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Fayetteville, Arkansas
72701

Price: Five Dollars
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ARKANSAS ACADEMY OF SCIENCE

Fifty-third Annual Meeting
Fayetteville, Arkansas
April 11-12, 1969

OFFICERS

President .................................................. Dr. Arthur Fry
President-Elect .............................................. Professor M. L. Lawson
Secretary .................................................. Dr. George Templeton
Treasurer .................................................. Dr. John P. Jones
Editor ...................................................... Dr. Lester C. Howick

SECRETARY'S REPORT

The first business meeting was called to order by President Fry at 10:30 a.m. April 11. The members were welcomed to the campus of the University of Arkansas, Fayetteville, by Dr. David W. Mullins, President of the University.

President Fry called for a report of the officers:

SECRETARY:

President Fry announced that Dr. Templeton, Academy Secretary, was not able to attend because of a death in the family and introduced Dr. W. C. Guest who would act as secretary. The acting secretary moved that the minutes of the fifty-second meeting as published in the Arkansas Academy of Science Proceedings, Vol. 22, 1968, be approved. The motion was seconded and the motion passed.

TREASURER:

Copies of the following financial statement and summary were distributed and discussed by Dr. J. P. Jones. Dr. Jones moved that the financial report be accepted. The motion was seconded and the motion passed.
FINANCIAL STATEMENT

ARKANSAS ACADEMY OF SCIENCE

April 1, 1969

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance on hand April 1, 1968</td>
<td>$1777.14</td>
</tr>
<tr>
<td>Reserve Fund</td>
<td>517.64</td>
</tr>
<tr>
<td><strong>Total Assets</strong></td>
<td><strong>$2294.78</strong></td>
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<table>
<thead>
<tr>
<th>Receipts April 1, 1968 - March 31, 1969</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dues</td>
<td>$1650.00</td>
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<tr>
<td>2. Sales of Proceedings</td>
<td>815.55</td>
</tr>
<tr>
<td>3. FICA Refund</td>
<td>8.25</td>
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<td><strong>Total</strong></td>
<td><strong>$2473.80</strong></td>
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<table>
<thead>
<tr>
<th>Disbursements April 1, 1968 - March 31, 1969</th>
<th></th>
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<tbody>
<tr>
<td>1. John J. Chapman—Meeting Expense</td>
<td>44.68</td>
</tr>
<tr>
<td>2. Tom Hecox—Talent Search</td>
<td>3.60</td>
</tr>
<tr>
<td>3. William Adams—Talent Search</td>
<td>3.60</td>
</tr>
<tr>
<td>5. U. of A.—Photoduplication of Proceedings</td>
<td>27.00</td>
</tr>
<tr>
<td>6. U. of A. Bookstore—Supplies</td>
<td>9.30</td>
</tr>
<tr>
<td>7. Fayetteville Building &amp; Loan—transfer to Reserve Fund</td>
<td>800.00</td>
</tr>
<tr>
<td>8. E. E. Hudson—Junior Academy Expenses</td>
<td>200.00</td>
</tr>
<tr>
<td>9. Marilyn Johnson—Postage</td>
<td>16.00</td>
</tr>
<tr>
<td>10. Marilyn Johnson—Postage</td>
<td>5.00</td>
</tr>
<tr>
<td>11. Leo Paulissen—Talent Search</td>
<td>3.64</td>
</tr>
<tr>
<td>12. Marilyn Johnson—Post office box rental and postage</td>
<td>7.50</td>
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<tr>
<td>13. U. of A.—Printing of cards</td>
<td>8.50</td>
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<tr>
<td>15. Southwest Printing Co.—Proceedings</td>
<td>1045.04</td>
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<tr>
<td>17. AAAS—Annual Contribution</td>
<td>6.00</td>
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<tr>
<td>21. U. of A. Bookstore—Supplies</td>
<td>9.68</td>
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<tr>
<td>22. Ark. Industrial Development Comm.—Directory</td>
<td>10.00</td>
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<tr>
<td>23. Myrna Ashorn—Postage</td>
<td>30.00</td>
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<tr>
<td>24. U. of A.—Photoduplication of Proceedings</td>
<td>10.20</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$2387.03</strong></td>
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SUMMARY

<table>
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<tr>
<th>Item</th>
<th>Amount</th>
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</thead>
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<tr>
<td>Original Balance</td>
<td>$1777.14</td>
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<tr>
<td>Receipts</td>
<td>2473.80</td>
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<tr>
<td>Total Receipts</td>
<td>4250.94</td>
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<tr>
<td>Less Disbursements</td>
<td>2387.03</td>
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<tr>
<td>Balance</td>
<td>$1863.91</td>
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<tr>
<td>Reserve Fund</td>
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<td>Deposit in Reserve Fund</td>
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<tr>
<td>Interest on Reserve Fund</td>
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<tr>
<td>Balance</td>
<td>$1358.35</td>
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<tr>
<td>Total Assets April 1, 1969</td>
<td>$3222.26</td>
</tr>
</tbody>
</table>

JUNIOR ACADEMY OF SCIENCE:

Mr. E. E. Hudson reported on the activities of the Junior Academy. There are active chapters in 34 high schools with a total membership of 373 members. There were more than 60 papers presented by students in the regional competition and about 20 of these were presented at the state meeting held April 11, 1969, on the University of Arkansas campus. There are eight regions in the state. The majority of these have a college affiliated individual as director. Each member contributes fifty cents as dues which are retained within the region. The Senior Academy makes $200 available to support regional activities.

COLLEGIATE ACADEMY OF SCIENCE:

Dr. J. L. Wickliff, co-sponsor of the Collegiate Academy, reported on the activities of the group. The Collegiate Academy is solvent but there are only three campus chapters and only the chapter at Harding College is active. There has been an attempt to encourage research participation and the reporting of research at the annual meetings. There is a research award given for the best paper presentation in the physical sciences and in the biological sciences. One boy and one girl can also be recommended for junior membership in the AAAS.

Dr. Wickliff pointed out that the Academy had only 26 members in three chapters, and he felt that the Senior Academy needs to give the collegiate group more support if the Senior Academy feels the Collegiate Academy is worthwhile.

A lengthy discussion followed Dr. Wickliff's report. Several possible reorganizations were discussed and President Fry suggested that the membership give the problem some thought before the matter was discussed further at the next business meeting.
JUNIOR SCIENCES AND HUMANITIES SYMPOSIUM:

Dr. Eugene Wittlake, Director of the Symposium, reported for the Symposium and his report is summarized briefly below. The third symposium was held November 14-16, 1968. Sixty students and 39 teachers attended the sessions held at the Grady Manning Hotel and at the Arkansas Power and Light Co. Auditorium in Little Rock. Field trips to area industries as well as to educational and health facilities were held. Representatives of key Arkansas industries conducted lecture-discussions. Six student delegates were chosen from 25 students submitting papers to go to the National Symposium on April 30-May 3, 1969. Support for the Symposium comes from the Pine Bluff Arsenal and from state industries. A Planning Board, broadly representative of the Arkansas Academy, the Pine Bluff Arsenal, state industry, and secondary and higher education in Arkansas provides program planning and leadership for the Symposium.

(Dr. Wittlake's full report is a part of the secretary's record of the Business Meeting)

THE EDITOR, AAS PROCEEDINGS:

Dr. Howick reported that the editorial board has considered the policy of publication of papers presented by title only. The policy adopted by the editorial board is that only papers read at the annual meeting of the Academy will be considered for publication in the Proceedings.

The editorial board received a request from the Collegiate Academy to publish their Proceedings (including minutes, financial statement and abstracts of papers). The board recommends that the Collegiate Academy proceed to develop its own Proceedings. The editorial board will recommend that no more than $30 be made available to help the Collegiate Academy defray the expense of such a publication.

THE PRESIDENT:

Dr. Fry reported that the Academy had found someone willing to serve as director of the Cooperative College-School Science Curriculum Improvement Program. The Executive Committee was directed to proceed to prepare a proposal in 1969. The proposal can now be submitted although National Science Foundation funds may no longer be available.

A questionnaire was sent to members, high schools and participants regarding the Visiting Scientist Program. The response was small but the expression of interest high among those who responded. The Executive Committee reviewed the answers to the ques-
tionnaire and felt that interest was such that a commitment of funds by the Academy was not warranted for this year.

President Fry made the following committee appointments:

Future Meetings — Paul Sharrah and William W. Trigg
Nominations — Eugene B. Wittlake, Don England, Denver Prince
Audit — Robert W. Shideler and Alex Nisbet
Resolutions — M. L. Lawson and Dwight Moore

President Fry then introduced Dr. J. P. Jones, Chairman of the Constitution Revision Committee. Dr. Jones circulated a series of amendments to the constitution and by-laws. Dr. Jones then moved the adoption of the amendments to the constitution and by-laws and the motion was seconded. No action was taken at this business meeting and discussion was deferred.

The President adjourned the meeting at 12:05 p.m.

SECOND BUSINESS MEETING

The second business meeting was called to order by President Fry at 1 p.m., April 12, 1969. Before calling for reports, the President read a letter from Dr. George Templeton, retiring Secretary of the Academy. Dr. Templeton's letter follows:

Dear Dr. Fry:

Please express my regrets to the Academy members that I am unable to be with them during their annual meeting. I want to express my appreciation to all those with whom I have worked during the past five years for the cooperative, progressive attitudes they have all had. It is especially appropriate to thank the presidents with whom I have worked: Dr. Lowell Bailey, Dr. Jim Fribrough, Dr. Howard Moore, Dr. John Chapman, and you. Each has made a substantial step in our growth and development toward a more active, meaningful Academy, and I am grateful for having had the chance to work with them.

Best regards,

Sincerely,

George Templeton

Dr. Fry introduced Mr. Tom Pyron, Director of the State Science Fair, to make a report.
STATE SCIENCE FAIR:

Mr. Pyron reported that there had been 181 participants in the State Science Fairs. There were 8 categories in the junior and senior divisions. Twenty-seven first, second, and third place awards were given in the junior and senior divisions as well as 17 honorable mentions. There were two sweepstakes winners who were to go to the National Science Fair in Fort Worth.

President Fry then called for committee reports.

AUDIT COMMITTEE:

Dr. Shideler reported that his committee had examined the records and books of the Treasurer and found them to be true and accurate. It was moved and seconded that the report be accepted and the motion passed.

AD HOC COMMITTEE ON REVISION OF CONSTITUTION AND BY-LAWS:

Dr. J. P. Jones, chairman of the committee, discussed the amendments that the committee had proposed and circulated to the membership. A discussion regarding the wording of By-Law Number 12 as proposed by the committee followed. It was moved that the words "and approved" be stricken from the proposed By-Law to make it read as follows:

"The Academy shall sponsor such activities as it deems necessary to the furtherance of its objectives. All activities sponsored by the Academy shall be reviewed annually by the Executive Committee."

The amendment passed.

The President then called for a vote on the original motion of Dr. Jones as amended. The original motion had been introduced at the first business meeting. This motion to approve the amendments to the constitution and by-laws passed.

FUTURE MEETINGS COMMITTEE:

Dr. Trigg reported that the committee had considered several invitations and moved that the Academy accept invitations to meet as follows:

1970—Arkansas Polytechnic College—Russellville
(approved at 1968 meeting)
1971—Harding College, Searcy.
1972—University of Arkansas, Fayetteville
1973—State College of Arkansas, Conway
Dr. Trigg pointed out that both Harding and State College invited the Academy for 1971. Since Harding College had not had a meeting recently, the committee proposed that this invitation be accepted. Representatives of State College of Arkansas assured the Academy that their invitation would extend to 1973.

It was moved and seconded that the report be accepted. The motion passed.

**NOMINATIONS COMMITTEE:**

Dr. Wittlake reported for the committee that the following were being nominated for election to office:

President-elect—Professor Robert Kirkwood, State College of Arkansas.

Secretary—Dr. W. C. Guest, University of Arkansas

Historian—Dr. Dwight Moore, El Dorado, Arkansas

It was moved and seconded that nominations cease and the above officers were elected by acclamation.

**AAAS FELLOWS COMMITTEE:**

Dr. Clayton reported for the committee. The membership of the Academy was checked by the Business Manager of AAAS and 42 Academy members are also members of the AAAS and 16 Academy members are Fellows of the AAAS.

The committee recommended the nomination of Dr. Leo Paulissen and Dr. Lester Howick for fellowship in the AAAS. It was moved and seconded that the committee report be accepted. The motion passed.

**RESOLUTIONS COMMITTEE:**

Professor Lawson moved the adoption of the following resolutions:

1. Be it resolved that the secretary express written appreciation to Dr. Mullins and the administrative staff for the arrangements and use of facilities here at the University for holding our annual meeting.

2. Be it resolved that a letter of appreciation be sent to Dr. George Templeton expressing the appreciation of the Academy of Science and other activities related to the Academy, and for the high quality of that service.
3. Be it resolved that this assembly express to Dr. Fry its appreciation for his excellent direction of the Academy during the past year by giving him a rousing hand. The three resolutions passed unanimously.

OTHER BUSINESS:

President Fry discussed Senior Academy support of the Junior Academy. For the past year $200 was made available to the Junior Academy and the President relayed Mr. Hudson's request for continuation of this support. Dr. Bailey moved that a grant of $200 be awarded to the Junior Academy. The motion was seconded and the motion passed.

Dr. Fry briefly discussed the Visiting Scientist Program. The response to the questionnaire was favorable but the problems are financial. The program was supported by NSF for several years and for a brief period by the Valley Education and Research Foundation. The program started again in 1968 but was terminated because of lack of financial support. It was moved and seconded that the executive committee continue to explore means by which the Visiting Scientist Program might be continued in some form. The motion carried.

President Fry summarized the discussion of the previous day concerning the Collegiate Academy. He pointed out that it is not clear what responsibility the Senior Academy has with regard to the Collegiate Academy. Following the discussion Dr. Howick moved that the Academy go on record in support of the aims and objectives of the Collegiate Academy and empower the executive committee to study various ways to revitalize the Collegiate Academy. He further moved that the Academy provide a thirty dollar grant to the Collegiate Academy to assist in the publication of the Collegiate Proceedings including the minutes, financial statement and abstracts of papers presented at the annual meeting. The motion was seconded. In the discussion of the motion it was pointed out that the motion does not specify where the Collegiate Proceedings are to be published. The motion carried.

Dr. Bailey then moved to publish the minutes, financial statement, and abstracts in the Academy Proceedings this year and that this policy be continued until such time as the Senior Academy votes to discontinue it. The motion was seconded and the motion passed.

President Fry then introduced incoming President M. L. Lawson who adjourned the meeting at 2:27 p.m.
GUIDELINES FOR AUTHORS

Eligibility of publication in the Proceedings is limited to those papers which have been presented at the annual meeting by one of the authors. In addition, at least one of the authors must be a member of the Academy except that the Editorial Board is authorized to accept articles for publication from invited speakers. In all cases manuscripts must be presented to the section chairmen at the time of the reading of the paper. The Editorial Board reserves the right to edit, shorten, or reject any papers submitted to it. In general, all submitted papers will be reviewed by persons competent in the area of study.

Manuscripts should be clearly typewritten, double spaced throughout, with the format followed being that of a commonly used journal in the area of study. Illustrations may be used but special care should be exercised to insure that drawings and photographs are of the highest quality. Such illustrations should be properly proportioned to fit the Proceedings page and lettering should be large enough to be legible upon size reduction. Manuscripts will normally be limited to ten (Proceedings) pages with pages in excess of this being charged to the author at cost. In addition, authors may be expected to bear charges arising from exceptional typesetting or illustration.

The Editor will inform authors of the arrangements for ordering reprints and of the cost of reprints at the time that corrected page proofs are prepared.
PROGRAM

ARKANSAS ACADEMY OF SCIENCE

Fifty-Third Annual Meeting

University of Arkansas
Fayetteville, Arkansas

Friday, April 11

9:00 a.m. to 4:00 p.m. SENIOR COLLEGIATE ACADEMY—Registration

9:00 a.m. to 12:00 noon JUNIOR ACADEMY—Registration

9:30 a.m. to 10:30 a.m. COLLEGIATE ACADEMY—Executive Committee Meeting

9:30 a.m. to 10:30 a.m. SENIOR ACADEMY—Executive Committee Meeting

9:30 a.m. to 10:30 a.m. SENIOR ACADEMY—Editorial Board Meeting

10:45 a.m. to 12:00 noon SENIOR ACADEMY—Business Meeting

11:00 a.m. to 12:00 noon NASA SPACEMOBILE

10:30 a.m. JUNIOR ACADEMY—Mixer

11:15 a.m. to 12:00 noon COLLEGIATE ACADEMY—Business Meeting

12:00 p.m. to 1:00 p.m. LUNCH HOUR—Unscheduled

2:30 p.m. to 4:30 p.m. SEFOR FACILITIES TOUR

1:00 p.m. to 4:00 p.m. JUNIOR ACADEMY—Section Meetings

1:00 p.m. to 3:00 p.m. PHYSICAL SCIENCE

1:00 p.m. to 3:00 p.m. BIOLOGICAL SCIENCE

1:00 p.m. to 3:00 p.m. GENERAL SCIENCE

1:30 p.m. to 4:00 p.m. SCIENCE BUILDING DEDICATION

1:00 p.m. to 4:00 p.m. OPEN HOUSE
2:00 p.m. to 4:30 p.m. \textbf{COLLEGIATE ACADEMY—Section Meetings}

- Physical Science Section
- Biological Science Section

2:00 p.m. to \textbf{5:30 p.m.} \textbf{EDUCATIONAL TV DISPLAY}

3:30 p.m. to 5:00 p.m. \textbf{SENIOR ACADEMY—Science Education Section}

4:00 p.m. to \textbf{5:30 p.m.} \textbf{SCIENCE FAIR}

5:30 p.m. to 7:00 p.m. \textbf{JUNIOR ACADEMY—Picnic Dinner}

5:30 p.m. to 7:00 p.m. \textbf{SENIOR ACADEMY—Banquet}

7:00 p.m. to \textbf{9:30 p.m.} \textbf{SCIENCE FAIR}

\textbf{Saturday, April 12}

7:30 a.m. to 9:00 a.m. \textbf{ARKANSAS SCIENCE TEACHERS ASSOCIATION—Breakfast}

8:00 a.m. to \textbf{10:00 a.m.} \textbf{SCIENCE FAIR}

10:00 a.m. to \textbf{12:00 noon} \textbf{SENIOR ACADEMY—Section Meetings}

- Archeology and Anthropology
- Biology and Agriculture
- Chemistry
- Geology
- Mathematics

*Physics—Joint meeting with Arkansas-Oklahoma-Kansas Section of American Association of Physics Teachers

\textbf{*Archeology and Anthropology Section and Physics Section begin at 9:00 a.m.*}
12:00 noon to LUNCH HOUR—Unscheduled
1:00 p.m.
1:00 p.m. to SENIOR ACADEMY—Business Meeting
2:00 p.m.
2:00 p.m. to SENIOR ACADEMY—Section Meetings
4:00 p.m. Biology and Agriculture

PHYSICAL SCIENCES SECTION

PRESIDING: Tom Goodwin

“Synthesis of and Hydrolysis Studies on 6,8-Dichloro-2-Methylbenzisoxazinone.” Pat Lyon

“Synthesis and Reversible Inhibitory Effects of Some 1,1-Cycloalkyldicarboxylic Acids on Succinic Dehydrogenase.” James Word

“The Synthesis and Attempted Reductive Cyclization of 2-Pyridalidiacetophenone.” Robert Higbee

“Meteoritic Material from Hopewell Indian Burial Mounds: Investigation of Possible Sources.” Sally P. Sedwick

“Construction and Calibration of a Light Source for Prep-Scale Photochemical Reactions.” H. Barager and T. D. Roberts

“Features of the Lunar Surface.” Robert F. George

“Synthesis and Solvolytic Studies of Methylene and Dimethylene-Norbornyl Benzoates.” Gene DeBons and D. E. Gwynn

BIOLOGICAL SCIENCES SECTION

PRESIDING: Harold Betton

“Intraspecific and Interspecific Growth Patterns in 14 Members of the Genus, Bacillus.” Harold B. Betton

“Determination of the Contribution of Nitrogen Fixed by Nodules to Growth of Green-Snap Bean Variety, Richgreen.” Harold B. Betton

“Discrimination and Preference in Texture in Albino Rats.” Darrell F. Brown
SCIENCE EDUCATION SECTION
PRESIDING: Don England
Opening remarks by presiding officer.
"An Undergraduate Research Program at Philander Smith College." James O. Wear
"A Survey of High School Chemistry in Northeast Arkansas and Southeast Missouri." William H. Ponder
"The Uses of Educational Television." Richard R. Shurtz
Business Meeting

ARCHEOLOGY AND ANTHROPOLOGY SECTION
PRESIDING: Michael P. Hoffman
"Experiments in Aerial Photography." Dan Printup
"Controlled Surface Collections at the Spinach Patch Site, 3FR1." Michael P. Hoffman
"Implications of Land and Fresh Water Gastropods in Archeological Sites." John Clark
Coffee break.
"Preliminary Description of the Blue Snake Society." Diana Weathersby
"Skeletal Analysis of Three Bluff Shelter Burials." Eugene Hickman
"The Type-Variety Concept: A Possible Indicator of Diffusion and Culture Areas." John B. Huner
Business Meeting

BIOLOGY AND AGRICULTURE SECTION
CHAIRMAN: H. Jack Walters
ZOOLOGY SESSION—Presiding: Phil Rouse
"Analysis of Regurgitated Food from the Cattle Egret Babulcus ibis and the Little Blue Heron Florida caerulea from the Luxora Heronry in Mississippi County, Arkansas." Earl L. Hanebrink and Gene Denton
"Electrophoretic Patterns of Plasma Proteins and Hemoglobin of the Pigeon Columba livia domestica." Dale Snow, Earl L. Hanebrink, and Bob Johnson
"Spiders Collected from Mud-Dauber Nests in Clark County, Arkansas." Peggy Rae Dorris

"An Addition to the List of Spiders Collected in Clark County, Arkansas." Peggy Rae Dorris

"Preliminary Study of the Small Mammals of Northeast Arkansas." J. Maxine Hite

"Histochemistry and Ultrastructure of Some Elapid Venom Glands." Max A. Nickerson

"Hemolysis by Crotalus horridus atricaudatus Venom." Franklin E. Byrd and Bob D. Johnson

"A Survey of the Helminth Parasites of Selected Game Fishes of Lake Fort Smith, Arkansas." David A. Becker and Walter C. Houghton

"Direct and/or Indirect Effects of Domestic and Oil Refinery Effluents on Meristic and Morphometric Characteristics of Three Cyprinid Fishes." John K. Beadles

"The Oxygen Regime of Some Arkansas Reservoirs." Joe E. Nix

"A Preliminary Investigation of the Siphonaptera of Craighead County, Arkansas." G L. McCrackin

"The Pieridae of Arkansas." Phil Rouse

"Metabolic Responses of White Rats to Glucose or Fructose Fed with two Safflower Oils Containing Different Proportions of Fatty Acids." Paula Lynn Yates

Biology and Agriculture Section Business Meeting

BOTANY SESSION—Presiding: H. Jack Walters

"Note on Digitaria sanguinalis and D. adscendens (Gramineae) in Arkansas." Albert Robinson, Jr.

"A Morphological Study of the Quercus stellata (Fagaceae) Complex." Freeman Thomas

"A Seed Study in a Section of the Genus Penstemon (Scrophulariaceae)." Aileen L McWilliams

"A Survey of the Arkansas Campanulaceae (including the Lobeliaceae)." Edwin B. Smith

"Growth Patterns in Bacillus stearothermophilus." Harold Betton

"Notes on the Responses of Perilla frutescens (L.) Britt. var. frutescens to Controlled Environments." S. A. Covington
“Effect of Culture Environment upon Sporangium and Zoospore Production of three Species of Phytophthora.” James L. Dale and J. P. Jones

“The Forest Vegetation and Soils of Selected Sites near Lake Wedington, Washington County, Arkansas.” John T. Youree

“Some Noteworthy Species of the Arkansas Flora.” Gary Tucker

“Relationships of the Bean Leaf Beetle to Cowpea Strain of Southern Bean Mosaic Virus.” Don Henry and H. J. Walters

“The Geography of the Mosses of the Interior Highlands.” Paul L. Redfearn

“Correlations between Vegetation and Soil Factors in the Slymore District, Ozark National Forest, Stone County, Arkansas.” Thomas L. Foti


“A Study of the Herbaceous Vascular Plants from Selected Sites in Faulkner County, Arkansas.” Sara Miles Barnett

“Fossil Phylloxerid Plant Galls from the Lower Eocene.” Eugene B. Wittlake

“Dardanelle Reservoir Illinois Bayou Embayment Background Survey.” Clarence B. Sinclair


“The South Arkansas Arboretum at El Dorado.” Dwight M. Moore

CHEMISTRY SECTION
CHAIRMAN: Donald E. Gwynn

ORGANIC SESSION—Presiding: T. D. Roberts


Discussion of Paper.

“On the Preparation and Properties of Some 1,1'-Diphenyl-syn,trans-Truxane Derivatives.” Frank Setliff

Discussion of Paper.

Discussion of Paper.

"Studies on the Carbon-Hydrogen Insertion Reaction of Divalent Carbon Intermediates." Jerry D. Collins and Donald E. Gwynn

Discussion of Paper.

"A Carbon-14 Kinetic Isotope Effect Study of the Mechanism of the Oxidation of p-Substituted Acetophenones with m-Chloroperbenzoic Acid." Billy Palmer and Arthur Fry

Discussion of Paper.

"Total Synthesis of Hinokiol." Anthony W. McCollum and Walter L. Meyer

Discussion of Paper.

Chemistry Section Meeting

GENERAL SESSION—Presiding: Dale A. Johnson

"Subsite Mapping of Enzyme." Charles Brothers and John A. Thoma

Discussion of Paper.

"The Structures and Properties of \( P_4S_3I_2 \)." Gary Hunt and A. W. Cordes

Discussion of Paper.

"Photochemical Nitro-nitrito Linkage Isomerization in Co(III) Complexes." Dale A. Johnson and Walter H. Delphijn

Discussion of Paper.

"Lysozyme Catalysis." G. V. K. Rao and John A. Thoma

Discussion of Paper.

"Variation of the Strontium Isotope Ratios in the Atmosphere and Their Application in Tracer Studies." Wilson W. Cooper and P. K. Kuroda

Discussion of Paper.

"Determination of Sulfhydryl in Proteins Using an Ion Sensitive Electrode." Wilbur W. Everett and Leon Johnson

Discussion of Paper.
GEOLOGY SECTION
CHAIRMAN: Orville A. Wise

"Biostratigraphy of the Morrow Group." J. H. Quinn

"Biostratigraphy of Peccary Cave." L. C. Davis

"Origin of Continental Granitic Crust—An Hypothesis." K. C. Jackson

"Facies Complexes in the Marble Falls Formation of Central Texas." D. L. Zachery

"Middle Archaic—Complex in N.W. Arkansas." M. A. Beckmon

"Water Resources of Arkansas." S. Keith Jackson

"Engineering Geology—Foundation Design, Excavation and Treatment of Concrete Dam Structures." Robert A. Anderson

Business Meeting

MATHEMATICS SECTION
CHAIRMAN: William R. Orton

"An Exact Test for Simple Correlation in Analysis of Dispersion." James E. Dunn

"Semi Groups." Mrs. Barbara Alexander

"The P-adics." William Coker

"Near-rings." Kathleen Stell

Business Meeting

PHYSICS SECTION
CHAIRMAN: Glenn T. Clayton

Joint Meeting with Arkansas-Oklahoma-Kansas Section of American Association of Physics Teachers.

"Computer Assisted Instruction." Guenter Schwarz

"The Introductory Laboratory." Robert B. Bennett

Coffee Break

"The Making of Short, 4 minute, Cartridge Films for Teaching" Guenter Schwarz

"Education and Manpower of the American Institute of Physics and the Society of Physics Students." Cecil G. Shugart
Business Meeting of AOK AAPT.

"Molecular Photo Dissociation." Charles J. Broncho

"A Distribution of Photo Electrons Above A Metallic Surface When Irradiated by Black Body Radiation." Hal E. McCloud

"Pulsed Magnetic Resonance in Cesium Fluoride." Darrell Hutchins

"What is Statistical Mechanics?" Arthur Hobson

"An Application of the Curie Principle to the Coupling Between Mass Transport and Chemical Reaction in an Open System." O. C. Mikulecky

"Optical-Ionization Excitation Functions of Mercury and Cadmium by Electron Impact." R. J. Anderson, J. Rowe, and J. Hester

"Production of H-Atoms in the 3s State by Fast Ground State H-Atom Impact." A. Filippelli and H. Petefish

Business Meeting
ARKANSAS COLLEGIATE ACADEMY OF SCIENCE
Annual Meeting April 11, 1969
Fayetteville, Arkansas

OFFICERS
President .................. Tom Goodwin, Ouachita Baptist University
President-Elect .......... Cynthia Wilson, Quachita Baptist University
Secretary-Treasurer ...... Harold Betton, University of Arkansas
Advisors .................. Dr. J. L. Wickliff, University of Arkansas
                       Dr. Joe F. Nix, Ouachita Baptist University

REPORT OF THE GENERAL BUSINESS MEETING

The annual meeting of the Arkansas Collegiate Academy of Science was called to order by President Goodwin at 11:15 a.m. in Room 220, University of Arkansas Student Union.

As the first item of business, members present recognized Cynthia Wilson (Ouachita Baptist University) and Harold Betton (University of Arkansas) for meritorious service to the Collegiate Academy and requested the advisors, Dr. Wickliff and Dr. Nix, to recommend to the Senior Academy these two students as recipients of one-year honorary junior memberships in the American Association for the Advancement of Science.

New officers elected to serve for the year 1969-70 are:
President—Cynthia Wilson, Ouachita Baptist University
President-Elect—Gary Linquist, University of Arkansas
Secretary-Treasurer—David Roll, Harding College
Advisors—Dr. Joe F. Nix, Ouachita Baptist University
                       Dr. Don England, Harding College

New business included a discussion on how to make the Collegiate Academy more attractive to students. It was suggested that a seminar program on the individual campuses which involved visiting professors from other state campuses (invited by the appropriate departmental chairmen) might help achieve student interest in the Collegiate Academy activities. Student representatives designated to assist such a program organization on their respective campuses are: David Roll, Harding College; Richard Brown, University of Arkansas; and Cynthia Wilson, Quachita Baptist University.
SUMMARY FINANCIAL STATEMENT

Balance Deposited April 19, 1968  $131.25

Receipts:
1. Dues collected at 1968 meeting  26.00
2. Dues collected 1968-69  70.00
3. Dues for 1969-70 collected at 1969 meeting  42.00
   Total  $269.25

Disbursements:
1. Travel expenses for officers to 1968 meeting  39.10
2. Operating supplies  50.61
3. Awards for best paper presentations at 1968 meeting (two subscriptions to *Scientific American*)  16.00
   Total  $105.71

Total Receipts  $269.25
Less Disbursements  105.71
Balance Transferred to New Treasurer  $163.54
ARKANSAS COLLEGIATE ACADEMY OF SCIENCE
Abstracts of Papers Presented April 11, 1969

PHYSICAL SCIENCES SECTION

SYNTHESIS OF AND HYDROLYSIS STUDIES ON 6,8-DICHLORO-2-METHYLBENZISOXAZINONE. Pat Lyon, Harding College.

The compound 3,5-dichloro-2-aminobenzoic acid was prepared by the chlorination of anthranilic acid. This compound was reacted with acetic anhydride to give the desired 6,8-dichloro-2-methylbenzisoxazinone (I) which was recrystallized from anhydrous solvents and characterized.

(1)

\[
\begin{align*}
&\text{Cl} \\
&\text{Cl} \\
&\text{N} \\
&\text{CH}_3 \\
&\text{O} \\
&\text{O}
\end{align*}
\]

Studies on the characterization of (I) and the identification of products resulting from its hydrolysis in aqueous solvents will be noted.

SYNTHESIS AND REVERSIBLE INHIBITORY EFFECTS OF SOME 1,1-CYCLOALKYLDICARBOXYLIC ACIDS ON SUCCINIC DEHYDROGENASE. James Word, Harding College.

The reversible inhibitory effect of malonic acid on succinic dehydrogenase in the conversion of succinic acid to fumaric acid of the Citric Acid Cycle is well known. Some simple 1,1-cycloalkylidicarboxylic acids have been synthesized for the purpose of studying their malonic acid-type inhibitory effect on this enzyme system of Escherichia coli.

The synthesis of these dicarboxylic acids and a preliminary report on the biological activities of these compounds will be given. An attempt will be made to correlate biological activity with chemical structure.


The compound 2-pyridaldiacetophenone (I) was obtained in small yield as the Mannich addition product in the base promoted condensation of 2-pyridinecarboxaldehyde with acetophenone. The yield of (I) was increased by adjustment of the reaction conditions.
Reductive cyclization was attempted on (I) using PtO$_2$ catalyst and 50 p.s.i. hydrogen pressure in ethanol. Thin-layer chromatography of the reduction product indicated three components two of low yield and one of high yield. Elution chromatographic separation of the components followed by infrared spectral investigations showed the components to be ketonic, non-hydroxylic, and differing from the reaction starting material. Structures for the reduction reaction products will be proposed.

Meteoritic Material from Hopewell Burial Mounds: Investigation of Possible Sources. Sally P. Sedwick, University of Arkansas.

(Guest paper)


(Guest paper)


(Guest paper)


(Guest paper)

Biological Science Section

Intraspecific and Interspecific Growth Patterns in 14 Members of the Genus, Bacillus. Harold B. Betton, University of Arkansas.

Investigations of growth patterns of several bacteria in the genus Bacillus have been made to elucidate any standard growth pattern which might exist among the members of this genus. Growth
assays involved turbidimetric measurements as a function of time. Growth curves of bacterial isolates of the same species prove to be similar, but not identical. One important fact is that not all of the bacteria in this genus show similar growth curves at the same temperature (29°C. in these experiments). Studies were made of the following Bacillus species: B. lacterosporus, B. cereus, B. subtilis, B. megaterium, B. cereus var. mycoides, B. licheniformis, B. polymyxa, B. firmus, and B. stérothermophilus.

*B. licheniformis* demonstrated a significant reduction in turbidity between 8 and 24 hours, somewhat like the 3 isolates of *B. cereus*, but the drop in turbidity was much more exaggerated in the *B. licheniformis* growth curve. All of the bacteria showing reduction in turbidity showed a high rise in turbidity after the crucial period (8 to 24 hours). This high rise is probably due to the germination of spores released during the 8 to 24 hour period.

**DETERMINATION OF THE CONTRIBUTION OF NITROGEN FIXED BY NODULES TO THE GROWTH OF GREEN SNAP BEAN VARIETY, RICHGREEN.** *Harold B. Betton, University of Arkansas.*

The contribution of nitrogen fixed by *Rhizobium phaseoli* (ATTC No. 14482) to the growth of *Phaseolus vulgaris* var. Richgreen has been investigated employing a novel assay method. The method involved chlorophyll content of the plant as an indirect indicator of nitrogen fixed. Although no documented evidence was found supporting such a technique, the data indicate that differences in chlorophyll give definite correlations with nitrogen content. Results show that the rate of plant growth is somewhat independent of the amount of bacteria to which they are exposed. However, more chlorophyll is found in leaves of plants root-inoculated with low levels of bacteria (ca. 160,000 cells) than in plants exposed to larger inocula.
EXPERIMENTS IN AERIAL PHOTOGRAPHY

Dan Printup

Arkansas Archeological Survey, Fayetteville, Arkansas

In recent years ancient roads, walled areas, architectural features, long forgotten works of man, have been discovered, often accidentally, as a result of aerial reconnaissance. Improved equipment, aircraft, cameras, and materials have made it possible to photograph these areas and produce valuable prints for laboratory analysis. Dr. W. B. McCoy, Department of Civil Engineering, University of Saskatchewan, in a paper presented at the Sixth Annual Saskatchewan Archaeological Society Meeting, offered several suggestions for the use of aerial photography in archeology (1968). He particularly mentioned the work at Louisbourg, an 18th century French fortress on Cape Breton Island. The site is being restored by the Canadian Government as a National Park, and aerial photographs were used in delineating and exploring the fortress area (McCoy 1968).

The value of aerial photography to archeological research has been recognized for some time, but the cost of equipment and trained personnel has limited its use by those with small resources of money and equipment. Some excellent work has been done by a few, but the obstacles have discouraged too many of us. In the early summer of 1968 an opportunity arose for some experiments of this nature in connection with archeological work being done in northwest Arkansas in the Ozark Reservoir, under a cooperative agreement between the University of Arkansas Museum and the National Park Service, Southeast Region (Hoffman 1968).

In the latter part of May and early June, 1968, two aerial flights were arranged by the University of Arkansas Museum for the purpose of photographing certain archeological sites in the Ozark Reservoir. It was hoped that the resulting photographs would reveal additional information that would supplement that already obtained during surface investigations of these sites (Hoffman 1965). I agreed to handle the photographic chores, although my previous experience in aerial photography had been limited to making a few color slides of sites on which I had worked. These slides were used to show the general lay of the land and appearance of the areas, and not for analysis of details of the sites.
AIRCRAFT

The aircraft used on both flights in 1968 was a high wing, single engine Aero Commander. The door on the right (the photographer's side) was removed to give an unobstructed view and to avoid reflections. This necessitated sitting far enough back from the opening to prevent prop-wash hitting the camera. It goes without saying that the cameras were secured by straps. A seat belt gave the photographer a small feeling of security.

CAMERAS AND FILM

The cameras used were a Retina III, with a 50mm. f:1.9 Schneider lens, and a Contaflex I, with a 45mm. f:2.8 Zeiss Tessar lens. The films used were Kodachrome II, Plus-X Pan, and Kodak Infrared. A skylight filter was used with the Plus-X film, and a No. 25(A) with the IR 135 (infrared).

Subjects of the same visual appearance may be quite different in the amount of infrared radiation that they emit. Infrared film used without a filter will produce only "ordinary" results. To get the desired infrared effect, it is necessary to use a filter over the lens (or the light source) in order to eliminate the blue light to which the film is also sensitive. In the case of the red filter used with the infrared film the exposure time is increased considerably. Visual and infrared rays do not focus in the same plane. Unless the camera has a setting for infrared it is usually necessary to compensate for this difference. From the distance at which we were working in the Ozark Reservoir, with relatively short focus lenses, this was no problem. The camera was set on infinity, and the results were good.

EXPOSURES

Since the sites to be photographed were in cultivated bottomland along the Mulberry River, with no elevations that might be delineated by shadows, both flights were made toward the middle of the day. At the time of the first flight the weather was clear, and soil conditions were good, although there was some water standing in the fields. Too much water results in a loss of visible detail on ground surfaces, and completely arid conditions are even worse. Differences in soil colors (often significant in archeological work) are most visible when the ground has been wet and has partially dried. This is particularly true when one is checking old stream channels from the air. The old stream beds are quite visible when they are still
moist and the higher areas bordering them have dried out. They are best seen, of course, on relatively level cultivated land.

On the first flight Kodachrome II was used in the Retina. Exposures were at 1/250 second at f:5.6; one stop smaller would have given better exposures. The built-in exposure meter could not be relied upon, as the slight bumping of the plane caused too much fluctuation of the indicator needle.

Plus-X film was used in the Contaflex on the flight. Good exposures were obtained at 1/500 second at f:8, with the skylight filter.

The weather was partly cloudy at the time of the second flight, but the site areas were clear for the first part of the flight. On this flight Plus-X film was used in the Retina, with a skylight filter, and IR 135 (infrared) in the Contaflex with the No. 25 filter.

In the publication *Kodak Black and White Films in Rolls* (Eastman Kodak Company 1967), the manufacturers explain that, since photoelectric cells measure only visible light and this may vary considerably from infrared radiation from the same area, it is impossible to give exact data for exposing infrared film. On the basis of a suggested trial exposure our infrared pictures were taken at 1/250 second at f:2.8, using the No. 25 filter. (The advantage of using a fine lens such as the Zeiss Tessar is that it will give excellent definition at full aperture.) Our results were very good.

All shots were necessarily oblique because they were made through the plane door, with the camera held inside the plane. Altitudes were between 200 and 500 feet.

**RESULTS**

The results of our aerial photography were rewarding (Hoffman 1968: 10), the infrared film brought out some elements that were not picked up by the Plus-X film. This was particularly true at the Spinach Patch Site (3FR1) where the infrared pictures suggested there may have been a second mound in addition to the one already recognized on the surface and from Plus-X photographs made during the first flight (Hoffman 1968: 3). What looked like a featureless sandy area when we flew over the Natural Levee Site (3FR33) showed some soil discolorations in the Plus-X pictures. These discolorations were much more noticeable in the infrared photographs. The aerial photographs suggested that the River Bank Site (3FR23) extended into an area that had not been recognized
during surface investigations. This has since been confirmed by surface examination.

At the Spinach Patch Site the soil was drier at the time of the second flight (when infrared film was used), and this usually results in a loss of detail. Even so, the infrared photographs showed more detail than did the Plus-X pictures made under more moist conditions. It is possible, of course, by manipulations during printing to produce pictures from the same negative that look quite different from each other. In processing the film from these flights and printing the pictures every effort was made to get "normal" prints with no exaggeration of any aspect.

**SUGGESTIONS**

Although we were pleased with the results of our first aerial reconnaissance, there are several points that deserve consideration before additional flights are made:

1. If possible, flights for aerial photographic purposes should be made on clear days. Although haze penetration is one of the qualities of infrared film, ground shadows cast by clouds were quite dark in prints. This would seem to indicate that the cloud cover had obstructed the infrared as well as the visual rays.

2. Unless the photographer and pilot are familiar with the area being photographed, it would be helpful to have ground markers delineating the area of interest. Strips of white cloth of known length would give scale as well as location.

3. While a 50mm. lens with an angle of approximately 46 degrees does well enough in showing a large site, it necessitates flying too low in order to get a large image of a small area. Most of our pictures were made at around 400 feet altitude; an effort to get a larger image at the Spinach Patch Site from about 200 feet was unsuccessful.

Using a 45mm. lens from about 400 feet altitude we got good over-all pictures of the Spinach Patch Site and adjacent areas. Had we then switched to a 135mm. lens we could have made detailed pictures of specific areas. These would have been more useful in analyzing the site.

4. Excellent sketch maps can be made from aerial photographs, but detailed measurements are probably beyond the range of our equipment.
Another factor is safety. With lenses of suitable focal length there is no need to fly dangerously low.

The cameras that we have described are not ideal for aerial work. We have determined, however, that it is possible to do useful aerial reconnaissance without special equipment. The 135mm. lens might seem to be special, but anyone doing serious photographic work should have lenses of different focal lengths. The skylight filter is standard with many photographers who keep it on cameras in which ordinary film is used. It protects the lens and does not alter exposure requirements. The No. 25 filter is not an expensive item.

Obtaining the use of a plane is a bit more of a problem. All similar flights that I have made prior to the Ozark Reservoir have been in a plane owned by a friend who was interested in what we were doing. I know of several others who are sufficiently interested in the archeological work being done in their areas to contribute the use of their personal aircraft. Local flying schools would seem a good place to start trying to locate such persons.

Having discovered the possibility of doing relatively inexpensive aerial reconnaissance, we are hoping to use this archeological tool to good advantage during the coming season. We were pleased with the results obtained last summer, but additional experience will undoubtedly result in photographs of even greater archeological value.

REFERENCES CITED

Eastman Kodak Company

1967 

Hoffman, Michael P.

1965 An Archeological Survey of the Ozark Reservoir in West-Central Arkansas. Manuscript on deposit at the Southeast Archeological Center, Macon, and the University of Arkansas Museum, Fayetteville.

1968 Aerial Photography over Ozark Reservoir in West-Central Arkansas. Manuscript on deposit at the Southeast Archeological Center, Macon, and the University of Arkansas Museum, Fayetteville.

McCoy, W. B.

CONTROLLED SURFACE COLLECTION AT THE SPINACH PATCH SITE, FRANKLIN COUNTY, ARKANSAS
Michael P. Hoffman
Department of Anthropology, University of Arkansas, Fayetteville

PROBLEM
This paper discusses the technique of controlled surface collection as an interpretative aid at the Spinach Patch site, 3FR1, a prehistoric village site in Ozark Reservoir. The research involved was made possible through a cooperative agreement with the National Park Service, Southeast Region.

THEORY OF CONTROLLED SURFACE COLLECTION
The collection of objects from the surface of archaeological sites is a common, often preliminary, technique of archaeological investigation. Generally somewhat selective surface collection is done over an entire site area and the materials collected bagged and analyzed as a unit. This probably is an adequate technique for initially locating areas of past human habitation and judging the possible periods of occupancy, but it is lacking when attempts are made to make more complex temporal or social interpretations from the data. Gross whole site surface collections simply do not supply the information concerning intra-site debris variability which is necessary to judge continuity or discontinuity of occupation, site or component boundaries, micro-stylistic areas and functional activity areas. These faults of gross surface collections are nowhere illustrated better than in the Phillips, Ford, and Griffin work (1951) Archaeological Survey in the Lower Mississippi Alluvial Valley, 1940-1947, in which repeated gross surface collections were not adequate to evaluate the relationships of Baytown and Mississippian cultures when both clay- and shell-tempered sherds were present on a site. Any technique which increases the control of site surface collection potentially can be a more sensitive tool for archaeological interpretation.

Controlled surface collection is such a tool. Simply stated it is merely collecting everything on the surface from small intra-site spatial units of known location and comparatively analyzing and interpreting the material from them. The randomness (collecting everything) and small provenience units give the fine control.

In recent years the most extensive and effective use of the technique of controlled surface collection has occurred in Illinois and was initially stimulated by Lewis Binford, then of the University of Chicago (Morrell 1965; Binford et al. 1966). This technique,
as utilized in Illinois was directed to the problems of site boundary definition and determination of internal site structure. In the Carlyle Reservoir on the Kaskaskia River in southern Illinois, on several occasions, sites were plowed and allowed to be rained on before surface collecting. Then a grid system of 6-meter squares was established and everything within each of them was picked up and bagged as material from separate provenience units. The material recovered was categorized into groupings which were postulated to have functional or stylistic significance and the frequency in relation to location of the categorized items was compared. In several cases interpretations based on these data allowed fine component or activity separations within sites before excavation was begun.

THE SPINACH PATCH SITE

GENERAL DESCRIPTION

During the course of salvage archaeology in the Ozark Reservoir on the Arkansas River it was decided that controlled surface collection could potentially yield valuable information. The initial survey of the reservoir (Hoffman 1965) had as its basic aim the location of sites within or near the reservoir area, and only gross collection was attempted. This initial survey recommended thirteen sites for further investigation (Hoffman 1965: 35). Investigation was to be of three sorts—low level aerial photography of cultivated sites (see Printup, this volume) to determine site boundaries and features, controlled surface collections within sites and excavation based on the aerial photography, and excavation. The remainder of this paper deals with the controlled surface collection on one of these thirteen sites in Ozark Reservoir, the Spinach Patch site.

The Spinach Patch site is in the Mulberry River bottomland section of the Ozark Reservoir region. The whole bottomland is ideal for surface collecting because during the fall, winter, and spring months the soil there is kept perpetually raw by frequent plowing and discing. The lower terraces of the bottomland are almost all cultivated and site survey there can be relatively complete.

The Spinach Patch site, itself, (Figure 1) is in several ways an ideal location in which to use the technique of controlled surface collection. One reason is that natural features delimit the potential area of habitation on three sides, and the problem of delimiting site boundaries is not as difficult as in many locations. Another feature of this site is that nearly all previous collections indicate that only a single archaeological component, the Gober Complex, is represented. The latter fact acts as a control over the temporal element so that changes in the site over time are probably not responsible for internal variation. Still another ideal quality about the Spinach
Surface Collection at the Spinach Patch Site

Legend:
- Timber
- Terrace Edge
- Midden
- Railroad
- Area of Controlled Surface Collection
- Burial Area

SPINACH PATCH SITE
3FRI
Controlled Surface Collection

scale
20 meters
Patch site is that visual (both ground and aerial) inspection of the site reveals soil color differentiation which indicates areas of concentrated debris and organic material (midden) and an area of lighter soil enclosed by midden, which probably represented the plowed-down base of a burial mound. The surface collection was also made soon after an extensive rain at the site.

SITE PHYSIOGRAPHY

The site area is bounded on three sides by streams, while on the remaining side a railroad embankment presents a modern intrusion. Within this area enclosed by streams and the railroad there is an added factor of elevation, for most of the site and all of the midden is located on a terrace of land about 2 meters above the level of the stream banks. The terrace is highest and most apparent on the western edge of the site. There is also a slight rise of land near the center of the terrace which may indicate a mound destroyed by cultivation.

COLOR VARIATION

Two features of soil color variation were apparent from the ground surface—the boundary of the darkly stained midden area, and the lighter burial area enclosed by midden. The midden is located along the western side of the site, paralleling the western crest of the terrace. Surface observation of the midden gave an estimated length of approximately 300 meters for its north-south extent and from 50 to 80 meters for its east-west extent. Later aerial photography showed its east-west extent was somewhat underestimated by the surface survey. The soil outside the midden area had a light brown sandy consistency.

The burial area was roughly circular and had light tan sandy soil about 25 meters in diameter. It was located just north of the central portion of the midden and was elevated slightly above the surrounding midden.

METHODS OF COLLECTION

The methods for making the controlled surface collection were simple, considerably less elaborate, for instance, than Illinois practices, because of time and personnel limitations. The whole site area was first walked over and physiographic and soil color features were noted. Then areas of collection were delimited in order to obtain representative collections from the various sections of the site. Six east-west bands or zones were visualized in the entire site and collections were made from 3 squares within each band, an east square, a center square, and a west square. These zones were keyed to the meanderings of Sandy Branch on the east side of the site. Each collection area was 10 meters square. The procedure in collect-
ing was to pick up everything portable within the 10-meter square, although this did not prove entirely practical in the squares located in the midden which were littered with fire-cracked rock (squares 4, 17, 7, 10, 9, and 14).

ANALYSIS

One problem that occurred was the determination of categories of analysis. As the problems of a long time span or multiple components presumably were not present at the site, the categories of analysis were aimed at the interpretation of intra-site activity areas, such as burial, domestic, or farming activity areas. The categories used in this analysis were mainly those defined in the Ozark Reservoir Survey report (Hoffman 1965: 19-21).

What is locally called argillite refers to a dark gray stone with conchoidal fracture native to the Boston Mountains to the north of the Mulberry River bottomland. There is considerable controversy concerning the correct identification of the stone by archaeologists and geologists which does not concern us here. What does seem to be important about the stone as a raw material for artifacts is that it was not commonly used to make projectile points, drills, or other finely worked chipped stone tools which were normally made of chert; instead it was used mainly for more coarsely worked tools such as choppers, thicker knives, and, most characteristically, spades, many of which show bit polish. A great use of argillite is characteristic of the Gober Complex, of which the Spinach Patch site is a component, in the Ozark Reservoir region. Also the distribution of spades in the Ozark Reservoir suggests that they were associated with agricultural activities (Hoffman 1965: 74). Thus the presence of spades on a portion of a site, along with a relatively high frequency of argillite flakes (spade chips) would suggest agricultural activities. On the other hand, few spades and a relative paucity of argillite flakes would indicate non-agricultural activities.

Domestic activity in the site was considered to be indicated by fire-cracked rock, chert debitage, daub, potsherds, animal bone fragments, handstones, hammerstones, knives, choppers, and various raw materials used in the manufacturing of objects.

Material indicative of burial activity consisted of fragmentary human bones.

Gross counts of material collected work quite well to delimit the midden area of the site. If all the fire-cracked rock which litters the surface of the midden had been collected the contrast with other parts of the site would have been more dramatic. All the squares in the midden (4, 7, 9, 10, 14, and 17) had total numbers of items which significantly exceeded other squares with the exception of 2 other
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Table IV: Spinach Patch Site, 3FR1. Surface Collection Counts by item and area.
Surface Collection at the Spinach Patch Site

Squares, both of which had a high number of argillite chips. In all of the midden squares chert chips outnumber argillite chips while the opposite is true of squares with adequate samples and outside the midden. All the animal bone and potsherds occur within the midden squares. Fire-cracked rock occurred in profusion in all squares in the midden area.

The samples of other items which would represent domestic activities also occur mainly in the midden areas but the sample sizes are not large. Most of the chert knives come from these squares and all the chert choppers; most of the chert raw material and all of the argillite raw material do also. Handstones show an interesting distribution; the majority occur in squares outside the midden, a fact that suggests that some of the activities in which they were used were conducted outside of the immediate house area. Most of the projectile points come from the midden area, as does the sole piece of daub.

The burial area is easily discerned from the surface material by the presence of human bone fragments and a general lack of other debris.

Squares 1 and 3 at the north end of the site, though outside of the midden area, still were responsible for high totals of items collected. These totals, however, represent only a limited number of categories. The number of argillite chips predominate over chert chips by a 3 to 1 or higher ratio. In Square 1, 3 argillite spades were found and an argillite chopper (although none were found in Square 3). These facts suggest that the north central and northeastern portions of the site were used for a garden area. This argument is buttressed by negative facts — the absence of potsherds, bone, or many worked chert artifacts, all of which were present in the midden habitation area. The presence of handstones in this area may indicate, as has been stated, that some sort of plant processing occurred in the garden area.

Comparisons

A review of the surface collection made during the 1965 survey in nearby sites in the Mulberry River bottoms suggests that the nearby Mulberry Village and the Across from the Spinach Patch sites could be similar garden areas. On the Mulberry Village site (3FR22) 15 argillite and 8 chert chips were collected. The number of argillite spades was 2 and there were 2 sandstone hammerstones, both points of similarity with squares 1 and 3 of the Spinach Patch collection. No midden, no pottery, and no bone were present. The site character was described as, "extremely scattered cultural material over an area several hundred yards square" (Hoffman 1965: 40). The Across from the Spinach Patch site (3FR2) is similar to the Spinach Patch garden area in that there is a relatively large
number of argillite spades and other argillite tools, no midden, no bone, and no pottery, but unlike it in that chert chips outnumber argillite ones.

SUMMARY

A visual inspection and controlled surface collection of the Spinach Patch site have indicated that 3 functionally separate areas may be present. One is a habitation area visually demarcated by dark organically stained midden and littered with domestic trash — fire-cracked rock, pottery, animal bone, chert tools, and daub. One would expect to find indications of domestic structures here as well as storage and refuse pits and trash accumulations. In the lighter colored area with scattered human bones we would expect to find burials or the remains of partially plowed-out burials and perhaps indications that a mound was once present. The third functional area is in the north and northeast portion of the site, which reveals argillite debitage, argillite spades, and, negatively, a lack of midden and midden debris; this is the postulated garden area. Excavation here might reveal soil disturbances resulting from past cultivation.

Both aerial photography (Hoffman 1968) and test excavation have occurred at the Spinach Patch site since the controlled surface collections. The aerial photographs confirmed postulates made on the basis of surface collections and suggested additional intra-site structural details (such as the presence of 2 mounds and a plaza area). Minor excavation at the site confirmed the burial/habitation area distinction but no excavation has yet been attempted in the postulated garden area.

The technique of controlled surface collection should become more common in Arkansas, for it can be brought to bear on a number of problems. The Spinach Patch case illustrates its usefulness in postulating activity areas within a single component site. I would particularly recommend its use as a guide for the placement of excavations, as a second step after initial location and collection from a site.

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IMPLICATIONS OF LAND AND FRESH-WATER GASTROPODS IN ARCHEOLOGICAL SITES

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Snails have been of passing interest to a few archeologists in the New and Old Worlds. Archeologists have recognized their presence in archeological sites in all parts of the world. In some cases, the archeologists supposed that snails must have been eaten and, in a very few cases, archeologists have had snails identified and occasionally have drawn ecological significance from certain species. This paper is an attempt to describe snails and their significance to archeological studies. Land and fresh-water snails are members of the phylum Mollusca. They belong to the class Gastropoda, the subclass Pulmonata, the order Stylommatophora and the families Polygyridae, Bulimulidae, Archatinidae, Oleacinidae, Zonitidae and Helicinidae (Burch 1962).

The most characteristic aspect of the snail is its shell. It may be conical, pupiform, discoidal or turreted, but it always has a columella. Like all mollusks, they have a mantle through which are perforations for the respiratory organs and the anus. The foot contains the mouth, two pairs of tentacles (the upper pair having the eyes at the tips), and the genital opening (Burch 1962). A significant feature is found in the mouth. Snails have a radula. It is a "... ribbon-like organ with many fine chitinous teeth used in rasping food." When the snail is feeding the radula protrudes through the mouth and is moved across a cartilage by strong muscles. This allows the snail to rasp off particles of food over which it crawls. The great diversity in the form of the radular teeth among various groups of snails has been the basis for a large part of their classification (Burch 1962:2). The radular formula for snails is written in the following form: 24-1-24 Biomphalaria alexandrina, 130±-1-130± Physa (Malek 1962). The middle number represents the central cusp and the flanking numbers represent the number of cusps on either side of the middle cusp (Fig. 2).

Snails are able to move their shells in a number of angles demonstrating torsion (Borradaile et al. 1961). They are univalve mollusks with either gills or lungs, often hermaphroditic and exhibiting reciprocal fertilization (Farb 1963). One snail will assume the part of the female and the other the part of the male. They shortly reverse the positions (Wiswell and Browning 1967). Eggs are produced in a limited period of time during the summer and as many as two hundred eggs may be produced in a single mating (Polley
Implications of Gastropods in Archeological Sites

McClure, Dept. of Zoology, U. of Texas; personal communication. The eggs hatch during late August or early September.

Snails may cluster around a specific plant which they eat alive and dead, use for shade and for moisture (McClure, personal communication). They generally need to be near a source of lime or calcium carbonate material in some form (Burch 1962) which they may ingest as small bits of limestone (Dias-Piferrer 1961). The epidermis of angiosperms, decaying plants, minute fungi, lichens, algae, and mosses form the primary food sources. They may, however, eat other snails.

Harry (1967) described three types of behavior in fresh-water snails. These were reactions to changes in the ion content in the water. The forms he observed were: 1) normal crawling and feeding, 2) distressed behavior manifested by retraction into the shell or extension on a surface, 3) retracted behavior manifested by retraction into the shell and detachment from all surfaces. Polley McClure (personal communication) described three types of behavior for land snails. They are: 1) normal feeding and crawling, 2) estivation, withdrawing into the shell due to temporarily unfavorable conditions, and 3) hibernation during winter months. During their winter hibernation, they burrow into the ground to varying depths (Wiswell and Browning 1967). Bulimus may burrow from two to four inches and Rumina decollata may be found a foot or more below the surface. Other snails may bury themselves so that only their aperture is exposed to the surface.

After feeding, land snails climb for three to six hours on the average, during which time their body size shrinks due to moisture loss. They are generally immobile while aloft. (Blinn 1963). Feeding and most activity occurs at night so that they climb to attach themselves beneath leaves or other protection during the daylight hours. They may have a home range which is more or less restricted by the amount of moisture on the ground (Lokke 1963, and Van Der Schalie and Getz 1962). This range may shift with variation in temperature and/or moisture (Segal 1961). Thus, they live where there is “...certain condition of lime, moisture and light” (Lee 1952: 59). The rates of function shift with changes in moisture and temperature (Van Der Schalie and Getz 1962).

The lifespan of a snail may be between one and four years depending on the environmental conditions. They generally become senile when they achieve a certain size (McGraw 1961). During the winter hibernation there is about an 18% mortality rate (when the shells are oriented naturally with the aperture upward) which increases slightly among individual snails that orient their apertures downward (Carney 1966).
There is a fundamental difference between the snails in the eastern and western United States. In addition there is a third division in southern Texas and in southern Florida (Burch 1962). These differences are based on occurrences of snail families. The boundary for the eastern and western divisions is the eastern edge of the Rocky Mountains.

Much description of snail species was done in the eastern United States during the early and middle 19th century. One of the more recent descriptive compilations was made by Pilsbry (1939) who provided detailed physical descriptions and the geographical ranges of species. He identified snail species in northwestern Arkansas in 1903. Berry (1962) described the snails of the Canadian Rockies providing physical descriptions and ranges. Allen and Cheatum (1961) provided the first descriptive information directed specifically toward archeologists.

No work on archeological specimens from Arkansas has been attempted. In the archeological sites of Texas there are a few species that are regularly encountered. They are:

*Rumina decollata*. Found in damp areas in which the ground level humidity is greater than 44% (Lokke 1963). They are a Mediterranean snail presumably imported by the Spanish. These nails burrow deeply into the ground during their winter hibernation.

*Bulimulus dealbatus*. These snails are encountered in semi-arid to arid areas in grassy fields with low brush (Allen and Cheatum 1961). They are the most frequently encountered snail found in central Texas sites. In western Texas other species of Bulimulus are encountered. Presumably these were eaten by the Indians.

*Mesodon thyroidus*. These are found in heavily wooded areas (Allen and Cheatum 1961) and around moist midden trash. They are very sensitive to moisture (Dr. H. Gray Merriam, Dept. of Zoology, U. of Texas, personal communication).

*Polygyra texana*. Found in open fields and open woods, these snails are the most populous natural species in the Texas area (Allen and Cheatum 1961).

*Anguispira alternata*. Woodlands and upland grasses form the preferred habitat of these snails (Allen and Cheatum 1961).

*Helicina orbiculata*. Unprotected fields and open woods form the habitat of these snails (Allen and Cheatum 1961). They may also be located around juniper and pine trees (Polley McClure, personal communication).

*Zonitoides arboreus*. These animals are found in wooded areas bordering streams (Allen and Cheatum 1961). They prefer a high humidity environment.
Implications of Gastropods in Archeological Sites

**Euglandina texasiana.** Found in protected areas where abundant moisture occurs (Allen and Cheatum 1961) these snails are fragile and require special care in collection.

**Succinea grosvenori.** These snails are encountered in moist wooded areas with considerable woodland floor cover (Allen and Cheatum 1961).

**Carychium exiguum.** These very small snails are found in moist wooded areas (Allen and Cheatum 1961). They are about the size of a pin head so careful collection is necessary.

**Helicodiscus singleyanus.** Found beneath leaves and rotting logs in moist wooded areas, these animals must be collected carefully as they are pin head in size (Allen and Cheatum 1961).

**Zonitoides excavatus.** This western snail prefers damp protected environments and may be found in a non-calcareous habitat (Sparks 1963).

Snails have been noted by archeologists working in sites all around the world. Numbers of snails were observed by A. T. Jackson (Mayhall 1939) at Oso Creek and by Holden (197) at Murrah Cave. Jackson (1938) again mentioned snails, this time at the Fall Creek sites. Martin (1933), Campbell (1947), Schmitt and Tolden (1953), Suhm (1957, 1959), Crook and Harris (1957), Col. Thomas Kelley (1961), Scheutz (1961), Allen and Cheatum (1961), Johnson (1961), Honea (1962), Jelks (1962), Johnson, Suhm, and Tunnell (1962), Reed (1962), Shafer (1963), Pollard, Greer and Sturgis (1963), Watt (1965), Story and Shafer (1965), Parmalee (1965), Scheutz (1966), Sorrow (1966), Sorrow, Shafer and Ross (1967), Hester (1968) and M. B. Collins (personal communication) have all mentioned land snails in connection with archeological sites. Most merely mention the presence of snails. A few had the snails identified and still fewer drew cultural and/or ecological implications. There is only one which identifies, makes cultural and ecological inferences and quantification (Parmalee 1965).

When the presence of snails is noted in the literature, more often than not they will be merely mentioned in passing. More often the presence is not even noted. However, the following reports merely note the presence of snails: Holden (1937), Holden (1938), Jackson (1938), Johnson, Suhm and Tunnell (1962), Shafer (1963), Pollard, Greer, and Sturgis (1963), Story and Shafer (1965), and Sorrow, Shafer and Ross (1967). They do not draw any conclusions about the snails. The following reports noted the presence of snails and suggested that they were utilized as food: Suhm (1957, 1959), Kelley (1961), Scheutz (1961), Honea (1962), Jelks (1962), Reed (1962), Watt (1965), Parmalee (1965), Scheutz (1966), and Sorrow (1966). These reports mention snails as food sources and occasional-
ly draw further conclusions. The following reports noted their use as decoration: Mayhall (1939), Martin (1933), Tolden (1953), Scheutz (1963), Parmalee (1965), and Hester (1968). In the following reports snails were identified by species: Campbell (1947), Suhm (1957, 1959), Crook and Harris (1957), Allen and Cheatum (1961), Watt (1965), Parmalee (1965), and Scheutz (1966). The following reports utilized snails to draw ecological inferences: Suhm (1957, 1959), Crook and Harris (1957), Allen and Cheatum (1961), Reed (1962), and Parmalee (1965). Only one report contains all the possible uses to which snail shells may be put (Parmalee 1965). Collins (personal communication) may make some important conclusions from snails from his salvage work in Val Verde county.

Fresh water snails that have been encountered in archeological sites are:

_Helisoma trivolis_. These snails are found in permanent or temporary water and reach maximum size in semi-stagnant water (Allen and Cheatum 1961).

_Lymnaea dalli_. Found in shallow water with mud bottoms, these snails prefer areas of considerable pond vegetation (Allen and Cheatum 1961).

_Pseudosuccinea columella_. These animals prefer shallow and stagnant water with abundant vegetation (Allen and Cheatum 1961).

_Helisoma anceps_. These snails prefer fresh flowing water (Allen and Cheatum 1961).

Little has been published on fresh-water snails from archeological sites. Parmalee (1965) found three species of aquatic snails at Tick Creek Cave, Missouri. From these three species, he reconstructed the stream environment near the site. One species was evidently large enough to eat and was found in large numbers. Sorrow (1966) found one aquatic snail from the Pecan Springs site probably coming from the spring. Scheutz (1966) found aquatic snails in the Granberg site and assumed that this represented periodic flooding of the site. Cheatum (1966) identified aquatic snails at the Devil's Mouth site.

It has been suggested that snails may act as scavengers on midden debris. The snail _Mesodon thyroidus_ is often found today, around trash heaps where there is an abundance of moisture. _Rumina decollata_ will often be found in similar conditions. Most often they will collect under boards and bricks (H. Gray Merriam, personal communication). Bulimulus prefers grassy dry areas, but may collect around dryer trash piles of organic material.
Implications of Gastropods in Archeological Sites

It is often implied rather than stated, that snails were eaten as food by prehistoric Indians. Such an implication appears in Scheutz (1963) in which a net bag containing Bulimulus and Unio shells was described. Similarly, at the Granberg site in Bexar county (Scheutz 1965), a large quantity of mature Bulimulus shell were found. Sorrow (1966) observed snail association with hearths and food refuse areas. A correlation of snails and intensive occupation was noticed by Jackson (1938).

It has been stated in several reports that the snails must have been eaten. Suhm (1959) suggested that the snails at the Williams site had been eaten and that Bulimulus had been eaten at Smith Rockshelter (1957). Allen and Cheatum (1961) stated that snails were used as food, and Kelley (1961) stated that Bulimulus were eaten at the Crumley site. Martin (1938) said that snails in the Val Verde area were eaten raw or roasted, and Jelks (1962) stated that Central Texas Aspect Indians prepared snails by boiling or steaming. He suggests that they were placed in nests of damp leaves placed over hot stones. Harrington (1960) suggests the utilization of snails for food in northwest Arkansas; however, fecal analysis (Wakefield & Dellinger 1936) failed to produce indications of snail radulae in bluff-dweller coprolites. In Missouri, Parmalee (1965) stated that snails there had been used as food. And in Iraq, Reed (1962) stated that Helix was eaten by peoples there.

Unfortunately, eyewitnesses to Indians eating snails are few and far between. Cabeza de Vaca indicated that Indians on the coast would leave the coast when the cactus tunas were ripe to eat the tunas. While they were doing this, apparently they also collected snails. Honea (1962) compared the middens of northwest Africa to those of central Texas. He found that Takrouian Berbers and some unidentified group of Berbers are presently making burned rock middens and eating snails. Nick Hopkins (Department of Anthropology, University of Texas, personal communication) stated that Maya Indians at Chuj, Cuchimatan and Zinacantan in Chiapas eat snails today. They make special trips to the lowlands to collect them. The snails are boiled and sucked out of their shells. Ruecking (1955), in discussing the Coahuiltecans, mentioned that they ate a wide variety of foods and that little was not utilized. No mention was made, however, of their eating snails. Mayhall (1939) discussed a wide variety of food utilized by the Atakapa, Karankawa and Tonkawa but no specific mention was made of snails. In discussing the Coahuiltecans, Newcomb (1961: 41) says that “few living creatures were overlooked as a source of food. . . .” Again, there is no specific mention of snails. The ethnographic evidence is very poor.

There is, however, one means by which reasonably good evidence of the use of snails for food may be obtained. It will be remembered that the snail has a mouth part called the radula. “The radular
ribbon is enclosed in a radular sac inside the muscular buccal mass. It is a membranous ribbon (lingual ribbon) with a large number of transverse rows of teeth which overlap like shingles on a roof. The central tooth or 'rachidian' is bicuspid in the Planorbidae, and there is a series of duplicating teeth on each side of the central tooth. . . . If the radular formula of a Biomphalaria is given as 24-1-24, this means that in each transverse row there are 24 teeth on each side of the central tooth (Malek 1962: 22).” The teeth are made of a chitinous material which are moved across a cartilage when the snails are feeding (Burch 1962). “The number, shape, size and position of cusps on central, lateral and marginal teeth are important in taxonomy. In pulmonates the rows of teeth on the lingual ribbon may be V-shaped as in the Physidae or in a straight line as in the other families” (Malek 1962: 22).

Since the radula is made of tough chitinous material like the shell, it is resistant to acidic action for a period of time longer than 24 hours (Malek 1962). Thus, an ingested snail would be digested except for the radula. The radula, then, would be present in coprolites found in archeological sites. After removing the radulae from the fecal samples, they could be compared to mounted slides of radulae from identified species of snails.

Slides of the radulae of known snail species may be prepared in the following manner:

1. From the head-foot organ of the snail remove buccal mass together with jaws around mouth opening.
2. Wash in warm water for a few minutes and transfer to a 10 per cent solution of sodium or potassium hydroxide. It requires at least a day for all the tissues around the radular ribbon to be digested.
3. Wash radula and jaws in water to remove the hydroxide then add a two-per cent solution of hydrochloric acid to neutralize the excess hydroxide.
4. Stain in an aqueous solution of orange G for an hour (haematoxylin stains could also be used). Wash in water and destain with two per cent solution of HC1.
5. Transfer radula to a small drop of glycerine on a slide, and with a fine clean brush clean the ribbon, especially the lower surface. The ribbon should then be flattened in the center of the slide with the teeth upwards.
6. Remove glycerine with 95% alcohol. You can place the jaws on the same slide or on a separate slide. Dehydrate with two successive changes of absolute alcohol on the slide, one drop each. Clear the chitinous ribbon in one drop of xylol and mount in
Canada Balsam. If the ribbon is not well flattened break it horizontally into two pieces. You can also mount in ‘Euparal’ directly after the dehydration in 95% alcohol” (Malek 1962: 119-120).

These slides can be used to compare known species to the radulae found in fecal samples. In this way it may be shown that snails were eaten.

Snails were used as decoration by Indians in Texas. Martin (1933) mentioned decorated snail shells from Val Verde county in some sites other than Shumla Caves. These snails were painted red or black with lines painted on in the form of chevrons. He also illustrated five shells strung on a leechgilla leaf. At the Blue Mountain rockshelter, Holden (1938) described a single snail shell bead with a hole rubbed into the body whorl. The following year, Mayhall (1939) described a burial excavated by A. T. Jackson at False Oso Creek. The burial (M-28) had a bracelet of 16 snail shells around one arm. Another shell bead was found by Schmitt and Tolden (1953) in Oklahoma. Scheutz (1961) described a group of snails strung on a fiber cord from the Shumla Caves. In Missouri, Parmalee (1965) found a number of perforated river snails. Finally, Tommy Hester (1968) excavated a burial that had a cache of 430 Bulimulus near the left foot of the burial. In addition, there were two bifaces, one bone awl and one stemmed knife with the burial.

Snails may be used to a limited extent to determine the climatic and ecological conditions during the past. They are sensitive to ground level conditions (McClure, personal communication) and occupy narrow zones of preference (Van Der Schalie and Getz 1962). They may congregate around a source of lime (Burch 1962). Environmental factors are important to general activity, habits, and success of snails, varying in degree according to species (Dias-Piferrer 1961). When the environment becomes unfavorable they may estivate, up to five years for one species. Reed (1962) attempted to make climatological inferences from large land snails in Iraq. He was largely unsuccessful because he chose a large adaptive snail which happened to be utilized as food by earlier inhabitants of the area. Cheatum (1966) utilized snails to establish that the climate in the Amistad area has not changed significantly since the occupation of sites used for analysis. He stated that the smaller species are generally better indicators of climate than the larger specimens. In 1963 Cheatum and Allen (1963) compared Pleistocene gastropods of Ben Franklin and Clear Creek samples. The Ben Franklin fauna reflected a wetter climate than there is in the area at the present time and the Clear Creek fauna were more like the present. Cheatum and Allen (1965) determined, in north Texas, that during the Pleistocene, snails now common in Wisconsin were common in north Texas. With the retreat of the glaciers and the general desiccation
of the area the snails moved north. No significant faunal changes have occurred in north Texas since the retreat some 9,000 years ago. Emiliani (1968) used snails in northern Europe to measure temperature and environmental change. Crook and Harris (1957) used snails to show that there was a Pleistocene climate during the time in which the Lewisville site was presumably inhabited.

Gastropods are sensitive to environmental changes and tend to be limited to a varying extent, to a particular set of conditions. They are limited by chemicals in the water if they are aquatic (Harry 1967), as well as the availability of lime, moisture, suitable food, the proper temperature, and the proper light conditions (McClure, personal communications). Some reports have attempted environmental reconstructions to a varying degree.

In 1959 Orchard (in Suhm 1959) concluded that the area around the Smith rockshelter had not changed much since aboriginal habitation. He broke down the habitats of snails at the Williams site (in Suhm 1959) by species. This was limited, though, to brief comments. The Wetherill Mesa Project produced samples of microscopic snails taken from soil samples (Colyer and Osborne 1965) which were identified. Parmalee (1965) was able to determine that the environment around Tick Creek Cave, Missouri consisted of damp woods of oak and hickory with an abundance of rotted logs and forest floor debris. He was also able to determine the nature of streams near the site from snails. Allen and Cheatum (1961) identified snails commonly found in archeological sites and listed their environments. They provided a helpful field guide for the identification of snails from archeological excavation.

Attempts to utilize snail shells for dating archeological deposits have been made. Sam Valastro (Assistant Director of the University of Texas Radio-Carbon Dating Laboratory, personal communication) has dated Bulimulus shells and associated charcoal from the Smith rockshelter (Suhm, 1959). The snails dated a little more than twice as old as the charcoal. This ratio was consistent in all the samples run. He suggests that the area in which the snail lives influences the amount of fossil calcium carbonates assimilated into the shell. The dilution of the fossil calcium carbonates in these particular snails was about five or six percent. Since snails need a source of lime (Burch 1962) and ingest small bits of limestone (Dias-Pifferer 1961), it is to be expected that snails would give an older date than charcoal. With a number of correlations between snail shells and carbon dates a correction factor may be worked out for various areas making snails useful in radiocarbon dating. In addition to radiocarbon dating Allen and Cheatum suggest that Oxygen 18 may be used in dating snail shells. Relative dating using extinct and newly introduced snails may be used with caution. Rumina decollata and Helix have been introduced to America from Europe. Rumina pre-
Implications of Gastropods in Archeological Sites

sumably was introduced by the Spanish in the middle sixteenth century and Helix has recently been introduced.

Snails are restricted to a specific set of conditions at ground level. These conditions are more or less restrictive, depending on the species under consideration. Many of the more sensitive species are small and special care should be taken to collect them.

Gastropods are frequently encountered in archeological sites. Most species occur in a natural depositional population. However, one species apparently was brought in: Bulimulus. Inferential evidence suggests they were eaten and used for decoration. The scant ethnographic data, Hopkins (personal communication), and Honea (1962), indicate that snails are edible.

They are important to the archeologist because of their cultural uses as food and decoration and their possibilities in determining climatic and environmental changes. Dating is another use for time because of the fossil calcium carbonates assimilated into the shells. Relative dating must be done with care realizing that fossil snails may be carried into a site and that Rumina may burrow deeply.

Unfortunately, most archeological reports merely mention the presence of snails. A few reports contain species identification and only one report provides population counts (Parmalee 1965). Population concentrations may be important temporally and spatially. They may represent climatic change or concentrations of food refuse. I suggest that matrix samples be systematically collected and be washed through a fine screen to retrieve the smaller species. Searches through fecal material from sites should be made in order to retrieve any radulae that might be there. Important archeological information can be gained from snails in conjunction with vertebrate and pollen analysis. They deserve better treatment than they have hitherto received.

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PRELIMINARY DESCRIPTION OF THE BLUE SNAKE SOCIETY*

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The Blue Snake Society is a spiritualist group now centered in Oklahoma. They are attempting through a new revivalistic religion to restore the Indian way of life. There are about 250 members scattered around the country. The Oklahoma group, led by Dr. (Chief) Davis, now numbers around thirty. Most of the Oklahoma group formerly lived in Los Angeles and as a result of their peyote prophecies they came “to put down their fire” in Oklahoma. They are in the process of buying land, as a community, on which at some future time they will live and work communally. This will leave them freer to practice their religion which they see as their whole way of life. Their emphasis is on anything Indian (which is by definition good). They are completely pan-tribal, but, in actuality, aside from their religion, they have a Cherokee base. The majority of persons involved are Cherokee and all have adopted such things as the Cherokee kinship system of clans. The idea of community is central to them and they feel an affinity with the recent hippie movement because of its emphasis on spiritualism and communal life. They feel that their group has been together as a community in four former lifetimes. Their goal is to reach the end of the reincarnation cycle together. One way of doing this is to keep members who are ready to return to the Great Spirit on earth, this Shadow World, as a sacred bundle until all have reached the same high spiritual level and are ready to return to the Great Spirit.

They have their own view of history. Dr. Davis (who holds two post-graduate degrees) has told me that the Aztecs may be ancestral to the Blue Snake Society. He sees them as a people who reached a high level of spirituality. They deviated when they began human sacrifice, even though he sees those sacrificed as being on a high spiritual plain and ready to return to the Great Spirit. The Aztecs own spiritual power had reached the point where even though their gods weren’t real, they could move and talk by force of the spiritual power of the people. They were destroyed for their deviation.

The Society has a rich ceremonial life, selected from many tribes. Most are animal and plant ceremonies where men, through their dancing, try to imitate a certain life form in order to understand it. Animals are considered a higher form of life than man because they are closer to the Great Spirit. I was told that when a man does the eagle dance he tries to attain the level of wisdom of the eagle.

*All names and place names have been changed to protect the informants and future research.
Their ceremonial grounds are located east of Indian City on the land where they will some day live. The center of all activity is the fire which is kindled and tended by the warriors. Women are forbidden any contact with it. When in the vicinity of the fireplace one always must walk counterclockwise (countersunwise) around it.

Every ceremony begins with the sweat bath or Asi, which is used to purify. Participation is a matter of free choice and proper spiritual attitude. It helps to release the spirit so it can travel in the Spirit World. All evil and evil thoughts are burned out. The Asi I participated in (April 6, 1968) is fairly typical. It always begins with everyone smoking tobacco. Tobacco is considered a gift of the Great Spirit and the rising smoke symbolizes the rising to meet Him. The sweat house is a small hogan-like building, about ten feet in diameter with a pit about two feet in diameter and four feet deep in the center and a low crawl entrance. All movement was countersun, even if this meant crawling over someone. After taking places around the central pit, shoes, glasses, towels, whatever was brought in (especially metal jewelry which would heat and blister the skin) was passed out countersun. Buffalo acted as leader (although they do not like to acknowledge chiefs or leaders), pouring water on glowing hot rocks that were brought in after everyone was seated. He began with comforting words about the Great Spirit, the Old Indian way of life, and the beauty of the human body. Three times prayer was offered, once in Cherokee by a Cherokee boy. Between prayers the flap over the door was opened and Buffalo passed around a bowl of water (symbol of gift of life from the Great Spirit), first sunwise, then countersun. The temperature was about 170°; it was almost impossible to breathe and the steam painfully burned the skin. There was a thin layer of cool air next to the ground but it wasn't satisfying to breathe. It ended with Buffalo very eloquently saying he would be proud to be associated with any person there. We were free to leave at any time. Upon crawling out we received towels and had to walk around the sweat house seven times (the number of prayers). Then we splashed cool water over our bodies at least seven times, more if one wanted. We were free to dress and join the others. This Asi, because of a late start, lasted only about forty-five minutes; the usual time is about two hours. The Asi does its job well. One comes out of it highly elated, all the senses tingling and with an overall feeling of clarity. The world and sky are perceived very sharply and the mind has a free feeling of total alertness.

The Society sees the Great Spirit as a community of being, the Everywhere Spirit, yet he can take any form he likes and come to earth, the Shadow World. Each person is seen as having a spiritual umbilical cord from a soft spot on his head to the Great Spirit. The soul comes from the Great Spirit and will return to Him and yet it is an entity in itself.
Their knowledge of the Great Spirit comes to them through the use of peyote. It is used as a means of speeding up the learning process. With it they can cross over to the spirit world to be enlightened, not for healing or miracles in the manner of the Native American Church. It is a way to understanding, of feeling affinity with all other life. Man strives to realize he is an integral part of a union of all life.

Peyote is used only about four times a year whenever the need is felt. It isn't used more frequently because time is needed to understand the things that happen on the trips. The Society sees the body as a limitation on the soul. Peyote helps break down the barriers between the Shadow World and the Spirit World, freeing the soul to wander through space and time.

A basic element of their religion is reincarnation. A soul is created by the Great Spirit and will return to Him. It is given about seven lives to face certain decisions and if it chooses evil it will continue to come back until it chooses right. If it chooses wrong it must begin the cycle all over again. All violence is considered wrong except in the case of defensive violence. There is no transmigration involved. If a soul consistently chooses wrong, about the fifth or sixth lifetime the spirit will be dispersed back into the Everywhere Spirit. Sometimes on this path to the Great Spirit a man must go through a period of being a witch, a state of thinking evil. But this is rare. Since the time of reckoning is coming shortly, no new souls have been created since around 1940.

The age of the soul determines a man's wisdom. Ancient souls have acquired more wisdom through experience than younger ones and so are better equipped to make decisions. They have come further back to the Great Spirit. A person learns of his former lives through the peyote experience. Children who die are sometimes explained as holy persons who had only a few right choices left to make so were quickly returned to the Great Spirit. Children and old people are considered closer to the Great Spirit because they aren't involved with the physical aspects of living as are those in their prime.

The spirit can will itself to die if its lot in life is unhappy. In a certain case an unhappy child died. The soul was so anxious to return that it came quickly back as another child and this child would cry in the night because it remembered the bad things from its former life. But there is usually some time between a soul's earthly lives. Sometimes a soul can be in such a hurry to get back that it will force the soul from another's body and take over.

The spiritual leader of the Blue Snake Society, Dr. Davis, is the prophet of the future for the group. In peyote visions he has
seen the black, white and yellow snakes rise out of the volcano and devour each other while the red snake watched. He sees this country devastated by civil war and natural catastrophe. The west coast will fall into the sea and one of our major cities will be burned to the ground. He sees the entire country as a sea of flame with Oklahoma as the only oasis. That is why the Society members are moving to Oklahoma. During this upheaval, stragglers will come into Indian City where they will have to remain in quarantine for forty days. Dr. Davis assures me this will all be over by the year 2000. Then the Indians will reclaim their land and return to the idyllic purity of the old days. These prophesies are essential in the Blue Snake view of life; they quietly go about making preparation for returning to the old way of life. Yet they are not evangelistic. People come to them first and are taken in by gradual exposure to more and more sacred ritual.

The value of this group in respect to individual is tremendous. An excellent example of this was my informant. He is a young Souix who in his childhood on the Souix reservation grew up intensely hating white men. As he told me, this hatred dominated his life, twisting everything he touched. With the Blue Snake he found more people like himself who were struggling to remain Indian in white man's society. The Blue Snake encourage him to be as Indian as possible teaching that the Indian is pure as opposed to the moral decadence of the white man. He even has developed a very subtle sense of superiority in the confidence that the Indian will once again own the land by the year 2000. He has subdued a great inferiority complex and finds much pleasure and satisfaction in his family and the rich ceremonial life of the Blue Snake Society.
SKELETAL ANALYSIS OF THREE BLUFF SHELTER BURIALS

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INTRODUCTION

The following data and descriptions come from three multiple bluff shelter burials. The first two were excavated with no provenience control and collected by Glen Clark of Springdale, who presented them to the University of Arkansas Museum. They came from the vicinity of War Eagle Cave and Peterbottom Cave and were dug by some individuals apparently searching for artifacts. The burials are extremely fragmentary and consist of at least four individuals, which will be described at greater length.

The other burial comes from 3WA143 northwest of Fayetteville on the Illinois River and was excavated by John Clark and William Westbury, both graduate students in anthropology at the University of Arkansas. This burial consists of two individuals with enough skeletal material from both to be able to determine sex and age. All three burials are now stored with the University of Arkansas Museum.

John Clark and Dr. William W. Klusmeier helped with this paper immeasurably. Mr. Clark helped with a bibliography, measuring of the bones, and supplying forms from the University of Texas on which to record the data. Dr. Klusmeier, an orthodontist from Fort Smith, listened to the original hypotheses concerning the pathology of the skull of Burial III. He added comments of his own, some of which were incorporated with his permission. Both men were invaluable.

ARCHEOLOGICAL BACKGROUND

There is no material of archeological significance with any of these burials. The first two were presented to the museum with no context at all and no information except for the general area of their burial. Some cracked stones, mussel shells, and a deer mandible along with a few other animal bones is all that was received with these.

The burial from 3WA143 had been dug up by some persons who, for some reasons, decided they no longer wanted it and reburied it. They had glued the mandible to its articulation surface of the skull before redeposition. This destroyed all context, making archeological interpretation impossible. Found with this burial was a fill of ash mixed with soil, leaves, ovate scats, hackberry seeds, acorn fragments and a massive roof fall.
DESCRIPTION OF BURIALS I AND II

The first two burials were so fragmentary that measurements were almost impossible. Out of 110 identifiable bones and bone fragments only two left and one right femurs and part of one reconstructed skull were measurable. The breakdown is shown in Table I:

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<td>Clavicle</td>
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</tr>
<tr>
<td>Fragments</td>
<td>1</td>
</tr>
<tr>
<td>Scapula (Fragmentary)</td>
<td>4</td>
</tr>
<tr>
<td>Humerus:</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>2</td>
</tr>
<tr>
<td>Left</td>
<td>2</td>
</tr>
<tr>
<td>Fragments</td>
<td>2</td>
</tr>
<tr>
<td>Ulna</td>
<td>7</td>
</tr>
<tr>
<td>Radius</td>
<td>8</td>
</tr>
<tr>
<td>Carpals</td>
<td>2</td>
</tr>
<tr>
<td>Metacarpals and</td>
<td></td>
</tr>
<tr>
<td>Metatarsals (no distinction made)</td>
<td>9</td>
</tr>
<tr>
<td>Pelvis (fragmentary)</td>
<td>6</td>
</tr>
<tr>
<td>Sacrum (fragmentary)</td>
<td>1</td>
</tr>
<tr>
<td>Femur:</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>1</td>
</tr>
<tr>
<td>Left</td>
<td>2</td>
</tr>
<tr>
<td>Epiphyses</td>
<td>2</td>
</tr>
<tr>
<td>Fragmentary</td>
<td>3</td>
</tr>
<tr>
<td>Patella</td>
<td>1</td>
</tr>
<tr>
<td>Tibia:</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>3</td>
</tr>
<tr>
<td>Left</td>
<td>2</td>
</tr>
<tr>
<td>Epiphyses</td>
<td>1</td>
</tr>
<tr>
<td>Calcaneum</td>
<td>8</td>
</tr>
<tr>
<td>Talus</td>
<td>4</td>
</tr>
<tr>
<td>DEER</td>
<td></td>
</tr>
<tr>
<td>Mandible:</td>
<td></td>
</tr>
<tr>
<td>Fragments</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
</tr>
<tr>
<td>OTHER</td>
<td></td>
</tr>
<tr>
<td>Unidentified</td>
<td>1</td>
</tr>
</tbody>
</table>
Besides these there are numerous unidentifiable fragments and ribs that were not counted. The small sampling of measurable material made it difficult to reach any conclusions through measurements. Those that were obtainable are listed in Table II: (measurements after University of Texas)

<table>
<thead>
<tr>
<th>TABLE II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SKULL</strong></td>
</tr>
<tr>
<td>Maximum Length</td>
</tr>
<tr>
<td>Maximum Breadth</td>
</tr>
<tr>
<td>Left Parietal Thickness</td>
</tr>
<tr>
<td>Foramen Magnum:</td>
</tr>
<tr>
<td>Maximum Basion-Opisthion</td>
</tr>
<tr>
<td>Maximum Transverse Diameter</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>FEMUR</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LEFT</strong></td>
</tr>
<tr>
<td>Bicondular Length</td>
</tr>
<tr>
<td>393 mm.</td>
</tr>
<tr>
<td>Morphological Length</td>
</tr>
<tr>
<td>Maximum Diameter of Head</td>
</tr>
<tr>
<td>Subtrochantor Anterior-Posterior</td>
</tr>
<tr>
<td>Subtrochantor Lateral</td>
</tr>
<tr>
<td>Middle Anterior-Posterior</td>
</tr>
<tr>
<td>Middle Lateral</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>FEMUR</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RIGHT</strong></td>
</tr>
<tr>
<td>Subtrochantor Anterior-Posterior</td>
</tr>
<tr>
<td>Subtrochantor Lateral</td>
</tr>
<tr>
<td>Middle Anterior-Posterior</td>
</tr>
<tr>
<td>Middle Lateral</td>
</tr>
</tbody>
</table>

The skull is probably male, as are the two left femurs. Judging from the thinness of the left parietal and the openness of some of the sutures, this particular individual was probably an adolescent. The femurs appear to be from three different individuals. Left femur 1 is probably from a male younger than left femur 2 because of the difference in size and because there appears to be more matrix in 1 than 2. The right femur is judged to be female because it is less robust than the other two, even though its measurements almost coincide with 1. The lesser trochantor is little more than a bump while the greater trochantor is smoother than that in 1 (Edwards, 1963: 219).

The other skull is smaller than the one measured, but it is much more fragmentary. It was probably an immature individual and may have been male. It is doubtful if any of the femurs went with it, since they appear to be older. The number of radii show a min-
imum of four people, possibly more. It is my opinion that these burials contain probably no more than parts of four individuals. This is borne out by eight radii and calcanea, conveniently in four lefts and four rights. Of course, it could be that they do not go together, but, if that is the case, a few extra arms and feet would have been thrown in at the time of the burial. There are five tibia, three right and two left, with the left probably going with the right, in at least one case, making a maximum of four. In no other case are there enough bones that could conceivably surpass four individuals. It was interesting to note there was no pathology with any of the bones in Burials I and II.

DESCRIPTION OF BURIAL III

Burial III was in much better condition than the others and had fewer bones; however, those that it had were measurable. Those bones present and measurements of each, with exception of the skull and mandible which will be treated separately, are listed as follows in Table III:

The main aging and sexing techniques used were comparing the public symphysis with the component outline in Brothwell's *Digging Up Bones*, pp. 64-65, viewing the general robustness of the bones, measuring the greater sciatic notch and looking for the amount of matrix.

The humera obviously belonged to two different individuals, but both were robust and probably male. The pelvises belonged to two different individuals on the basis of the comparison of the public symphyses. The left pelvis belonged to a male probably 22 to 25 years of age while the right was probably a male, although that could not be ascertained with as much definitiveness as the other, and was from 28 to 36 years of age. The sacrum, due to the sharp curve starting at the fourth segment and complete closure of all the segments was judged to be a male over 25 years old. The femur and tibia were all robust. There is pathology present in the smaller humerus. It appears that it was broken because the distal end is much thicker and rougher than is normal.

The skull is that of a male probably between 35 and 40. This was determined by the sutures and the wearing of the teeth. His teeth were worn down to a flat and smooth surface on one side and on the other side to an acute angle that would have taken a minimum of 30 years to wear so completely (Brothwell: 68).

There was much pathologically wrong with this individual, which is what prompted the writing of this paper. Before the pathology is described, it would be better to enumerate the measurements and indices:
Table III

<table>
<thead>
<tr>
<th>BONE</th>
<th>L</th>
<th>R</th>
<th>CONDITION</th>
<th>MEASUREMENTS TAKEN</th>
<th>MEASUREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scapula</td>
<td>1</td>
<td>2</td>
<td>broken</td>
<td>unmeasurable</td>
<td></td>
</tr>
<tr>
<td>Humerus</td>
<td>2</td>
<td>3</td>
<td>good</td>
<td>maximum length</td>
<td>285 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>maximum middle</td>
<td>302 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>diameter</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>minimum middle</td>
<td>18 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>diameter</td>
<td>21 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>maximum diameter</td>
<td>16 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>maximum diameter</td>
<td>38 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>38 mm.</td>
</tr>
<tr>
<td>Ribs</td>
<td>1</td>
<td>2</td>
<td>broken</td>
<td>were not measured</td>
<td></td>
</tr>
<tr>
<td>Pelvis</td>
<td>1</td>
<td>1</td>
<td>broken</td>
<td>maximum pelvic</td>
<td>18.6 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>height</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>diagonal conjugate</td>
<td>164 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>diameter</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>normal conjugate</td>
<td>150 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>diameter</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>sagittal diameter</td>
<td>155 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>of pelvis inlet</td>
<td></td>
</tr>
<tr>
<td>Sacrum</td>
<td>1</td>
<td>1</td>
<td>in good</td>
<td>sacral height</td>
<td>96 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>condition</td>
<td>sacral breadth</td>
<td>105 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>maximum diameter</td>
<td>46 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>of superior body</td>
<td></td>
</tr>
<tr>
<td>Femur</td>
<td>2</td>
<td>3</td>
<td>broken</td>
<td>unmeasurable</td>
<td></td>
</tr>
<tr>
<td>Tibia</td>
<td>1</td>
<td>2</td>
<td>left</td>
<td>morphological</td>
<td>363 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>broken</td>
<td>length</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>nutrient foramen</td>
<td>67 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>lateral</td>
<td></td>
</tr>
<tr>
<td>Calcaneum</td>
<td>1</td>
<td>2</td>
<td>good</td>
<td>maximum length</td>
<td>63 mm.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>maximum breadth</td>
<td>38 mm.</td>
</tr>
</tbody>
</table>

There were other bones and bone fragments that were measurable but not measured.
### TABLE IV
#### CRAINAL MEASUREMENTS AND INDICES

<table>
<thead>
<tr>
<th>PALATE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>length</td>
<td>53 mm.</td>
</tr>
<tr>
<td>breadth</td>
<td>36 mm.</td>
</tr>
<tr>
<td>depth</td>
<td>16 mm.</td>
</tr>
<tr>
<td>maxillo-alveolar length</td>
<td>55 mm.</td>
</tr>
<tr>
<td>maxillo-alveolar breadth</td>
<td>58 mm.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CALVARIA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>maximum length</td>
<td>90 mm.</td>
</tr>
<tr>
<td>maximum breadth</td>
<td>125 mm.</td>
</tr>
<tr>
<td>basion-bregma height</td>
<td>133 mm.</td>
</tr>
<tr>
<td>minimum frontal breadth</td>
<td>90 mm.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FACE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>total height</td>
<td>140 mm.</td>
</tr>
<tr>
<td>upper height</td>
<td>74 mm.</td>
</tr>
<tr>
<td>basion-nasion</td>
<td>110 mm.</td>
</tr>
<tr>
<td>basion-nasospinale</td>
<td>94 mm.</td>
</tr>
<tr>
<td>basion-prosthion</td>
<td>97 mm.</td>
</tr>
<tr>
<td>prosthion nasospinale</td>
<td>15 mm.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ORBITS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>height L</td>
<td>36 mm.</td>
</tr>
<tr>
<td>height R</td>
<td>37 mm.</td>
</tr>
<tr>
<td>breadth L</td>
<td>40 mm.</td>
</tr>
<tr>
<td>breadth R</td>
<td>38 mm.</td>
</tr>
<tr>
<td>interorbital breadth</td>
<td>24 mm.</td>
</tr>
<tr>
<td>biorbital breadth</td>
<td>93 mm.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NOSE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>height</td>
<td>62 mm.</td>
</tr>
<tr>
<td>breadth</td>
<td>22 mm.</td>
</tr>
<tr>
<td>upper breadth</td>
<td>20 mm.</td>
</tr>
<tr>
<td>lower breadth</td>
<td>22 mm.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FORAMEN MAGNUM</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>basion-opisthion</td>
<td>38 mm.</td>
</tr>
<tr>
<td>transverse diameter</td>
<td>31 mm.</td>
</tr>
<tr>
<td>mean</td>
<td>34.2 mm.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MANDIBLE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>bicondylar diameter</td>
<td>112 mm.</td>
</tr>
<tr>
<td>height of left ascending ramus</td>
<td>60 mm.</td>
</tr>
<tr>
<td>minimum breadth of left ascending ramus</td>
<td>31 mm.</td>
</tr>
<tr>
<td>length of mandibular body</td>
<td></td>
</tr>
<tr>
<td>between M1 and 2L</td>
<td>23 mm.</td>
</tr>
<tr>
<td>angle</td>
<td>62°</td>
</tr>
</tbody>
</table>
INDICES

- Cranial index: 73 mm.
- Length-height index: 77 mm.
- Breadth-height index: 93 mm.
- Total facial index: 78 mm.
- Nasal index: 36 mm.
- Orbital index L: 90 mm.
- Orbital index R: 97 mm.
- Palatal index: 67 mm.
- Maxillo-alveolar index: 94 mm.
- Skull capacity: 1298.49 mm.

Unfortunately, these measurements and indices do not mean very much since there is no other skull to compare them with. From the indices it is possible to determine this was a dolichocranic (long headed), euryposopic (broad and low faced), leptorrhine (high and narrow nosed) individual with a leptostaphylic or long and narrow palate, and a small cranial capacity or oligencephalic (University of Texas). There is no way to determine if this is the norm or if this was a variant individual. He was certainly variant pathologically, however.

The two most notable injuries are a depression on the right side at the juncture of the frontal and parietal bones and the odd wearing of the teeth on the left side. Besides these, one discovers on closer examination, a depression in the left orbit beside the upper part of the nose, extreme infection of the teeth, and a smaller depression behind the larger on the parietal bone.

It is impossible to determine what caused the trauma. About the only two things that can definitely be determined are that it happened a number of years earlier and was not trepanning. The reason these conclusions were reached is that the bone has healed over entirely, and a blow strong enough to cause such damage was probably strong enough to shatter it. If this were the case, it would take a number of years for the bone to grow back as well as it did. On the other hand, the bone was probably not totally destroyed because the suture is still intact. This is what leads me to believe trepanning is not the cause of the depression. If the section were totally removed, as it would have been with trepanation, then the suture would probably either be non-existent or very indistinct. Consequently, trauma of some sort is the logical conclusion.

In spite of having completely healed over, the bone is very thin here and the convolutions on the interior are indistinct. This led to the question of whether that blow may have caused paralysis or in some way affected the motor operations of this individual. This is a particularly valid question in light of the angular wearing of
the teeth on the left side which could have well been caused by motor disturbances causing the individual to chew in such a way as to use those teeth almost to exclusion. It is certainly a possibility, but, when one takes into consideration all the circumstances of the mouth, it does not seem to be the best one. Three of his palatal incisors are missing and apparently were lost at a very early age, since there is no sign of where the roots were in the bone. Consequently, the individual had a severe protrusion of the mandible, putting the mandibular incisors over where the palatal incisors would have gone. This threw his entire mandible out of normal occlusion, putting the outside cusps of the mandibular molars on the outside of the outside cusps of the palatal molars on the left side. This is completely the reverse of normal occlusion. With his left side so maloccluded, the molars would have worn each other down.

Another possibility is that he inherited his "jutting jaw" which would have caused the same process. If either of these were the case, which seems likely, his face would not have been thrown out of line, which it is not. Another reason why this would appear to be the case is that it would have taken practically his entire lifetime to wear his left molars down to that great an extent. I do not believe the trauma happened early enough to cause that. On the other hand, if a motor disturbance were the cause, his face would have a drastic alignment toward the left, which it does not.

Besides having a malocclusion, this individual had severe periodontal and pariapical infection of the teeth. His left second and third palatal molars, all the right palatal premolars and molars, right mandibular molars and left first mandibular molar had severe periodontal infection. The left first palatal molar, second premolar, canine, right second premolar and first molar, and left mandibular second and third molars had periapical infection. The main difference between the two forms of infection is that periapical is infection of the nerve which eventually destroys all bone in contact with it and periodontal is infection of the gums and spongy bone beneath. This particular individual had lost six teeth to these infections and the only remaining teeth he had that were uninfected were the four mandibular incisors.

The last pathology to be brought up is that of the depression in the left orbit. There are three possibilities of what may have caused it. The first is that it could have been a tumor of the lachrymal gland. If that were the cause, it would have most likely been malignant and may have contributed to his death. However, this possibility is the least likely, simply because lachrymal tumors are rare, almost to the point of non-existance.

A second possibility is that a polyp could have grown from his nose into the orbital region. However, this would probably not have
happened because polyps grow along the lines of least resistance, and to invade the orbital region, it would have to destroy bone. More likely it would have grown down the nose or the back of the throat.

The third alternative, and the one that best fits this case has to do with sinusitis. Sinusitis has been discovered to be one of the most prevalent diseases among Indians of this area. Since that is the case, this individual may well have had it (Wakefield and Dellinger: 1940). In severe cases, when the sinuses are infected continuously for long periods of time, the bone can be destroyed through decay from the infection. Often in a case like this, a benign tumor will invade surrounding areas. This particularly happens with frontal and maxillary sinuses (Thoma, 1946: 932).

The first two possibilities are not entirely out of the question, but since sinusitis was a common infection found in the native Americans of this area, the third alternative explains the orbital depression better. This is particularly so because the depression is immediately beside the left frontal sinus.

CONCLUSION

The first conclusion to be stated is that no conclusion can be drawn from these three burials, archeologically. Since the first two had no controls, they are practically useless except to study for whatever morphological, physiological, or genetical problems one may want to investigate concerning Indians of Northwest Arkansas. Although the third had controls, it had been redeposited, thereby destroying all context, so the same can be said about it.

In my observations I was able to determine the Burials I and II contained parts of probably four individuals, one of whom was female and all of whom were young. Since the burials were so fragmentary and lacking in pathology and context, little besides that can be said.

In concluding on Burial III I would add that the skull, sacrum, and right pelvis probably belong to each other, although that is not completely ascertainable. It seems logical, since there are only two individuals and those three parts are approximately the same age, that they would have gone together. As for the skull itself, it would be safe to say that this individual lived in severe pain all of his adult life. Why he did not die before he did is a point worth pondering.

The pathology of the skull is what prompted this paper and it has been intriguing following this through. It would be interesting to find another skull with similar oral pathology to compare this one with and find out if these theories have any substantiation.
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Brothwell, Don R.
1963 *Digging Up Bones*. British Museum (Natural History), London.

Edwards, Linden F.

Harris, J. A.

Thoma, K. H.

Wakefield, Elmer G. and S. C. Dellinger
THE TYPE-VARIETY CONCEPT: A POSSIBLE INDICATOR OF DIFFUSION AND CULTURE AREAS

John B. Huner, Survey Archeologist
Arkansas Archeological Survey, Conway

For the last 30 years there has been an effort on the part of archeologists to demonstrate the process of diffusion and localization of prehistoric culture groups within the North American Gulf Coast. By investigating one pottery type, French Fork Incised, which has been assumed to have diffused from east to west, the process of diffusion can be demonstrated. This pottery can be shown to be composed of many varieties and, if any diffusion is to have taken place, it will have occurred and can be demonstrated along the 300 miles (approximately) of Coastal Louisiana. There are many varieties of French Fork Incised. If there are any cultural factors operating to select certain stylistic elements of the overall pottery design concept, it can be assumed that if differential selection took place there are different cultures selecting them. That is, it is highly unlikely that two cultures will select the same set of varieties at the same period in time, although some overlapping should be expected which would allow for the more or less continuum of diffusion.

The conceptual framework for this paper will be the Wheat-Gifford-Wasley "Type Variety" taxonomic system (1958) as modified by Phillips (1958) for Eastern Ceramics. Simply, this system can be explained as follows: A mode is the smallest discernable attribute of pottery; modes cluster to yield varieties; the varieties, in turn, make up the type clusters or, as Phillips terms them, types; and types or type clusters form ceramic systems. It should be noted that each level or stage is more temporally and spatially restricted than the next higher level. Thus, if the varieties of French Fork Incised can be established, it can be deduced that there was, in a specific area at a unique time, a culture or group of people who, while still sharing ideas with the mainstream of cultural thought, were at least partially distinct. This distinction would be, of course, on the local level both temporal and spatial.

The widespread relationships of French Fork Incised to similar types in adjoining areas have been pointed out by Ford and Willey (1939), Newell and Krieger (1949), and Ford (1951 and 1952) and others. These types would be: French Fork Incised in the Lower Mississippi Valley, Weeden Island Punctated and Incised in the Florida Gulf Coast and Crockett Curvilinear Incised and Crockett-Pennington from the Caddoan area. All of these types have a common design motif in which the technique is to decorate the background or negative area in order to bring out the undecorated positive design in much the same way as the well-known negative painting is ren-
dered. These types fit the definition of a ceramic system and I have proposed that the term Gulf Coast Negative Design Ceramic System be introduced to include all of the above mentioned types and any other types of the plastic negative design motif that may become established.

French Fork Incised is defined by abstracting Ford's 1951 description so that it may include any and all of the varieties. The definition is, therefore, any pottery type of the Troyville-Coles Creek Period of the Lower Mississippi Valley whose design is composed of "Meander and wavy patterns formed by the smooth, un-roughened surface of the vessel, which were made to stand out by roughening the background" (1951: 62-67). By this definition, the number of varieties of French Fork Incised could theoretically be determined by finding the set of all possible combinations of the modes present.

Since a variety is both more local in space and more restricted temporally, both of these factors must be accounted for. The aboriginal inhabitants of Coastal Louisiana were restricted to certain geomorphic features which provided them with relatively dry land. These features are natural levees, piercement-type salt domes, and chenieres, or relict beach ridges, and they vary in frequency of occurrence in each of the three natural areas of Coastal Louisiana. These natural areas are: the Chenieres to the west, the Mississippi River Delta in the center, and the Lake Pontchartrain Basin to the east. Being relatively isolated from one another by the physical environment, each of the natural areas could thus create areas in which cultural groups could become somewhat independent of their neighbors. The natural areas which correspond to these culture areas are: the Chenieres, the Belle River Area, and the South Lake Pontchartrain-Bayou Cutler area. In addition, a fourth area, the Amite River which is along the north shore of Lake Pontchartrain, was added as a check on the method since any diffusion that would have occurred from east to west would, by necessity, go around Lake Pontchartrain. By dividing Coastal Louisiana in such a manner, the basis for the spatial differentiation of the varieties of French Fork Incised was established.

The temporal aspects of the French Fork Incised varieties present some problems, for there has been very little stratigraphic excavation in Coastal Louisiana. Since the Chenieres and the Amite River areas are relatively stable, geologically speaking, and French Fork Incised is generally restricted to the Troyville period (700-850 A.D.) in Coastal Louisiana, it is felt that the temporal aspects can be held constant.

The modes of French Fork Incised fall into two classes: those that are employed to render the background and those that form the
The Type-Variety Concept

outline. Hypothetically, there are three methods of outlining the design: drag punctating, linear punctating, and incised lines. Drag punctating is defined as a series of punctates which have been formed into a line by "dragging" the tool. This is done when the craftsman fails to lift the implement completely when moving it from impression to impression. Linear punctating, on the other hand, is a row or series of rows of cleanly rendered individual punctates. Again, by supposition and definition, there is a possibility of eight methods of rendering the background. There are: drag punctating, linear punctating, incised lines and overhanging incised lines that terminate in punctates, crosshatched incised lines, red filming, and those cases in which the background was not decorated or it would not be determined.

Groups of background modes cluster with only two of the three methods of outlining. There does not appear to be a large use of linear punctating as a method of outline. Drag punctating does not seem as popular as incised lines but both were employed for outlines. The background modes seem to cluster differentially with the method of outline. While these are not distinct or obvious clusterings, certain ones are of greater occurrence than others. The background modes which appear to cluster with a greater frequency with a drag punctated outline are: drag punctating, overhanging incised lines and incised lines. Those background motifs which cluster with an incised line outline more frequently are: incised lines, both those which terminate in punctates and those which do not; drag punctating; linear punctating, and overhanging incised lines which terminate in punctates.

The clustering of given background modes with given methods of outline simply represent the preferred method of behavior within a culture group and indicate that certain forms were more popular than others. This does not exclude the "minor" varieties, because in most cases they are represented, but, rather suggests that they were not necessarily in "vogue."

The locus of the aesthetic focus is not important for our purposes. If any patterning of conscious or unconscious behavior can be established, then an insight into cultural behavior and hence knowledge of human behavior is gleaned. When employing the type-variety concept, patterning can be established for both spatial and temporal distributions. In this case, both the locus of a variety and its quantity can establish the direction of diffusion and the centers of modification which in turn radiated to surrounding areas. It is obvious to the most casual observer that there are differences in the varieties of French Fork Incised among the geographical and native areas of Coastal Louisiana. The most apparent of these differences is the lack of any of the Drag Punctated Outline varieties, with one exception, in the Chenieras area. This could be due to a
low sample, but I prefer to believe that it is the product of diffusion. Assuming that the Northern Gulf Coast of Florida is the origin of the Gulf Coast Negative Design Ceramic System, it would be logical to conclude that if the design concept is moving from east to west, the areas closest to the center would be more similar. The degree of similarity between Florida and Louisiana types is best illustrated by the method of outline. Since Weeden Island Punctated and Weeden Island Incised (Willey 1949: 411-422) originated in Florida, it would be logical to expect to find an equal distribution of French Fork Incised varieties outlined by drag punctating and those varieties outlined by incised lines. Then, any modification of the total design concept by the diffusion process would affect this distribution. This, in fact, is what occurs, for in the Amite River area the ratio of drag punctated outline to incised line outline is approximately 1:1. As the design moves from east to west there is a decline in the number of sherds which are outlined by drag punctating as compared to those outlined with an incised line. In the South Lake Pontchartrain-Bayou Cutler area the ratio becomes approximately 1:2, in the Belle River area it is approximately 2:3, and in the Chenieres, drag punctating as a method for outlining is almost non-existent. It then becomes apparent that each group, because of its relative isolation and lack of contact, failed to absorb the complete design complex or all of the methods employed or used to render the design from the group to the east. There are other possible indicators of this phenomenon such as the adaptation of a stylized design in French Fork Incised as opposed to the effigies of the Weeden Island types and increased stylization in the Caddoan area. Thus it can be said that as the Gulf Coast Negative Design Ceramic System diffused from east to west each group did not acquire the complete design complex, undoubtedly modified some of the design elements, and when the design complex was "passed on" the reciprocal group repeated a similar process.

The total number of varieties and sherds in any given area, however, does not agree with this statement. The largest number of both varieties and sherds are found in the Belle River Area which is one of the more westward areas. This statement is not disturbing when one realizes that the direction of design movement is not necessarily deterministic of the total amount of pottery produced or the amount of innovation within a culture group. In fact, it has already been demonstrated that there were centers of modification of the Gulf Coast Negative Design Ceramic System which could be called "type centers". The main requirement for a "type center" is a population which is relatively dense and at a similar cultural stage, for any center of population usually becomes a center of modification and adaptation. A group of sites in the Belle River area centered near Grand Lake appears to be a major center in Coastal Louisiana for the modification of French Fork Incised pottery. In addition
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to the great number of varieties and sherds of French Fork Incised pottery, this location has several other features which reinforce it as a cultural center. Of all of the sites in Coastal Louisiana the sites centered near Grand Lake show the greatest degree of similarity with the Troyville-Coles Creek type site in cultural attainment and artifactual similarities. It should be noted that the type site (Greenhouse) is located near the confluence of the Red and Mississippi Rivers. The majority of pottery decoration techniques of the Red River Mouth Ceramic Tradition are found at these sites, not only in the varieties of French Fork Incised but also in the other types of these periods as well. The sites of the Belle River area are built on natural levees of what was then the active Mississippi River, which would have had a twofold benefit. First, communications and hence diffusion between the Belle River center and other areas would have been easy and, second, the large natural levees could have supported agricultural peoples with a fairly dense population. It should be noted that the sites themselves are rather large when compared to the majority of sites in Coastal Louisiana. Assuming that this is the locus for modification and adaptation of the traditional techniques to a new stylistic concept, the newly modified design complex would then radiate or diffuse to surrounding areas. This would also indicate a temporal difference among varieties, which, unfortunately, cannot be demonstrated. The Bayou Cutler area seems to be rather homogeneous, for the few sites that appear to be possible centers have been collected fairly intensively. There also appears to be a slightly later shift in the discharge of the Mississippi River, and the Bayou Cutler "center" around Lake Salvador and New Orleans could be the result of this. The Chenieres on the other hand were probably marginal to the other parts of Coastal Louisiana and did not participate fully in any of the cultural stream except for the initial diffusion of the negative design motif. The Amite River area has most of its similarities with the Northern Gulf Coast area; however, it is marginal to the Mississippi Valley where the majority of cultural activity is believed to have taken place and would retain the original patterns longer than the other areas.

It appears, therefore, that the Gulf Coast Negative Design Ceramic System diffused into Coastal Louisiana from east to west, from culture area to culture area, losing its traditional styles which were retained in the marginal eastern areas. When the design concept reached the Belle River Area or Grand Lake center it was modified and adapted to the already existing ceramic tradition. From this point it radiated in its modified form to reoccupy the areas to the east while this westernmost area remained somewhat stagnant after the impetus from the initial diffusion.

Thus, it is indicated that both diffusion and culture areas can
be determined by the application of the type-variety concept. It has been demonstrated that by examining one type of pottery and reducing it to its varieties, as indication of potential culture areas and diffusion "routes" can be established. Of course, it is recognized that the study of only one type of pottery cannot describe the complete culture nor its geographical extent.

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The Type-Variety Concept

Wheat, J. B., J. C. Gifford, and W. W. Wasley


Willey, Gordon R.

INTRODUCTION

A study was made of regurgitated food items collected from young nestlings of the Cattle Egret (Bubulcus ibis) and Little Blue Heron (Florida caerulea). The largest nesting colony of these two species in the state occurs at the Luxora Heronry in Mississippi County. This heronry is located three miles northwest of the Mississippi River and seven miles northwest of Luxora on Arkansas Highway No. 120. During the past four years (1965-68) the senior author has studied the nesting and species composition at this heronry. The Luxora Heronry was first introduced into the literature by Hanebrink and Cochran (1966), when the first nesting record for the Glossy Ibis (Plegadis falcinellus) was reported. A description of this heronry including nesting sequence and species composition was reported by Hanebrink (1968). Cattle Egrets were first reported nesting in the Luxora Heronry in 1965 when five pairs were found nesting there by Ben Coffey, Jr. (Stewart, 1965). Meanley (1955) previously published on a nesting study of the Little Blue Heron at Swan Lake in eastern Arkansas.

During the 1968 breeding season approximately 100 pairs of Cattle Egrets nested in this heronry. Also five pairs of Snowy Egrets (Leucophoys thula) nested there for the first time in 1968. The Glossy Ibis has not nested at this site since the 1966 breeding season, but stray individuals were observed several times each breeding season. The most abundant nesting species in this heronry is the Little Blue Heron. The total number of nesting birds of all species is over 3000 for this eight acres of lowland deciduous woods. The number of individual nests of all species is approximately 200 per acre.

The objectives of this study were to: (1) determine food items of the Cattle Egret and Little Blue Heron at this heronry, (2) study feeding behavior of the two species, (3) make a comparison of the food items of these two species, and (4) study the feeding areas for each species.

ACKNOWLEDGEMENTS

This study was supported by a research grant from Arkansas
Feeding Behavior of the Cattle Egret and the Little Blue Heron

State University. John Stoll helped with some of the field work and Dr. Bob D. Johnson of the biology faculty at Arkansas State University critically read the manuscript. The writers greatly appreciate their help.

METHODS AND MATERIALS

Regurgitated pellets of identifiable food from nestlings and older but still flightless young of both species were collected at the heronry. Young herons and egrets regurgitated their last meal when they became disturbed. The amount of disturbance necessary to cause regurgitation varied according to species and age level. Regurgitation and defecation of the young flightless herons and egrets which cannot escape are described by Dusi (1966) as displacement behavior characteristic of many herons and egrets.

The regurgitated pellets were collected throughout the summer and were immediately preserved in a 70 per cent isopropyl alcohol solution. From one to several days later the pellets were washed and food items were sorted, counted, and identified.

Observations were made at the various feeding areas to determine feeding behavior of the birds. Bushnell 7 x 35 custom binoculars were used when necessary. Cattle Egrets could often be studied from very short distances.

RESULTS AND DISCUSSION

Food for the young Little Blue Herons was obtained from nearby drainage ditches and from "barrow pits" and "sloughs" along the Mississippi River levee. Feeding also occurred in nearby flooded rice fields. When young Little Blue Herons were able to fly, they frequently were observed at ditches at the borders of fields. Young were also found feeding along the "sloughs" and "barrow pits" of the river levee.

Cattle Egrets fed in open fields when they first arrived in late March and early April. Many were found in the newly plowed or disked fields. Later, during the nesting season (May-August), the Cattle Egrets associated themselves with horses and cattle, which were numerous on the levee.

The Little Blue Heron was observed feeding as far away as 21 miles from the heronry during the nesting season. During early fall (September-October), they scatter and feed at much greater distances (Coffey, 1943; Hanebrink and Rhodes, 1968). Observations of birds of both species coming to the heronry at sundown and leaving near sunup indicated that they fed in all directions from the heronry.
At the Luxora Heronry feeding areas, the well known symbiotic association of the Cattle Egret with cattle was observed constantly during the months of May through August. Although the egrets sometimes fed on their own, catching insects in the pasture and other prey along shallow mudholes and sloughs, they were seldom seen feeding over 100 yards from cattle or horses. One notable exception was observed in early June when eight Cattle Egrets were found following two tractors plowing a wheat field. They fed from 15 feet to 100 yards behind the tractors, searching the freshly turned soil for earthworms and insects much in the same manner as species of blackbirds.

When feeding with cattle, the egrets were usually quite active. They constantly made short runs, changed positions and flew short distances from animal to animal in their search for food. Cattle Egrets were most often found at the sides or near the heads of the cattle. The individual egrets carefully watched for insects disturbed by the cattle. These birds often examined the legs, flanks and head of the cattle for flies. In addition, these birds often alighted on the backs of the cattle. This was more for a perch rather than to feed on flies or ectoparasites. On more than one occasion a bird used a cow to ride across a water-filled area of the pasture.

In the heat of the day the cattle moved into the shade or into nearby water-filled sloughs along the Mississippi River levee. The egrets would not, however, follow a cow into water more than a few inches in depth. They notably preferred animals which were grazing or moving about and quickly abandoned an inactive or reclining cow to hurridly run or fly to a feeding animal. Cattle Egrets also examined weeds and grass very carefully for insects. Although these birds usually caught their prey when it became disturbed and moved, they sometimes caught prey by slowly stalking it or by remaining very still, then suddenly catching it with a quick jab.

Sometimes the egrets were almost stepped on by the cattle as they searched for food, but only when a fly was picked from the head or face did the cattle seem bothered. Even then, the reaction was usually only a shaking of the head.

The Little Blue Heron has long been known in the United States and return to breeding areas each spring from wintering areas in Mexico, Central and South America and from the southern portions of the Gulf Coastal States (Coffey, 1948; Dusi, 1967). The adult Little Blue Herons associated with the Luxora Heronry were observed to stand, wait, and wade or walk slowly while feeding. They feed mostly in water a few inches deep near the edges of the "sloughs" and "barrow pits" between the Mississippi River levee and the Mississippi River. Some were observed feeding in nearby flooded rice fields. Both young and adult birds were observed feeding
Feeding Behavior of the Cattle Egret and the Little Blue Heron

while standing on floating vegetation and partly submerged logs and stumps.

There was no association between cattle and Little Blue Herons, even though they frequented the same sloughs and pastures. Little Blue Herons occasionally fed on grasshoppers or other insects but rarely moved far from the edge of the water.

A comparison, made of food items of the Little Blue Heron and Cattle Egrets associated with the Luxora Heronry, is presented in Table 1. Food items listed include parts of entire organisms collected from the young in the heronry. The most common food for the Cattle Egret was grasshoppers. Small frogs were the most numerous vertebrates in their diet. A comparison of food items of these two species revealed that, with the exception of crayfish, vertebrates made up the bulk of the food of the Little Blue Heron, while invertebrates mostly comprised the diet of the Cattle Egret. Therefore, there is little competition between these two species for food in this area.

Since 1965, the number of nesting Little Blue Herons has remained relatively constant. During the 1968 breeding season these two species far outnumbered the other species of herons and egrets at this heronry. There is little competition with the Common Egret (Casmerodius albus), as this species wades in deeper water to collect larger species of fish. The Common Egret is the third most common nesting bird in this heronry. There is very little interspecific activity between the Cattle Egret and the Little Blue Heron even though they frequently nest in the same tree.

TABLE I

REGURGITATED FOOD ITEMS COLLECTED FROM THE LITTLE BLUE HERON AND CATTLE EGRET FROM THE LUXORA HERONRY (11 MAY - 26 JULY, 1968).

<table>
<thead>
<tr>
<th>Food Items</th>
<th>Little Blue Heron</th>
<th>Cattle Egret</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invertebrates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oligochaetae (Earthworms)</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>Arachnida (Spiders)</td>
<td>3</td>
<td>80</td>
</tr>
<tr>
<td>Crayfish (Cambarus spp.)</td>
<td>410</td>
<td>0</td>
</tr>
<tr>
<td>Fairy Shrimp</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Chilopoda (Centipedes)</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Odonata (Dragon Fly Nymphs)</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Grasshoppers</td>
<td>45</td>
<td>2,888</td>
</tr>
<tr>
<td>Crickets</td>
<td>1</td>
<td>33</td>
</tr>
<tr>
<td>Carabidae (Ground Beetles)</td>
<td>1</td>
<td>311</td>
</tr>
<tr>
<td>Dytiscidae (Diving Beetles)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Elateridae (Click Beetles)</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Pentatomidae (Stink Bugs)</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Noctuidae larva 1 2
Cercopidae (Froghoppers) 0 1
Tipulidae (Crane Flies) 0 1
Tabanidae (Horse and Deer Flies) 1 88
Calliphoridae (Blowflies) 0 25
Diptera larvae 6 1

Vertebrates
Amiidae (Bowfin) 1 0
Lepisosteidae (Gars) 3 0
Cyprinidae (Minnows, Carp) 94 0
Poeciliidae (Gambusia affinis) 1 0
Aphredoderidae (Pirateperch) 1 0
Sciaenidae (Drum) 16 0
Centrarchidae (Sunfish and Bass) 72 0
Ranidae (Frogs) 60 22
Tadpoles 25 0
Bufonidae (Toads) 1 2
Scincidae (Eumeces) 0 1

SUMMARY

A study was made of the feeding areas, feeding behavior, and regurgitated food items collected from the young nestlings of Cattle Egrets and Little Blue Herons in the Luxora Heronry located in Mississippi County, Arkansas.

A comparison was made of food items of these two species. Food items are summarized and include parts or entire organisms collected from nestlings.

The most common food item for Cattle Egrets was grasshoppers. Invertebrates rather than vertebrates were the more common food for the Cattle Egret. Small frogs were the most common vertebrates found in the regurgitated pellets of the Cattle Egrets.

The Little Blue Heron's diet consisted mainly of vertebrates such as tadpoles, frogs, and fish. The most common invertebrate food items for this species was crayfish.

There is very little competition for food among the various species at this heronry. Each species occupies its own niche and does not interfere with its allied species in feeding territories.

LITERATURE CITED

Feeding Behavior of the Cattle Egret and the Little Blue Heron


ELECTROPHORETIC PATTERNS OF PLASMA PROTEINS AND HEMOGLOBIN OF THE PIGEON COLUMBA LIVA DOMESTICA

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INTRODUCTION

Electrophoresis is being used with increasing frequency by vertebrate taxonomists. This technique takes advantage of the different migration rates of protein molecules in an electric field.

The objectives of this study were to: (1) determine if breeds of pigeons could be distinguished by studying plasma protein components and (2) determine if hemoglobin is useful by this technique in separating various breeds of pigeons. If so, this technique could be useful in studying molecular evolution during the development of present pigeon breeds. According to Darwin (1897) the Rock Pigeon (Columba livia) may be confidently viewed as the common parent pigeon stock. It is from this parent stock that numerous breeds and varieties have been developed. For this study three distinct breeds were used; namely the Modena, English Trumpeter and German Beauty Homer (Die Deutsche Schautaube). These breeds differ much in body characteristics, origin and time of development, and their "gene pools" have been somewhat isolated for many years.

The Modena (Fig. 1) is an Italian creation which had its beginnings as far back as 1328. The English Trumpeter (Fig. 2) is also an old breed. Aldrovandi in 1603 apparently described it as a variety of the Runt. The breed was well recognized in England by 1735 (Levi, 1957). The German Beauty Homer (Fig. 3) is a German creation which owes its origin to German breeders who developed a show pigeon from crosses of Racing Homers, Antwerps and others around 1908 (Weger, 1954).

ACKNOWLEDGEMENTS

This study was primarily supported by a grant from the Faculty Research Committee of Arkansas State University and partly by NIH Grant ES 00275-02. Photographic work was done by Jeneane Saunders.

MATERIALS AND METHODS

Fifty samples of 1.5 ml of whole blood were taken from the wing vein on the inside of the elbow joint from individuals of Modenas, English Trumpeters and German Beauty Homers. The pigeon was held with its back downward and the wing laterally spread. Removal of a few feathers made the vein visible (Schermer, 1967).
Fig. 1. The Blue Gazzi Modena Pigeon.

Fig. 2. The English Trumpeter.
Fig. 3. The German Beauty Homer (Die Deutsche Schautaube).

Fig. 4. Eight Column Electrophoresis Apparatus.
Whole blood was drawn from each pigeon by a B-D insulin syringe needle and put in a solution of 3.8 percent sodium citrate (4 parts blood and 1 part sodium citrate) to prevent clotting. The blood was centrifuged for 5 minutes. The plasma was removed by a transfer pipette and frozen. The RBC's were washed six times in a 0.75 per cent bird physiological saline solution (Humason, 1967). A ml of distilled water was added to the RBC's to cause hemolysis. Hemoglobin was drawn off with a transfer pipette and frozen until used.

Disc electrophoresis procedures closely followed those of Davis (1961). The analyses were performed with an eight column electrophoresis apparatus (Fig 4) utilizing graphite electrodes and two circular reservoirs (2 in. deep and 6 in. in diameter) constructed from 6 in. acrylic tubing. Acrylamide gels (0.5 cm x 4.8 cm) and TRIS buffer at pH 8.3 were used throughout. Separation of plasma proteins was conducted at 25°C and at 12 mA for 150 min at 100 volts. After separation the staining was accomplished by using Naphthol Blue Black. The most distinct electrophoretic patterns were obtained with 15 ul of plasma. The gels were then destained and stored according to procedures outlined by Davis (1961).

RESULTS AND DISCUSSION

Studies prior to 1957 on electrophoresis of avian plasma or serum proteins have been limited to a few isolated birds. Wall and Schlumberger (1957) investigated the plasma electrophoretic patterns of the shell parakeet (Melopsittacus undulatus). Sibley and Johnsgard (1959) published on the variability in the electrophoretic patterns of avian serum proteins. Their studies included a variety of avian species. In this study the Rock Dove (Columba livia) was investigated. The histogram profiles of the serum proteins showed two large components for this species. Perkins (1964) published on electrophoretic patterns of the serum proteins and hemoglobins of the genus (Larus). He showed no more variation between the species than within a single species for this genus even though there is a wide variation in the size and coloration of these birds. It was concluded by Baker and Hanson (1965) that species and subspecies of geese cannot be distinguished on the basis of the blood proteins and that there are only minor differences between the genus (Anser) and (Branta). Eleven species including subspecies were used in their study. Rylander (1967) studied electrophoretic patterns of the serum proteins of two genera of the family Scolopacidae. He concluded that intraspecific variation is great and that there is no significant difference between the species or even genera in this family. Sibley and Johnsgard (1959) stated that if reliable measurements of avian sera are desired, sample size must be large, and birds must be separated by age and sex, just as in studies of morphological characters.
The results from this study by using acrylamide gel electrophoresis techniques on three distinct breeds of domesticated pigeons show minor individual differences within the breed and also differences between individuals of different breeds. Because of these variations there was no one representative electropherogram for each breed of pigeon. Some samples from individuals within a breed were remarkably similar. Intrabreed variation is not always easy to explain. These variations may be caused by differences in experimental procedures, by sex, age and perhaps health of individual pigeons. In general, there was some uniformity in protein patterns among the pigeons studied. These patterns are shown in Figs. 5-8. Some protein components did not migrate from the starting zone of the small pore acrylamide gel. For all three breeds a pronounced disc appeared at 3 to 4 mm below the starting zone. In the region of 1 to 15 mm from the starting zone the breeds varied in the number of narrow slowly migrating protein discs. In this region there were 7 to 8 protein discs for the English Trumpeter; 8 to 9 for the German Beauty Homer; and 6 to 8 for the Modena. For all three breeds two wide rapidly migrating plasma protein discs appeared in in the 15-30 mm region of the gels. In the lower 15-30 mm region the most significant variation between different breeds was found in the number of narrow rapidly migrating discs preceeding each wide disc. English Trumpeters had 1 or 2 narrow protein components before the first wide protein disc and sometimes one small disc before the second wide disc. The German Beauty Homer usually had one narrow protein disc preceeding each large one. Plasma from Modena's also had 1 or 2 narrow discs preceeding each wide disc. The absence of the narrow disc in certain individuals was probably due to extremely faint discs caused by low concentrations of a plasma protein component and to masking by the wide fast moving disc, some of which migrated at different speeds between individual pigeons.

Because of technical difficulties hemoglobins of the breeds were not extensively studied by this electrophoretic technique. Hemoglobins from the above mentioned breeds seemed to have exceptionally low specific gravities. Hemoglobin from the White King breed showed one large component. Other studies have shown hemoglobin to be of no value in identifying bird species by electrophoresis techniques.

SUMMARY

Fifty pigeons of three distinct breeds (English Trumpeter, German Beauty Homer and Modena) were used in studying patterns of plasma proteins and hemoglobin with disc electrophoresis techniques. Individual variations of protein patterns were observed and described. Disc electrophoretic techniques were not useful in studying pigeon hemoglobins.
Fig. 5. Electrophoreograms Of Three Modenas.

Fig. 6. Electrophoreograms Of Three English Trumpeters.
Fig. 7. Electrophoreograms Of Three German Beauty Homers.

Fig. 8. Disc Electrophoresis Patterns Of Plasma Proteins On Acrylamide Gels (From left: English Trumpeters, German Beatuy Homers and Modenas).
CITED LITERATURE


SPIDERS COLLECTED FROM MUD-DAUBER NESTS IN CLARK COUNTY, ARKANSAS

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Arkadelphia, Arkansas 71923

It is well known that social wasps often use spiders as food for their larvae. They catch the spider, paralyze it by the sting, and carry it to the nest where it is used as food by the young.

The writer has found wasps very helpful in making a thorough study of an area because sometimes they store species which are not found in that specific area by other methods of collection. In many instances an insight into the prevalence of certain species of spiders in an area can be ascertained from the large numbers stored in nests.

An interesting observation in making collections from mud-dauber nests throughout Clark County indicated that emergence of wasps from nests occurred from June until early September. However, in late August and early September very few spiders could be collected from nests because apparently the wasp larvae had used the edible parts of most spiders and only dried unidentifiable remains were found. June and July proved to be the best months for collecting from Hymenopterous nests in Clark County.

Very few spiders could be collected from mud-dauber nests in agricultural regions heavily sprayed with insecticides. In these areas reliable collecting methods such as sweeping the vegetation with a net also failed to reveal spiders in significant numbers. It appeared the population was so small that wasps turned to other food sources for their young.

The solitary fossorial wasps are, however, the spiders' chief enemy, and it is probable that they are more effective in control of the spider population than all other factors combined.

Among the wasps of the family Pompilidae, one of the largest and most important of the group which is spread over most of the world, all species use spiders as the chief food for their larvae. They usually excavate holes in the earth, provide them with spiders deposit eggs and seal the holes. The spiders are stung, paralyzed, remain quiescent, and do not struggle and endanger the young larvae. These paralyzed spiders may live for several weeks during which time they are unable to feed and their movement is very limited. Wasp of this group show great efficiency in attacking even comparatively large spiders and the writer has made plans to more carefully study
this group at a latter date. Denny's (1963) removed a paralyzed Phidippus spider from a digger wasp nest and kept it in a vial. After two months the spider was still alive; when given water and flies it recovered fully and lived for more than 18 months. Apparently the venom from the wasp acts only as a tranquilizer which subsides in time.

Spears (1965, unpublished M.S. Thesis) collected mud-dauber nests throughout Northern Mississippi and found that two genera, Trypoxylon and Sceliphron were responsible for most of the nests under bridges and around other similar collecting sites which she used. In the present study of Clark County spiders these two genera were also responsible for the mud-dauber nests from which spider specimens were collected.

Muma (1945) made a special study of the spider prey of several mud-dauber wasps and collected only 10 families. In the Clark County study 12 families and 50 species were collected as opposed to the 10 families and 28 species collected by Dorris (1968) throughout 82 counties of Mississippi.

Studies made in Clark County, Arkansas may be summarized as follows:

1. Rare and uncommon spiders as well as common species were found in nests of mud-dauber wasps.

2. Prey collected by members of Sceliphron was limited by the hunting environment of the wasp, size and prevalence of the spiders, and season.

3. Individuals of Trypoxylon collected common spiders among foliage apparently preferring species of the genera Neoscona and Eustala but took almost anything available. Many small or immature spiders common on flowering plants in open areas were also used by members of Trypoxylon.

The 12 families and 50 species of spiders the writer collected from mud-dauber nests in Clark County, Arkansas are as follows:

ARANEIDAE
Acacesia hamata (Hentz)
Acanthepeira moesta Comstock
Acanthepeira stellata (Marx)
Araneus miniatus (Walckenaer)
Araneus nordmanni (Thorell)
Araneus marmoreus Clerck
Araneus thaddeus (Linnaeus)
Araneus cavatica (Keyserling)
Neoscona domiciliorum (Hentz)
Neoscona arabesca (Walckenaer)

Eustala anaestra (Walckenaer)
Glyptoeranium bisaccatum
Comstock
Mangora ornata (Walckenaer)
Metazygia witfieldae (McCook)
Metepeira labyrinthica (Hentz)
Cyclosa turbinata (Walckenaer)
Neosconella pegnia (Walckenaer)
Alleperia lemniscata
(Walckenaer)
MIMETIDAE
Ere furcata (Villers)

THERIDIIDAE
Theridion tepidariorum (C. L. Koch)

THOMISIDAE
Misumenops asperatus (Hentz)
Tmarus angulatus (Walckenaer)
Misumena vatia (Clerck)
Synema parvula (Hentz)
Thanatus formicinus (Clerck)

GNAPHOSIDAE
Cesonia bilineata (Hentz)

ULOBORIDAE
Uloborus glomosus (Walckenaer)

OXYOPIDAE
Oxyopes salticus Hentz

CLUBIONIDAE
Clubiona obesa Hentz

SALTICIDAE
Phidippus purpuratus Keyserling
Phidippus audax (Hentz)
Phidippus whitmani Peckham
Phidippus mystaceus Emerton
Phidippus rimator (Walckenaer)

Icius elegans Emerton
Agassa cerulea (Walckenaer)
Habonattus coronatus (Hentz)
Habronattus borealis (Banks)
Paraphidiuups marginatus (Walckenaer)
Paraphidippus aurantius (Lucas)
Metaphidippus protervus (Walckenaer)
Metaphidippus flavipes (Peckham)
Metaphidippus galathea (Walckenaer)
Maevia inclemens (Walckenaer)
Marpissa undata (DeGeer)
Neon nelli Packham
Ayska gracilis (Hentz)
Tetragnatha versicolor
Tetragnatha versicolor
Tetragnatha elongata
Tetragnatha elongata
LYSSOMANIDAE
Lyssomanes viridis (Walckenaer)

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AN ADDITION TO THE LIST OF SPIDERS COLLECTED IN CLARK COUNTY, ARKANSAS

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A preliminary list of spiders collected from Clark County, Arkansas was presented by Dorris (1968). At that time collections had been made for a period of one year only. Intensive collecting during each season of the year from 1967-1968 yielded an additional 3 families and 108 species of spiders unreported from Clark County.

The present research indicates that there is a very rich fauna of spiders in Arkansas and that spider populations of this state may far exceed those of surrounding southern states. Because of the unlimited expanse of varying habitats such as Delta, prairie, hills, mountains, swamps and other similar places a rich fauna of species ranging from the most common to the least common is expected.

From previous reports of nearby surrounding southern states and preliminary research of Clark County spiders, it appears that Arkansas offers a much richer spider fauna than most southern states. For instance, Fitch (1963) reported 192 species from Oklahoma, Dorris and McGaha (1967) reported 280 species from Mississippi, and Peck (1966) found 202 species in Missouri. Other surrounding states have reported similar species lists which are seemingly smaller than that expected from Arkansas.

At the present time, from Clark County alone, 28 families representing 216 species have been collected. The writer believes that more intensive collecting over a longer period of time and over a wider area of Arkansas will yield a very large list of species from the state.

Additions to the list found in Clark County prior to this time are as follows:

**DICTYNIDAE**

*Dictyna segregata*  
Gertsch & Mulaik

*GNNAPHOSIDAE*

*Rachodrassus echinus*  
Chamberlin

*Drassylus covensis* Exline

*Drassylus creolus*  
Chamber & Gertsch

*Drassylus mephisto* Chambers

*Drassylus fallens* Chambers

*Sergiolus capulatus*  
(Walckenaer)

*Clyphosa sericata* (L. Koch)

*Cesonia bilineata* (Hentz)

*Zelotes laccus* (Barrows)

*Zelotes hentzi* Barrows

*Dressylus depressus* (Emerton)

**CLUBIONIDAE**

*Mertola decepta* Banks

*Clubiona abbottii* C. L. Koch

*Clubiona moesta* Banks
Scotinella formica (Banks)
Trachelas laticeps Bryant
Castianeira vulnerea Gertsch
Castianeira descripta (Hentz)
Castianeira longipalpus (Hentz)

ANYPHAENIDAE
Anyphaena maculata Banks
Anyphaena fragilis Banks
Anyphaena celer (Hentz)

THOMISIDAE
Misumenops celer (Hentz)
Misumenops oblongus Keyserling
Xysticus texanus Banks
Xysticus ferox (Hentz)
Xysticus auctifrons Keyserling
Xysticus funestus Keyserling
Philodromus pernix Blackwell
Philodromus rufus Walckenaer
Philodromus keyserlingi Marx
Philodromus marxii Keyserling
Philodromus vulgaris Keyserling
Oxyptila conspurcata Thorell

SALTICIDAE
Phidippus princeps (Peckham)
Phidippus clarus Keyserling
Phidippus carolinensis
Peckham & Peckham
Phidippus purpuratus
Keyserling
Phidippus incertees Peckham
Phidippus mysetaceus Emerton
Phidippus insignarius C. L. Koch
Phidippus pulmanii (Peckham)
Agassa cyanea (Hentz)
Agassa cerulea (Walckenaer)
Eris aurantia Lucas
Eris pineus (Kaston)
Eris marginata (Walckenaer)
Maevia vittata (Hentz)
Metacyrba undata (DeGreer)
Metacyrba taeniola (Hentz)
Pechhannia picata (Hentz)
Metaphidippus insignis (Banks)
Metaphidippus protervus
(Walckenaer)

Paraphidippus marginatus
(Walckenaer)
Sitticus floridanus
Gertsch & Mulaik
Hentzia palmum (Hentz)
Hentzia mitra (Hentz)
Thiodina sylvana (Hentz)
Icius elegans Emerton
Habronattus coronatus (Hentz)

THERIDIIDAE
Archearenia tepidariorum
(C. L. Koch)
Theridion differens Emerton
Argyrodes trigonum (Hentz)
Euryopsis funebris (Hentz)

MIMETIDAE
Mimetus interactor Hentz
Ero furcata (Villers)

ARANEIDAE
Glyphocranium bisaccatum
Comstock
Gasteracantha elipsoides
(Walckenaer)
Acacesia hamata (Hentz)
Araniella disparcata (Hentz)
Conopeira ozarkensis Archer
Epeira cornuta (Clerck)
Wixia ectypa (Walckenaer)
Aranea nordmanni (Thorell)
Aranea marmoreus Clerck
Aranea thaddeus (Linnaeus)
Neoscona sacra (Walckenaer)
Neoscona pratensis (Hentz)
Neosconella pegnia (Walckenaer)
Acanthopeira moesta Comstock
Singa pratensis Emerton

TETRAGNATHIDAE
Mimognatha foxi (McCook)
Pachygnatha tristriata C. L. Koch
Tetragnatha laboriosa Hentz

OECOBIIDAE
Oecobius texanus Bryant

ERIGONIDAE
Eperigone maculata (Banks)
Eperigone autumnalis Emerton
**Spiders Collected from Mud-Dauber Nests**

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
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<tbody>
<tr>
<td>Erigone tridentata</td>
<td>Lycosa helluo Walckenaer</td>
</tr>
<tr>
<td>Grammonata maculata</td>
<td>Lycosa helluo annexa Chambers &amp; Ivie</td>
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<tr>
<td>Grammonata inornata</td>
<td>Pardosa pauxilla Montgomery</td>
</tr>
<tr>
<td>Walckenaera vigilax</td>
<td>Pardosa saxatilis (Hentz)</td>
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<td>LYSSOMANIDAE</td>
<td>Pardosa saxatilis atlantica Emerton</td>
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<td>LYCOSIDAE</td>
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<td>Meioneta micaria</td>
<td>Pirata sylvanus</td>
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<tr>
<td>LYNYPHIIDAE</td>
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<tr>
<td>Schizocosa avida</td>
<td>Pirata sedentarius Montgomery</td>
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<tr>
<td>Arctosa funerea</td>
<td>OXYOPIDAE</td>
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<tr>
<td>Lycosa antelucana</td>
<td></td>
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</tbody>
</table>

**LITERATURE CITED**


THE PIERIDAE OF ARKANSAS

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The members of the family Pieridae are medium to small sized butterflies usually having white, yellow, or orange background color, with dark gray or black marginal wing markings. The radius may be three or four branches, rarely five, and some branches are always stalked in the front wing. The cubitus appears three branched (Fig. 1). There are always two anal veins present in the hind wing. The front legs are well developed in both males and females, and the tarsal claws are bifid.

The chrysalids are elongate and are attached to supporting surfaces by the cremaster and a silken girdle around the middle of the body. They may be recognized by the presence of a sharp point or projection in front (Fig. 2). The larvae are usually long and green with short fine hairs. Some of the larvae in this family are highly destructive, especially to clovers and some of the better known crucifers. For clarity a phylogenetic list follows.

SUBFAMILY PIERINAE

(Whites)

Appias drusilla (Cramer). Florida White*
Pieris protodice Boisduval and LeConte. Southern cabbage worm
Pieris rapae (Linnaeus). Imported cabbageworm
Ascia (Ascia) monuste (Linnaeus). Great Southern White*

SUBFAMILY COLIADINAE

(Sulphurs)

Colias (Colias) eurytheme Boisduval. Alfalfa catepillar
Colias (Colias) philodice Godart. Clouded sulphur
Colias (Zerene) cesonia (Stoll). Dog face
Anteos maerula (Fabricius). The Maerula*
Phoebis (Phoebis) sonnae (Linnaeus). Cloudless sulphur
Phoebis (Phoebis) philea (Johansson). Orange barred sulphur
Phoebis (Phoebis) agarithe (Boisduval). Orange sulphur
Phoebis (Aphrissa) statira (Cramer). The Statira*
Kricogonia lyside (Godart). The lyside*
Eurema (Eurema) daira (Godart). Fairy yellow*
Eurema (Eurema) mexicana (Boisduval). Mexican sulphur
Eurema (Pyrisitia) lea Boisduval and LeContet. Little sulphur
Eurema (Pyrisitia) nise (Cramer). Nise sulphur*
Eurema (Abaeis) nicippe (Cramer). Sleepy orange
Nathalis io Boisduval. Dainty sulphur

*Not likely to be taken by the general collector.
The Pieridae of Arkansas; Rouse

SUBFAMILY EUCHLOEINAE
(Orange Tips)

Anthocaris (Falcapica) midea Hubner, Falicate orange tip
Euchloe olympia (Edwards). The Olympia

KEY TO SUBFAMILIES

1a. Wings white above with black markings. In some species
the front wing may have a falcate (hooked) orange tip above ........................................... 2

b. Yellow to orange above with black markings. Some species
have white forms, but the dark markings on the lighter
forms are the same as the yellow forms (Sulphurs) .. Coliadinae

2a. The underside of the hind wing has a greenish network, or
marbled green mottling which usually shows through when
viewed from above (orange tips) ........................................... Euchloeinae

b. The marking on the hind wing may vary from white to
black and white checkered spots, but are never mottled or
marbled (Whites) ........................................................................ Pierinae

KEY TO THE GENERA AND SPECIES OF THE
SUBFAMILY PIERINAE

1a. At least one or more large medial dark spots in the fore
wing above ........................................................................ 2

b. No large medial dark spot above. If dark spot is present
it is a discoidal mark usually small and obscure .......... 3

2a. Front wings creamy white above with the apex grey and
with at least one and often two circular medial dark spots
above. Hind wing may be clear or with only one medial
dark spot above. Female not noticeably more heavily marked.
Fig. 3 ........................................................................ Pieris rapae (L.)

b. Wings white with subrectangular dark spots above giving
them a checkered appearance. Females are much more
heavily marked Fig. 4 & 5 ........... Pieris protodice Bois. &LeC.

3a. White, with a pearly iridescence at the base of front wing
above, and wing margin slightly concave. Orange at the
base of the hind wing beneath in the males. Hind wing
color variable in the female from creamy white to a very
pale orange. Fig. 6 ..................... Appias drusilla (Cramer)*

b. White above usually with a dark margin. The under side
of hind wing and the apex of the front wing may be yellow-
ish tinged, but never orange at the base beneath. Fig. 7

*Rare
KEY TO THE GENERA AND SPECIES OF THE SUBFAMILY COLIADINAE

1a. Dark brown or black margins on front wing above that never cover more than one eighth of the wing. Color variable, can be pale yellow, orange, or yellow fading into white distally ........................................ 2
   b. Dark margins on the front wing cover more than one eighth of the wing on an orange to grayish-white background above ........................................ 7

2a. Front wing angulate, slightly falcate distally, a clear yellow, with a medial dark discocellular spot above. A yellowish to white patch present in the hind wing at the base of the costa. Fig 8 .................................. Anteos maerula (Fab.)
   b. Front wing rounded apically, no trace of falcation present ........................................ 3

3a. Wide orange barred caudal edge on a yellowish background, hind wing above in both sexes. Males also barred medially on front wing above. Fig 9 .......................... Phoebis philea (Johan)
   b. Orange bars on a yellow background absent above. If any bi-coloring of orange and yellow is present, it is basic, never barred caudally ........................................ 4

4a. Wings above with a clear orange background margined with gray or black. Females with a dark discocellular spot, absent in males. Large 2 1/2"-2 3/4" wing spread. Fig. 10 & 11 .......................... Phoebis agarithea (Bois.)
   b. Entirely yellow or yellow fading into white distally. Dark color markings variable above. Never with a clear orange background .................................................................... 5

5a. Entirely yellow above in the males to yellow margined with black with a dark discocellular spot in females. Fig. 10 & 11 .................................................. Phoebis senaeae (L.)
   b. Background color not evenly distributed over entire wing, fades into different shades ........................................ 6

6a. Wings yellow basally, white medially, merging into yellow distally above. Often with a short dark bar on the costa of the hind wing. Fig. 12 .......................... Kricogonia lyside (Godart)
   b. Wings yellowish-pink basally, fading into white distally above. Wing margin clear to bordered with black. Discocellular spot variable Fig. 23 .......................... Phoebis statira (Cram.)

7a. "Dog face" pattern in front wing above. Figs. 13 & 14 ........................................ 8
   b. Without a "dog face" pattern in front wing ........................................ 9

*Rare
The Pieridae of Arkansas; Rouse

8a. "Dog face" pattern with dark round spot giving the "dog face" an "eye" above. Fig 13 Colias cesonia (Stoll.)

b. "Dog face" pattern without an "eye" above; angular hind wing. Fig. 14 Eurema mexicana (Bois.)

9a. Dark bar lengthwise above on leading edge of hind wing near costa. Small, 1 inch wing spread; front wing above with dark apex and a dark bar posteriorly on a yellow background. Fig. 15 Nathalis idole Bois.

b. No such dark bar above on leading edge of hind wing near costa 10

10a. Medium in size; 1 1/4" wing spread; dark bar missing on hind wing above with dark marginal splotching. Front wing barred baso-laterally in summer, not barred in winter; front wing apex dark above. Fig. 16 Eurema daira (Godart)

b. Not baso-laterally barred in either front or hind wing. Wings variable, usually evenly colored predominately orange or yellow with black margins 11

11a. Discocellular spot above in the front wing, small, dark and comma shaped, or missing 12

b. Discocellular spot noticeably more rounded, and a conspicuous orange spot medially in the hind wing 14

12a. Wing background color above orange, bordered in black with a dark, comma shaped discocellular spot. Fig. 17 Eurema nieippe (Cram.)

b. Wings above whitish to yellow, never a bright orange background 13

13a. Wings whitish to yellow with a dark discocellular comma shaped spot. Fig. 18 Eurema lisa Bois. and LeC.

b. Wings whitish to yellow, with no discocellular spot Eurema mise (Cram.)

14a. Wings above yellow margined with dark marking. No trace of an orange color except for orange in the medial spot in the hind wing. Fig 19 & 20 Colias philodice Godart

b. Wings above whitish to orange with dark markings. Never a clear yellow background. Fig. 19 & 20 Colias curytheme Bois.

KEY TO THE GENERA AND SPECIES OF THE SUBFAMILY EUCHLOEINAE

1a. Front wing falcate, apex orange above in males; grey in females. Wings mottled with greenish grey. Fig. 22 Anthocaris midica Hubner

b. Front wing not falcate. White, or white with dark markings. Front wing above sparsely mottled with grey; hind wing

*Rare
marbled beneath with green, which shows through above.

Fig. 21       Euchloe olympia (Edw.)

Adults of the family Pieridae fall readily into three subfamilies based mostly on color. These are Pierinae (whites), Euchloeinae (orange tips) and Coliadinae (sulphurs). Of the twenty-one species listed that might be found in Arkansas ten species are common, four are collected occasionally in late summer or fall, and seven may be taken as strays.

Specimens of the subfamily Pierinae are characterized by a white background colored with gray or black markings. Some very light yellowing may be present giving the insect a creamy color. A yellow form rarely occurs. Only two species are commonly found in Arkansas.

The other species of Pierinae included in this writing are rarely taken by the average collector but are included because of their migratory habits.

Pieris protodice Boisduval and LeConte, the southern cabbage-worm is readily separated from Pieris rapae by its checkered appearance. The markings are rectangular and sexual dimorphism is present. The female is always noticeably more heavily marked. It has three or more broods yearly. Wing spread is about one and three fourths inches. The larvae feed on members of the family Cruciferae (Mustard family).

Pieris rapae (L.), the imported cabbageworm, has rounded markings and very little sexual dimorphism. The wing tip is a solid gray. This species was introduced into North America about 1860 and has since spread over most of the continent. The larvae are very destructive to cabbage and related plants (Family Cruciferae). Adults appear in March and may be seen late in the fall. Three or more broods usually occur annually. Wing spread is about one and three fourths inches.

Appias drusilla (Cramer), the Florida white, is not a native of Arkansas, but it becomes migratory at times and has been taken as far North as Nebraska. It is larger than P. rapae and P. protodice, having a wing span of about two and one half inches. It is mostly a silky white to grayish with dark borders. Sexual dimorphism is present with the females darker. The insect is separated from Ascia monuste (L.) by the characteristic orange marking basally beneath on the front wing.

Ascia monuste (L.), the great southern white, like A. drusilla migrates into the state. At times it is quite common in the south of Arkansas along the Gulf coast. It has light and dark forms. The darker form has been shown to be the migratory phase. The com-
mon form is white with dark borders. The brownish gray form has similar but more diffuse dark margins. It has a wing spread of about two and one half inches.

The subfamily Coliadinae is the group of butterflies commonly known as the sulphurs. This group is easily recognized by the yellow or orange coloring. Although whitish forms may occur they need not be confused with other subfamilies as the wing pattern is identical in both the orange and yellow form, and the background color is much more gray.

*Colias eurytheme* Boisduval is the alfalfa caterpillar. Although it varies greatly in shading it is recognized by its orange coloring above. It has dark submarginal spots on both wings beneath, along with a silvery centered round, mostly double, orange or red discocellular spot in the hind wing below. Sexual dimorphism is present with the females more heavily marked with dark markings, though often on a grayish-white background with the characteristic dark markings. Whitish males are rare. Hosts are in the family Fabaceae, the clovers and vetches. Alfalfa is its preferred food.

Adults may be taken readily from blooming plants in open fields and along roadsides. These butterflies appear from April to late fall and there are three or four broods annually. Wing spread is about one and one half to two inches.

*Colias philodice* Godart, the clouded sulphur, is readily separated from *C. eurytheme* by its yellow background color. The other wing markings and size are similar. The females can be separated by the yellow color and a narrower black border on the upper side of the front wings. The preferred host of *C. philodice* is white clover, but otherwise its habits are similar to *C. eurytheme*.

*Colias cesonia* Stoll, the dog face, is easily identified by its large size about two and one half inch wingspread; its sharply pointed front wing; and the typical “dog face” yellowish pattern above on the front wing facing outward. The discocellular dark spot gives the appearance of an “eye” in the yellow pattern.

It feeds upon false indigo (*Amorpha fruticosa*) and clover (*Trifolium spp*.*), and there are three to four broods annually. Adults are usually collected in open fields, and on blooming flowers along roadsides.

*Anteos maerula* (Fab.) is the only large, clear yellow, butterfly with falcate front wing likely to be taken in Arkansas and should be considered a stray, being a breeding resident of south Texas. The wings are yellow, very finely edged in black and with a conspicuous dark discocellular spot in the front above. Wingspread is about two and one half to three inches. Members of the group are commonly referred to as the angled-sulphurs.
Phoebis sennae (L.), the cloudless sulphur, is a member of the genus Phoebis known as the tropical sulphurs. It is the one found most commonly in Arkansas.

The males are an unmarked clear yellow. The females vary from whitish to yellowish orange and are brokenly bordered with dark brown or black with a large discocellular spot above in the front wing. It feeds mostly on members of the family Fabaceae and has two or more broods annually. Wing spread is about two and one half inches.

Phoebis agarithea (Boisduval), the orange sulphur, is reported to be indigenous in the state. It superficially resembles P. sennae but the clear unmarked orange of the males is characteristic.

Dimorphism is present. The females may vary from salmon pink to orange and are more heavily marked with dark brown. Wing spread is about two and one half inches.

Phoebis philea (Johansson), the orange barred sulphurs, is a strikingly beautiful butterfly with its broad wings marked with orange on a yellow background. Wingspread often is two and three quarters to three inches. Dimorphism is present and the females, while yellow orange marked with dark brown, have the caudal edge of the hind wing marked conspicuously with orange, and the front wings a more even colored orange yellow. The female also has a row of marginal dark spots in both wings. In addition it has both a post-medial and a submarginal row of dark brown spots on the front wing above.

Phoebis statiru (Cramer) is a beautiful white and yellow butterfly with black-edged wing. It may occasionally be found in Arkansas, but must be considered a stray. The wings are yellow fading into white distally. The wing spread is about two inches. Kricogonia lyside (Godart) another butterfly that may be taken as a stray, is similarly colored but narrowly or not at all margined in black and the wings are yellow basically, white medially and yellow distally.

Nathalis io le Boisduval, the dainty sulphur, is one of our more common butterflies and is our smallest member of the group known as the little sulphurs. It is yellow and dark brown or black above with longitudinal dark bars in both the front and hind wings. The wing tips of the front wings are also dark, faintly tipped with yellow distally. Wingspread is usually less than one inch. It feeds on members of the family Fabaceae. It is indigenous to Arkansas and the adults may be taken at flowers in similar habitat to C. eurytheme.

Eurema daira (Godart), the fairy yellow, may be found within the borders of the state, but is rare. It has a wingspread of about
one inch. The wings are conspicuously margined in dark brown or black with a dark bar in the front wing above. The dark bar may be present or absent in the winter form, but is always present in the summer form. It may be confused with *Eurema nise* (Cramer) whenever the dark bar is absent, but can be separated by the broader dark markings on the margin of the hind wing. Preferred habitat for the adult is brushy places along the edge of woods near open places. Preferred hosts are members of the family Fabaceae. Wingspread is about one and one eighth inches.

*Eurema mexicana* (Boisduval). The downward projecting “eyeless dog face” and pointed front wing are characteristics of this species. It is reported to be common in Oklahoma and is usually taken on flowers along the western edge of Arkansas. Dimorphism is present with the females differing from the males in having less dark marginal marking in the hind wing. These dark markings are usually present only as an apical patch whereas the males are noticeably more deeply margined in black. Wingspread is about one and three eighths inches. The ecology of this insect is poorly understood.

*Eurema nicippe* (Cramer), the sleepy orange, is easily recognized by its bright orange, black tipped wings with a dark discocellular comma shaped mark. The wingspread is about one and one half inches. Dimorphism is present. The males are usually solid orange with wide black margins, the females with orange and diffused black margins. Its preferred food is *Senna* (*Cassia sp.*) and clover. Other species of Fabaceae are frequently fed upon. Three broods or more occur annually. Adults are usually taken in swamps and meadows.

*Eurema lisa* Boisduval and LeConte, the little sulphur, is easily separated from similar species by a discocellular dark mark and a wide black border on the rounded wing tip. Food plants are from the family Fabaceae. Wingspread is about one and three eighths inches. Adults may be taken on flowers in open fields and along roadsides.

*Eurema nise* (Cramer), the nise sulphur, a widespread tropical species that might stray into the state, is separated from *E. lisa* by the absence of any discocellular dark mark and a narrower dark margin. Its hind wing is usually lighter yellow than its front wing. The adults prefer edges of woods but when disturbed do not fly out into open spaces as do the similar *E. lisa*. Its preferred host is the sensitive plant, (*Mimosa pudica*). Wingspread is about one and one quarter inches.

The subfamily Euchloeinae is separated from other white butterflies by the characteristic mottling or marbling on the underside
of the hind wing. They are known as the orange tips. Characteristically, the males in most species have a bright orange patch above on the front wing. There are only two species found in the state.

*Anthocaris midea* Hubner, the falcate orange tip, is a small white butterfly with a wing spread of about one and one half inches. The front wing tip is falcate, and is a bright orange color in the males and gray in the female. The underside of the hind wing in both sexes is mottled in yellow-green. It is found mostly in deciduous woodland. Larval food is principally rock cress (*Arabis lyrata*) and Hedge mustard (*Sisymbrium*). It has about one and one half inch wingspread.

*Euchloe olympia* (Edwards), the olympia is the only representative of the genus *Euchloe* with in which the males are not orange tipped. It is easily recognized by its yellow-green marbled pattern on the underside of the hind wing which shows through the delicate wing. The front wing is white with scattered dark markings. It is native to the state and is found in open woodland and nearby meadows in early spring. Its food is similar to *A. midea*. Wingspread is about one and one half inches.

**LITERATURE CITED**


HENOMOLYSIS BY CROTALUS HORRIDUS
ATRICAUDATUS VENOM

Franklin E. Byrd and Bob D. Johnson

Canebrake rattlesnakes *Crotalus horridus articaudatus* (Figure 1) are common to Arkansas. These snakes are infrequently found in timber uplands or wooded hills adjoining streams but usually they are found in swamp or bottom lands (Wright and Wright, 1957). Canebrakes are large, heavy-bodied, poisonous snakes which may reach six feet in length. On their posterior body there is a median series of blotches expanding transversely to connect with a ventrolateral series, forming chevron-shaped bands. On many specimens there is a rich red-brown mid-dorsal stripe about four scales wide (Anderson, 1965).

Minton (1967) and Johnson et al. (1968) have described several of the characteristics of *C. h. articaudatus* venom. In this work hemolytic activity of *C. h. articaudatus* venom is studied. Hemolysis tests with and without lecithin as well as hemolysis tests using isotonic and hypotonic solutions were conducted. Hypotonic lysis tests (Seeman, 1966) are used in attempting to determine the effects of heat labile venom components on hemolysis of human erythrocytes (RBC).

MATERIAL AND METHODS

Specimens of *C. h. articaudatus* were obtained from Max Allen’s Zoological Garden, Eldon, Missouri. After extraction, the venom was centrifuged to remove insoluble residues and cellular debris and then lyophilized. L-a-lecithin, Type 11-E from Sigma Chemical Company was used.

Phospholipase A activity was assayed by following the procedures of Brown and Bowles (1966).

Whole venom (50 mg samples) was boiled for 10 min before the supernatants were removed by centrifugation. Disk electrophoresis (Davis, 1964) was used to show the number of heat stable components in the boiled venom supernatants.

Hemolysis tests using washed RBC were performed in isotonic solutions before tests in hypotonic solutions were conducted. The cells were washed in isotonic saline, 154 mM NaCl in 10 mM sodium phosphate buffer, pH 7. Three ml of isotonic saline containing venom (2.0 mg/ml) and 0.2 ml of RBC (1 x 10⁶ RBC/ml) were incubated for five min at room temperature to determine the presence of direct hemolysis. Indirect hemolysis was indicated by incubating 0.2 ml of RBC in three ml of isotonic saline containing venom (2.0 mg/ml)
plus crude lecithin (1 x 10^{-3} M).

Hypotonic solutions ranging from 22 to 151 mM NaCl in 10mM sodium phosphate buffer, pH 7, were tested to determine the concentration causing 50 percent hemolysis. In these tests a 0.2 ml RBC suspension (1 x 10^8 RBC/ml) was added to a three ml hypotonic solution, mixed, and incubated for five min at room temperature. After incubation, the suspension was centrifuged one min before removing the supernatant. Hemoglobin (Hb) content was used to indicate percent hemolysis. This was measured by recording the optical density at 543 mu (O.D.\text{}_{543}) in a Beckman DB spectrophotometer. The blank was always prepared by replacing the RBC with buffer. All tests were run in triplicate.

Stabilization effects of lecithin on RBC membranes were induced by adding 0.1 ml lecithin solutions to the hypotonic solution causing 50 percent hemolysis. The blank consisted of buffer and lecithin. In other lysis tests, C. h. atricaudatus venom was reconstituted in the hypotonic solution (66 mM NaCl), 10 mM sodium phosphate buffer, pH 7) causing 50 percent hemolysis.

Relative hemolysis was obtained by dividing the amount Hb released (during 5 min hypotonic hemolysis) in the presence of venom by the amount Hb released in the absence of venom. A relative hemolysis unit of less than one indicated a nonspecific lysis behavior whereas a relative hemolysis unit of more than one was indicative of specific lysis.

RESULTS AND DISCUSSION

Repeated phospholipase A determinations showed no, or quite low, phospholipase A activity in C. h. atricaudatus venom. Similar determinations with other crotalid venoms showed high phospholipase A activities. Phospholipase A determinations for all venoms were conducted simultaneously.

Disk electrophoresis of the boiled venom supernatants showed the presence of one wide disk and one or two small disks. Perhaps one of these protein components was phospholipase A.

RBC incubated for five min in isotonic saline containing venom (2.0 mg/ml) were not hemolyzed. When RBC were incubated for five min in isotonic saline containing venom (2.0 mg/ml) and lecithin (1 x 10^{-3} M) hemolysis occurred. Approximately one eighth of the RBC were lysed.

Fifty percent hypotonic hemolysis occurred at 66 mM NaCl in 10mM sodium phosphate buffer, pH 7. Use of varying concentrations
fo lecithin showed that the greatest RBC membrane stabilization against hypotonic lysing occurred at 10\(^{-3}\) M final concentration. These stabilizations resulted in a biphasic curve as evidenced by relative hemolysis values of less than one. In this concentration of lecithin (1 x 10\(^{-3}\) M), stabilization persisted even in the presence of C. h. atricaudatus venom (Figure 2).

The hypotonic lysis tests indicated that heat labile components in C. h. atricaudatus venom have no effect on nonspecific lytic behavior. This non-specific lytic behavior seemingly was the result of low quantities of heat stable phospholipase A causing the hydrolysis of lecithin to form lysolecithin and fatty acid. Lysolecithin is capable of inducing hemolysis and is also a compound with the capacity to induce RBC membrane stabilization (Seeman, 1966). Crotalid venoms such as Agkistrodon contortrix mokeson, A. piscivorus leuco-stoma, and C. scutulatus however, induce a specific lytic behavior in the presence of lecithin. These three venoms also have high phospholipase A activities. Hemolysins with a specific affinity for a membrane component will not cause stabilization whereas non-specific hemolysins will. Thus, hypotonic lysis by these venoms seems to involve other venom components as well as phospholipase A (Byrd and Johnson, unpublished data). From these data, crotalid venoms seem to have varying modes of hemolysis.

**SUMMARY**

*Crotalus horridus atricaudatus* venom demonstrated negligible phospholipase A activity. Indirect hemolysis was indicated but no direct hemolysis was observed. Hypotonic lysis tests indicated only non-specific hemolysins in this venom.

**ACKNOWLEDGEMENTS**

We thank Jeanine Saunders, Douglas M. Presley, Gary L. McGrew and Linda Hammond for their technical assistance. This work was supported by NIH Grant 1 RO ES00275-02 TOX.
Figure 1. A specimen of a canebrake rattlesnake *Crotalus horridus atricaudatus*.

![Image of a canebrake rattlesnake](image)

Figure 2. A comparison of effects of *Crotalus horridus atricaudatus* whole venom and *Crotalus horridus atricaudatus* boiled venom supernatant on RBC membrane stabilization in the presence of lecithin. A relative hemolysis of 1.0 represents a hemolysis of about 50 percent.
Crotalus horridus atricaudatus Venom

LITERATURE CITED


A SURVEY OF THE HELMINTH PARASITES OF SELECTED GAME FISHES OF LAKE FORT SMITH, ARKANSAS

David A. Becker* and Walter C. Houghton*

INTRODUCTION

The only published study of the parasites of game fishes in Arkansas is that of Becker, Heard, and Holmes (1966) who limited their investigations to a pre-impoundment survey of the helminth and copepod parasites of the black basses of Beaver Reservoir in northwest Arkansas and samples of basses used in the stocking of Beaver Reservoir from hatcheries at Centerton, Hamilton, and Lonoke, Arkansas.

The present study thus attempts to extend this knowledge to other fishes and becomes only the second investigation of this nature to be conducted in Arkansas.

The primary purpose of the present study was to determine the species, number, and extent of parasitism of selected game fishes in Lake Fort Smith, Arkansas.

Lake Fort Smith was impounded in 1936 as a water supply for the city of Fort Smith. The lake is located on the southern slope of the Boston Mountains in Crawford County, about 28 mi northeast of the city of Fort Smith. The lake has a maximum depth of 63 ft and a surface area of 525 acres. The southern half of the lake is closest to the dam, and ranges in depth from 30 to 63 ft; the northern half is less than 30 ft deep with a greater portion less than 15 ft in depth. The watershed is covered primarily with an oak-hickory forest. The lake bottom is composed of silty materials washed into it from its watershed, small rocks, and shale fragments. There is little emergent vegetation along the shores except for weed beds along the north shore (Nelson, 1952; and Rorie, 1961).

MATERIALS AND METHODS

The fishes were collected from Lake Fort Smith from February to November, 1961, with the largest number taken during April, May, June, October, and November. The fishes were obtained by the following methods: 100 ft experimental nets with a mesh

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*Biologist-in-Charge, State Fish Hatchery, Harrietta, Michigan 49638.
size ranging from 1 to 3 in; application of Rotenone to a 7 acre section of the lake; a trap net; and fishing with rod and reel. After collection, the fishes were placed in a live box or packed in ice and brought directly to the laboratory for dissection.

The helminths were fixed, stained, and mounted according to Cable (1950 and 1958). Trematodes, cestodes, and acanthocephalans were fixed in alcohol-formalin-acetic acid at a temperature of 50 C. Trematodes and cestodes were stained with Delafield’s hematoxylin; acanthocephalans with Ehrlich’s acid hematoxylin. These helminths were cleared in Terpineol and mounted in Permount.

After fixation in glycerine, small nematodes were mounted on slides in hardened varnish craters filled with liquified glycerine jelly and sealed with a cover glass and varnish. The larger nematodes were fixed in liquid glycerine, cleared in lactophenol, and identified in their glycerine storage solution.

RESULTS

Table 1 indicates that a total of 107 fishes was examined representing 10 species. Of these, 103 fishes or 96.3% were infected with at least two species of helminths. A total of at least 16 species of helminths was recovered. Micropterus salmoides was infected with more species of helminths (11) than any of the other hosts examined. The average number of parasites per fish was 22.9, with M. punctulatus having the highest average number of parasites per fish (76).

Table 2 gives an indication of host specificity with each species of parasite. Camallanus oxycephalus appeared to be the least host specific, while Posthodiplostomum minimum and Leptorhynchoides thecatus had the highest host specificity. The largest number of one species of parasite per fish was Camallanus oxycephalus: 75 were recovered from one Pomoxis annularis or P. nigromaculatus. Of at least 16 species of parasites recovered, six species were found to infect 100% of their respective hosts examined.

DISCUSSION

None of the parasites recovered represented a human health hazard.

As fishes were not returned to the laboratory alive, it was impossible to make an accurate recovery or to properly prepare monogenetic trematodes for indentification.

The study of fish parasites is of value to the fisheries scientist, parasitologist, and sportsman because of the detrimental effects certain parasites may have on the fish population. These effects may be summarized as follows: stunting, emaciation, sterility, and
<table>
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<tr>
<th>Host</th>
<th>Number Examined</th>
<th>Number Infected</th>
<th>Percent Infected</th>
<th>Ave. No. Insected Per Fish</th>
<th>Parasites Found</th>
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<td>(Rafinesque)</td>
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<td>(Le Sueur)</td>
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<td>Host</td>
<td>Number Examined</td>
<td>Number Infected</td>
<td>Percent Infect.</td>
<td>Ave. Per Fish</td>
<td>Parasites Found</td>
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<td>Site in Fish</td>
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<td>0-54 59.09</td>
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<td>Parasite Classification</td>
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<td>Fish Host and Number Examined</td>
<td>Parasites % Fish Per Fish Infected</td>
<td>Site in Fish</td>
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<td>Family Camallanidae</td>
<td><em>Camallanus oxycephalus</em></td>
<td>Ward &amp; Magath, 1917</td>
<td><em>Chaenobryttus gulosus</em> (21) 0-7 19.04 Intestine</td>
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<td><em>Micropterus punctulatus</em> (2) 0-7 50.00 Intestine</td>
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<td><em>Spinitectus carolinii</em> Holl, 1928</td>
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<td><em>Contracaecum spiculigerum</em> (Rudolphi, 1809)</td>
<td><em>Micropterus salmoides</em> (22) 0-1 .05 Mesenteries of stomach</td>
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<tr>
<td>Family Echinorhynchiidae</td>
<td><em>Leptorhynchoides thecatus</em> (Linton, 1891)</td>
<td><em>Micropterus salmoides</em> (22) 0-3 0.09 Intestine</td>
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<tr>
<td>Neoechinorhynchidae</td>
<td><em>Neoechinorhynchus cylindratum</em> (Van Cleave, 1913)</td>
<td><em>Ictalurus natalis</em> (4) 0-1 25.00 Intestine</td>
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<td><em>Micropterus punctulatus</em> (2) 5-22 100.00 Intestine</td>
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<td></td>
<td><em>Micropterus salmoides</em> (22) 0-62 81.81 Intestine</td>
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mortality, not to mention the rejection of fishes by the sportsman for being "grubby" or "wormy" (Sinderman, 1953). The parasite causes these effects by three methods: (1) mechanical injury to the host caused by the parasite, (2) physiological injury to the host through interference with the normal functioning of organs, and (3) physiological injury due to the toxins produced by the parasite (Van Cleave, 1919). Thus, "Parasites definitely affect all phases of fishery operations, production, preparation, marketing, and research. Many of their effects remain to be assessed. Undoubtedly, fishery science must pay increased attention to parasites, not only because they are commercially important but also because they have potential value as research tools" (Hargis, 1958).

Control or eradication of parasites in a large body of water is economically impossible. Therefore, the best temporary solution seems to be the applied chemical treatments at fish hatcheries prior to stocking of fishes. Of course this does not insure that these stocked fishes will not become parasitized at a later date. In small bodies of water practical solutions may be found in draining, or a complete kill of infected fishes with Rotenone. Restocking may then be accomplished with hatchery fishes, samples of which have been checked for parasites.

It is hoped that the information contained in this paper will be of value in future determinations of the geographic distribution of the parasites of fishes and their host-parasite relationships.

**LITERATURE CITED**


METABOLIC RESPONSES OF WHITE RATS TO GLUCOSE OR FRUCTOSE FED WITH TWO SAFFLOWER OILS CONTAINING DIFFERENT PROPORTIONS OF FATTY ACID

Paula Lynn Yates
University of Arkansas

Several studies have shown that metabolic responses of weanling rats to the dietary source of carbohydrate are partially dependent on the type of fat in the diet, i.e., saturated or unsaturated. For example, in rats fed rations containing 15% of corn oil, more liver lipid accumulated if the dietary carbohydrate was glucose than if it was fructose. But in rats fed 15% of hydrogenated coconut oil, the amount of liver lipid was greater when the dietary carbohydrate was fructose (1).

The purpose of this experiment was to investigate the responses of various components of carbohydrate and lipid metabolism to changes in the type of carbohydrate and in the proportions of fatty acids in the diet. Comparisons were made of the effects of the type of carbohydrate in the diet (glucose or fructose) with oils containing different proportions of fatty acids (high-oleic safflower oil or regular safflower oil). Criteria for determining metabolic responses to the diets were levels of total lipid, cholesterol, phospholipid, glycogen, and nitrogen in the liver; and proportions of individual fatty acids in liver lipids. Also, amount of lipid and fatty acid composition of the lipid from epididymal fat pads were determined.

Thirty-two male weanling rats, weighing approximately 51 grams each initially, were divided into 4 groups. The rats were fed nutritionally adequate diets, the only variables being the type of carbohydrate and the oils containing different proportions of fatty acids (table 1). These oils have an almost complete reversal in percentages of linoleic and oleic acids. Regular safflower oil contains approximately 12% oleic acid and 79% linoleic acid. High-oleic safflower oil contains 80% oleic acid and 15% linoleic acid. Rations for groups I and II contained high oleic safflower oil; rations for groups III and IV contained regular safflower oil. Glucose was the carbohydrate in rations for groups I and III, and fructose in rations for groups II and IV.

At the end of a three-week feeding period, the rats were sacrificed and tissues analyzed. Substituting high-oleic safflower oil for regular safflower oil or replacing glucose with fructose in the rations had no significant effect on growth, food intake, or food efficiency ratio.
Metabolic Responses of White Rats to Glucose

TABLE 1
Fatty acid composition of oils in diets containing different carbohydrates and regular or high oleic safflower oil

<table>
<thead>
<tr>
<th>Fatty acid*</th>
<th>Safflower</th>
<th>High oleic</th>
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<tbody>
<tr>
<td>Palmitic</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Stearic</td>
<td>2</td>
<td>trace</td>
</tr>
<tr>
<td>Oleic</td>
<td>12</td>
<td>80</td>
</tr>
<tr>
<td>Linoleic</td>
<td>79</td>
<td>15</td>
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* Per cent of total fatty acids by Gas Liquid Chromatography of the methyl esters.

Relative liver weights (g of liver/100 g body weight) of rats fed fructose and high oleic oil were more than those of rats fed diets containing glucose and high oleic oil. No significant differences were attributable to dietary fat. No dietary influences on the concentration of glycogen in liver were observed, nor were any differences in protein content noted when values were expressed as percentages of liver weight. However, percentages of lipid in the liver were altered by the carbohydrate-fat combinations fed. Livers of rats fed diets containing glucose and regular safflower oil contained more lipid than those of rats fed either fructose and regular safflower or glucose and high oleic oil (fig. 1a). Types of carbohydrate in diets containing high oleic oil had no significant effect on percentage of lipid in liver. Decrease in amount of liver lipid of rats fed fructose rather than glucose in rations containing safflower oil is consistent with previous studies at this laboratory. When rats were fed diets containing 15% of corn oil (53% of total fatty acids from linoleate) for 4 weeks, lipid accumulated liver to a greater extent when dietary carbohydrate was glucose than when it was fructose (1). In another study (2), with diets containing only 5% of corn oil, lipid did not accumulate in livers of rats fed the corn oil with either glucose or fructose.

High levels of oleate in the high oleic safflower oil fed with either carbohydrate did not cause an increase in liver lipid (fig. 1a). It seems that feeding high levels of linoleate, as in corn oil or in regular safflower oil, with glucose causes an accumulation of lipid in liver. These rats fed fructose with safflower oil accumulated less lipid in the liver but tended to deposit more lipid in fat pads.
than those fed glucose and safflower oil (fig. 1b). Also, proportions of linoleate were greater in fat-pad lipid of rats fed diets containing fructose and safflower oil than in that of rats fed glucose and safflower oil. These observations suggest that, under the conditions of this study, fructose may have facilitated transport of lipid high in linoleate from the liver to the adipose tissue.

Liver cholesterol values (% of total lipid) of rats fed diets containing fructose and high oleic oil were less than cholesterol values of rats fed diets containing regular safflower oil with either carbohydrate (fig. 2). This suggests that dietary linoleate enhanced cholesterol deposition in the liver. Levels of 18C fatty acids did not differ in the regular and high oleic safflower oils, but the degree of unsaturation was much greater in the regular safflower oil (fig. 3). Other investigators reported that increased levels of unsaturated fatty acids in diets were accompanied by increased amounts of liver lipid and cholesterol (2,3).

Most significant differences in proportions of individual fatty acids were related to dietary fat. Proportions of oleic and linoleic acids in liver lipid were altered markedly by dietary fat. Liver lipid of both groups of rats fed high oleic oil contained approximately three times as much oleic acid as liver lipid of rats fed diets containing regular safflower oil, and percentages of linoleate in liver lipid of rats fed regular safflower oil were six times greater than those in liver lipid of rats fed high oleic oil. Similar, less striking, relationships were noted in the percentages of fat-pad lipid fatty acids.

The only significant differences in proportions of liver arachidonate (20:4) were due also to dietary fat. Liver lipid of rats fed high oleic oil contained a much smaller proportion of arachidonate than that of rats fed regular safflower oil (fig. 3). Substrate competition in fatty acid metabolism was evident since the linoleate: oleate ratio in regular safflower oil was sufficient to inhibit the conversion of liver oleate to its 20:3 product, eicosatrienoic acid. But the oleate: linoleate ratio in high-oleic safflower oil did not completely, if at all, repress conversion of liver linoleate to arachidonate. This concept of substrate competition agrees with the assumption by Mohrhauer and Holman (4) that the same or similar metabolic pathways are responsible for all conversions of oleic, linoleic, and linolenic acids to the polyunsaturated fatty acids of their particular series, i.e., characterized by the position of the double bond nearest the methyl end, and that the triene, linolenate, blocks the conversion of the diene, linoleate. Either linoleate or linolenate blocks the conversion of the monoene, oleate. So the affinities for the enzyme sites seem to be linolenate linoleate oleate.
Interesting fatty acid patterns are associated with the different carbohydrate-fat combinations fed. Rats fed glucose and regular safflower oil accumulated more liver lipid than others, but proportions of palmitate, (16:0), the major product of lipogenesis (5), were lower than that in liver lipid of rats fed the three other diets. It seems that accumulation of lipid in livers of these rats is not aided by increased synthesis of fatty acids. It may be possible that levels of safflower oil were sufficient to inhibit fatty acid synthesis, while oversupplying the liver with linoleate. Rats which accumulated more liver lipid did have a slightly greater percentage of liver linoleate and accumulated slightly less fat-pad lipid than rats fed the other rations. Fructose has been shown to stimulate fatty acid synthesis, and may have done so sufficiently to reduce accumulation of lipid in livers below that in rats fed safflower oil with glucose. Liver lipid of rats fed fructose and regular safflower oil contained a larger percentage of palmitate and a slightly lower percentage of linoleate than liver lipid of rats fed glucose and regular safflower oil. Further research should reflect some of the mechanisms involved in these dietary carbohydrate-fat interrelationships.

FOOTNOTES

1Supported in part by Public Health Service Research Grant no. AM-04854-07 from the National Institute of Health. Published with the approval of the director of the Arkansas Agricultural Experiment Station.

2Graduate Research Assistant, Department of Home Economics.

LITERATURE CITED


Fig. 1  Percentage of total lipid in liver (a), and mg. fat pad lipid per 100 g body weight (b), in rats fed different carbohydrates and oils containing different proportions of fatty acids for three weeks. G = glucose, F = fructose, S = safflower oil, O = high oleic safflower oil.

Fig. 2  Percentage of cholesterol in liver lipid of rats fed different carbohydrates of fatty acids for three weeks. G = glucose, F = fructose, S = safflower oil, O = high oleic safflower oil.
Fig. 3 Percentages of oleic, linoleic, and arachidonic acids in dietary oils and in tissue lipids of rats fed diets containing each of the oils with glucose and with fructose. G = glucose, F = fructose, S = safflower oil, O = high oleic safflower oil.
DIGITARIA ADSCENDENS AND D. SANGUINALIS (GRAMINEAE) IN ARKANSAS

Albert Robinson, Jr.

INTRODUCTION

The genus Digitaria constitutes a prominent element among the weedy grasses found in Arkansas. Typical habitats are areas along paths, roads, and other locales which have been disturbed by man’s activities. There has been controversy whether D. adscendens should be considered a distinct species or lumped with D. sanguinalis. In the course of a study of Arkansas grasses, the author has been forced to consider the validity of D. adscendens as a species.

Hitchcock (1950) and Steyermark (1963) do not recognize D. adscendens, but lump it with D. sanguinalis. Henrard (1950) considers D. adscendens distinct from D. sanguinalis, and Ebinger (1962) presents criteria which have diagnostic value in such differentiation. Contrasted with D. sanguinalis, D. adscendens has second glumes two-thirds as long as the spikelets, nerves of the sterile lemma smooth, and leaves usually completely glabrous. Gould (1963) reports that specimens morphologically referable to D. sanguinalis revealed chromosome counts of 2n=36, and those referable to D. adscendens give counts of 2n=54. A specimen showing hybrid morphological characteristics gave a count of 2n=48.

The author examined a total of 92 specimens of Arkansas material. Using Ebinger's criteria, 64 of these could readily be designated as D. adscendens; 11 as D. sanguinalis; 17 as morphologically intrograding between the two species. The distribution of these specimens is shown in Fig. 1.

DISCUSSION

The distribution pattern shown in Fig. 1 might be altered if extensive collections were made throughout Arkansas. Particularly interesting would be the pattern shown in the Mississippi Alluvial Plain area.

The basic problem, however, is to determine whether one is dealing with introgressive hybridization or clinal hybridization. The answer awaits more intensive study of this taxon.

ACKNOWLEDGEMENTS

Appreciation is expressed to the curators of the following herbaria: University of Arkansas, University of Kansas, University of Texas, and Southern Methodist University.
Fig. 1. Distribution of *D. adscendens* and *D. Sanguinalis* in Arkansas.

**LITERATURE CITED**


Department of Biology, Kansas Wesleyan University, Salina 67401.
A SURVEY OF THE ARKANSAS CAMPANULACEAE
(INCLUDING THE LOBELIACEAE)

Edwin B. Smith

Department of Botany & Bacteriology
University of Arkansas, Fayetteville

This paper is a summary of the Campanulaceae of Arkansas, based on the material on file in the University of Arkansas herbarium. A key to the species is included, followed by an alphabetical listing by genus and species of the taxa in the Campanulaceae known to occur in the state. After each taxon, the following information is included in this order: blooming period (as indicated on our material), known distribution in general terms (NW-northwest, E-east, G-general, C-central, etc.), habitat, chromosome number (as reported in Darlington & Wylie, 1955; in the Index to Plant Chromosome Numbers, Vol. I. II, and Supplement; and in Vol. 50 of Regnum Vegetabile), synonymy in double parentheses (this is minimized), citation of two specimens, and in some cases comments about the particular taxon. All of the taxa have been previously reported from the state. One species previously listed for the state is excluded. The survey includes 12 species in 4 genera. The distribution of most of the taxa is probably more extensive than indicated.

Differences in the key to the species, as compared to Steyermark (1963) or McVaugh (1943), reflect overlap in characters of Lobelia appendiculata and L. spicata observed in the study of Arkansas material.

KEY TO THE ARKANSAS CAMPANULACEAE
(including the Lobeliaceae)

1. Anthers united in a ring about the style; flowers irregular ......2

2. Length of perianth, from base of calyx tube to the tip of the longest petal, about 7-12 mm (stem glabrous, spreading-hairy, or densely puberulent only at the base) .........................................................3

3. Calyx becoming inflated as fruit matures, the tube portion becoming about 7-9 mm long in fruit; stem spreading-hairy at least toward the base and usually branched above Lobelia inflata L. ........................................4

3. Calyx not inflating as fruit matures, the tube portion about 2-4 mm long in fruit; stem glabrous to sparsely hairy or densely puberulent toward the base, and usually unbranched above ........................................4

4. Median leaves broad-based, ovate to elliptical; stem glabrous or sparsely hairy toward the base; auricles
usually present, nearly always drying blue or purplish-blue (when auricles are absent, calyx lobes nearly always drying blue or purplish-blue) ... Lobelia appendiculata A. DC.

4. Median leaves usually tapering to a narrow base (sometimes broad-based), usually oblong to oblanceolate (sometimes elliptical); stem densely puberulent at the base; auricles absent or present, drying green or purplish (infrequently blue); calyx lobes drying green or purplish (infrequently blue) ...5

5. Auricles present and 1-5 mm long ... Lobelia spicata Lam. var. leptostachys (A. DC.) Mackenz. & Bush

5. Auricles absent, or present but less than 1 mm long ... Lobelia spicata Lam. var. spicata

2. Length of perianth, from base of calyx tube to tip of the longest petal, about 14-44 mm (when less than about 25 mm, stem uniformly densely puberulent) ...6

6. Perianth length about 30-44 mm; corolla usually bright red (rarely pink or white); filaments united in a tube about 18-35 mm long ... Lobelia cardinalis L.

6. Perianth length about 14-25 mm; corolla usually blue or purple (rarely pale purple or white); filaments united in a tube about 9-15 mm long ...7

7. Median leaves elliptical; stem uniformly densely puberulent ... Lobelia puberula Michx. var. mineolana E. Wimm.

7. Median leaves lanceolate; stem glabrous or very sparsely spreading-hairy ... Lobelia siphilitica L.

1. Anthers free; flowers regular ...8

8. Corolla whitish or greenish; flowers born in a dense terminal spike; filaments adnate to the corolla ... Sphenoclea zeylanica Gaertn.

8. Corolla blue or purplish; flowers born from the axils of leaves or in a loose terminal raceme; filaments free or nearly so ...9

9. Flowers with pedicels, in a loose terminal raceme; median leaves about 8-16 or more cm long ... Campanula americana L.

9. Flowers sessile or nearly so, 1-few in the axils of the leaves; median leaves about 0.5-3.5 cm long ...10

10. Median leaves linear, lanceolate, or oblanceolate, about 5-8 times as long as wide ... Specularia leptocarpa (Nutt.) Gray
10. Median leaves reniform, orbicular, or ovate, about 1-3 times as long as wide

11. Pores in fruits (release of seeds is through lateral holes in the fruit wall) located near the summit of the fruits

12. Seeds 0.8-1.0 mm long, nearly flat, with shiny surface; leaves usually with 5 or more evident veins near the base; usually several flowers in bloom at once. *Specularia lamprosperma* (McVaugh) Fern.

12. Seeds 0.5-0.65 mm long, plumply biconvex, the surface dull to somewhat shiny; leaves with 1 (or sometimes 3) evident vein(s) near the base; usually only 1 flower is in bloom at a time. *Specularia biflora* (R. & P.) Fisch. & Mey.

11. Pores in fruits located near the middle of the fruits (seeds as in *S. biflora*). *Specularia perfoliata* (L.) A. DC.

*Campanula americana* L.
June-Sept.; N & NW; rich moist woods, thickets; 2n = 34, 58, 102; ((*C. americana* L. var. illinoensis (Fresn.) Farw.; *Companionastrum americanum* (L.) Small)); Newton Co., A. McWilliam 103; Sharp Co., R. G. Wade 86.

*Lobelia appendiculata* A. DC.
April-early July; G; prairies, low woods; 2n = 14, 14 + 1; Franklin Co., D. M. Moore 520545; Prairie Co., E. J. Palmer 25054. Overlaps morphologically with *L. spicata*, and perhaps would be better considered a variety of that species. Several specimens in our herbarium combine the characters of the two species in various ways, as, for example: auricles tiny or absent with calyx lobes drying blue, lower stem puberulent, and leaves broad-based.

*Lobelia cardinalis* L.
Late July-Sept.; G; moist woods, gravel bars near streams; 2n = 14, n = 7 + 1; Saline Co., D. M. Moore 400376; Washington Co., E. B. Smith 1246.

*Lobelia inflata* L.
July-Oct.; C & N; open woods, stream banks, roadsides; 2n = 14; Franklin Co., E. B. Smith 961; Polk Co., D. M. Moore 480549.

*Lobelia puberula* Michx. var. *mineolana* E. Wimm.
July-Oct.; W & S; moist sandy open areas; 2n = 14, n = 7 + 1; Polk Co., A. McWilliam 530; Union Co., D. M. Moore 410320.

*Lobelia siphilitica* L.
Aug.-Oct.; N & C; wet meadows, stream banks; 2n = 14; ((L.
A Survey of the Arkansas Campanulaceae

siphilitica L. var. ludoviciana A. DC.; L. syphilitica L.); Sharp Co., R. G. Wade 135; Washington Co., M. Hite 639. The specimens we have of this species combine the nearly glabrous leaves of var. ludoviciana with the more or less hirsute calyx of var. siphilitica. The median leaves of our material are 1.3-3.6 cm wide at the widest part of the blade. Steyermark (1963) noted that the varieties are not well marked in Missouri, and the same can be said of Arkansas. I do not believe the varietal designations are useful in Arkansas material.

Lobelia spicata Lam.
This species overlaps morphologically with L. appendiculata in all or nearly all characters.

var. spicata
May-June; W & S; open woods, moist prairies; 2n = 14; ((L. spicata Lam. var. parviflora A. Gray; L. spicata Lam. var. originalis McVaugh)); Benton Co., D. Demaree 6779; Franklin Co., E. B. Smith 914. Material of one collection (E. B. Smith 914) had white anthers, a characteristic of var. campanulata McVaugh. This variety has been recorded from northern Missouri by Steyermark (1963), but is not known from Arkansas. The corolla color of my collection 914 was pale blue (characteristic of var. spicata), not dark purplish-blue (characteristic of var. campanulata), and it therefore probably differs from typical var. spicata by merely a single gene. McVaugh (1943) indicated that his var. campanulata may be only a minor genetic variant of var. “parviflora” (a synonym of var. spicata).

var. leptostachys (A. DC.) Mackenz. & Bush
Late May-Aug.; G; open woods, moist prairies; 2n = ?; ((L. leptostachys A. DC.)); Franklin Co., E. B. Smith 967; Stone Co., D. M. Moore 56-225.

A variety hirtella Gray, differing in being more or less hirtellous throughout, has been collected in Missouri (Steyermark, 1963) but probably does not occur in Arkansas.

Specularia biflora (R. & P.) Fisch. & Mey.
May-June; N & C; roadsides, open woods, fields; 2n = 28; Benton Co., D. M. Moore 450.380; Sebastian Co., D. M. Moore 4113.

Specularia lamprosperma (McVaugh) Fern.
May-June; W & C; open upland woods, prairies; 2n = ?; Conway Co., J. E. Moore 698; Logan Co., H. H. Iltis 5360. Depauperate specimens of this species resemble S. biflora.

Specularia leptocarpa (Nutt.) Gray
May-July; W near Ark. River valley; dry ledges, open sandy cliffs; 2n = ?; Franklin Co., D. M. Moore 480149; Logan Co., D. M. Moore 4330.
Specularia perfoliata (L.) A. DC.
April-June; G; roadsides, open areas; 2n = ?; Sevier Co., J. C. Nickerson 9A; Washington Co., I. L. Brown (no number).

Sphenoclca zeylanica Gaertn.
Aug.-Nov.; E; marshy areas, rice fields; n = 12; Arkansas Co., R. Toler 37; Lonoke Co., D. M. Moore 420351.

EXCLUDED SPECIES
Lobelia brevifolia Nutt.
This species was reported for the state by Branner & Coville (1891), but we have no specimens of it. Small (1913) and McVaugh (1936, 1943) reported it from Florida to Louisiana, near the coast.

LITERATURE CITED


GROWTH PATTERNS IN BACILLUS STEAROTHERMOPHILUS

Harold B. Betton
Dept. of Chemistry, University of Arkansas

INTRODUCTION

Bacillus stearothermophilus was isolated from spoiled canned corn and string beans in 1920 by Donk. He found the organism to be a heatloving or thermophilic organism—hence, its name thermophilus. Recently, this organism has been isolated from tomato plants (Lycopersicum esculentum var. Bradley) thought to be suffering from fusarium wilt, a fungal disease of tomato.

Before pathological work was initiated, the bacterium was identified.

This paper involves a detailed growth study of this bacterium under a wide range of conditions.

MATERIALS AND METHODS

Experiments were done at constant temperature (without shaking) and at room temperature with Burrill wrist-action shakers. The assay systems for the determination of the cell population were turbidimetric and cell counts. The Bacteria were grown in either Nutrient agar and/or nutrient broth and potato dextrose agar (PDA).

RESULTS

The first experiment was designed to determine the upper and lower temperature limits for the growth of Bacillus stearothermophilus.

1Present address: Dept. of Agriculture, A.M.&N. College, Pine Bluff, Arkansas 71601
## TABLE I

**Growth of B. stearothermophilus on PDA**

1. (Growth after 46 hours-lower limit)

<table>
<thead>
<tr>
<th>Temperature°C</th>
<th>*Growth (+, ++, +++..) After 24 hrs at 27°C</th>
<th>Frozen (less than —10°C)</th>
<th>+ + +</th>
<th>+ + +</th>
<th>+ + +</th>
<th>+ + +</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>+</td>
<td>+</td>
<td></td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+++</td>
<td>+</td>
<td>+ +</td>
</tr>
<tr>
<td>9</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+++</td>
<td>+ +</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+ +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td>+ +</td>
<td>+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(upper limit — growth after (24 hrs.)

<table>
<thead>
<tr>
<th>Temperature°C</th>
<th>+</th>
<th>+</th>
<th>++</th>
<th>+++</th>
<th>+++</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>++</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>+++</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>+++</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>68</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>+ +</td>
</tr>
<tr>
<td>70</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>+ +</td>
</tr>
</tbody>
</table>

*Growth comparison +, vs. +++ etc.

higher + means more growth
The data (table I) indicates that the ability of a previously frozen bacterial culture as well as one grown at 70°C to resume growth when placed at 27°C for 24 hours. Autoclaving kills the cells and their spores. The procedure for determining the effect of autoclaving is outlined in figure 1.

(FIGURE 1)

Stock culture inoculated into Nutrient Broth

Shake 57 hrs. on
Burrill-Wrist action shaker

Incubate 27°C for 48 hours.

Autoclave tubes (45 min) 120°C 15 lb. pressure

Shake on Burrill shake machine 85.5 hrs.

*Inoculate to PDA plates

40°C

36°C

(stationary)

Plate out on Nut. Broth

Incubate at 36°C

Shake 48 hrs

Plate out

*Growth occurs better on PDA than nutrient agar
Growth Patterns in *Bacillus stearothermophilus*

**Fig. 2**

- OD = 0.1
- KL = 0.5
- OD = 0.95
- KL = 0.4

KL = Klett Units
OD = Optical Density

(time hrs.)

**Fig. 3**

- KL = 0.8
- KL = 20
- KL = 32.5

**Fig. 4**

- Shake 30.17°
- Stationary 40
- OD = Optical Density
- $1 \times 10^6$
- $2 \times 10^8$
- $3 \times 10^6$
- $2.5 \times 10^6$
- $4 \times 10^6$
Growth was measured at different temperatures utilizing stationary and shake nutrient broth cultures. The results of these experiments are shown in Figures 2-4.

DISCUSSION

Previously published papers and texts (1,2,3) indicate that most bacterial growth curves are sigmoid in shape. Growth studies of the genus, Bacillus indicates a deviation from the sigmoid pattern (4). From the data presented in Figures, 2-4 the following can be said:

1. Figure one shows a graph of cells grown on a shaker at 30.17°C and grown stationary at 40°C. The interesting observation here is that rapid growth is followed by a rapid death rate; whereas, stationary cultures show the usual increased growth with time.
2. Figure 2 shows the growth curve for a stationary culture of the bacterium illustrating the conventional sigmoid shape.
3. The data plotted in Figure 3 is from the same experiment as in figure 1 except that cell population is plotted instead of optical density as a function of time. The rapid decrease in cell count indicates that either the bacteria are nontolerant to very aerobic conditions, or culture conditions became toxic to the organisms.

These growth differences can account for the numerous times that this bacterium was isolated from various solanaceous and curcurbitaceae crops (5) in that the bacterium can survive many physical environments.

This study enables the feasibility of planning future experiments to determine the optimum growth for this bacterium when introduced in certain plant hosts because the relationship of the growth is worked out in fair detail.

LITERATURE CITED

EFFECT OF CULTURE ENVIRONMENT UPON SPORANGIUM AND ZOOSPORE PRODUCTION OF THREE SPECIES OF PHYTOPHTHORA

J. L. Dale and J. P. Jones
University of Arkansas

Species of Phytophthora are cosmopolitan in nature and are responsible for economically important diseases of potato, soybeans, tobacco, and tomato. The Phytophthora spp. are Phycomycetes and reproduce sexually by the formation of oospores, and asexually by the production of sporangia and zoospores.

Since species of Phytophthora are common and of economic importance, conditions favoring their growth and reproduction have been studied rather extensively. These fungi have also been used for teaching purposes as examples to demonstrate asexual reproduction by zoospores.

Various techniques have been used to promote oospore and sporangium production within the genus Phytophthora. For sporangium and zoospore production Gooding and Lucas (2) grew Phytophthora parasitica (Dastur) var. nicotianae (Breda de Haan) Tucker on solid oatmeal agar and stripped aerial mycelium from cultures after 6-20 days growth. The mycelium was then transferred to plates and moistened or floated on water at 24-26°C for 6-10 days. Fresh distilled water was then added to the cultures, they were chilled for 25 min at 8°C, and then returned to room temperature. Zoospores were released after about 15 min. This procedure requires from 16-32 days. Sporangia and zoospores can also be obtained from oatmeal agar cultures by taking small squares of agar with the organism and floating them on water in Petri dishes for 10-12 days, during which time additional mycelium and sporangia develop. The cultures are then chilled for about 30 min and the mycelium and sporangia are then transferred to water at room temperature and zoospores are released. This latter method is also time consuming, and sporangium development and zoospore release are often erratic.

Reproduction on semi-solid media has been studied and is used less extensively (3, 4). The authors have successfully used such media for a number of years for both research and teaching purposes. For sporangium production by Phytophthora parasitica Dast., the causal organism of a tomato disease known as buckeye rot, very

1Published with the approval of the Director of the Arkansas Agricultural Experiment Station.

2Professors of Plant Pathology, Department of Plant Pathology.
good results have been obtained by growing the organism on 1/10 strength lima bean agar (LBA). After 7-10 days, when sporangia have been produced, a small volume of mycelium and residual media are put on a microscope slide and an equal or slightly larger volume of distilled water is added to the slide. The mycelium is teased apart with needles to expose the sporangia to the distilled water, and the preparation is covered with a cover slip. Zoospores normally begin to be released within a few minutes after the slide is prepared. If the film of water is maintained under the cover slip, the zoospores will usually stop swimming, encyst, and germinate by the formation of a germ tube within an hour.

The authors have used P. parasitica for instructional purposes because it is readily available from diseased plants or professional sources and it is easy to culture. The optimum conditions for reproduction of this organism on semi-solid media have not been fully determined. The present study was undertaken to further delineate conditions favoring sporangium and zoospore production.

MATERIALS AND METHODS

The cultures used in the study were: an isolate of P. parasitica obtained locally from tomato, two isolates of P. parasitica var. nicotianae from tobacco (NC 1156 and NC 1030),1 and an isolate of P. cactorum (Leb. & Cohn) Schroet.2 Isolates were maintained on plates of solid LBA (Difco). A 4 mm disc of each organism on agar was aseptically transferred to a 125 ml Erlenmeyer flask containing 20 ml of sterile 1/10-strength LBA. Appropriate numbers of such inoculated flasks were immediately incubated in the dark at temperatures of 20, 24, 28, and 32°C, and a series of flasks were also incubated at room temperature under normal light conditions. At 3-day intervals, for a period of 18 days, individual flasks of each organism at each temperature were checked for sporangium formation and zoospore release. Forty ml of sterile distilled water was added to each flask, the flasks were gently shaken on a shaker for 20 min., and a 1 ml sample was scanned under low magnification to check for presence of zoospores. The zoospores in the flasks were then inactivated by the addition of 1 ml of 1-1000 HgCl₂ per flask. The numbers of zoospores in the diluted medium were determined by the use of a hemacytometer, and the results were transferred into number of zoospores per ml of original growth medium.

1 Cultures supplied by Dr. J. L. Apple, North Carolina State University.
2 Culture supplied by Dr. Donald C. Erwin, University of California, Riverside.
RESULTS AND DISCUSSION

The results of tests are shown in Figures 1 and 2. Since few zoospores were produced at 32°C, this temperature was omitted from the graphs. The results show that considerable variation occurred among the isolates in number of zoospores released and that sporangium production and zoospore release was affected by time, temperature, and light conditions. The isolate from tomato, *P. parasitica*, produced the largest number of zoospores, with 187,000/ml being released from flasks incubated 15 days at room temperature in the light (Fig. 1-A). Isolate NC 1030 of *P. parasitica* var. *nicotianae* produced the second largest number of zoospores, with 176,000/ml released from cultures incubated in the dark at 20°C for 18 days (Fig. 2-A). Isolate NC 1156 from tobacco produced consistently low numbers of zoospores at all temperatures (Fig. 2-B). Except for *P. cactorum* the cultures were somewhat cyclic in zoospore release, with periods of high zoospore release followed by periods of low zoospore release. This undoubtedly resulted from the fact that zoospores were released in the flasks during incubation even though no distilled water was added, and a time interval was necessary for production of additional sporangia. Interestingly, *P. cactorum* released a maximum number of zoospores after 9 days incubation at all but room temperature (Fig. 1-B). Except for *P. parasitica*, the largest numbers of zoospores were generally produced by the cultures incubated in darkness, regardless of temperature.

The results in the present study differ somewhat from those obtained by other workers. Dukes and Apple (1), using the technique of Gooding and Lucas (2), reported that tobacco isolate NC 1156 was more pathogenic and produced more sporangia than isolate NC 1030. This contrasts with the low number of zoospores produced by NC 1156 and the high number produced by NC 1030 in the present work. Harnish and Barnett (3) reported that *P. cactorum* grown on dilute LBA produced only a few sporangia when grown in darkness. Although grown on the same medium in the present work, a different isolate of the organism produced more sporangia and zoospores in darkness than under conditions of fluctuating darkness and light.

Results obtained in the present work thus indicate that cultural conditions have a pronounced effect on sporangium and zoospore production, and that the reaction of isolates is dependent upon the technique used. The results also indicate that individual isolates may vary even when grown under similar cultural conditions.

For instructional purposes to demonstrate zoospore release and activity, the utilization of 1/10 strength LBA as a growth medium is more simple, rapid, and reliable than use of other methods. With *P. parasitica*, the cultures can be grown under normal conditions of light and room temperature, and abundant zoospores for obser-
Figure 1. Effect of incubation time and temperature upon number of zoospores produced by (A) Phytophthora parasitica, and (B) P. cactorum.
Figure 2. Effect of incubation time and temperature upon number of zoospores produced by (A) *Phytophthora parasitica* var. *nicotianae* NC 1030, and (B) *P. parasitica* var. *nicotianae* NC 1156.
vational purposes can be obtained as early as 6 days following incubation of a culture. The fungus will release even greater numbers of zoospores with longer incubation periods under the same conditions.

**LITERATURE CITED**


SOME NOTEWORTHY SPECIES OF THE
ARKANSAS FLORA

G. E. Tucker
Arkansas Polytechnic College

Recent Arkansas collections have revealed the presence of several vascular plant species of interest floristically, including some apparently new for the state. While several do not constitute state records, they are here recorded as a contribution toward a better understanding of the state’s flora.


Voucher specimens of all collections are deposited in the Herbarium of Arkansas Polytechnic College (APC), Russellville, Arkansas.

Cynosurus echinatus L.


This introduced grass has been reported by Moore (1961) from only three other Arkansas counties.

Xyris iridifolia Chapman

HOT SPRING COUNTY: 4 m. E of Perla, margin of pond on S side of U.S. 270, on moist soil and in shallow water, 9 Sept. 1967, G. Tucker 6551.

OUACHITA COUNTY: Chidester, E edge of White Oak Lake, open boggy area, 27 April 1968, G. Tucker 6995.

This southeastern species of Xyris has been collected once previously in Arkansas by Dr. Delzie Demaree. Demaree’s station also in Ouachita County, has been destroyed by drainage, however, and no plants were evident there the past season.

Murdannia keisak (Hassk.) Hand.-Mazz.

CONWAY COUNTY: Petit Jean Mountain, Lake Bailey, N shore of lake, locally abundant, 30 Sept. 1968, G. Tucker 7760.

This weedy member of the Commelinaceae, known in most American manuals as Aneilema keisak Hassk., has previously been reported as an introduction in Virginia, the Carolinas, and Georgia. At the Lake Bailey station it occurred abundantly on the north shore of the lake along with other typically aquatic and semiaquatic vegetation, including Pilularia americana (G. Tucker 7768), Eleocharis quadrangulata (G. Tucker 7770), and Utricularia gibba (G. Tucker 7752).
Some Noteworthy Species of the Arkansas Flora

Allium ampeloprasum L.


This Old World introduction is becoming established at widely scattered localities in the southeastern states. It has been observed in disturbed areas along highways in several southeastern Arkansas counties but collected by me only at the above location. The standard manuals do not include Arkansas within the range of this introduced species. The University of Arkansas, however, has one specimen collected in St. Francis County.

Polygonum orientale L.

WHITE COUNTY: ½ m. E of Walker, on state highway 11, edge of barn lot, 13 May 1967, Glenn Corder 26.

This cultivated species was found at the above location in an apparently naturalized condition with no evidence of nearby cultivation. The collection possibly represents a state record.

Dalea lanata Spreng.

POPE COUNTY: Holla Bend National Wildlife Refuge, on sand of old channel of Arkansas River, 24 June 1968, G. Tucker 7173.

This colorful legume has not been reported east of Oklahoma and Texas; the University of Arkansas herbarium, however, has two specimens collected at Little Rock in the 1880’s. At the Holla Bend station it was locally abundant on sand along with Eragrostis oxylepis (G. Tucker 7235), Cycloloma tripliicifolium (G. Tucker 7205A), and Froelichia floridana (G. Tucker 7236).

Celastrus orbiculatus Thunb.


This Asiatic bittersweet is occasionally cultivated; the above collection may represent a remnant of former cultivation but showed evidence of spreading. It has not been reported from Arkansas.

Breweria pickeringii var. patersoni Fern. & Schub.

OUACHITA COUNTY: Chidester, edge of oak woods, sandy soil, 8 July 1967, G. Tucker 5728.

The standard manuals do not include Arkansas within the range of this species’ variety.

Veronica hederifolia L.

POPE COUNTY: Russellville, Wesley Methodist Church on N Yuma Street, weedy lawn, 18 March 1969, G. Tucker 7822.

None of the standard manuals include Arkansas within the range of this weedy introduction. Dr. Edwin Smith, of the University of Arkansas, has recently collected the plant also in Washington County.
REFERENCES


THE FRESHWATER ALGAE OF ARKANSAS

Richard L. Meyer
Department of Botany and Bacteriology
University of Arkansas, Fayetteville, Arkansas

I. INTRODUCTION AND RECENT ADDITIONS

This paper presents an initial annotated inventory of the freshwater algae of Arkansas. These collections include one-hundred forty-eight new records. Thirty-three Chlorophyceae, 11 Xanthophyceae, 33 Chrysophyceae, 6 Bacillariophyceae, 11 Pyrrhophyceae, 27 Euglenophyceae, 6 Cryptophyceae, 20 Cyanophyceae and 1 Rhodophyceae are newly reported. A brief description of the habitat and sub-community position is given with each organism. A review of previously published literature is included.

This paper presents the first in a series of annotated inventories of Freshwater algae collected in Arkansas. These collections were made for the most part by the author. These collection were taken during the fall and winter of 1968-69; therefore, the numerous spring and summer organisms were not studied.

Published literature on the algae of Arkansas is limited. A partial search of the literature produced only three papers. Drs. Hoffman and Causey (1952) and Hoffman (1952) reported certain members of the phytoplankton in Lake Fort Smith. In a short paper of Bacillariophyceae from two ponds in Izard County Robinson, Jr. (1953) recorded 25 species. Further published records of Arkansas algae will be included in future papers.

The annotation accompanying the inventory gives a brief description of the habitats and principle aquatic sub-community in which the species was collected. The aquatic freshwater sub-communities used are those described by Round (1965) and indicated by the letters in parenthesis. There are: euplankton (P), neuston (N), epipellic (EP), epilithic (EL), ephiphytic (ET) and epizoic (EZ). Those algae which are in close association with epiphytes but not attached to them are the metaphyton (M) (Behre, 1956).

A total of 148 species and varieties previously unreported are listed. Thirty-three Chlorophyceae, 11 Xanthophyceae, 33 Chrysophyceae, 6 Bacillariophyceae, 11 Pyrrhophyceae, 27 Euglenophyceae, 6 Cryptophyceae, 20 Cyanophyceae and 1 Rhodophyceae are newly reported. The new records for the State of Arkansas are indicated with an asterisk (*).

ACKNOWLEDGEMENTS

The author wishes to express his appreciation to Mr. J. H. Wheeler for his aid in collecting samples. The samples contributed
by Drs. J. Brown and J. Rakes, R. Gearheart and W. Smith included
interesting algae. This research was supported by the Water Re-
sources Research Center, University of Arkansas grant No. A-001-
ARK and National Institutes of Health grant No. FR107101-02.

Division Chlorophyta

Class Chlorophyceae

Order Volvocales
The nomenclature used within this order is that of Huber-

Eudorina elegans Ehr.
Organically rich pools, Eutrophic lakes and ponds. (P)

Gonium pectorale Mul. *
Organically rich ponds. (P)

Pandorina morum (Mull.) Bory *
Eutrophic lake and organically rich pools. (P)

Phacotus lenticularis (Ehr.) Stein *
Eutrophic lake. (P)

Pteromonas agulosa Lemm. *
Organically rich vernal pool. (P)

Order Tetrapsorales

Apiocystis brauniana Nag. ©
Organically rich pond. (ET)

Asterococcus limneticus Smith *
Eutrophic lakes. (P)

Tetraspora gelatinosa (Vauch.) Desvaux. *
Organically rich pools and ditches. (ET & P)

Order Chlorococcales

Ankistrodesmis falcatus (Cor.) Ralfs *
Organically rich pool and ditches, eutrophic lakes. (P)

Botryococcus braunii Kutz. *
Organically rich ponds. (P)

Chlorella vulgaris Bej. *
Organically rich ponds. (P)

Closteriopsis longissima Lemm.
Organically rich ponds. (P)

Dictyosphaeridium ehrenbergianum Nag. *
Moderately eutrophic lakes. (P)

D. punchella Wood *
Slightly eutrophic lakes. (P)
The Freshwater Algae of Arkansas

Kirchneriella lunaris (Kirch.) Mob. *
Eutrophic ponds and lakes, rivers. (P)

Micractinium pusillum Fres. *
Eutrophic lake. (P)

M. quadrirsetosum (Lemm.) Smith *
Organically rich ponds. (P)

Pediastrum boryanum (Turp.) Menegh. *
River. (P)

P. duplex var. graciliumum W. & W.
Slightly eutrophic lakes. (P)

P. simplex (Mey.) Lemm. *
Eutrophic lakes. (P)

Planktosphaeria gelatinosa Smith
Eutrophic lakes. (P)

Scenedesmus acuminatus (Lag.) Chod. *
Organically rich ponds. (P)

S. dimorphus (Turp.) Kutz. *
River. (P)

S. incrassatulus Boh. *
Organically rich ponds. (P)

S. quadrircaudata (Turp.) deBreb. *
Eutrophic lakes. (P)

Sphaerocystis schroeteri Chod.
Eutrophic lakes. (P)

Tetraedron minimum (Braun) Hansg. *
Eutrophic lakes. (P)

Tetrallantos lagerheimii Teil. *
Eutrophic lakes and ponds. (P)

Tetrastrun staurogeniaforme (Schroed.) Lemm. *
Eutrophic lakes.

Order Ulotrichales

Binuclearis tatrana Witt. *
Organically rich roadside ditch. (ET)

Geminella mutabilis (deBreb.) Willie *
Moderately eutrophic lake. (EL)

Microspora floecosa (Vauch.) Thur. *
Eutrophic ponds. (EP)

Stichococcus bacillifera Nag. *
Eutrophic pond. (ET)

Order Chaetophorales

Aphanochaete polychaete (Hansg.) Fritsch *
Organically rich pond. (ET)
Chaetophora elegans (Roth) C. Ag. *
Organically rich roadside ditch. (ET)

C. incrassata (Huds.) Haz. *
Organically rich pond. (ET)

Draparnaldia glomerata (Vauch.) C. Ag. *
Seepage pool. (ET)

D. mutabilis (Roth) Bory *
Organically rich seeps and ditches. (ET)

Class Conjugatophyceae

Order Zygnematales

Desmidium baileyi (Ralfs) Nords.
River, tychoplankto. (P)

D. schwartzii C. Ag.
River, tychoplankto. (P)

Staurastrum furcigerum deBreb.
Eutrophic lake. (P)

Division Chrysophyceae

Class Xanthophyceae

The nomenclature used within this class is that of Pascher (1939).

Order Heterotrichales

Chloridella simplex Pasch. *
Organically rich pond. (P)

Chlorobotrys simples Pasch. *
On damp clay soil. (EL)

Goniochloris fallax Fott *
Organically rich pond. (M)

Monallantus brevicylindrus Pasch. *
Organically rich pond. (M)

Ophiocytium cochleare A. Br. *
Organically rich pond. (M)

Order Heterococcales

Tribonema affine West
Moderately eutrophic lake. (M)

T. ambiguum Skuja *
Organically rich pond. (M)

T. minus Haz. *
Seepage pool. (M)

T. viride Pasch. *
Organically rich pond. (M)
T. vulgare Pasch. *
  Seepage pool. (M)

Class Chrysophyceae

Order Chrysomonadales

Anthophysa vegetans (Mul.) Stein *
  River, tychoplanktor. (P)

Chromophyton rosanoffii Wor. *
  Organically rich vernal pool. (N)

Chromulina gonoides Skuja *
  Seepage pool. (M)

C. tenera Matv. *
  Organically rich vernal pool. (P)

Chrysochromulina parvum Lack. *
  Eutrophic lake. (P)

Chrysococcus minutus (Fritsch) Nyg. *
  Eutrophic lake. (P)

C. rufescens Klebs *
  Organically rich roadside ditch and eutrophic lakes. (P)

C. triporus Matv. *
  Organically rich pool. (P)

Dinobryon divergens Imn.
  Eutrophic lakes. (P)

D. elegans Korsch. *
  River, tychoplanktor. (P)

D. sertularia Ehr. *
  Eutrophic lakes and ponds. (P)

Epipyxis utriculus Ehr. *
  Organically rich pond. (ET)

Kephyrion capuliforme Con. *
  Eutrophic lakes. (P)

K. inconstans Schm. *
  Eutrophic lakes. (P)

K. rubri-claustri Con. *
  Eutrophic lakes. (P)

K. spirale (Lack.) Con. *
  Eutrophic Lakes and ponds. (P)

Mallomonas acaroides Petry *em. Kreig. *
  Eutrophic lakes. (P)

M. caudata Iwan. *em. Kreig. *
  Mesotrophic lake. (P)

M. coronata Boloch. *
  Eutrophic ponds and vernal pools. (P)
M. elliptica (Kiss.) Con. *
  Organically rich roadside ditch. (P)
M spinifera Con. *
  Organically rich roadside ditch. (P)
M. tonsurata Teil. *
  River. (P)
Pseudokephyrion pilidium Schil. *
  Eutrophic lake. (P)
P. schilleri Con. *
  Eutrophic lake. (P)
Stenokalyx cylindrica Schm. *
  Eutrophic lake (P)
S. laticollis Con. *
  Eutrophic lake. (P)
Synura petersenii Kor. *
  River and lakes. (P)
S. sphagnicola Kor. *
  Mesotrophic lake. (P)
S. uvela Ehr. em. Kor. *
  Eutrophic ponds. (P)
Order Rhizochrysidales
Chrysoamphitrema brannea Scher. *
  Eutrophic lake. (ET)
Chrysopyxis ascendens Wisl. *
  Organically rich pond. (ET)
C. bipes Stein *
  Organically rich pond. (ET)
Order Chrysocapsales
Phaeoplaca thallosa Chod. *
  Creek. (ET)
Class Bacillariophyceae
Order Centrales
Melosira granulata (Ehr.) Ralfs *
  Eutrophic lakes. (P)
M. italica Kutz.
  Eutrophic lakes. (P)
Order Pennales
Eutrophic lakes. (P)
Asterionella formosa Hass. *
Fragillaria crotonensis Kitt. *
Eutrophic lakes. (P)

Synedra acus Kutz.
Eutrophic lakes. (P)

Tabellaria fenestrata (Lyngb.) Kutz. *
Mesotrophic lake. (P)

T. floccusosa (Roth) Kutz. *
Eutrophic lake. (P)

Division Pyrrhophyta

Class Dinophyceae

The nomenclature followed within this class is that of Schiller (1933)

Order Gymnodiniales

Gymnodinium obesum Schil. *
Organically rich pond. (P)

Massartia musei (Danysz.) Schil.
Organically rich pond. (P)

Order Peridinales

Ceratium cornutum Ehr. *
Mesotrophic lake. (P)

C. hirundinella Mull. *
Mesotrophic lake. (P)

Hemidinium natusum Stein *
Organically rich pond. (P)

Peridinium bipes Stein
Organically rich pond. (P)

P. cinctum Mull. *
Eutrophic lake. (P)

P. palustre (Lind.) Lefev. *
River. (P)

P. pusillum (Pen.) Lemm. *
Mesotrophic lake. (P)

P. willei Huit.-Kass. *
Eutrophic lake. (P)

P. wisconsinense Eddy. *
Mesotrophic lake. (P)

Division Euglenophyta

The nomenclature used within this division is that of Huber-Pestalozzi (1955).
Class Euglenophyceae

Order Euglenales

Colacium vesiculosum Ehr. *
Vernal pool. (EZ)

Euglena agilis Cart. *
Organically rich vernal pool. (P)

E. piciformis Klebs *
On damp clay soil and in eutrophic lakes. (P)

E. sangunea Ehr. *
Organically rich pond. (P)

E. sangunea var. furcata Hub. *
On damp clay soil. (EL)

E. schmitzii Goj. *
Organically rich pond. (P)

E. spirogyra Ehr. *
Mesotrophic lake. (P)

E. van gooii Defl. *
Vernal pool. (P)

E. variabilis Klebs *
Seepage pool. (M)

E. viridis Ehr. *
Creek. (P)

Monomorphina pyrum (Ehr.) Mereschk. *
Vernal pool. (P)

Phacus acumunatus Stokes *
Vernal pool. (P)

P. brevicaudata (Klebs) Lemm. *
Mesotrophic lake. (P)

P. curvicaudata Swir. *
Organically rich pond. (P)

P. tortus (Lemm.) Skv. *
Vernal pool. (P)

Strombomona deflandrei (Rool) Defl. *
Organically rich pond. (P)

S. longicauda (Swir.) Defl. *
Organically rich pond. (P)

Trachelomonas helvetica var. cordiformis (Roll) Pop. *
Organically rich pond. (P)

T. hispida var. australica Playf. *
Eutrophic lake. (P)

T. hispida var. punctata Lemma. *
Organically rich pond. (P)
T. intermedii Dang. *
  Organically rich pond. (P)

T. rugulosa Stein *
  Organically rich pond. (P)

T. scabra Playf. *
  Organically rich pond. (P)

T. sydnensis Playf. *
  Organically rich ponds and vernal pools. (P)

T. volvocina Ehr.
  Mesotrophic and eutrophic lakes. (P)

T. volvocinopsis Swir. *
  Mesotrophic and eutrophic lakes and ponds. (P)

Order Heteronematales

Peranema inflexum Skuja *
  Organically rich pasteur pool. (P)

P. trichophora (Ehr.) Stein *
  Organically rich pasteur pool. (P)

Class Cryptophyceae

Order Cryptomonadales

Chroomonas acuta Uter. (?) *
  Organically rich pond. (P)

Cryptomonas caudata Schil. *
  Seepage pool. (M)

C. erosa Ehr. *
  Organically rich ponds and mesotrophic lakes. (P)

C. oblonga Playf. *
  River. (P)

C. obovata Skuja *
  Organically rich pools. (P)

C. ovata Ehr. *
  Mesotrophic lakes. (P)

Division Cyanophyta

Class Cyanophyceae

The nomenclature used within this class is that of Geitler (1932).
Order Chroococcales

Anphantocapsa biformis A. Br. *
On limestone seep. (EL)

A. grevellei (Hass.) Rab. *
River. (P)

Chroococcus turgidus (Kutz.) Nag. *
River (P)

Daetylocoecopsis smithii Chod. et Chod. (?) *
Eutrophic lake. (P)

Gomphosphaera aponina Kutz. *
River. (P)

Merismopedia marsonii Lemm. *
Organically rich pond. (P)

M. punctata Mey. *
Organically rich pond. (P)

M. tenussima Lemm. *
Organically rich, slow flowering stream. (P)

Polycystis aeruginosa Kutz. *
Organically rich ponds and eutrophic lakes. (P)

Order Chamaesiphonales

Chamaesiphon incrustans Grun. *
On Cladophora sp. in creek. (ET)

Order Oscillatoriales

Aphanizomenon flos-aquae (L.) Ralfs *
Eutrophic lakes and ponds. (P)

Nostoc planctonicum Por. et Tschern. *
Organically rich vernal pool. (P)

Oscillatoria agardhii Gom. *
Organically rich pond. (P)

O. amoena Gom. *
Seepage pool. (EL)

O. chlorina Kutz *
Seepage on clay soil. (EL)

O. ornata Kutz. *
Organically rich pond. (P-EL)

O. princepeea Vauch. *
Organically rich pond. (P)
The Freshwater Algae of Arkansas

O. rubescens deCand. *
Mesotrophic lake. (P)

O. tenuis C. Ag. *
Mesotrophic lake. (P)

O. tenuis var. natans Gom. *
Organically rich vernal pool. (P)

Division Rhodophyta

Class Rhodophyceae

Order Nemalinionales

Audouinella violacea (Kutz.) Ham. *
Stream. (EL)

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617 pp.
A STUDY OF THE HERBACEOUS, VASCULAR
PLANTS FROM SELECTED SITES
IN FAULKNER COUNTY, ARKANSAS

Sara Mills Barnett
State College of Arkansas and Texarkana, Texas

Collections of wildflowers and ferns were made from selected sites in Faulkner County, Arkansas, during March and April, 1968, to add to the information concerning the vegetation of the state (Dale, 1963). Sites for collecting were selected on the basis of elevation, topography, and drainage situations which reflected differences in soils.

Faulkner County, which is slightly north of the geographical center of the state, lies entirely within the Arkansas River Valley. It is bounded on the north by Van Buren and Cleburne Counties, on the east by White, Lonoke, and Pulaski Counties, and on the south by Pulaski County. On the west it is separated from Perry County by the Arkansas River and from the greater part of Conway County by Cadron Creek. Collections were made in the Greenbrier area in the northern part of the county. Greenbrier lies in a valley, surrounded on all sides by small ridges. Here the average annual rainfall is 46.57 inches; for the 1968 season the Greenbrier weather station recorded 8.86 inches in March (4.61) and April (4.25). Old timers of the area refer to 1968 as a "late" spring. Snowfall was recorded in mid-March. Temperatures during the collecting months ranged from fourteen in March to eighty-six on April 18. The high for the last day of collection was eighty-four on May 1.

Complete descriptions of the soils and the various sites can be obtained (Barnett, 1968). Brief descriptions follow:

Site number 1 is along Cadron Ridge with its Allen-Hector Soil Complex and a shale phase of Montevallo. The ridge gives way to rolling pasture land with a slope of about 30 percent. The pasture land is Linker soil, a gravelly fine sandy loam; in the more poorly drained areas, the soil is Leadvale. Near the crest of the ridge is a rock outcropping. Elevations range from 350 feet on the ridge to 300 feet along Cadron Creek; the pasture ranges from 330 to 340 feet.

Site number 2 was flooded on several occasions during the collecting dates. Soils at this site include Linker soil on the gently, slightly rolling area blending into Leadvale which contains a fragipan and hence is very poorly drained. Also found here is Atkins Soil in very low areas and Casa along the small stream. Elevation here is about 290 feet.
Site number 3 is a rolling to very hilly farm with Horseshoe Mountain as the northwestern boundary. Here the soil is of the Allen-Hector complex. Most of the area is in open pasture of the Linker and Leadvale soil types. Elevations range from 330 feet in the pasture to 450 feet on the mountain.

Site number 4, near Springhill, extends southward nearly to Kaney Ridge. Elevations range from 340 to 420 feet. Linker is the predominant soil with mounds of Taft. Montevallo was found in one location that had been cleared in recent years. The topsoil is thin except in the mounded area and the subsoil is shale. The soil at this site dries out quickly.

Site number 5 lies within Greenbrier. The land is very gently sloping from an elevation of 340 to 330 feet. On the higher area soils are Linker; this fine sandy loam blends into a Taft silt loam. It contains a fragipan. Running south to north through the open field is a low, poorly drained area consisting of Leadvale soil with its fragipan.

Site number 6 has elevations ranging from 380 feet along Cadron Creek to 584 feet in some of the hills. Large outcroppings of Atoka sandstone rocks and fallen slabs provide small pockets of sandy-mixed alluvial soil beneath straight rock walls. An adequate, constant moisture supply supports a more luxuriant vegetation than that at the other sites.

Various manuals were used in the identification of plants; however, the plant families are listed according to Fernald (1950). Following is a check list, along with the site number where each species was collected.

Site Number

1 2 3 4 5 6

Selaginellaceae

6 Selaginella apoda (L.) Fern.

Polypodiaceae

3 6 Asplenium platyneuron (L.) Oakes

6 Asplenium Trichomanes L.

1 Cheilanthes lanosa (Michx.) D. C. Eat.

6 Dryopteris marginalis (L.) Gray

1 Polypodium polypodioides (L.) Watt

6 Polystichum acrostichoides (Michx.) Schott

1 3 4 5 Woodsia obtusa (Spreng.) Torr.
<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
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<tbody>
<tr>
<td>Araceae</td>
<td>6 <em>Arisema triphyllum</em> (L.) Schott</td>
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<tr>
<td>Commelinaceae</td>
<td>5 <em>Tradescantia ohiensis</em> Raf.</td>
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<tr>
<td>Liliaceae</td>
<td>1 4 <em>Allium canadense</em> L.</td>
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<td></td>
<td>1 <em>Allium mutabile</em> Michx.</td>
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<tr>
<td></td>
<td>4 <em>Amianthium Muscatoxicum</em> (Walt.) Gray</td>
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<tr>
<td></td>
<td>1 <em>Camassia scilloides</em> (Raf.) Cory</td>
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<td></td>
<td>4 <em>Erythronium americanum</em> Ker</td>
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<td></td>
<td>1 2 3 4 <em>Nothoscordum bivalve</em> (L.) Britt.</td>
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<tr>
<td>Amaryllidaceae</td>
<td>3 <em>Hypoxis hirsuta</em> (L) Coville</td>
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<tr>
<td>Iridaceae</td>
<td>6 <em>Iris cristata</em> Ait.</td>
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<tr>
<td></td>
<td>2 <em>Sisyrinchium albidum</em> Raf.</td>
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<tr>
<td>Polygonaceae</td>
<td>1 2 3 4 5 6 <em>Rumex acetosella</em> L.</td>
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<tr>
<td></td>
<td>3 <em>Rumex crispus</em> L.</td>
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<tr>
<td>Portulacaceae</td>
<td>6 <em>Claytonia caroliniana</em> Michx.</td>
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<tr>
<td></td>
<td>3 4 5 6 <em>Claytonia virginica</em> L.</td>
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<tr>
<td>Caryophyllaceae</td>
<td>2 3 5 <em>Cerastium nutans</em> Raf.</td>
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<tr>
<td></td>
<td>1 2 4 5 <em>Cerastium viscosum</em> L.</td>
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<td></td>
<td>2 <em>Cerastium vulgatum</em> L.</td>
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<td></td>
<td>2 3 4 5 <em>Sagina decumbens</em> (Ell.) T. &amp; G.</td>
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<td></td>
<td>1 2 3 4 5 <em>Stellaria media</em> (L.) Cyrillo</td>
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<tr>
<td>Ranunculaceae</td>
<td>4 <em>Anemone caroliniana</em> Walt.</td>
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<td></td>
<td>3 6 <em>Anemonea thalietroides</em> (L.) Spach</td>
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<td>4 <em>Myosurus minimus</em> L.</td>
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**Berberidaceae**

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<td></td>
<td><strong>Podophyllum peltatum L.</strong></td>
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**Cruciferae**

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<td>6</td>
<td><strong>Arabis missouriensis</strong> Greene</td>
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<td><strong>Capsella Bursa-pastoris (L.) Medic.</strong></td>
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<td><strong>Dentaria luciniata</strong> Muhl.</td>
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<td><strong>Draba brachycarpa</strong> Nutt.</td>
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<td><strong>Erysimum cheirioides</strong> L.</td>
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<td><strong>Lepidium virginicum</strong> L.</td>
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<td></td>
<td><strong>Sibara virginica</strong> (L.) Rollins</td>
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**Saxifragaceae**

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<td>6</td>
<td><strong>Saxifraga virginica</strong> Michx.</td>
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**Rosaceae**

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<td></td>
<td><strong>Potentilla simplex</strong> Michx.</td>
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**Leguminosae**

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<td></td>
<td><strong>Trifolium dubium</strong> Sibth.</td>
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<td><strong>Trifolium incarnatum</strong> L.</td>
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<td><strong>Trifolium pratense</strong> L.</td>
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<td><strong>Trifolium procumbens</strong> L.</td>
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<td><strong>Trifolium repens</strong> L.</td>
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<td><strong>Vicia sativa</strong> L.</td>
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**Oxalidaceae**

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<td><strong>Oxalis stricta</strong> L.</td>
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<td><strong>Oxalis violacea</strong> L.</td>
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**Geraniaceae**

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<td><strong>Geranium carolinianum</strong> L.</td>
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**Guttiferae**

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<td></td>
<td><strong>Hypericum denticulatum</strong> Walt.</td>
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**Herbaceous, Vascular Plants of Faulkner County**

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<td>Viola Langloisii Greene</td>
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<td>Viola pedata L.</td>
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<td>Viola sororia Willd.</td>
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<td>Veronica peregrina L.</td>
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**Bignoniaceae**

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**Plantaginaceae**

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**Valerianaceae**

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**Campanulaceae**

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**Compositae**

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<td>Senecio glabellus Poir.</td>
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<td>Senecio tomentosus Michx.</td>
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<td>5</td>
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<td>Taraxacum erythrospermum Andrz.</td>
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The 299 specimens collected included 108 different species. Site 6, with its greater variation in topography (open fields, precipitous rock cliffs, overhanging rocks, and rich woods), yielded 16 species not found at the other sites. Among these was *Claytonia caroliniana*, reported from only one other location in Arkansas. Site 1 yielded 11 species not found elsewhere, including those found on dry ledges and in open woods recently cleared of timber. Many of the species found at several sites were weeds or other plants requiring no special habitat.

**ACKNOWLEDGEMENT**

I am deeply grateful for the guidance, assistance, and moral support given me by Dr. Jewel E. Moore of State College of Arkansas.

**LITERATURE CITED**


FOSSIL PHYLLOXERID PLANT GALLS
From the Lower Eocene

Eugene B. Wittlake
Arkansas State University

Fossil Plant galls were encountered in an investigation of sandstone outcrops of the Upper Wilcox formation at Lafe, Arkansas. These deposits consist of very fine, buff-colored to whitish sandstone. Great detail of a structural nature is recorded in individual specimens. The deposit must represent the central area of a large lake or lagoon that was fed by streams with a moderate current. All coarse material in suspension had been filtered out or settled out, before the area of the deposit had been reached by the diminishing current. Apparently, finer particles then slowly settled out after being in suspension for some time. Individual sand grains are all of the same size. Another factor that lends support to the supposition that the area of the deposits was some distance from land, is the fact that the fossils are sparse and are chiefly the casts of stems, leaves and fruits of aquatic, emergent plants. Dicotyledonous leaves exist here and there; most have entire margins. In the last analysis, monocotyledons dominate.

Galls incited by insects are very scarce in the fossil record to date. Berry (1916) cites two examples from the lower Eocene and specifically locates them in the beds of the Wilcox from Lagrange formation near Puryear, Tennessee. Collins (1925) refers to them as found in the lower Eocene, and in another work Berry (1931) cites Wilcox specimens. Brooks (1955) received specimens collected in the area near Puryear, Tennessee and reviews the literature on the status of the fossil record of both galls and other types of injury to angiosperm fossil leaves. In fact, to the best knowledge of the author, these are the only papers there are on any reference to fossil insect galls from the lower Eocene. The remaining six papers in the Tertiary literature are in reference to galls found in the Oligocene Epoch from Florissant, Colorado: Scudder (1886), Cockrell (1908), Brues (1910) and Kinsey (1919); Hoffman (1932) has described Miocene galls and Brues (1946) refers to an observation of Cretaceous insect galls. None of the galls described in the preceding works resemble the galls presented here. All evidence of the specimens collected by the author, point to one insect family, namely, the Phylloxeridae.

The Phylloxerids belong to the insect order, Homoptera, the family Phylloxeridae and the subfamily Phylloxeridinae. This family

*This study was supported by a grant from the Faculty Research Committee, Arkansas State University.
of aphids that attack modern hickories, for the most part produce a
great variety of plant galls. Felt (1940) states that 29 kinds of galls
on *Carya* can be attributed to this family alone, and others appear
on *Quercus* and *Juglandis*, not to mention the long known forms
that infest the leaves and roots of *Vitis*.

Most phylloxerid galls have an orifice that is usually found on
the surface of the gall, exposed on the lower side of the leaf. Accord-
ing to Comstock (1949) the orifice is produced by the emergence
of a young generation of aphids that hatch from the egg-packed
gall. The eggs are laid by a wingless, agamic, stem-mother aphid
whose activity initiates the growth of the gall to its mature size.
In some forms, galls of this type are armed around the orifice and
rim of the gall, by spines or bristle-like plant hairs.

The fossil galls in question, lie well within the limits of size,
shape and other characteristics exhibited by present-day phylloxerid
galls that occur on plants belonging to the *Juglandaceae* and
specifically in the genus *Carya*. In fact, the fossil forms presented
here have characteristics very close to the gall produced by *Phylloxera
rimosalis* Perg. on hickory, described and illustrated by Felt.

The mature fossil galls average 9mm. long and 6 to 7mm. wide.
The conical body of the gall is 2-3mm. high. Young to older galls
range in length from 2 to 12mm. Three to four of the larger galls
show raised and rimmed margins with compression of equally-
spaced spines or bristles, 14 in number and attached at their bases
to the flange-like rim of the gall. The orifice at the summit of the
eone in the mature galls, ranged in diameter from 0.75mm. to 2.5
mm. The fossil galls are clustered in aggregates as are modern
galls.

The leaf compressions on which the fossil galls are situated,
are not detailed enough to show their complete outline, and the
margins of the leaves are not too distinct. However, the leaf margins
appear to be serrulate and not entire. On the surface of the compres-
sions are many casts of leaf hairs. Perhaps this indicates that the
underside of the leaf is exposed rather than the upper side. Most
of the species in the *Juglandaceae* have leaves that are clothed with
hairs on the underside, at least when the leaves are young. Many
retain this hirsute nature in the mature leaves. Some species in the
modern flora have minute glands along the veins and distributed
among the plant hairs. These fossil forms also show gland distributed
along the only midrib visible in these compressions. As a result of
the above discussion, the author makes no commitment as to the
generic designation of the fossil leaf compressions because they are
too fragmentary. In the light of the present day restriction of this
type of gall on a number of species in the family *Juglandaceae*,
it seems likely in the author’s opinion that these leaf compressions
do represent some genus in this plant family. It has been shown by past studies of other authors, i.e. Berry (1916), (1924) and (1930a), (1930b), Knowlton (1922), MacGinitie (1941) and Potbury (1935) that genera of the Juglandaceae were prevalent throughout the Eocene epoch.

In Fig. 1, a complete restoration of the mature fossil gall is illustrated, as seen from above with its rim fringed with spines. Fig. 2 is a diagrammatic vertical section of the fossil gall. Figs. 3 and 4 are photographs of the total number of young and mature fossil gall specimens studied in this work. Specimens illustrated in Figs. 3 and 4 (L 66031 and L 64101) are in the Paleobotanical Herbarium of Arkansas State University Museum.

In conclusion, the author wishes to thank Dr. Harvey E. Barton for his analysis and comments on these fossil specimens.

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Figs. 1-4: Fig. 1, Restoration of Fossil Gall, Fig. 2, Vertical section of gall, Fig. 3 and 4, Fossil gall specimens. X1.25
Fossil Phylloxerid Plant Galls

LITERATURE CITED


N.Y.
DARDANELLE RESERVOIR ILLINOIS BAYOU EMBAYMENT BACKGROUND SURVEY

Clarence B. Sinclair
Biology Department
Little Rock University

I. Introduction.

On June 1, 1968, faculty and student personnel from the Division of Biological Sciences at Little Rock University began preparations necessary for conducting the Dardanelle Reservoir Illinois Bayou Embayment Background Survey for the Arkansas Power & Light Company hereinafter designated as AP & L. This survey is intended to supply AP & L with data concerning the environmental influence exerted on the water of Dardanelle Reservoir resulting from its utilization as a coolant in a proposed 850 MW nuclear generating facility. The stated purpose of the project is to establish a program for testing and reporting on temperatures, biological conditions, chemical conditions, and radiological conditions in those sections of the reservoir that might be influenced by the Russellville Nuclear Unit. The survey began approximately five years prior to plant operations and will continue five years past the activation of the unit. Assistance and guidance was given to Little Rock University personnel by the AP & L Production Department, U. S. Geological Survey, U. S. Army Corps of Engineers, U. S. Coast Guard, Arkansas Pollution Control Commission, Arkansas Game and Fish Commission, Arkansas State Department of Health, U. S. Department of Interior Bureau of Fish and Wildlife, and Dr. Joe Nix of Ouachita Baptist University. The survey consists of four phases: thermal, chemical, biological, and radiological surveys.

II. Procedures.

A. Site Locations. The sites for sampling were established from a grid network determined by AP & L. Sites on specified line transects are located 500 feet, 800 yards, and 1800 yards from the entrance of the discharge canal, plus other designated points. These sites have been marked by use of permanent marker buoys, sight transects from permanent shore markers, and depth soundings made with a Jefferson sonar instrument. These are shown by number on the map given in Figure 1. There are ten sites within the potential affected area and two sites well outside the area. The latter two will serve as control sites. It is estimated that the test sites can be relocated within a fifty foot radius.

B. Thermal Survey. Thermal measurements were made during the months of January, April, June, July, August, and October. They were made at depths of 1, 2, and 7 feet below the surface, and each
succeeding 5 foot interval to bottom. Thermal values were taken by means of a YSI Model 54 Oxygen Meter with an automatic temperature compensating oxygen probe on a 100 foot cable. The instrument was checked with a mercury laboratory thermometer before each test series.

C. Chemical Survey. Chemical tests included determinations for dissolved oxygen, hydrogen ion concentration (pH), iron, manganese, chlorine, boron, total hardness, and turbidity. Dissolved oxygen content was determined in parts per million by means of the YSI Oxygen Meter. The sensing element was a Clark type membrane-covered polarographic probe which was calibrated before each test series by means of a standard Winkler determination as described in Standard Methods (Anon. 1965).

The remainder of the tests were performed on water samples pulled from the designated depths by means of a 2 liter Van Dorn Water Sampler Model 120. Determinations of pH, chlorine, turbidity, iron, and manganese were made on site. Water for the boron and total hardness tests was then collected into 18 ounce sterile plastic bags and transported in an insulated ice chest to the university laboratory for testing.

The pH measurements were made on site by means of a Taylor pH slide Comparator, model T-O. Chlorine, iron, manganese, and turbidity measurements were made on site by means of a Hach 1967). The Hach orthotoluidine method was used for chlorine determination, the total iron 1,10-Phenanthroline method was used for measurements of iron, and the Cold Periodate Oxidation method was used for manganese. These values were recorded in parts per million. The Hach Turbidity method was used for turbidity determinations and results were reported as the number of Jackson Turbidity Units (JTU).

In the laboratory, an Orion Research Model 401 specific ion meter with a divalent cation electrode and single junction reference electrode was used to determine total hardness values. These values were recorded as parts per million of calcium carbonate. This instrument was calibrated against an EDTA titrametric method determination before each test series.

The measurement of boron has presented certain problems. The Hach carmine method of boron determination using a B and L Spectronic 20 Colorimeter was utilized first, but the results seemed questionable. An acid-base titration method recommended by the research staff at the Connecticut Yankee Nuclear Power station which titrates the mannitoboric acid complex was also used, but with uncertain results (Thorpe 1968). An ion exchange method as described by Carlson and Paul (1968) which utilized the Orion
Specific Ion meter and fluoroborate electrode is also being tested. The Curcumin Colorimeter method from standard methods (Anon. 1965) is currently being utilized in our laboratory.

D. Biological Survey. The biological survey includes a fish population and species count, a bottom sample analysis, and a plankton analysis for zooplankton, phytoplankton, and periphyton. General observations were made on the quantity of aquatic life in these samples. A fish population survey was made by use of nylon gill nets with 24 hour sets in three sites during mid-summer and mid-winter. The test sites are shown on the map in Figure 1. Site I, in the discharge cove, was checked by use of a 6 foot x 100 yard sinking type gill net composed of 100 feet each of 1, 1½, and 2 inch mesh. Site II, on Goose Island, was tested by use of a 12 foot x 100 yard sinking type gill net consisting of 100 feet each of 2, 3, and 4 inch mesh as was Site III which was located approximately 500 yards south of Bunker Hill. At the end of the 24 hour set, the nets were pulled and the fish were counted and typed with reference to the mesh size from which they were taken.

The bottom samples were collected at Sites 5, 10, and 11 which were approximately 500 feet, 800 yards, and 1800 yards from the entrance of the discharge cove. These collections were made at mid-summer and mid-winter intervals. Samples were taken by use of a 6 inch x 6 inch Ekman type dredge. Dredgings were then screen-washed through a U.S. Standard Sieve Series No. 30 with openings of 0.589 mm. Residual material was transferred into 18 ounce sterile plastic bags and placed in an insulated ice chest which was transported to the laboratory. With the aid of a stereo-microscope, living material was observed in the sample, removed, and preserved in 10 percent formalin. The organisms were then counted, identified, and the results reported in terms of the number of organisms per square foot of bottom sampled (Welch 1948).

The water for plankton samples was pulled from representative depths using a 2 liter Van Doren Water Sampler. Plankton from 10 liters of water was concentrated by means of a Wisconsin type plankton net made up of No. 25 size nylon mesh with 200 meshes to the linear inch. Ten ml. of concentrated sample was then collected into a 25 ml. specimen bottle and neutral formalin was added to make a 5 percent solution. Collection sites and time intervals were the same as for the bottom samples given above. In the laboratory, three quantitative determination were made on the plankton samples. A gravimetric determination was made by drying a 5 ml. aliquot of the concentrated sample in a 60°C. oven until all water was evaporated. The dried sample weight was then determined and the value was reported as wet weight per liter of sample (Lagler 1956). A quantitative determination was also made and reported as field count. The
field count was obtained by use of a Whipple ocular disc and a Sedgwick-Rafter counting cell. The total number of organisms observed in 10 Whipple disc fields using the 10X objective of an AO microscope was recorded. From this, the total number of organisms was calculated as indicated in Standard Methods (Anon. 1965) and reported as the number of organisms per liter of water sampled. A differential strip count was also made and the zooplankton and phytoplankton were reported by type and number per liter of sample.

E. Radiological Survey. Samples of fish, bottom sediment, and water are to be taken for radiological tests (beta and gamma radiation counts). Water and sediment samples are also to be tested for radiation (beta and gamma from sources such as tritium, strontium 90, etc.). A mussel cage was planted at Site number 5 and mussels are to be recovered at 6 month intervals for beta and gamma radiological examinations. The required samples are to be obtained by L. R. U. personnel and the determinations are to be made by the Radiological Health Division of the Arkansas State Department of Health.

III. Summary.

Firm conclusions cannot be reached from the limited amount of data collected to date. However, the following generalizations are possible at this time.

1. Water temperatures one foot below the surface ranged from a high of 84.2°F in July to a low of 41°F in January. Bottom temperatures for the same sites ranged from a high of 82.4°F in July to a low of 32.9°F in January. Temperatures extremes at any one site have been quite small and no true thermal stratification has been detected.

2. Dissolved oxygen minima ranged from a low of 6.2 ppm in September to a high of 9.6 ppm in January one foot below the surface, and from a low of 4.0 ppm in September to a high of 9.1 ppm in January on the bottom. A possible oxygen stratification was detected during September in the deep water sites in the Arkansas river channel, but was not found elsewhere.

3. Fish population studies during October netted 263 fish including 8 species, and for December netted 65 fish from 7 species. Bottom samples contained 27 organisms per square foot from 6 taxa in October, and 70 organisms per square foot from 7 taxa in December. Field counts of plankton in October were 21,501 organisms per liter of water, and for December were 3620 organisms per liter of water.
Figure 1. Map of Dardanelle Reservoir Area.
LITERATURE CITED


CATTLE POISONING RELATED TO THE BLUE-GREEN ALGA, POLYCYSTIS AERUGINOSA KUTZ.

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Numerous isolated incidents of animal poisoning by toxic algae have been reported in the literature (Gorham, 1962, Kingsbury, 1964). However, this condition is not generally represented in human or veterinary medical clinical texts.

The aforementioned episode involved 16 cattle deaths in two herds near Fayetteville, Arkansas, one in which another toxic material (an organophosphate compound) was in use in a research project and was suspected as the lethal agent. Poisoning by the phosphate material was ruled out on the basis of extensive experience with these compounds by one of the authors (J. F. B.). In the search for the cause of the illness, high concentrations of blue-green algae were found in the water supply for the cattle.

As a result of these incidents, a preliminary research project has begun to further investigate the potential implications of this isolated suspected algal poisoning episode. Limnological, phycological and clinical investigations are incorporated in the research program.

A concise presentation of the occurrence, etiology, clinical findings, and control of algal poisoning in animals follows.

OCCURRENCE

A usually acute and highly fatal disease of animals results from drinking water containing high concentrations of toxic strains of blue-green algae. Extensive loss of life and severe sickness of livestock, pets, wild animals and humans have been associated with algal blooms in the northern half of the U. S. (also in Texas), the southern provinces of Canada, Russia, Argentine, Australia, South Africa and other countries.

Poisoning does not occur unless there is a dense bloom of toxic material. The factors leading to the formation of such blooms include warm sunny weather, ample nutrients (especially nitrates), and a gentle prevailing wind which drifts and collects the algae against the windward shore. Such conditions commonly occur during the summer months in drainage ponds and lakes used for watering livestock.
ETIOLOGY

Early studies indicated the primary toxic principle to be an alkaloid which affects the central nervous system and liver. A secondary toxic principle was described to be algal phycobilin pigments which accumulate in the skin of animals with a resultant increase in photo sensitivity.

More recent research discounts the alkaloidal nature of the toxic principle and incriminates a seven-amino acid cyclic polypeptide which produces rapid toxic symptomatology. In general, the crude toxic principle has the following characteristics: It can exist outside the cells in the water around the algae; it passes through cellophane and animal membranes by dialysis; it is non-volatile; it is relatively heat stable; it is soluble in water, alcohol (95% or less) and acetone, it is resistant to extreme pH changes. Several toxic fractions have been obtained by chromatographic procedures and one of these may be identified by a characteristic absorption curve having an almost complete absorption from 210-290 millimicrons. This fraction produces paralytic symptoms in mice and is lethal to 20 gram mice at a dosage of 0.7 mg.

CLINICAL FINDINGS

Toxic symptoms appear rapidly, usually within 15 to 45 minutes, after ingestion of poisonous material. Poisoning proceeds rapidly and is severe; death is common, occurring in less than 24 hours, often within one or two hours. The most commonly reported sequence of events are rapid prostration, convulsions and death; although convulsive signs are not always marked. Abdominal pain, muscular tremors, dyspnea, cyanosis and excessive salivation are commonly reported. A moderate number of cases have shown severe gastrointestinal manifestations including diarrhea, bloody feces, and icterus. Photosensitization frequently occurs in animals who survive for several days.

CONTROL

Removal of all animals from the affected water supply is an essential first step to all other measures. Algae growth may be suppressed with copper sulfate or other algacide treatment, but does not remove the toxin already present in the water. If no other water supply is available, animals should be allowed to drink from the clearest part of the water source opposite the windward shore (wind currents tend to blow and accumulate algal growth on the windward shore).

It is essential that animals dying from algae poisoning not be used for food as the toxic principle is quite stable and consistently produces toxic symptoms in the consumer. This is especially true with respect to the liver of diseased animals.
TREATMENT

Following removal from the contaminated water supply, affected animals should be placed in a relatively protected holding area, especially out of direct sunlight. Ample quantities of water and excellent quality feed should be made easily available. Mild to moderate laxatives may be used to move the toxic material out of the body (Caution: Affected animals are usually very weak and a minimum of violent procedures should be employed). In vomiting animals, an emetic may be used to good effect.

Even though the alkaloidal nature of the toxin has been discounted, 1 to 2 oz of sodium thiosulfate intravenously or orally seems to be of benefit. In surviving animals, a long recuperation period is to be expected before normal production is resumed.

It is anticipated that initial research findings of the present study will justify a more intensive investigative effort of the previously described phenomenon.

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ACKNOWLEDGEMENTS

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ON THE PREPARATION AND PROPERTIES OF SOME 1,1'-DIPHENYL-syn,trans-TRUXANE DERIVATIVES

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INTRODUCTION

In a previous report (1) we described the unique stereochemistry of several 1,1'-disubstituted syn,trans-truxanes as well as the utility of nmr spectroscopy in distinguishing the exo,exo, exo,endo, and endo,endo stereochemical modifications of these derivatives. To briefly summarize these nmr spectral considerations, an exo,exo-

1,1'-syn,trans-truxane exhibits the two benzylic (H_b) protons as a sharp singlet, while the non-equivalent H_b protons in the exo,endo derivative appear as two separate signals, a 1-H singlet and a 1-H doublet (J = 8Hz), and the spectrum of endo,endo disubstituted compounds displays the equivalent H_b protons as a 2-H doublet (J = 8 Hz).

RESULTS AND DISCUSSION

During the course of our work it became necessary to prepare a 1,1'-diphenyl-syn,trans-truxane as a synthetic intermediate. We now wish to describe some of the chemistry relative to these preparations, which is summarized in Scheme I.
The exo-exo dibromide 1a (1) coupled smoothly with two equivalents of phenylmagnesium bromide in ether-benzene to yield the exo,exo-diphenyltruxane 1b (mp 205-206°) in 50% yield. The appearance of the exo,exo product is not surprising, for it is almost certain that reactions of this type proceed homolytically, (2) and the coupling of a truxane and phenyl radical would be expected to occur preferably from the less hindered exo direction. The structure of 1b was assigned on the basis of its elemental analysis, infrared spectrum (monosubstituted phenyl, 698 cm⁻¹), and nmr spectrum (two-proton H \( \beta \) singlet at \( \gamma 5.68 \)). Furthermore, degradative ozonolysis of 1b in acetic acid at room temperature followed by esterification of the crude acid product afforded cis,trans,cis-1,2,3,4-tetrcarboxymethoxycyclobutane 4 (3), thus demonstrating the preservation of both the cyclobutane ring and the trans nature of the molecule.

\[
\text{MeO}_{2}C \quad \text{CO}_{2}\text{Me}
\]

In an alternate route to 1b, benzene was alkylated with the dibromotruxane 1a. Slow addition of excess aluminum chloride to a well-stirred benzene solution of 1a affords exclusively 1b in 20% yield when the reaction time is limited to 12 hr at room temperature followed by 1 hr at 50°. Allowing the reaction to proceed for longer periods together with raising the reaction temperature results in gradual disappearance of 1b with the formation of a new hydrocarbon (mp 147-149°). A reaction time of 24 hr culminating by heating 2 hr at gentle reflux affords exclusively the latter compound in 30% yield. The structure of this compound was established as exo,endo-1,1'-diphenyl-syn,trans-truxane (2a) on the basis of its elemental analysis, infrared spectrum (monosubstituted-phenyl, 695 cm⁻¹) and nmr spectrum (one-proton doublet at \( \gamma 4.67 \) and one-proton singlet at \( \gamma 6.28 \)). Degradative ozonolysis followed by esterification of the crude product yielded cis,trans,cis-1,2,3,4-tetrcarboxymethoxycyclobutane (4), thus demonstrating that the cyclobutane ring had survived the rather drastic treatment with aluminum chloride.

It was established by independent experiment that 2a may be formed by isomerization of the first-formed exo,exo isomer. Treatment of a boiling benzene solution of pure 1b with excess aluminum chloride in the presence of gaseous hydrogen chloride affords 2a in 37% yield. This result is not in accord with the expected thermodynamics of the system, in which the exo,exo isomer is assumed to be the most stable.
The sequence shown in Scheme II is offered as a possible account for the observed isomerization.

![Scheme II](image)

Initial protonation of one of the 1,1′ phenyl groups in either the o or p position would generate carbonium ion 1c. Subsequent loss of the truxane benzyl proton and reprotonation from the less hindered exo direction would ultimately yield the endo product. It is not clear as to why this process would occur at only one site and not at the other to yield the endo,endo isomer 3a. Perhaps the latter was formed but was too unstable to be isolated under the conditions employed, resulting in conversion to observed intractable materials.

An alternate explanation (Scheme III) might involve intermolecular hydride transfer to an initially formed carbonium ion (possibly 1c). A resulting chain process would then involve subsequent generation of the benzylic carbonium ion 1d which would in turn abstract hydride from another truxane molecule with the phenyl group of 1d tucked in the endo position. An endo,endo isomer formed by this process could have escaped detection.

![Scheme III](image)

**EXPERIMENTAL SECTION**

*Coupling of exo,exo-1,1′-Dibromo-syn,trans-truxane with Phenylmagnesium Bromide; Formation of exo,exo-1,1′-Diphenyl-syn,trans-truxane (1b) — To a solution of phenylmagnesium bromide generated*
from magnesium turnings (0.73 g; 0.03 gatom) and freshly distilled bromobenzene (2.1 ml; 0.02 mole) in dry ether (10 ml) was added dropwise with manual agitation a solution of the dibromotruxane (3.0 g; 7.7 mmoles) in dry benzene (30 ml). The addition required 20 min and the rate was such that the temperature of the reaction mixture did not exceed 35-40°. A small crystal of anhydrous cobaltous chloride was added and the resulting dark solution gently heated (65°) for 5 hr. The solution was then decanted from the excess magnesium and poured into 300 ml of cold water. The organic phase was then separated and washed with two 100-ml portions of 5% potassium hydroxide solution followed by two 100-ml portions of water. After drying over calcium chloride the volatile solvents were removed (rotary evaporator) affording the crude diphenyltruxane 1b as a yellow-white solid (1.5 g; 51% mp 195-205°). In some cases the crude product was obtained as a viscous oil which could be crystallized by digestion with hot 95% ethanol. Three recrystallizations from methylcyclohexane afforded pure material (mp 205-206°). The infrared spectrum exhibits strong absorption at 760, 739, and 698 cm⁻¹. The nmr spectrum (CDCl₃) is characterized by absorption at 2.2-3.1 (18 H-multiplet), 5.68 (2 H-doubled), 7.11 (2 H-doublet), and 6.06 (2 H-doublet).

Anal. Calcd for C₃₀H₂₄: C, 93.75; H, 6.25. Found: C, 93.57; H, 6.45.

The Reaction of exo,exo-1,1'-Dibromo-syn,trans-truxane with Benzene in the Presence of Aluminum Chloride; Formation of exo, endo- and exo,exo-1,1'-Diphenyl-syn,trans-truxane (2a) and (1b) —

A. exo, endo-1,1'-Diphenyl-syn,trans-truxane (2a) — Finely pulverized anhydrous aluminum chloride (2.0 g; 0.015 mole) was added in small portions over a 1 hr period to a stirred solution of the dibromide (3.0 g; 7.7 mmoles) in 50 ml dry benzene (distilled from sodium metal). The original colorless solution became reddish-brown during the course of the addition of the aluminum chloride, and hydrogen bromide was evolved at a moderate rate. The resulting dark solution was then allowed to stir at room temperature for 23 hr and subsequently warmed to 70° for 2.5 hr. This reaction mixture was allowed to cool to room temperature and finally poured with stirring onto a mixture of 25 ml 10% hydrochloric acid and 100 g crushed ice. The yellow-green fluorescent organic phase was separated, and the aqueous phase extracted with 150 ml ether. The organic layers were combined, washed with 5% potassium hydroxide solution followed by water (100 ml), and dried over calcium chloride. Removal of the volatile solvents (rotary evaporator) afforded 2.8 g of a heavy oil which was dissolved in the minimum amount of benzene. The concentrated benzene solution was then chromatographed in two equal portions on two separate 2 x 30 cm chromatographic columns packed with acid-washed aluminum oxide. Each column was
Derivatives of 1,1'-Diphenyl-syn,trans-Truxane

eluted as follows: 1:4 benzene-cyclohexane (200 ml), 1:2 benzene-cyclohexane (100 ml), 1:1 benzene-cyclohexane (100 ml), and pure benzene (100 ml). Evaporation of the first eluted fractions (150 ml total) in an air stream afforded a clear viscous oil which solidified on drying overnight in a vacuum desiccator. Later eluates provided only polymeric materials which were not characterized further. The combined crude material from both columns (900 mg; 30.5%) was purified by recrystallization from 95% ethanol yielding white crystals of the exo,endo product (mp 147-149°). The infrared spectrum exhibits strong absorption at 760, 747, and 695 cm⁻¹. The nmr spectrum (CDCl₃) shows absorption at 2.35-3.15 (multiplet), 5.67 (doublet), 6.32 (unsymmetrical doublet), 6.55 (singlet) and 7.31 (quartet) in the respective area ratio of 6:33:1:33:33.

Anal. Caled for C₃₀H₂₄: C, 93.75; H, 6.25. Found: C, 93.69; H, 6.34.

B. exo,exo-1,1'-Diphenyl-syn,trans-truxane (1b) — When the above reaction was repeated with stirring at room temperature for 12 hr followed by 1 hr at 50°, there was obtained on evaporation of the first total 100 ml of eluted fractions from each chromatographic column a total of 580 mg (20%) of the exo,exo isomer (mp 198-202°). The infrared spectrum was superimposable on that of the hydrocarbon 1b derived from the Grignard coupling reaction, and a mixture melting point determination showed no depression.

Ozonolysis of exo,exo-1,1'-Diphenyl-syn,trans-truxane (1b) — A well-stirred suspension of the diphenyltruxane (350 mg; 0.91 mmole) in 90% aqueous acetic acid (100 ml) was treated with a stream of ozone at a flow rate of approximately 3.66 g of ozone per hour for 21 hr at room temperature. The resulting homogeneous reaction mixture was then allowed to stand in the presence of 30% hydrogen peroxide (20 ml) for 48 hr. The excess peroxide was subsequently destroyed by stirring the resulting reaction mixture with 10-20 mg of 10% palladium-on-charcoal catalyst at room temperature for 8 hr. The catalyst was removed by filtration and the filtrate evaporated on a rotary evaporator. The residual viscous oil was heated to 125° in an oil bath for 10 min prior to dissolution in anhydrous ether (20 ml). Excess diazomethane (approximately 2.0 g) in ether (70 ml) was then added and the reaction mixture was stirred at room temperature for 12 hr. After evaporation of the volatile solvents, a light yellow oil (25 mg) remained which crystallized on trituration with cold 95% ethanol. Recrystallization from methanol provided pure cis,trans,cis,trans-1,2,3,4-tetracarbomethoxycyclobutane (4) (15 mg; 6%; mp 139-144°; lit (3) mp 144-145°). The infrared spectrum of this material was identical to that of an authentic sample, and a mixture melting point determination showed no depression.

Ozonolysis of exo,endro-1,1'-Diphenyl-syn,trans-truxane (2a) —
When subjected to ozonolysis under conditions identical to those previously described for the \textit{exo,exo} isomer in the preceding experiment, the \textit{exo,endo} diphenyl derivative 2a (700 mg; 1.85 mmoles) yielded, after esterification of the crude ozonolysis product, a light yellow oil which partially crystallized on standing several days at room temperature. Further crystallization was achieved by trituration with cold 95\% ethanol, and subsequent recrystallization from methanol afforded the cis,\textit{trans},cis-1,2,3,4-tetracarbomethoxycyclobutane (4) (22 mg; 4.3\%; mp 140-144°).

\textbf{Isomerization of \textit{exo-exo-1,1'-Diphenyl-syn,trans-truxane} (1b) to \textit{exo,endo-1,1'-Diphenyl-syn,trans-truxane} (2a)} — Finely puverized anhydrous aluminum chloride (200 mg; 1.5 mmoles) was added in small portions over a 30 min period to a stirred solution of the hydrocarbon 1b (250 mg; 0.65 mmole) in 15 ml dry benzene. A slow stream of hydrogen chloride gas was bubbled through the solution during the course of the addition. The dark solution was stirred under reflux for 1.5 hr as treatment with hydrogen chloride gas was continued. The gas inlet tube was then removed and reflux was continued for an additional 40 min. The reaction mixture was poured with stirring onto a mixture of ice and hydrochlore acid, the organic phase was separated, and washed in turn with a saturated sodium bicarbonate solution (two 25 ml-portions) and water (50 ml) prior to drying over sodium sulfate. Removal of the volatile solvent afforded a yellow-brown oil which was dissolved in the minimum amount of benzene and applied to a 1 x 20 cm column packed with acid-washed aluminum oxide. Elution was performed with 1:4 benzene-cyclohexane (50 ml), 1:1 benzene-cyclohexane, and pure benzene (50 ml). Evaporation of the first 100 ml of eluted solvent afforded a clear viscous oil which solidified on drying overnight (vacuum desiccator). Recrystallization from 95\% ethanol yielded 92 mg (37\%) of the \textit{exo, endo} isomer 2a (mp 142-147°).

\textsc{REFERENCES AND LITERATURE CITED}


BIOSTRATIGRAPHY OF THE MORROW GROUP
OF NORTHERN ARKANSAS

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The Morrow Group of northwest Arkansas (p. 184, fig. 1) is of early Pennsylvanian age (300 M. Y., Kulp et. al. 1961, p.111, fig. 1) and includes the Hale and Bloyd Formations. The term Morrow was introduced by Adams (1904, p. 3 and p. 28) to include strata earlier described by Simonds but introduced by Branner (in Simonds' 1891, p. XIII) as Washington shale and sandstone, Pentremital limestone, coal-bearing shale and Kessler limestone. To each of these units Branner attached Simonds' name and the statement was published, over Branner's signature, as an introduction to "The Geology of Washington County" by F. W. Simonds.

Simonds described, mapped and illustrated, by means of photographs, the stratigraphic unit he called the Washington shale and sandstone (1891, pp. 75-82, photographs facing pp. 75 and 80). Simonds included in the unit all of the strata between the Archimedes limestone and the Pentremital limestone. Simonds also characterized the Pentremital limestone as two calcareous layers separated by a sandstone bed.

Henbest (1962) mentioned that part of Simonds' Pentremital limestone section belongs with the Hale formation. Also Henbest (1953, p. 1942) mentioned that the faunas of the upper part of the Hale Formation (Prairie Grove Member) had been confused with those of the Pentremital limestone (Brentwood Member of the Bloyd Formation) and wrote "This admixture, however, has probably made little difference in the fauna attributed to the Brentwood limestone because the Brentwood seems to represent a gradational change from Prairie Grove deposition with but little evident difference in age." This prognostication has not proved to be correct.

HALE FORMATION

Cane Hill Member. The Hale Formation was subdivided by Henbest (1953) into the Cane Hill and Prairie Grove Members. The Cane Hill section is composed largely of shale, siltstone and conglomerate lenses. In places sandstone lenses or calcareous bodies of considerable size and thickness occur. At the type locality chosen by Henbest (1962) near Evansville, Arkansas, there is a limestone conglomerate a few inches thick resting on the Pitkin Formation. About three miles south of this place at Davidson Post Office (abandoned) the conglomerate is as much as twenty feet thick and contains numerous fossils including goniattites. Above the conglomerate is a few inches of black, clay-shale, which at the type locality is
Diagrammatic stratigraphic column of the Morrowan section and some of the goniatites belonging in units of Bloyd and Hale rocks. Drawn by James E. Edson, University of Arkansas; goniatite illustrations from James A. McCaleb, Pan American Oil Corp.; Robert Miller, (former U. of A. student). The Hudsonoceras is from Poord & Crick, catalog of British Cephalopods III, 1897, and is the type of Hornatum which very closely resembles Hudsonoceras moorei, Quinn & Saunders (1968), from the lower portion of the Can Hill Member of the Hale Formation.
more than twenty feet thick and contains thin stringers of hard, dark siltstone which weathers to brown. There are also some small disc-shaped concretions in the shale. The siltstone layers increase in proportion, upward, and the shale is superceded by flaggy siltstone beds. At Davidson the rocks above the shale tend to resemble the calcareous material below. At Fayetteville, Arkansas, in the Frisco R.R. cut east of the campus, the basal conglomerate lies on Fayetteville shale and there is no Pitkin limestone. Above the conglomerate is as much as twenty feet of black shale, very similar to that at the type locality. Likewise, the shale grades into flaggy siltstone and thin beds of sandstone with numerous conglomerate lenses, some of which contain an elaborate and distinctive goniatite assemblage. Among the goniatites which are light colored there are also a number of phosphatized fossils, some of which are jet black, while others have been altered to a soft blue-gray material. These are reworked from older deposits which presumably lay farther north. All these goniatites are of Pennsylvania age, or, to rephrase, they do not belong in Mississippian assemblages. Two from the basal conglomerate indicate that it also is Pennsylvanian in age and of course the intervening black shale cannot be considered otherwise. The phosphatic goniatites appear to be indigenous to the black shale section and occur in a few places in lenses of conglomerate or siltstone. Several goniatite collections from this horizon indicate the occurrence of Syngastriceras, Cymoceras and a form probably not represented higher in the section which appears referable to Homoceratooides. This assemblage may indicate a distinguishable biostratigraphic zone in the lower part of the Cane Hill section.

The middle part of the Cane Hill section lacks the supposed Homoceratooides (except the reworked material) but contains Reticuloceras, Retites, and Hudsonoceras as well as longer ranging forms. This represents a second biostratigraphic zone in the Cane Hill sequence. The highest portion of the Cane Hill sequence has failed to yield Hudsonoceras but does contain some "advanced" components and may indicate a third biostratigraphic zone.

Cane Hill goniatites occur from the easternmost edge of Oklahoma to the eastern edge of Madison County, Arkansas, in some abundance. There is also some material from about fifteen miles south-southwest of Batesville, Arkansas, which contains goniatites of the basal Cane Hill biostratigraphic horizon. There is another locality on Lake Maumelle near Little Rock, Arkansas, which contains material referable to the second or Hudsonoceras biostratigraphic zone. Otherwise there are no known productive Cane Hill goniatite localities between Batesville and Madison County, although a section of siltstone and shale which may belong to the Cane Hill Member of the Hale Formation crops out in many places.
Middle Hale. The lower Pentremital limestone of Simonds was thought by Henbest to belong in the Prairie Grove Member of the Hale Formation. Gordon (1965 p. 39-40) identified limestone on the west slope of East Mountain in Fayetteville, Arkansas as "the lower Pentremital limestone," which he said "is overlain by about forty feet of calcareous sandstone . . . which belongs in the Prairie Grove Member." Gordon described two goniatites from a conglomerate lens at the base of the "first Pentremital limestone near West Fork, Arkansas, as Gastrioceras henbesti and textum. These indicate an advanced or descendant species of Retitea, one of the most abundant of the mid-Cane Hill goniatites. The assemblage contains no "true" Gastrioceras but does appear to represent the first appearance of Pygmaeoceras which has been encountered in abundance in three places at the top of the lower Pentremital limestone. One is at the East Mountain-type locality for the taxon, one is on Kessler Mountain, and the third is at (but below) the type locality of the Brentwood limestone and the Boyd Formation. This also is the type locality for R. henbesti and is doubtlessly the very place where Simonds developed the idea of the binary nature of the Pentremital limestone (Brentwood Member of the Boyd Formation). It is also evidently the place where Henbest conceived the idea that the Prairie Grove Member of the Hale Formation grades into the Brentwood. The position of the Prairie Grove sandstone is here occupied by dark shale as it is in both localities mentioned above. At the East Mountain locality P. pygmacum occurs high in the shale, indicating its mid-Hale affinities. Thus the Prairie Grove strata does not grade into the Brentwood but in fact the whole of the Prairie Grove section is missing above the R. henbesti type locality. The mid-Hale section is rich in brachiopods and Pentremites and goniatites are quite scarce in most places. The rock is mainly limestone and may be from a few inches to forty or fifty feet thick. (Behind the I.G.A. Store at Evelyn Hills Shopping Center the contact of the Middle Hale and the Cane Hill strata is exposed in the wall of the excavation made for the store.) Twenty to thirty feet above the mid-Hale limestone a six foot layer of Prairie Grove ss. crops out and the Brentwood is exposed behind the "Colonial Village" above and south of the I.G.A. Store. Failure to recognize the mid-Hale stratigraphic unit has caused considerable confusion not only with respect to faunal distribution but also concerning the value of unconformities involved.

Prairie Grove Member. With a single exception the goniatite fauna of the Prairie Grove Member of the Hale Formation seems to be without complexities. The exception is a locality on Bradshaw Mountain near Green Forest, Arkansas. At this place one of the typical Prairie Grove forms, Arkanites, occurs in abundance at and above the contact with a Cane Hill lithic unit. Arkanites is in the lower part of a sixty foot calcareous standstone typically Prairie
Biostratigraphy of the Morrow Group

Grove in aspect. In the base of the section a few Retites were recovered which appear to be reworked. The assemblage includes a completely exotic goniatite Baschkirites. Everywhere else the Prairie Grove assemblage involves principally Arkanites and Gastrioceras s. s. (first appearance).

Since the discovery at Bradshaw Mountain of Arkanites, an exceptionally distinctive taxon, this form has been encountered almost everywhere in Prairie Grove strata, from Bragg’s Mountain near Muskogee, Oklahoma, eastward to the Snowball Quadrangle about sixteen miles west of Marshall, Arkansas. With the exception of the Bradshaw Mountain anomaly Arkanites occurs everywhere in association with Gastrioceras (undescribed) which is also quite distinctive in that most small specimens have a ventral furrow, all are cadicone, and all have strong ribs around the umbilicus. A rule of thumb criterion is that the first or second goniatite from any Prairie Grove locality will be Arkanites. Gordon (1965) did not report Arkanites and it appears that none of his collections actually were derived from Prairie Grove strata as here defined.

The north-south distribution of Arkanites in Oklahoma is from Bragg’s Mountain to Caddo Village near Ardmore, Oklahoma, and in Arkansas from Bradshaw Mountain to the latitude of Cass, Arkansas, and Marshall, Arkansas.

The Hale goniatite assemblages are quite distinct from those of the Bloyd Formation but there is closer relationship than between Hale and Imo of the late Mississippian.

BLOYD FORMATION

Several biostratigraphic horizons are distinguishable in the Bloyd Formation. These include two horizons in the Brentwood Member of the Bloyd Formation and one in the Dye Shale-Kessler Members, as well as a probable “Trace Creek” horizon.

Brentwood Member. The Brentwood Member of the Bloyd Formation is a limestone unit ranging to as much as twenty feet thick. The strata crop out principally in Washington County, Arkansas where the Brentwood limestone is overlain by a shale interval and a supervening limestone to conglomerate unit previously unrecognized and which contains goniatites here called Gaither Mountain assemblage.

The Brentwood limestone contains rare Cymoceras (a form abundant in the Hale assemblages) and equally rare Bisatoceras secundum (typical of the Gaither Mountain goniatites). Both contain Branneroceras (confined to Brentwood-Gaither Mountain assemblage) and Syngastrioceras morrowense which ranges through the entire Bloyd section.

Cymoceras occurs in the Union Valley Formation of southeast
Oklahoma, indicating direct and close affinity with Brentwood rather than younger assemblages (Quinn, 1962, pp. 116, 120).

The Gaither Mountain goniatites are like those of the Brentwood except that the genus Gaitherites is abundant, Cymoceras is absent, and Bisatoceras secundum, rare in Brentwood, is also abundant. Proshumardites is a component of Gaither Mountain assemblages but rare in the Brentwood.

The Gaither Mountain biostratigraphic unit appears to be much more extensive than the Brentwood. In the north-south direction it is expressed at Gaither Mountain near Harrison, Arkansas, and at Long Pool, near Dover, Arkansas, a distance of about sixty miles. Gaitherites occurs in a limestone near Webber's Falls, Oklahoma, at approximately the same latitude as the Long Pool site. The Gaitherites limestone crops out along the Frisco Railroad one-half mile south of Woolsey, and in the bed of West Fork of White River, one-half mile south of the Brentwood type locality Gordon (1965, p. 242, USGS Loc. 2849) confused juveniles of Gaitherites from this place with Cymoceras. At the Brentwood type locality the Gaitherites limestone has not yet been isolated. Henbest (1953, p. 1943) expressed the idea that younger strata were deposited on a truncated surface which may have obliterated the Gaither Mountain horizon just at this place. Farther east on Porter Branch of White River it lies twenty-seven feet below the Baldwin coal and about an equal distance above the Brentwood proper. The unit can be traced eastward to the area of Limestone, Arkansas, where Pryor (unpublished M.S., 1967, p. 57) collected Gaitherites from a thick, brown, sandy sequence of rocks not otherwise identifiable. It appears that the strata containing Gaitherites thickens to the south and east of Gaither Mountain and is the principle unit in the beds Glick, Frezon and Gordon (1964) have called Witts Springs Formation. To the west, in Madison County, the Gaither Mountain horizon is represented by a thin stratigraphic unit between the Brentwood limestone below and the Winslow Formation above. The rock is siltstone, conglomerate (in places with cobbles), and lenses of limestone and sandstone or calcareous sandstone. In many places the position of the Gaither Mountain horizon is marked by a weathered zone or unconformity or a paleosoil horizon. In Washington County the Gaither Mountain horizon tends to range from ten to thirty feet thick and be composed principally of limestone rich in fossils. The Webber's Falls, Oklahoma, locality is in algal limestone. The Long Pool occurrence is a coarse conglomerate with a calcareous matrix.

Woolsey Member. The Brentwood-Gaither Mountain section of the Boyd Formation is separated in places from supervening strata by a thin bed of coal and some associated sediments. Henbest, 1953, indicated that this part of the Boyd is represented by continental deposits which he called the Woolsey Member of the Boyd Forma-
tion. The continental interval is terminated upward by a limestone unit, conglomeratic in places, which Henbest called informally "cap rock". The cap rock is the basal unit of Henbest's (1962, p D43) Dye Shale Member of the Boyd Formation.

**Dye Shale Member.** The section included in the Dye Shale Member of the Boyd terminates upward in the Kessler limestone, which, as Henbest (1953, p. 144-5) pointed out, closely resembles the cap rock and has been consistently confused with it. The cap rock is never more than a few feet above the coal and the Kessler limestone is as much as seventy feet higher in the section. Where the coal is missing and one or the other of the limestones is not exposed, identification can only be based on proximity of the Brentwood-Gaither Mountain below or the Winslow Formation above.

The goniatite assemblage appears to range from the cap rock through the Kessler limestone without discernible change. The taxa are quite distinctive. They include *Pseudoparalegoceras*, a form abundant in younger Pennsylvanian rocks; *Axinolobus*, confined to the Dye Shale assemblage, *Diaboloceras neumeyeri* which extends into the Trace Creek Shale above the Kessler limestone, and *Syngastrioceras* which does not occur above the Kessler limestone.

**Trace Creek Member.** The Trace Creek Member of the Boyd Formation (Henbest 1962, p. D44) is a black shale unit of limited extent insofar as known which has furnished goniatites from a single locality on Lee Creek three miles west and two miles south of West Fork, Arkansas, in Washington County. The goniatites are *Pseudoparalegoceras*, *Diaboloceras neumeyeri* (type locality for the species), *Boesites* and perhaps some other unidentified taxa, as well as such perennials as *Pronorites*. This assemblage is distinguished by the total absence of *Syngastrioceras*, an abundant form in all the earlier Morrowan. Absence of *Axinolobus* further emphasises the uniqueness of the Trace Creek assemblage. Palynological material from this locality also indicates a Morrowan aspect. Elsewhere this black shale is superseded, or its position occupied, by black shale of the Winslow formation which has furnished no goniatites but has a Westphalian B aspect insofar as the palynological data is concerned (H. Sullivan and R. Mischell, personal communication).

**SUMMARY**

The Morrow group of northwest Arkansas is early Pennsylvanian and includes the Hale and Boyd Formations. The Hale Formation has been subdivided into the Cane Hill and Prairie Grove Members. The Cane Hill rocks are mostly black silty shale and flaggy siltstone with considerable conglomerate in places, especially along the northern border of outcrop. There are also extensive sand bodies of tabular or lensoidal shape some of which are calcareous and contain numerous fossils. The goniatites *Reticuloceras, Retites* and
Hudsonoceras occur with longer ranging forms. Above the Cane Hill section is an unnamed unit (the lower or first Pentremital limestone of writers) which contains advanced Cane Hill taxa, the longer ranging forms and Pygmaeoceras pygmaeum. The rocks of the unnamed unit are mostly limestones with vast numbers of brachiopods and numerous blastoids (Pentremites). Above this unit the Prairie Grove Member of the Hale Formation crops out in many places but appears to be somewhat discontinuous. The Prairie Grove rocks are mostly medium sandstones and reef limestones containing fossils in places including the goniatites Arkavites and Baschkirites.

The Brentwood Member of the Bloyd Formation lies unconformably on the Hale section and is mostly limestone containing the goniatite Branneroceras among others. Above the Brentwood limestone is an unnamed limestone section containing the goniatite Gaitherites, as well as Branneroceras and others. The upper part of the Bloyd Formation is separated from the lower part by a discontinuous coal horizon. The upper Bloyd contains the Dye Shale and Kessler Members which show a partially unique goniatitic assemblage including Axinolobus, Diaboloceras neumeieri and Pseudoparalegoceras.

Kessler rocks are succeeded by a black shale which retains D. neumeieri but the assemblage is distinguished by the loss of Synagastrioceras and the appearance of Boesites. This unit has been described as the Trace Creek Member of the Bloyd Formation but the black shale of the type locality appears to belong in the Winslow rather than the Bloyd Formation.

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THE BIOSTRATIGRAPHY OF PECCARY CAVE, 
NEWTON COUNTY, ARKANSAS

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Peccary Cave was discovered in January, 1965, when Jack McCutcheon of the Cave Creek community in Newton County, Arkansas, fashioned a rope ladder and lowered himself into a pit on his property. At the bottom of a 32 foot vertical descent, he discovered a passage into a large cave. There were few indications that people had preceded him into the cave although he did find two unfamiliar names scratched into the cave wall in a remote passage and one broken stalactite set upright on the cave floor. Some strange bones that were lying on the cave floor and the cave formations hanging from the ceiling and walls prompted him to dig a horizontal adit into the cave. We have continued to enlarge this artificial entrance until today it offers easy access to the cave.

The first bones that Mr. McCutcheon collected were referred to the Geology Department of the University of Arkansas for identification, and a small grant was secured from the University Research Committee for some exploratory excavation. On the strength of the material that was thus recovered in 1965, the National Science Foundation funded the present project which began in September, 1967.

Although there are more than 1000 feet of passages in Peccary Cave, most of the excavation has been near the two entrances. In the map of this area of the cave (Figure 1), the excavated portions are enclosed by dashed lines and the important trenches numbered.

A profile of the strata in the area around Trench 1 involves a top layer of dirt, as much as 20 inches thick, containing bones, gravel, peccary droppings, and thin layers of limestone. Beneath this is nearly 14 inches of limestone in fallen blocks that overlies granular red and yellow clays with scattered calcite layers and few bones. The limestone layer may vary in thickness and depth of burial or be expressed as several thinner units, but throughout its occurrence it appears to have been a single fall of rock for blocks are not piled one on another. There is a vastly greater number of bones above this layer than below it.

The peccarys for which the cave is named are Western Hemisphere animals and are considered to have diverged from the “true” swine stock in Oligocene time. However, they still retain some of the habits of domestic swine such as the selection of a restricted area for defecation where they occupy a confined space. Where the fallen rock layer is buried deepest, the top foot of the cave floor contains a large number of still recognizable droppings. In Trench 8, some
FIGURE 1  MAP VIEW OF PECCARY CAVE
droppings were encountered about a foot higher and two to three feet horizontally displaced from charcoal that was measured by Isotopes, Inc. to have an age of 4290 years. Therefore, these droppings are considerably younger than the charcoal, and the peccary, *Platygonus compressus*, must have persisted far past the date, circa 11,000 years, that is usually accepted for the time of its extinction. This peccary also retains another pig-like trait in that it apparently rooted out wallows and beds while living in the cave, which destroyed or fragmented the more fragile bones that have been found there and obliterated the finer divisions of stratigraphy in the clay and dirt fill of the cave.

Farther into the cave, in Trench 3, the division between bone-bearing and sterile clay is no longer marked by a rock fall, but there is a slight change in the color of the matrix filling the passages. There are tongues of calcite in the upper layers of clay which probably represent some kind of climatic change. Some of our finest specimens of dire wolf, *Canis dirus*, teeth were recovered from this area, usually in the upper foot of the fill. However, we have teeth and bones of this large carnivore from many trenches and levels of the cave. In Trenches 1, 4, and 8 near the artificial entrance, teeth of *Canis dirus* have been recovered from strata both above and below that of the dated charcoal.

Teeth of extinct musk oxen have nearly all been discovered in the more remote passages of the cave, and some have been encountered two or three feet below the surface although most are shallower.

A single tooth fragment which has been tentatively identified as that of a tapir was recovered from Trench 4 near charcoal that has been dated as having an age of 2980 years before present. We are still looking for definite evidence that the tapir's famous perissodactyl cousin, the horse, also can be found in the cave.

Remains of another interesting, extinct animal occur in some numbers throughout the cave. We have slightly over 100 shell scutes and one claw core of a large armadillo, *Dasypus bellus*. Where more than 3300 scutes can be counted on a modern, smaller armadillo, it is possible that the scutes from the cave represent but one individual. However, they have an interesting distribution in that 82 of all the scutes were found in the top layer of two squares in Trench 15. We might expect to find either the animal's skeleton in that area or even to encounter the old, original entrance to the cave which we have not definitely located.

Among the most interesting of the extinct animals in Peccary Cave are the proboscideans or elephant-like animals. In Trench 1 we collected a large bone fragment that must be part of a pelvis or
a scapula of either a mastodont or mammoth. A chip of enamel from a mastodont’s tooth was discovered near but lower than the charcoal dated at 4290 B.P., while a larger part of a mammoth’s tooth was picked up on the dump outside the cave and cannot be assigned to a specific horizon.

Of the extinct animals that have been mentioned, probably only the dire wolf and the peccary actually inhabited the cave for any length of time. The others may have been introduced into the cave by predators, scavengers, or floods. Of animals living today but occurring in the cave collection, brown bear, striped skunk, raccoon, gray fox, bobcat, coyote, and badger are carnivores that might den in a cave, while the woodchuck, porcupine, and opossum might also seek shelter there. Deer, elk, beaver, musk-rat and squirrel might have been carried to the cave as prey or been washed there as the otter probably was.

There are many small mammals such as mice, shrews, and bats in the cave collection. Their teeth were sent to the University of Iowa where Dr. Holmes Semken is making a study that promises to provide much more data, particularly on the subject of climate.

Also, there are snails, crayfish, seeds, fish, frogs, salamanders, snakes, turtles, and birds in the material from the cave.

When the general scarcity of vertebrate fossils of any kind in Arkansas is considered, a nearly unique set of circumstances must be envisioned as having acted to assemble the varied fauna found in Peccary Cave. The sterile layers of clay and rock appear to have been deposited in the cave when no connection with the surface suitable for the passage of animals existed. Some deposits of clay on shelves and walls in the cave indicate that these deposits may have been much deeper at one time than they are now.

Later, an opening to the surface developed and the animals and their remains began to collect in the cave. That this nearly horizontal opening developed quite late is proved by the radiocarbon dates, the absence of sabre-toothed cats or ground sloths which are usually found in late Pleistocene assemblages, and the climatic conditions which are necessary for the formation of deposits such as are contained in the cave.

At the time of the Altithermal or Climatic Optimum which lasted from approximately 7000 to 4000 years ago, Newton County and much of Arkansas was more desert-like than most people like to visualize. The accompanying discontinuous plant cover allowed mass wasting of the hillsides when infrequent rains fell. The consequences of such conditions can be appreciated when we consider the local topography. Peccary Cave, on the south side of Ben’s Branch, is in strata of middle and upper Ordovician limestones at an altitude
of 840 feet or about 25 feet above the present bed of the branch. Two and one half miles west of the cave on George Mountain near the head of Ben's Branch, there is an out-crop of Imo shale of latest Mississippian age at an altitude of 1600 feet. In this shale are fossils, particularly gastropods and cephalopods with a distinctive type of preservation in which the animal's shells are quite black. Identical fossils may occasionally be collected in Peccary Cave and are usually found below the layers containing the peccary droppings.

From this evidence we may infer that after an entrance to the cave developed, stream flooding carried alluvium from Ben's Branch, bearing the molluscan fossils and any animals that might have been encountered and began to fill the cave. That the cave was not sealed by alluvium and land sliding until near the end of the Altithermal is indicated by the presence of animals such as the beaver, otter, and muskrat which prefer permanent water in their habitat. That the peccarys continued to utilize the cave as a watering hole, shelter, or farrowing ground right up to the time that it was sealed, is suggested by the undisturbed droppings and by the presence on the cave floor of bones that were never gnawed by rodents.

Certainly a major factor in the preservation of the bones in this cave has been the influx of alluvium which covered the animal remains that were present there and insulated them from those factors, physical and chemical, which would normally have destroyed them long ago.

Until 1965 the cave had only minor contact with man as shown by a few bones that might have been burned, a very few possibly human bones, 6 teeth, 8 or 10 carved shell beads and one stone artifact. It is a green chert scraper about 2½ inches long and is not diagnostic of any culture. The chimney through which Mr. McCutcheon entered has played only a minor, modern role in the cave's development. Much of Peccary Cave's value lies in the fact that once it was sealed, it remained a "time capsule" until relatively recent times.

I wish to thank the Research Committee of the University of Arkansas and the National Science Foundation for the funds that made possible the excavation of Peccary Cave. Special thanks are due Dr. James H. Quinn, Chairman of the Department of Geology at the University of Arkansas, for his guidance and unfailing interest in the project. Mr. and Mrs. Jack McCutcheon have given access to the cave and their home for two years, and I am very appreciative of their generosity and assistance.
MIDDLE ARCHAIC COMPLEX OF NORTHWEST ARKANSAS

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Purpose

After the end of the Wisconsin glacial there occurred an interval called the Neothermal in the southwestern portion of the United States. The Neothermal is comprised of three consecutive temperature intervals: the Anathermal, Altithermal, and Medithermal, respectively characterized by rising, maximum, and moderate temperature. The Altithermal was the only period of extreme arid climate which has existed in North America since the Mankato glacial substage (Antevs 1955). During this "long drought" Arkansas developed a typical desert environment characterized by round clumps of bushes which gave rise to prairie mounds (Quinn 1961), and extensive alluviation took place. Contained within alluvial material deposited during the Altithermal are artifacts of the people who lived and hunted in the dry climate of that day. It is through projectile points collected from the alluvium that an age determination of the alluvium will be made.

Procedure

After many hours of searching alluvial material one datable point was finally discovered. This point is shown in Figure 2, point number 30. It was therefore decided that points in a collection accumulated by Dr. James H. Quinn would be used. This collection will be referred to hereafter as the basic collection. Points of the basic collection were discovered in alluvial material or in stream beds of the Fayetteville City Park (Figure 4), or Town Branch Creek. Various people contributed artifacts over a period of years; thus information concerning their discovery sites depth of burial, and exact association with the alluvial material is not known. It will be assumed that all points came from the alluvial material. To correct for possible contamination of points, categories which were not represented by two or more points were not considered to have come from the alluvial deposit. In addition, more weight in determining the age of the deposits will be given to six points which are known to have been discovered within alluvial material. These six points (Figure 2, points No 27-32) came from the same alluvial deposit in the Fayetteville City Park (Figure 4); points ranged in depth of burial from three feet (point 30) to six feet (point 32) below the present surface. The six points from the City Park represent four projectile point styles. These styles constitute eighty-one percent of all projectile points present in the basic collection. Perhaps the other nineteen percent represent points which were not in true association.
with the alluvium. W. W. Cook and R. K. Harris (1952) stated that ten percent of all the points used by Archaic Indians of the Carrolton Foci were points of an older time period. If this were true only nine percent of the points in the basic collection represent contamination.

As a basis for projectile point classification a Masters' thesis by James A. Scholtz (1967) was used. His thesis on artifacts in the Beaver Reservoir area in northwest Arkansas was extremely helpful. The four styles represented by the six points from the City Park are of the following general categories: Basal-Notched, Straight-Stem, and Contracting-Stem types Two and Three. The most abundant point style discovered in association was the Basal-Notched type. The various point styles will be discussed in detail later.

In addition to the basic collection, points from an occupation site (number 3WA107) near the spillway of Lake Sequoyah were used. The occupation site was brought to the writer's attention by Dr. Mike Hoffman. Only Basal-Notched points were collected from the site. Associated with artifacts of the site are large quantities of organic material which is suitable for C\textsubscript{14} dating. Organic material associated with the artifacts was collected and it is hoped that a C\textsubscript{14} date can be determined.

The artifacts of the Lake Sequoyah site are contained in a fine-grained alluvial deposit (Figure 5). Within the fine-grained material are isolated groups of stones (Figure 6). These stones do not occur throughout the deposit but are confined to small areas in the deposit. Some of the stones if not all of them were carried to their present location by people who occupied the site. This can be concluded from several lines of evidence. First one stone was collected which had a depression pecked into it. This stone is believed to have been used in cracking nuts. Secondly, many of the stones in the alluvial deposit appear to be heat cracked by fire. Thirdly, the presence of relatively large stones contained in isolated patches in the fine-grained alluvial deposits indicates the stones were carried in. The purpose of the stones is somewhat questionable. They may have been used for stone water boiling, grinding stones, or hearth stones. If some of these stones are in fact Archaic hearths the Lake Sequoyah site would be one of the few examples of hearths of such an age.

Occupation of the Lake Sequoyah site occurred penecontemporaneously with the deposition of the alluvial material. It is possible that the alluvium was first deposited as loess and later washed from the surrounding hills as the climate of the Altithermal became wetter. If this were true the point styles characteristic of the site would represent a time after the peak of the Altithermal. Points from the late site are shown in Figure 2, number 24-26.
POINT STYLES OF THE SIX POINTS FROM THE FAYETTEVILLE CITY PARK

Basal-Notched

Basic description: Generally a broad basally notched projectile point with long barbs and expanding base.

General form: The blade is most often wide in relation to the lengths of the specimens with the exception of point number 28, Figure 2. Barbs are long and massive, and were produced by chipping deep notches into the base of the point blank. These notches are narrow and U-shaped. The notches are cut at an angle ranging from ten to thirty degrees from the long axis of the point. The bases of the points are straight, round, or convex.

Basal-Notched points are characteristic of both the Fayetteville City Park and the Lake Sequoyah site. This point style is believed to range from late Early Archaic to Woodland. (Scholtz).

In the south central United States basal-notched points have been described in quite early early context; however the style’s upward range is somewhat questionable. The basally notched point is the principal point type of Early Middle Archaic Era, which is believed to have lasted from 6,000 to 4,000 B.C. (Marshall). Some authors have suggested that the point style may have been present as late as 1,000 B.C.

Straight-Stem

Basic description: A broad, medium sized projectile point with a slightly expanding stem and concave base. (Scholtz).

General form: Only one specimen of this type was discovered. It has a broad blade, in relation to its length. The blade edges curve thus producing a convex outline, with the maximum width occurring at the shoulders. The shoulders are short with very slight barbs. The stem expands slightly toward the concave base portion of the point.

The one point which was collected is shown in Figure 2, point number 32. The point was located within the coarse alluvium in the Fayetteville City Park and was some four to five feet below the surface.

Straight-Stemmed points appear to belong to an undefined projectile point type present in western Arkansas and possibly in Oklahoma (Scholtz). The closest comparable form is the Jakie Stemmed type described by Marshall (Marshall 1958: 109-110). Marshall lists Jakie Stemmed points as having an “Early and perhaps Middle Archaic” cultural affiliation.
Contracting Stem

Two types of Contracting Stem points were found. The difference between the two lies in the base. One type has a round base while the other’s base is concave.

Contracting Stem Type Three

Basic description: A dart point with a contracting stem and a concave base (Figure 2, point number 31).

General form: The blade has a straight outline, with one point slightly recurved (concave-convex). One point, figure 1, point 14, has been reworked and used as a drill. The widest portion of the point is at its shoulders. The shoulders tend to be short and slope gently into the stem, thus omitting the barbs. The stem contracts toward the base, which is concave.

Contracting Stem Type Three has been called by Marshall, *Standlee Contracting Stemmed* and is present in both the Fayetteville City Park and the basic collection (Figure 1, points 12-14, and Figure 2, point 31). *Standlee Contracting Stemmed* type is culturally affiliated with the “later phase of Early Archaic and continues through the Woodland period and into Marginal Mississippi period” (Marshall 1938: 120-121).

Contracting Stem Type Two

Basic description: A contracting stem projectile point with a rounded base.

General Form: The blade edges are straight to convex, with one point recurved (convex-concave). Maximum width occurs at the shoulders, which vary from horizontal and pronounced to slight and curved concavely into a well-rounded base (Scholtz).

One point, of this category, was discovered in position in the alluvial material of the Fayetteville City Park. Point number 3, figure 2 was found three feet below the surface. It was located in a fine-grained material which lies above the coarser alluvium. Contracting Stemmed Type II points should have a range in time either extending past the end of the Altithermal or beginning after the peak Altithermal. Unfortunately this type of point has a relatively large range in time; according to Marshall its range “starts in the early part of Late Archaic and continues through the Woodland into the Mississippian”.

POINT STYLES NOT REPRESENTED BY THE SIX POINTS FROM THE FAYETTEVILLE CITY PARK, BUT PRESENT IN THE BASIC COLLECTION

Four categories of points were present in the basic collection
that were not present in the points from the City Park. Styles that were not represented by two or more points were not considered, due to the possibility of contamination of points in the basic collection by older and younger points. Four dart points were excluded for this reason. They are shown in Figure 1, points 1, 2, 9, and 15. Their types and age indications are as follows: 1, Plainview type, Late PaleoIndian-Early Archaic; 2, pre-Dalton type, Early Archaic; 9, Frio type, minor Archaic; and 15, Stone Corner Notched, late Early Archaic to Woodland. General categories of point styles of the basic collection in quantities of two or more are Broad Corner Notched, Square Stemmed, and Corner Notched.

**Broad Corner Notched**

A small dart point with very broad corner notches and a slender expanding stem, giving the point a fir-tree outline (Scholtz). It has been called *Table Rock Stemmed* and is assigned to the “Middle Archaic” by Marshall. See Figure 1, points 16-18 for examples of *Table Rock Stemmed* points.

**Corner Notched**

Points of the Corner Notched type are medium-sized corner-notched points with pronounced shoulders which are most often barbed. The stem expands slightly and the base is straight to concave. The point is similar to the White River Corner Notched type but has a slightly concave base rather than a straight base (see Figure 1, points 6-8). The White River Corner Notched point has a wide range projectile points with smoothed stem and basal edges (Figure 1, continues through Woodland into the Marginal Mississippi period” (Marshall 1958: 123).

**Square Stemmed**

Square Stemmed points are large, shouldered, square-stemmed projectile points with smoothed stem and basal edges (Figure 1, points No. 19-23). These points conform closely to the description of the Stone Square Stemmed type defined by Marshall (1958: 110-112). Marshall regards this point type as having an Early and Middle Archaic cultural affiliation.

**Conclusions**

Five basic conclusions can be drawn from the data accumulated in this project.

1. The alluvial material from which the projectile points were collected was laid down during the Middle Archaic time period (6,000-3,000 B.C.). This can be seen from the graph of the ranges of point styles present in the entire artifact collection (Figure 3).

2. The Altithermal ended in northwest Arkansas by the be-
beginning of the Late Archaic period. This is evident from the range of Standlee Contracting Stemmed points. Point number 30, Figure 2 was found in position just above the alluvial material in the Fayetteville City Park and is of the Standlee Contracting Stemmed type.

3. If a C\textsubscript{14} date could be obtained from the organic material contained in the Lake Sequoyah site a time for the geological sequence which resulted in the deposition of alluvial material at the Lake Site could be determined. This sequence is believed to represent a time after the peak of the Altithermal.

4. Prairie mounds in northwest Arkansas represent a surface feature formed between 4,000 and 3,000 B.C. Prairie mounds of northwest Arkansas were formed by the accumulation of wind-blown dust and sand particles in the bases of round clumps of bushes, are related to the arid climate of the Altithermal (Quinn). As the Altithermal died out precipitation increased. Increasing precipitation was accompanied by increasing plant cover. New plant cover growing on the prairie mounds effectively "froze" the mounds in their size, shape, and distribution. Because of increased plant cover the wind could no longer dislodge mound material to build new mounds or destroy old ones. This new plant cover also prevented deposition of new alluvium on the scale of that which occurred during the Altithermal. The youngest points contained in the alluvial material should therefore represent the approximate time at which the prairie mounds were "frozen".

5. The presence of Archaic points a few feet from the surface in alluvial material indicates that alluviation is not a continuous process, but a discontinuous one, with the process of alluviation being regulated by climate and plant cover.
Figure A. Projectile point variation (from Scholtz)
Figure 1. 1, Plainview; 2, pre-Dalton; 3-5 Basal-Notched; 6-8, Corner-Notched; 9, Frio; 10-11, Contracting Stem Type Three; 12-14 Contracting Stem Type Two; 15, Stone Corner Notched; 16-18, Table Rock Stemmed; 19-23, Stone Square Stemmed.
Figure 2. PROJECTILE POINTS 24-26, Basal-Notched points from Lake Sequoyah site; 27-20, Basal-Notched points from Fayetteville City Park; 30, Contracting Stem type Three from City Park; 31, Contracting Stem type Two, City Park; 32 Straight-Stem, City Park.
Figure 3. Showing range in time of point types present in Dr. Quinn’s basic collection

Figure 4. Coarse alluvium and fine-grained alluvial material of the Fayetteville City Park, both types of material contain artifacts.
Figure 5. Fine-grained alluvial material of the Lake Sequoyah site.

Figure 6. Fine-grained alluvial deposit of Lake Sequoyah site containing hearth stones (?).
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AN EXACT TEST FOR SIMPLE CORRELATION IN ANALYSIS OF DISPERSION

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Suppose an experimental design results in $p$-variate experimental units $y_1, y_2, \ldots, y_n$ so that under usual assumptions of independence and normality, i.e. $y_i \sim N(\mu_i, \Sigma)$ for $i = 1, 2, \ldots, n$, the techniques of analysis of dispersion (multivariate analysis of variance) are applicable for testing linear hypotheses with respect to $\mu_1, \mu_2, \ldots, \mu_n$. But suppose the purpose of the experiment was not to test for differences in the mean but rather to examine the associations among the variables, i.e. a correlation analysis is called for. For example, an experimental design may have been used to provide data for path analysis (cf. Teng, 1969) in which case it is desirable to examine the correlations among the causal variables. Under these circumstances, the treatment means $\mu_1, \ldots, \mu_n$ simply serve as nuisance parameters to prevent one from proceeding to estimate the correlation matrix by standard methods.

On the other hand, the appropriate analysis of dispersion serves to adjust out these effects and will always result in an error matrix $E$ of residual sums of squares and products and an associated error degrees of freedom $v$. As is well known, this matrix provides the starting point for analysis of covariance, but the purpose of this note is to point out that $E$ also provides a means for making the most common correlation test of all; namely, the test of statistical independence between any pair of variables.

For the sake of notation, denote the elements of $\Sigma$ by $\sigma_{ij}$ and the elements of the associated correlation matrix $P$ by $\rho_{ij}$

$$P = \text{diag}(\frac{1}{\sigma_{11}}, \frac{1}{\sigma_{22}}, \ldots, \frac{1}{\sigma_{pp}}).$$

Denoting the elements of $E$ obtained from analysis of dispersion by $e_{ij}$, then the usual estimator of $P$ is
\[ R = D^{-1} E D^{-1} \]

with elements \( r_{ij} = \frac{e_{ij}}{\sqrt{e_{ii}} \sqrt{e_{jj}}} \) where \( D = \text{diag}(\sqrt{e_{11}}, \sqrt{e_{22}}, \ldots, \sqrt{e_{pp}}) \).

Formally, we want to test \( H_0: \rho_{ij} = 0 \). Fortunately, we can start with a relatively recent result (cf. Rao, 1965) which was not available to R. A. Fisher when he published his transformation of the estimated correlation coefficient into a \( t \) statistic (cf. Kendall, 1958), namely that \( E \) has the Wishart distribution with density function

\[
f(E) = \frac{\exp\left(-\frac{1}{2} \text{tr}(E^{-1})\right) |E|^{v-p-1}}{\frac{p(p-1)}{4} \gamma^{p/2} \pi^{p(p-1)/4} \prod_{i=1}^{p} \Gamma\left(\frac{v-i+1}{2}\right)}
\]

for any analysis of dispersion so long as \( E \) is positive definite.

Since the marginal distribution of any 2 x 2 partition, say \( E_2 \), on the principal diagonal of \( E \) also has a Wishart distribution with \( p = 2 \), we may write

\[
f(e_{ii}, e_{ij}, e_{jj}) = \frac{\exp\left(-\frac{1}{2} \text{tr}(E_2^{-1})\right) |E_2|^{v-3}}{\frac{1}{4} \gamma^{2} \pi^{2} \prod_{i=1}^{2} \Gamma\left(\frac{v-i}{2}\right)}
\]

where \( E_2 = \begin{bmatrix} e_{ii} & e_{ij} \\ e_{ij} & e_{jj} \end{bmatrix} \) and \( \Sigma_2 = \begin{bmatrix} \sigma_{ii} & \sigma_{ij} \\ \sigma_{ij} & \sigma_{jj} \end{bmatrix} \)

But when \( H_0 \) is true \( \rho_{ij} = \frac{\sigma_{ij}}{\sqrt{\sigma_{ii}} \sqrt{\sigma_{jj}}} = 0 \) so that \( \sigma_{ij} = 0 \) and the joint density simplifies to

\[
f(e_{ii}, e_{ij}, e_{jj}) = \frac{\exp\left(-\frac{e_{ii}^2 - e_{ij}^2}{2\sigma_{ii}} \right) (e_{ii} e_{jj})^{\frac{v-3}{2}} \left(1 - \frac{e_{ij}^2}{e_{ii}^2 e_{jj}^2}\right)^{\frac{v-3}{2}}}{\frac{1}{4} \gamma^{2} \pi^{2} (\sigma_{ii} \sigma_{jj})^{\frac{v}{2}} \prod_{i=1}^{2} \Gamma\left(\frac{v-i}{2}\right)}
\]

where \( e_{ii} > 0, e_{jj} > 0, \) and \(-e < e_{ij} < e\). Making the transformation
Correlation In Analysis Of Dispersion

\[ r_{ij} = \frac{e_{ij}}{\sqrt{\sum e_{ii} \sum e_{jj}}} \]

with Jacobian \( |J| = \sqrt{\text{det}(V)} \), the marginal density for \( r_{ij} \) is

\[
m(r_{ij}) = \frac{(1 - r_{ij}^2)^{\frac{v-3}{2}}}{\pi^{\frac{v}{2}} \Gamma\left(\frac{v}{2}\right) \Gamma\left(\frac{v-1}{2}\right)} \int_0^\infty \int_0^\infty \frac{x^{\frac{v}{2} - 1} y^{\frac{v}{2} - 1} \exp\left(-\frac{x}{2\sigma_{ii}} - \frac{y}{2\sigma_{jj}}\right)}{h\sigma_{ii}\sigma_{jj}} \, dx \, dy
\]

\[
= \frac{(1 - r_{ij}^2)^{\frac{v-3}{2}}}{B\left(\frac{\sigma_{ii} + \sigma_{jj}}{2}, \frac{v-1}{2}\right)}
\]

-1 < \( r_{ij} < 1 \)

Transforming once more, let

\[ t = \frac{r_{ij} \sqrt{v - 1}}{\sqrt{1 - r_{ij}^2}} \]  \hspace{1cm} (2)

with Jacobian \( |J| = \frac{v - 1}{2} \), so that after simplification

\[ g(t) = \frac{1}{\sqrt{v - 1} B\left(\frac{\sigma_{ii} + \sigma_{jj}}{2}, \frac{v-1}{2}\right) (1 + t^2)^{\frac{v-1}{2}}} \]

i.e. the t distribution with \( v - 1 \) degrees of freedom.

Hence, to test \( H_0: \rho_{ij} = 0 \) in the presence of nuisance location parameters, perform the appropriate analysis of dispersion to obtain \( E \) with \( v \) degrees of freedom. Compute the estimated correlation matrix \( R \) from \( E \) as shown in (1) and select the appropriate element \( r_{ij} \). Transform to the t statistic as given by (2) and reject \( H_0 \) at the \( \alpha \)-level of significance if

\[ |t| > t_{\alpha}(v-1) \frac{\alpha}{2} \]  \hspace{1cm} where \( t_{\alpha}(v-1) \frac{\alpha}{2} \) is the \( 1 - \frac{\alpha}{2} \) critical value

of the t-distribution with \( v - 1 \) degrees of freedom.
REFERENCES


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