected throughout the watershed; most abundant, however, in the clear Ozark waters. One of the most abundant cyprinids in the system.

*Notropis cornutus* cornutus (Cope). Northern mimic shiner. Frequently collected from the upper reaches of the watershed and from quiet pools along the main stream.

*Notropis venustus* Girard. Blacktail shiner. Most abundant cyprinid of the lowland region.

*Notropis volucellus* volucellus (Cope). Northern mimic shiner. Rare inhabitant of the turbid waters of the channeled part of the stream.

*N. texanus* (Girard). Weed shiner. Rare cyprinid of the lowland region.

*Ictalurus cyprinellus* cyprinellus (Rafinesque). Common inhabitant of quiet pools, backwaters, and small tributaries throughout the watershed.


*I. natalis* (Lesueur). Yellow bullhead. Most common ictalurid occupying the Ozark region. Collected from quiet shallow pools.


*Ictalurus natalis* (Lesueur). Black Bullhead. Rare inhabitant of the lowland region. One only specimen was taken, from a field drainage ditch.


Poeciliidae (Livebearers)

*Gambusia affinis* (Baird and Girard). Mosquitofish. Common inhabitant of quiet pools, sluggish backwaters, and evaporation pools throughout the system. Most common in the lowland region and the channelized section.

*Atherinidae* (Silversides)

*Labidesthes sicculus* (Cope). Brook silverside. Common throughout the watershed. Most often collected in the Ozark region, though never in large numbers.

*Percichthyidae* (Temperate Basses)

*Morone chrysops* (Rafinesque). White bass. Rare, migrating from Black River during the spawning season from the middle and lower part of the stream.

*Elassoma zonatum* Jordan. Banded pygmy sunfish. Uncommon inhabitant but was collected in the turbid waters of sluggish backwaters and Old Cane Creek. Collected in or near submerged aquatic vegetation.

*Centrarchidae* (Sunfishes)

*Ambloplites rupestris* (Rafinesque). Rock bass. Collected from clear pools of the Ozark region around submerged rocks or aquatic vegetation.

*Chaenobryttus gulosus* (Cuvier). Warmouth. Rare inhabitant of sluggish backwaters of the lowland region. The writers follow Miller and Robison (1973) in retaining the genus *Chaenobryttus*.


*Lepomis humilis* (Girard). Orangespotted sunfish. A rare inhabitant of sluggish backwaters. Collected only from Old Cane Creek.


*Poecilia reticulata* (Rafinesque). Banded pygmy sunfish. The most abundant centrarchid, found throughout the watershed. An inhabitant of shallow and deep pools. Most common in the Ozark region; in the lowland region it is replaced by *L. cyanellus* and *L. macrochirus*.

*Poecilia micropus* (Gunther). Redear sunfish. Rare inhabitant of the Ozark region. Only a single specimen was collected from a shallow pool. The presence of the redear sunfish in the system is possibly due to its having escaped from local farm ponds.

*Poecilia punctatus* (Jordan). Spotted sunfish. This species last was collected from Cane Creek before 1945 (Pflieger 1971).


*Micropterus punctulatus* (Rafinesque). Spotted bass. Most abundant bass in the system. Collected throughout the watershed from pools and riffles.

*Micropterus salmoides* (Lacepede). Largemouth bass. Fairly common inhabitant of the entire watershed.

*Pomoxis annularis* Rafinesque. White crappie. Confined to the turbid waters of the channelized region and the sluggish waters of Old Cane Creek.

*Pomoxis nigromaculatus* (Lesueur). Black crappie. Common throughout the watershed. Most often taken from clear pools.

*Percidae* (Perches)

*Etheostoma biennotoides* Rafinesque. Greenside darter. A common resident of swift riffles of the Ozark region. A few specimens were taken from the lowland region over sandy bottom.

*Etheostoma caeruleum* Storer. Rainbow darter. The most abundant darter in the system. Collected throughout the Ozark region in slow to swift current over gravel bottom.

*Etheostoma chlorosomum* (Hay). Bluntnose darter. Collected only from the channelized part of the system. Taken from quiet pools over sandy bottom.

*Etheostoma flabellare* Rafinesque. Fantail darter. A resident of the headwaters and small clear tributaries of the Ozark region. Collected from swift riffles over gravel and rocky bottom. Pflieger (1971) reported that the nominate subspecies, *E. f. flabellare*, inhabited the upper two thirds of the Current and Black River systems whereas *E. f. lineolatum* (Agassiz) possibly intergrades with the nominate subspecies in the lower Current River.

*Etheostoma gracile* (Girard). Slough darter. Rare inhabitant of sluggish pools and backwaters of Old Cane Creek and the lowland region. Most often collected in or near aquatic vegetation.

*Etheostoma histrion* Jordan and Gilbert. Harlequin darter. Rare inhabitant of the lowland region. All specimens were taken from moderate to swift current over mud and sand bottom.


*Etheostoma spectabile* (Agassiz). Orangebreast darter. Common inhabitant of the headwaters, collected from swift current over gravel or rubble bottom.

*Etheostoma stigmaeum stigmaeum* (Jordan). Speckled darter. Common throughout the lowland region, most often taken from quiet pools over sandy bottom.

*Etheostoma zonale* (Cope). Banded darter. Rare inhabitant of the lower Ozark and lowland region.

*Percina caprodes* (Rafinesque). Logperch. Uncommon inhabitant of shallow pools and deep riffles of the Ozark region. Also collected from sandy areas of the lowland region.

*Percina maculata* (Girard). Blackside darter. Uncommon inhabitant of the lower Ozark and lowland regions. Collected in moderate to slow current over gravel and sandy bottom.
Fishes of the Cane Creek Watershed in Southeast Missouri and Northeast Arkansas

Percina sciera (Swain). Dusky darter. Rare inhabitant of the lower Ozark and lowland regions. Collected from slow current over a sandy bottom.

Percina uranidea (Jordan and Gilbert). Stargazer darter. The most abundant member of the genus Percina in the system. Collected from moderate to slow current over gravel and sandy bottom. Found in the lower Ozark and lowland regions.

Stizostedion vitreum (Mitchell). Walleye. Local fishermen report the walleye to be rare in the deep pools of the lowland region. Not collected by the writers.

Aplodinotus grunniens (Rafinesque). Freshwater drum. Rare inhabitant of deep pools in the lowland region.

DISCUSSION

The known fish fauna of Cane Creek watershed is composed of 90 species distributed among 20 families. The great ichthyofaunal diversity is due to the presence of an Ozark region and a lowland region in the watershed. This survey resulted in a range extension of Lampera appypterus, Hiodon alvogenes, and Pimephales tenellus. It reaffirms the continued presence of Esox niger, Opsonoteus emiliae, Noturus gyrias, Etheostoma histrio, and Percina uranidea populations as reported by Pflieger (1971).

Of the several species reported by Pflieger (1971) and not collected by the writers, the most unusual are Hybopsis ambloplitis and Naeotis zonatus. Both species are typically Ozarkian and are common in the major Ozark streams of the area. The failure to collect either of these species suggests that they may have been eliminated from the system as a result of either a changing stream environment, competition, gravel mining operations, indiscriminate removal of trees along the shore, or poor agricultural practices. This hypothesis is reinforced by Pflieger (1971), who last reported these species prior to 1945.

LITERATURE CITED


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### TABLE OF CONTENTS

- **Secretary’s Report and Financial Statement** .......................................................... 1
- **Program** ..................................................................................................................... 6
- **Section Program** ......................................................................................................... 7
- **Arkansas Collegiate Academy of Science** ................................................................. 10
- **Dwight M. Moore**: Sixty Years of the Academy ......................................................... 11
- **James C. Adams, Raj V. Kilambi, William A. Wickizer, and Arthur V. Brown**: Macrobenthos Population Changes in Crystal Lake, Arkansas, Subsequent to Cage Culture of Fish ......................................................... 12
- **Edmond J. Bacon and Zane M. Anderson**: Distributional Records of Amphibians and Reptiles from Coastal Plain of Arkansas ......................................................... 14
- **M.S. Bangoo, D.J. Albritton, and Eugene Shoulders**: Aeration, Phosphorus, and Lime Affect Nitrogen Mineralization in Imperfectly Drained Forest Soils ............................................. 16
- **Thurman Booth, Fred Burnside, Jan Burnside, and Peggy Rae Dorris**: A Continuation of Mourning Dove Studies in Clark County, Arkansas, with Emphasis on Cyclical Behavioral Patterns ................................................................. 19
- **Steve M. Bounds and John K. Beadles**: Fishes of the Fourche River in Northcentral Arkansas ................................................................. 22
- **Billie G. Broach and Howard L. Hodges**: An Experimental Testing Program in Elementary Chemistry: A Preliminary Report ................................................................. 27
- **J.M. Brueske**: The Machismo Syndrome: A Residential Correlate of Its Expression in a Mexican Peasant Community ................................................................. 30
- **Frances E. Clayton**: Metaphase Configurations in *Drosophila*: A Comparison of Endemic Hawaiian Species and Non-Endemic Species ................................................................. 32
- **Beverly A. Clevidence**: Dietary Fat-Carbohydrate Combinations: Their Effects on Lipid Metabolism in Estrogen-Treated Rats ................................................................. 36
- **Marjorie Ellen Fitch**: Influence of Dietary Fats and Carbohydrates on Lipid Metabolism in Male and Female Rats ................................................................. 39
- **Earl L. Hanabrink**: Characteristics and Behavior of Guineafowl and Domesticated Chicken Hybrids ................................................................. 44
- **Julie W. Harris**: Effect of Estrogen and/or Supplemental Substrates on Uterine Utilization of Pyruvate for Lipid Synthesis ................................................................. 47
- **Greg S. Jackman and Phyllis J. Garnett**: Electrophoretic Patterns of Serum Proteins in Two Subspecies of *Odocolleus virginianus* ................................................................. 50
- **Cameron Jones, Dominic T. C. Yang, and Thomas O. Whitley**: Composition of Arkansas Grapes During Maturation .......................... 52
- **Timothy C. Klingler**: The Problem of Site Definition in Cultural Resource Management ................................................................. 54
- **V. Rick McDaniel and Kenneth L. Smith**: Cave Fauna of Arkansas: Selected Invertebrate Taxa ................................................................. 57
- **S.A. Murphy, B.D. Johnson, and D.H. Sifford**: Enzymes in *Heloderma horridum* Venom ................................................................. 61
- **Troy V. Orr and H. Gaston Griggs**: The Study of Ultraviolet-Induced Chromatid and Chromosome Aberrations as a Function of Dose in G. Phase Vertebrate Tissue Cultures ................................................................. 64
- **P.E. Pope and R.B. Vasey**: Effect of Soil Buffer Capacity on Soil Reaction (pH) Modification and Subsequent Effects on Growth and Nutrient Uptake of *Plantanus occidentalis* L. Seedlings ................................................................. 67
- **Robert H. Ray**: Freshwater Mussel Shells as Indicators of Seasonal Occupation of Archeological Sites: Review of the Method ................................................................. 71
- **John Rickett**: An Update of Arkansas Odonata (Anisoptera) ................................................................. 73
- **Ron Rosen**: A Preliminary Checklist of Arkansas Acrasiaceae ................................................................................................................................. 75
- **E. Phil Rouse and Joan B. Chapin**: A Checklist of the Coccinellidae of Arkansas ................................................................. 76
- **Walter L. Manger and Jack L. Shank**: Lower Mississippian Lithostratigraphy, Northern Arkansas ................................................................. 78
- **Clarence B. Sinclair**: A Scanning Electron Microscope Study of Brachysclereids of Pear (*Pyrus communis* L.) ................................................................. 81
- **Richard K. Spears, Jr.**: Ouachita Biological Station ................................................................. 83
- **K. Srisotai and J.T. Gilmour**: Soil Salinity Measurement by the Four-Electrode Probe Technique ................................................................. 84
- **Kenneth F. Steele and George H. Wagner**: 1974 Nonflood-Stage Chemical Loads of the Buffalo River, Arkansas ................................................................. 86
- **Robert E. Tehan**: Regional Carbonate Deposition of the Pitkin Limestone (Chesterian) in Washington and Crawford Counties, Arkansas ................................................................................................................................. 88
- **K.J. Thomas**: Hormone Receptor Site Maturation in the Secondary Sex Organs of Immature Male and Female Rats ................................................................. 90
- **Alex T. Warmath**: Algal-Bryozoan Carbonate Buildups Within the Pitkin Limestone (Mississippian-Chestarian), Northwest Arkansas ................................................................. 93
- **Charles G. Wilson**: Food Sharing Behavior in Primates: Another Species Added ................................................................. 95
- **D.T.C. Yang, F.H. Watson, Jr., J.O. Lay, and R. Getty**: Semiquantitative Infrared Analysis of Diketones and Anhydrides in a Reaction Mixture ................................................................. 97
- **Bruce E. Yeager and John K. Beadles**: Fishes of the Cane Creek Watershed in Southeast Missouri and Northeast Arkansas ................................................................. 100