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Academy Editors

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1972

Flagella and basal body of *Trypanosoma*

ARKANSAS ACADEMY OF SCIENCE
BOX 1709 UNIVERSITY OF ARKANSAS
FAYETTEVILLE, ARKANSAS 72701

GUIDELINES FOR AUTHORS

Eligibility for publication in the PROCEEDINGS is limited to those papers which have been presented at the annual meeting by one of the authors. 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. Papers should be original contributions by the authors to their respective fields of knowledge. The Editorial Board reserves the right to edit, shorten, or reject any papers submitted for publication. Submitted papers will be reviewed by persons competent in the area of study.

Good manuscript writing is expected. A manuscript requiring more than minor editing will be returned to the author(s) for revision. This process may cause sufficient delay to prevent publication in the issue of the PROCEEDINGS for which it was submitted. Two copies of the manuscript, the original and a clean copy for review purposes, must be submitted to the session chairman at the time of the paper reading. Manuscripts should be typewritten and double spaced throughout. Nothing in the manuscript should be underlined except Latin names of genera and species. The following format sequence is recommended as a guide: title, author(s), abstract, introduction, materials and methods, results, discussion, literature cited. Literature citations must be accurate and they should be arranged alphabetically on the final pages of the manuscript. The recommended generalized citation for a periodical is:

Author(s). Publication year. Complete title. Periodical name volume: complete pagination.

Illustrations, line drawings and photographs should be of the highest quality, and each should be numbered as figures on the back. Such illustrations should be proportioned properly to fit a PROCEEDINGS page (single column or double column) by direct reproduction. If size reduction during printing is necessary, lettering must be large enough to be legible after reduction. Legends for illustrations should be designated with arabic numerals and submitted separately, never on the illustrations. Original drawings and photographs need not be submitted with the original manuscript, but will be requested after the manuscript has been reviewed.

Tables should be planned to fit one or two printed columns of PROCEEDINGS format (3¼" or 7" wide). Avoid complex tables which will be difficult to read and which will require vertical lines for columns. Number tables consecutively with Roman numerals. Type all tables double spaced, one per manuscript page, with the table number and legend heading the page. Include enough information in each table legend to explain adequately the data of the table. Footnotes to tables should be avoided, but if necessary, they should be concise and clearly indicated.

Special instructions which the author deems necessary for placement of tables and figures within the printed text should be submitted with the manuscript, but separate from the body of the manuscript. These requirements will be honored if possible. The complete address of the author to which editorial correspondence is to be directed must be included on a separate page at the end of the original manuscript.

Manuscripts normally will be limited to three published pages. Additional pages will be charged to the author at cost. Authors should expect to bear charges arising from exceptional typesetting or illustration.

The Editor will inform authors of the review status of their papers and submit for their final review the page proofs of articles accepted for publication. Information concerning the ordering of reprints will be forwarded to the authors at the time of page-proof review.

BUSINESS AND SUBSCRIPTION INFORMATION

Remittances and orders for subscriptions and for single copies and changes of address should be sent to Dr. William C. Guest, Secretary, Arkansas Academy of Science, Box 1709, University of Arkansas, Fayetteville 72701.

Subscription rates for 1972 are $5.00 per copy with members receiving one free copy with their full membership of $8.00 or their sustaining membership of $10.00. Institutional members and industrial members also receive one free copy. Copies of back issues are available. The Secretary should be contacted for prices and for special complete back issue discounts available to libraries.

ABSTRACT COVERAGE

Each issue of the **Proceedings** is sent to several abstracting and review services. The following is a partial list of this coverage:

- Abstracts in Anthropology
- Abstracts of North American Geology
- Biological Abstracts
- Biological and Medical Abstracts
- Chemical Abstracts
- Chemical Titles
- Mathematical Reviews
- Science Citation Index
- Sport Fishery Abstracts
- Wildlife Review
- Zoological Record
- Review Journals of the Commonwealth Agricultural Bureaux

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ARKANSAS ACADEMY OF SCIENCE

Volume XXVI | Proceedings | 1972

Secretary's Report

MINUTES OF THE FIFTY-SIXTH ANNUAL MEETING - APRIL 7-8, 1972

FIRST BUSINESS MEETING

The first business meeting of the 56th Annual Meeting of the Arkansas Academy of Science was called to order by Dr. George Templeton, President of the Academy, at 10:45 a.m. on April 7, at the University of Arkansas, Fayetteville. Dr. Templeton introduced Dr. David W. Mullins, President of the University, who welcomed the members of the Academy to the campus.

President Templeton then called for reports from the officers of the Academy.

Secretary:

The Secretary reported that the minutes of the 55th Annual Meeting held at Harding College, April 16-17, 1971, were being distributed to the members at the registration desk and moved that the minutes be approved as circulated. The motion was seconded, after which the Secretary moved that the motion to approve the minutes be tabled until the second business meeting in order to give members an opportunity to read the minutes. The motion to table was seconded and the motion carried.

The Secretary discussed membership figures for the past three years. Dues-paying members in 1971 totaled 136 in contrast to 180 in 1969 and 189 in 1970. The 1971 dues-paying members were distributed among the sections as follows:

Anthropology	4	Geology	5
Biology	77	Physics	11
Chemistry	35	Science Education	26
Mathematics	7		

(Some members indicated an interest in more than one section.)

Treasurer:

Copies of the financial statement and summary were distributed by Dr. J.P. Jones, Treasurer. Dr. Jones' motion to accept the Treasurer's Report was seconded and the motion carried. The financial statement and summary follow.

Financial Statement
Arkansas Academy of Science
April 1, 1972

Balance on hand April 1, 1971	$2741.48
Reserve fund	1502.72
Total assets	4244.20

Receipts-April 1, 1971 - March 31, 1972

1. Membership dues	589.00
2. Institutional memberships	500.00
3. Sales of Proceedings	40.00
4. Page charges for Proceedings	337.20
5. Banquet tickets	235.00
Total receipts	1701.20

Disbursements-April 1, 1971 - March 31, 1972

1. Robert Kirkwood - expenses	34.03
2. Keith Jones - Talent Search winner	20.00
3. Bill's Restaurant, Searcy - banquet	170.50
4. U. of A. - office supplies	17.88
5. W.A. Guest - postage and supplies	57.04
6. U. of A. - office supplies	4.83
7. Southwest Printing - 1970 Proceedings	1770.37
8. Lowell Bailey - post box rent	2.00
9. AAAS - annual contribution	6.00
10. Southwest Printing - 1971 Proceedings	1944.85
11. E.E. Hudson - Junior Academy	200.00
12. U. of A. - office supplies	10.92
13. U. S. Postoffice - stamps	16.00
14. U. of A. - letter copies	5.75
15. U. S. Postoffice - stamps	12.00
16. U. S. Postoffice - stamps	4.00
17. U. of A. - letter copies	4.50
18. U. of A. - office supplies	20.01
Total disbursements	$4300.63

Summary

Original balance	$2741.48
Receipts	1701.20
Total receipts	4442.68
Less disbursements	4300.68
Balance	142.00
Reserve fund	1502.72
Interest on reserve fund	84.59
Total reserve	1587.31
Total assets April 1, 1972	$1729.31

Editor:

Dr. L.C. Howick, Editor, reported that Volume 25, 1971, of the Proceedings of the Arkansas Academy of Science had been distributed to the members. He said that the current volume is the second in the new format which has resulted in lower total cost and has provided greater editorial flexibility. He discussed briefly how papers are reviewed and how page charges are determined. The Proceedings is now abstracted by most of the important abstracting journals. Dr. Howick noted that Volume 25 was the last volume for which he would serve as Editor. His five-year term ends with this business meeting.

Historian:

Dr. Dwight Moore called the attention of the membership to the compilation of Academy officers published in Volume 25 of the Proceedings. This compilation includes all of the Academy officers since the organization of the Academy in 1917 along with other information of historical interest.

The President:

Dr. Templeton reported that he had written a letter on behalf of the Academy in support of the bill being considered by the U.S. House of Representatives which would designate the Buffalo River as a National River.

President Templeton then appointed the following Committees:

Nominations: Neil Fulton, P.M. Johnston, Samuel Siegel, James Fribourgh, W.W. Trigg
Audit: Eugene Wittlake, E.E. Hudson, R.L. Meyer
Resolutions: Robert Kirkwood, Joe Nix, M.L. Lawson, Douglas James
Meetings: Clark McCarty, Hugh Johnson, Virginia Kirk, C.B. Sinclair, Joe M. Guenter, Eugene Wittlake
A.A.A.S. Fellow Committee: Neal Buffaloe, Samuel Siegel, Paul Sharrah, Frances Clayton

President Templeton then called for reports from the representatives of organizations sponsored by or associated with the Academy.

Science and Technology Council:

Dr. R.C. Anderson described the new Council created by the Legislature and appointed by the Governor. The Council hopes to work closely with industrial scientists and engineers as well as with those in academic areas. The Symposium on the Interaction of Science, Industry, and Government, organized by Dr. John Imhoff, should provide an opportunity for an exchange of information among these various groups, as will the evening roundtable discussion on Technology Transfer with Dr. Anderson, Chairman of the Science and Technology Council, presiding.

Collegiate Academy of Science.

Dr. Joe Nix reported that the Collegiate Academy has about 150 members but the response to a call for papers for the meeting this year was not as good as last year. Only 10-12 papers are to be presented. This year the Collegiate Academy is conducting a symposium on the Natural History of the Buffalo River. The Academy has been operating for two years outside the constitution, which will be revised. The Collegiate Academy needs the help of the institutional members and the financial assistance of the Senior Academy.

Junior Science and Humanities.

Dr. Eugene Wittlake, Director, reported that the Sixth Symposium was held in Little Rock, November 11-13, 1971. Ninety-three students and 53 teachers from 61 school districts participated. Of 32 research papers submitted, seventeen were read before the judges. The six winners were to go to the National Symposium at Duke University. Dr. Wittlake indicated that increasing costs presented some budget problems for this Symposium and will mean that more financial assistance will be needed in the future.

New Business.

President Templeton reported that the Executive Committee recommended to the Academy that the Arkansas Academy of Science provide support for the Collegiate Academy of Science up to a total of $200 for the coming year. Dr. Fry moved that the recommendation be accepted and Dr. Beadles seconded the motion. After the discussion, the motion carried.

Dr. Wear moved that the Academy make available to the Editor of the Proceedings up to a total of $400 for one year for editorial assistance. Dr. Moore seconded the motion and the motion carried.

President Templeton discussed the role the Academy should play in matters of science and public policy. He announced that he had appointed a committee to draft a statement to clarify the mechanism by which the officers of the Academy may make statements on issues concerning the Academy. The committee consists of Dr. J.P. Jones, chairman, and Dr. Arthur Fry, Dr. James Scholtz, and Dr. Lowell Bailey, members. Dr. Jones presented the policy statement and Dr. P.M. Johnston moved that the statement be approved. The motion was seconded and the motion carried. The policy statement is as follows.

> The President or Secretary may make position statements on pertinent issues concerning the Academy only in the name of the Executive Committee and only after consultation with the Executive Committee. Any such statements will be reported at the next Annual Meeting so that the Academy as a whole may take suitable action. As an alternative, or in addition, the President may appoint an Ad Hoc Committee to study such issues and make recommendations to the membership for their action at the next Annual Meeting.

There being no additional new business, the first business meeting was adjourned by Dr. Templeton at 11:45 a.m.

SECOND BUSINESS MEETING

Dr. Templeton called the second business meeting to order at 1 p.m., April 8. The first order of business was the motion to approve the minutes of the 55th Annual Meeting. The minutes were approved as circulated.

President Templeton then introduced Dr. Dwight Moore, the first President of the reorganized Arkansas Academy in 1932. Dr. Moore reviewed the history of the Academy and introduced the following former presidents of the Academy who were present at the 56th Annual Meeting.

Dr. T.L. Smith (1939) - College of the Ozarks
Dr. L.B. Roberts (1943, 1944) - Arkansas A. & M. (now living in Montgomery, Ala.)
Dr. Jack Sears (1957) - Harding College
Dr. Carl Hoffman (1959) - University of Arkansas
Dr. Neal Buffaloe (1960) - State College of Arkansas
Dr. Herman Bogan (1961) - Arkansas State University (now at Univ. of Tenn.)
Dr. Lowell F. Bailey (1965) - University of Arkansas
Dr. James Fribourgh (1966) - University of Arkansas at Little Rock
Dr. Arthur Fry (1969) - University of Arkansas
Prof. M.L. Lawson (1970) - Harding College
Prof. Robert Kirkwood (1971) - State College of Arkansas

Dr. Templeton recognized Dr. Moore, Dr. Smith, Dr. Roberts, and Dr. Bogan and presented each with a University of Arkansas Centennial Medallion as a memento of the meeting.

Dr. Templeton then called for the reports of committees.

Nominations.
Dr. Fulton reported that the committee was nominating Dr. Clark McCarty as President-Elect, Dr. William L. Evans as Treasurer, and Dr. J.L. Wickliff as Editor. It was moved that nominations be closed and Dr. McCarty, Dr. Evans, and Dr. Wickliff were elected by acclamation.

Audit.
Dr. Wittlake reported that the books and records of the Treasurer had been examined by the committee and had been found to be in good order. The report of the Audit Committee was approved.

Resolutions.
Professor Kirkwood presented the following resolutions which were approved by the membership.

> Efforts of members of the Arkansas Congressional Delegation have resulted in the preservation of the Buffalo as a National River. Be it Resolved that the Arkansas Academy of Science commend these members of Congress for their efforts.
>
> The Arkansas Academy of Science was represented at hearings on the Buffalo River by Dr. Frances James, and members of the Academy express to her their gratitude for her efforts.
>
> The Arkansas Academy of Science expresses sincere gratitude to:
>
> 1. The University of Arkansas, for including us in its Centenniel Celebration, Dr. David Mullins, President, and all members of the University faculty and staff who helped prepare for our meeting.
> 2. President George Templeton for his efforts to make this year and this 56th session a success.
> 3. Dr. Lester Howick for the time and energy he has devoted as Editor of the Proceedings of the Arkansas Academy.
> 4. Dr. John P. Jones for his extended term as Treasurer.
> 5. Dr. Eugene Wittlake, Director of the Junior Science and Humanities Symposium; Professor E.E. Hudson, Director of the Junior Academy of Science; Dr. Noel Robotham and Dr. Joe Nix, sponsors of the Collegiate Academy of Science; and Dr. Leo Paulissen, Director of the Arkansas Science Talent Search, for their efforts with these organizations.

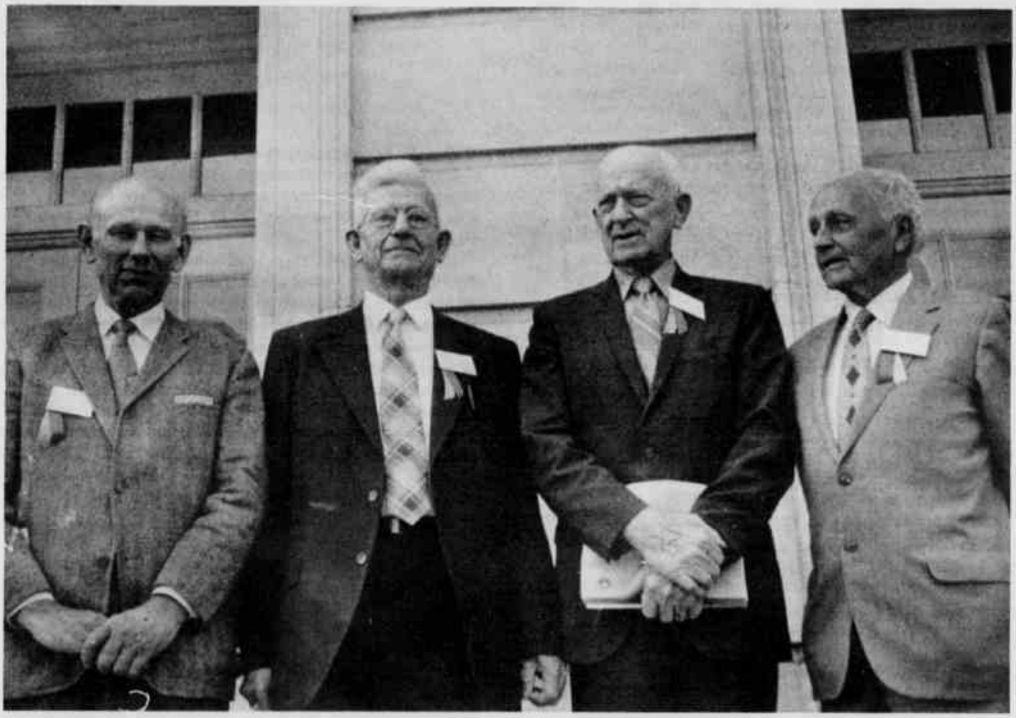
A.A.A.S. Fellows Committee.
Dr. Buffaloe announced that because of possible rules changes the committee was selecting five nominees this year. They are R.C. Anderson, W.C. Guest, John Keesee, and Leo Paulissen.

Dr. Templeton then introduced Dr. Eugene Wittlake, President-Elect, who appointed the following committee on nominations with instructions to consider possible nominations for Academy offices well ahead of the Annual Meeting: Dr. P.M. Johnston, chairman, Dr. Jewell Moore, and Professor M.L. Lawson. Dr. Wittlake also announced that the 57th Annual Meeting will be held at Arkansas State University on April 6-7, 1973.

There being no further business, Dr. Wittlake adjourned the 56th meeting of the Academy at 1:50 p.m.

Respectfully submitted,

William C. Guest, Secretary



Former presidents of the Arkansas Academy of Science in attendance at the 56th Annual Meeting of the Academy as a part of the Centennial Celebration of the University of Arkansas. From the left: H.L. Bogan (1961); L.B. Roberts (1943, 1944); T.L. Smith (1939); D.M. Moore (1932, 1933, 1964). These four distinguished gentlemen were presented with Centennial Medallions in recognition of their service to science and higher education. Collectively, these emeritus professors represent 167 years of professional service.

PROGRAM

Arkansas Academy of Science

Fifty-Sixth Annual Meeting
UNIVERSITY OF ARKANSAS
Fayetteville, Arkansas

Meeting concurrently with sessions of the:

Arkansas Science Teachers Association

Arkansas Council of Teachers of Mathematics

Society of Physics Students of the American Institute of Physics

American Chemical Society, Arkansas Sections

Arkansas Science and Technology Council

Friday, 7 April

SENIOR AND COLLEGIATE ACADEMIES -- Registration
SENIOR ACADEMY -- Executive Committee
COLLEGIATE ACADEMY -- Executive Committee
SENIOR ACADEMY -- Business Meeting
COLLEGIATE ACADEMY -- Business Meeting

JUNIOR ACADEMY -- Registration
JUNIOR ACADEMY -- Business Meeting
SENIOR ACADEMY -- Symposium: Interaction of Science, Industry, and Government
JUNIOR ACADEMY -- Science Talent Search
JUNIOR ACADEMY -- Papers
COLLEGIATE ACADEMY -- Symposium: Natural History of the Buffalo River
JUNIOR ACADEMY -- Banquet and Awards Presentation
SENIOR ACADEMY -- Roundtable Discussion: Technology Transfer in Arkansas
JUNIOR ACADEMY -- Astronomy Demonstration

Saturday, 8 April

ALL ACADEMIES AND PUBLIC - Moon Rock Display
NASA Space Mobile Demonstration
Space Shuttle Program
Lecture: The Power Crisis Is Fisssion the Answer?

SENIOR ACADEMY -- Papers
COLLEGIATE ACADEMY -- Papers
SENIOR ACADEMY -- Business Meeting
SENIOR ACADEMY -- Papers

Symposium: INTERACTION OF SCIENCE, INDUSTRY, AND GOVERNMENT

Presiding: John L. Imhoff, Head, Industrial Engineering Department, University of Arkansas, Fayetteville, Arkansas 72701

DEVELOPMENT OF CENTERS FOR REGIONAL PROGRESS
Karsten Vieg, Manager, Regional Resource Center, Midwest Research Institute, Kansas City, Kansas

SCIENCE AND CORPORATE PROFITS (LOSSES)
Barry Bebb, Director, Advanced Technology Laboratory, Texas Instruments Company, Dallas, Texas

MISSISSIPPI TEST FACILITY - INTERGOVERNMENTAL APPROACH TO ENVIRONMENTAL RESEARCH PROGRAMS
Gary North, Chief, EROS Program, United States Department of Interior, Bay St. Louis, Mississippi

THE STATE DEPARTMENT OF POLLUTION CONTROL AND ECOLOGY
Neil Woomer, Arkansas Department of Pollution Control and Ecology, Little Rock, Arkansas

DISCUSSION

Collegiate Academy of Science Symposium: NATURAL HISTORY OF THE BUFFALO RIVER

Presiding: Joe F. Nix, Department of Chemistry, Ouachita Baptist University, Arkadelphia, Arkansas 71923

AN INTRODUCTION TO THE BUFFALO RIVER COUNTRY
Dr. Neil Compton, President, Ozark Society

THE GEOLOGY
Joe M. Clark, Geologist, Arkansas Western Gas Company (retired)

THE PREHISTORY
Hester Davis, Arkansas Archeological Survey, University of Arkansas

THE VEGETATION
Edward E. Dale, Jr., Department of Botany and Bacteriology, University of Arkansas

SUMMATION AND DISCUSSION
Joe F. Nix, Department of Chemistry, Ouachita Baptist University

ARKANSAS SCIENCE AND TECHNOLOGY COUNCIL

Roundtable Discussion: TECHNOLOGY TRANSFER IN ARKANSAS

Chairman: Robbin C. Anderson, Dean, Arts and Sciences College, University of Arkansas, Fayetteville, Arkansas 72701

JAMES O. WEAR
Central Instruments Program
Veterans Administration Hospital
Little Rock, Arkansas

WILLIAM SHEPHERD
Vice President, Retired
Arkansas Power and Light Company
Little Rock, Arkansas

M. L. LAWSON
Chairman, Science Department
Harding College
Searcy, Arkansas

WILLIAM SOHL
Research Associate
Graduate School
University of Arkansas

JOHN REID
Vice President for Research
Baldwin Electronic Company
Little Rock, Arkansas

ROBERT KIRKWOOD
Professor of Biology
State College of Arkansas
Conway, Arkansas

ROGER CHAMBERLAIN
Plant Manager
Dow Chemical Company
Magnolia, Arkansas

GLEN ACHORN
Chief, Biological Laboratory
Pine Bluff Arsenal
Pine Bluff, Arkansas

JOHN OSOINACH
Department of Sociology
Arkansas State University
Jonesboro, Arkansas

HAROLD R. MUENZMAIER
General Manager, Reinforced Plastics Department
A. D. Smith Company
Little Rock, Arkansas

ARMAND DE LAURELL
Acting Director, Arkansas Department of Planning
Capitol Building
Little Rock, Arkansas

SECTION PROGRAMS

ANTHROPOLOGY SECTION
Chairman: Robert G. Chenhall

HENRY M. MILLER: A Floral Reconstruction of Early Historic Northwest Arkansas

SHELLY DAVIS: A Reconsideration of British Maglemose Technology - A Test of the function of "Harpoons"

ROBERT T. TAYLOR: Sayers - A Previously Undefined Caddoan Phase

DAVID J. WOLF: A Functional Analysis of the Artifact Assemblages from Three Union County, Illinois, Prehistoric Sites

MARY JO GRINSTEAD and SANDRA C. SCHOLTZ: Population Profiles via Factor Analysis - Study of a Rural Arkansas Community

ROBERT G. CHENHALL: Computerized Data Banks for Multi-Site Research

BIOLOGICAL SCIENCES SECTION I
Chairman: Richard L. Meyer

RENIE R. MALLORY: The Effects of Ammonium-Nitrogen, Nitrate-Nitrogen, and Ortho-Phosphate on Natural Algal Populations under Controlled Conditions

MARVIN W. HALDOR and JOHN K. BEADLES: A Study of Some Physico-Chemical Parameters and Phytoplankton Standing Crop in Four Northeast Arkansas Commercial Fish Ponds

STANLEY A WOLFRAM: Algal Population Studies via Substrate Pioneering

TOM N. PALKO: Zooplankton Population Variations in Lake Dardanelle and Several of its Tributaries as Affected by Introductions of Poultry Effluents - Preliminary Report

JERRY L. McGARY and GEORGE L. HARP: Distribution of Benthic Macroinvertebrate Fauna of a Cold Tailwater - Little Red River, Arkansas

TOM N. PALKO: Problems Encountered in Assessing Water Quality by Automated Methods

J. H. WHEELER and R. L. MEYER: The Applicability of Biochrome Analysis Technique to the Identification of Phytoplankton Populations

GEORGE L. HARP and RONALD HUBBARD: The Limnology of Bauxite Open Pits

PEGGY R. DORRIS: A Checklist of Spiders Collected in Mississippi Compared with a Preliminary Study of Arkansas Spiders

E. PHIL ROUSE and L. N. MEDVEDEV: Common Chrysomelidae in Arkansas

CHARLES LINCOLN, JACOB R. PHILLIPS, W. P. BOYER, and FLOYD D. MINER: Insect Pest Management for Cotton and Soybeans

T. R. C. ROKEBY, G. S. NELSON, and G. C. HARRIS, JR.: JR.: Bioclimatic Chambers for Research with Poultry

BIOLOGICAL SCIENCES SECTION II
Chairman: P. M. Johnston

DOUGLAS W. CURRAN: Survival of Placental Implants in Non-Pregnant Animals

LELAND F. MORGANS: Histological Study of the Liver of the Channel Catfish *Ictalurus punctatus*

DALE V. FERGUSON: Molecular Specificity Associated with Alleviation of Actinomycin D Inhibition of Protein Synthesis

TERRY W. SCHULTZ: Functional Morphology of the Oral Appendages and Foregut of *Lirceus garmani* (Crustacea: Isopoda)

CHRISTINA W. CHAN and DAVID A. BECKER: *Trypanosoma lewisi* Kent (Protozoa: Mastigophora) Ultrastructure and Theory of Locomotion

JUDITH D. CUNDALL: A Comparison of Plasma Protein Patterns of Four Species of Watersnakes (Genus *Natrix*)

EUGENE B. WITTLAKE: A Taxonomic Note on the Fossil *Glyptostrobus* Occuring in Northeastern Arkansas

FRANK H. TAINTER: Aquatic Fungi in the Classroom

HUGH A. JOHNSON: The Occurrence of Camelia Petal Blight in Southern Arkansas

DOUGLAS JAMES: Failure to Establish Feral *Coturnix* Quail Populations in Arkansas in the Late 1950's

GARY A. HEIDT: Anatomical and Behavioral Aspects of Killing and Feeding by the Least Weasel, *Mustela nivalis* L.

CHEMISTRY SECTION I
Chairman: T. D. Roberts

JERRY F. CASTEEL and EDWARD S. AMIS: Specific Conductance of Highly Concentrated Magnesium Salts in Mixed Solvents

SISTER MARY CARL MALMSTRON and A. W. CORDES: Crystal and Molecular Structure of Two Phenothiazines

KAY FAIR and A. W. CORDES: Crystal and Molecular Structure of Tetra-Substituted Tungsten (VI) Chlorides

KARAN PASHMAN and D. A. JOHNSON: Photochemical Linkage Isomerization

N. CHAN and D. A. JOHNSON: Crystal and Molecular Structure of Platinum (II) Imidazole Complexes

L. B. HANDY and C. C. HENDERSON: Reactions of Tungsten (VI) Chloromethoxides with Strong Bases

N. R. OSTLUND: A New Approach to Frequency-Dependent Perturbation Theory

JAMES O. WEAR: Silver in Dog Spinal Fluid by Activation Analysis

CHEMISTRY SECTION II
Chairman: W. L. Cairns

SAM MERSHON and J. A. THOMA: Computer Modeling of Enzymes

J. A. THOMA, G. V. K. RAO, J. ALLEN, A. JENNINGS, A. BOWANKO, and C. J. CROOK: Formation of Stable Cellodextrin-Lipoenzyme Complexes

W. L. MEYER and R. B. LEWIS: Amino Acid Sequence of Tentoxin

MITSUO OKA and ARTHUR FRY: The Acid-Catalyzed Rearrangement of 2,4-Dimethyl-3-Pentanone-3-^{14}C

M. FOREMAN and S. SIEGEL: The Reduction of Dienes by Diimide; Structure and Reactivity

R.E. LEA and R.P. QUIRK: Sodium Borohydride Reduction of 5-Hexenylmercuric Bromide

RALPH HOWARD: A Simple and Inexpensive Technique for Producing High Quality Line Drawings of Conformationally Complex Molecules

GEOLOGY SECTION

Chairman: Ronald H. Konig

BRADFORD HANSON: Fracture Patterns of Northwest Arkansas as Determined from Small Scale Aerial Photography

REINHARD FROLICH: Geoelectrical Possibilities of Detecting Stream Channels in Carbonate Rock

CHARLES STONE and BOYD HALEY: Late Paleozoic Stratigraphy in the Ouachita Mountains of Arkansas

RICHARD L. WILSON: Palynology of the Wills Point Formation of Southern Arkansas

JOHN GLENN: Stratigraphy and Sedimentary Structures of a Middle Bloyd Fluvial Sandstone

DOY L. ZACHRY: Morphology and Sedimentary Structures of an Early Pennsylvanian Beach Sandstone

E. CHARLOTTE GLENN: Conodont Biostratigraphy of Early Pennsylvanian Rocks of Northwest Arkansas

CHARLES STONE and BOYD HALEY: Windows and Klippen in the Core Area of the Ouachita Mountains of Arkansas

ALVIN A. CHINN and RONALD H. KONIG: Dynamic Interpretation of Calcite Twin Lamellae in Limestone of Northwest Arkansas

MATHEMATICS SECTION

Chairman: William Orton

CARL C. STEYER: Sunspot Analysis and Prediction

ROBERT P. SMITH: Hypotheses Testing for Continuous Time Parameter Gaussian Processes

ROY J. FULLER: Non-Abelian Gaussian Sums

R. B. HORA: Translations of a Semigroup Which is the Disjoint Union of Commutative Semigroups

W. FELDMAN: Order and Convergence Spaces

J. PORTER: The Krein-Milman Theorem in Convergence Spaces

WILLIAM D. HAMMERS: A Look at the Reisz-Markov Theorem

W. H. SUMMERS: The Weighted Approximation Problem

PHYSICS SECTION I

Chairman: Steve M. Day

W. F. WEI: Magnetoresistance in Single Crystal Cadmium Selenide

ROCKY WRIGHT and MIKE CHENG: Some Dielectric Measurements in Aluminum Potassium Alum

DAN SHELOR: An Experimental Apparatus for the Study of the Scott Effect

JOHN C. VLACHOYANNIS: A Helium Cooled Radio Frequency Pre-Amplifier for Use in Super-Conducting Accelerometer

S. J. MORRIS: A Foreigner Investigates

CHARLES POSEY: An Electrostatic Motor Designed to Run from the Earth Electric Field

PHYSICS SECTION II

Chairman: Paul Sherrah

RANDY SULLIVAN: Astronomy at Southeastern State College

HERBERT C. SCHADE: Construction of a Low Cost Planetarium

LARRY HUGGINS: Construction and Operation of a Radio Telescope

DAVID WOLFE: Computerized Map of the Radio Sky at 220 MHZ

Arkansas Collegiate Academy of Science

Neal Sumerlin President	Ramona Rice Secretary	Brian Smith Treasurer	Ronnie Sexton President-elect

MINUTES

The April 8 meeting of the Collegiate Academy of Science, Neal Sumerlin presiding, was called to order. Minutes of the last meeting were read by the secretary and a motion was made and passed to accept the minutes as read.

A new constitution for the Collegiate Academy was presented for discussion and possible adoption. The motion was made and passed to change the constitution to read that the representatives from each school should be elected by that school rather than appointed by the president of the Collegiate Academy.

A discussion of the relevancy of the office of President-Elect ended in the motion that the status of the President-Elect remain as stated in the proposed constitution. The motion passed.

A motion was made to adopt the new constitution as amended in the business meeting. The motion passed.

New officers elected are:

Eddie Reed, President-Elect, Philander Smith College; Kathy King, Secretary, College of the Ozarks; and John Gillean, Treasurer, Hendrix College.

Mrs. Johnson of Philander Smith College was elected to a two-year term as sponsor. Dr. Noel Robotham will be serving his second year as sponsor of the Collegiate Academy in 1972-73.

After the introduction of the new president, Mr. Ronnie Sexton, College of the Ozarks, the meeting was adjourned.

Respectfully submitted,
Ramona Rice, Secretary

FINANCIAL REPORT

Previous balance	$87.89
Credits	$16.00
Expenditures	
Annual Meeting	$76.14
Treasury expenses	3.81
Total Expenditures	79.95
Balance 1 June 1972	$23.94

ABSTRACTS OF PAPERS

HERMAN WENZLER (University of Arkansas, Fayetteville, Arkansas): Determination of Gibberellins in Plant Materials

Several bioassays have been used for determining gibberellins in plant materials. One of the most common is the barley endosperm bioassay based on sugar production. Reducing sugars are measured by use of neocuproine as the color reagent and glycine as the copper chelating agent. In other bioassays the ability of gibberellin (GA_3) to overcome dwarfness in some plants has been exploited.

Three bioassays were compared to determine which was the most sensitive to low concentrations of GA_3. The relative ease and length of time required for each test were evaluated also. The barley endosperm bioassay was the most sensitive for GA_3. Dwarf corn and rice bioassays, though less sensitive, were were useful because asepsis was not required.

(Research supported by NFS Undergraduate Research Participation Program grant no. GY-8918.)

ROBERT TAYLOR AND DAVID MAGOUYRK (Arkansas College, Batesville, Arkansas): Auxospore Production by *Melosira varians*

Melosira varians, a fresh-water colonial centric diatom, was found to be the dominant plant form growing on a concrete dam of a natural spring near Batesville, Arkansas. Auxospores were observed in the natural condition during the month of January. It was found that the rate of auxospore production could be increased significantly by raising the sodium chloride content of the water in which the diatom was incubated. *Melosira varians* was gradually replaced as the dominant flora of the dam with the advent of warmer weather, and auxospore production ceased under natural conditions. At present it appears that auxospore production can be induced in the laboratory by incubating the diatom near 4C with proper sodium chloride concentration.

LYNN REYNOLDS (College of the Ozarks, Clarksville, Arkansas): Wild Flowers of Lost Valley

A photographic documentation of the flora of Lost Valley has been made. Such documentation is necessary because many of the wild flowers of the area are being destroyed by the increasing number of visitors to this state park.

ROBERT B. WHITE (Hendrix College, Conway, Arkansas): Purification and Study of the Alkaline Phosphatase of *E. coli*

The alkaline phosphatase of *Escherichia coli* is a non-specific phosphomonoesterase which possesses phosphotransferase activity. It is a stable zinc metalloprotein (MW = 86,000) consisting of two identical subunits. The enzyme is of interest as a model for other phosphatases of wide occurrence which are studied clinically in relation to several diseases, including some cancers.

Escherichia coli cells were grown in a phosphate-deficient medium, harvested by centrifugation, then disrupted by sonication. The soluble enzyme was purified by double-pass, ion-exchange chromatography on DEAE-cellulose. These methods resulted in a 900-fold increase in specific activity from that of the original culture and a 17-fold increase from that of the crude extract, although total yield (13.5%) was low. Attempts to crystallize the enzyme have been unsuccessful.

KURT DOEGE (University of Arkansas, Fayetteville, Arkansas): Some Investigations on the Effects of Red Light on the Nucleic Acid Concentrations of Etiolated Corn Seedling Mesocotyls

This research had two objectives: first, to develop satisfactory procedures for extraction and assay of RNA and DNA from corn mesocotyl tissues; and second, to apply these techniques in investigation of nucleic acid levels in red-light-inhibited corn seedlings and in dark-grown seedlings, both DNA and RNA contents of the red-light-treated seedlings were lower, although DNA levels in the red-light-treated seedlings may have undergone a transient increase. Attempts were made to correlate these differences in nucleic acid levels with the observed red light inhibition of the mesocotyl growth.

(Research supported by NSF Undergraduate Research Participation Program grant no. GY-8918.)

MARILYN MARTIN (Hendrix College, Conway, Arkansas): On the Induced Function Theorem

The following theorem by A.R. Bednarek and A.D. Wallace is proved. Induced Function Theorem: Let X and Y be sets. Let R be a relation from X into Y, let E and F be equivalences on X and Y respectively, and let ψ and ϕ denote the respective natural maps. If $X=RY$ and if $R^{-1}{}_{0}E_{0}RCF$, then there exists an unique function h: $X/E \rightarrow Y/F$ such that $h\psi p=\phi q$ where p and q are the projections of R to X and Y respectively. Moreover, in addition to the foregoing hypotheses if $Y=XR$ and $R_0 F_0 R^{-1}CE$, then h is an isomorphism.

Sierpinski's Lemma: Let X, Y and Z be sets. Let F: $X\rightarrow Y$ and g: $X\rightarrow Z$ be functions with f onto, and let $f(x) = f(x')$ imply $g(x) = g(x')$ for all $x, x' \in X$. Then there is an unique function $h{:}Y\rightarrow Z$ satisfying $g = hf$. This lemma and the Induced Function Theorem are shown to be equivalent and the first isomorphism theorem, second isomorphism theorem, and third isomorphism theorem for groups are shown to be corollaries to the Induced Function Theorem.

DAVID GOGGANS (Hendrix College, Conway, Arkansas): Properties of the Ring of Continuous Functions on the Unit Interval

Let I be the unit interval and R be the ring of continuous functions on I. It is shown that R has proper zero division and contains subrings that are not ideals and ideals that are not maximal. It is proved that R is neither Artinian nor Noetherian. For any C in I, define $M_C = [f \in R{:}f(c) = 0]$. It is proved for any maximal ideal M, there exists a c in I such that $M = M_C$.

KEITH WAYLAND (Harding College, Searcy, Arkansas): Another Look at the Countability of the Rationals

Let N denote the set of positive integers and X denote the set $[u10^{+n} + v10^{n}\ \ u, v, n \in N,\ (u,v) = 1,\ 10^{n-1} \leq v < 10^{n}.\ ]$, where (u,v) is the g.c.d. of u and v. Theorem 1: Each element of X has an unique representation in terms of u, v, and n. Theorem 2: There exists an onto mapping from X to the set of positive rational numbers. The countability of the rationals follows immediately from these two theorems.

The Moon, Then and Now

KIRTLEY F. MATHER

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FOREWORD

Dr. Mather wrote this article on the state of moon research in honor of the University of Arkansas Centennial Celebration and the special exhibition of lunar material at the University Museum in connection with the 1972 meeting of the Arkansas Academy of Science at Fayetteville. The paper was written at the express request of Dr. Samuel C. Dellinger, Emeritus Professor of Zoology and former curator of the Museum at the University of Arkansas. Dr. Mather taught geology at the University of Arkansas from 1911 to 1914, and later was professor of geology at Harvard University for nearly 30 years. He was awarded his Ph.D from the University of Chicago, was associated with the U.S. Geological Survey for nearly 35 years, and has received a number of honorary degrees. He has been a member and officer of numerous professional organizations, and is a past president of the American Association for the Advancement of Science. Dr. Mather is a prolific author, having produced many technical and popular works in the fields of geology, physiography, and education over the past half century.

The moon has changed scarcely at all since the University of Arkansas was founded in 1871, but our knowledge about it has increased by several orders of magnitude, most spectacularly as a result of the "moon walks" performed by Apollo astronauts since 20 July 1969. Anyone interested in selenology -- the geology of the moon -- cannot but be thrilled by even the most casual inspection of the samples of the moon's surface materials that they brought back to earth.

This is not to say, however, that not much was known about the moon a hundred years ago. Using his home-made telescope, Galileo (1564-1642) had published sketches of the moon's surface in 1609 showing several of its largest craters, mountain ranges, and irregularly circular plains. Those plains were designated as "maria" by Riccioli (1598-1671) in his notable "book about the moon," published in 1651. In it he named a large number of the craters for famous scientists and philosophers, and gave highly imaginative names to many of the maria. The majority of Riccioli's names are still used today and some of them are now familiar to millions of people as a result of coverage of the exploits of the Apollo crews by the news media; for example, Mare Tranquillitatis (the Sea of Tranquillity), Mare Imbrium (the Imbrium Basin), and the craters named Copernicus and Archimedes.

Likewise, the 16th to 18th century astronomers had computed with increasing accuracy the size, mass, and average specific gravity of the moon and its tidal effects on the earth as it revolved around our planet. The years since 1871 have witnessed only somewhat greater precision of measurements concerning those bits of information. On the other hand, completely new instruments and techniques for observation of such a remote object have been invented during those years and especially during the last 10 or 15 of them. Combining these inventions with the new physics and chemistry of "the atomic age" and the techniques of space transportation developed in the even newer "space age," modern science and technology have given us an amazing amount of information about the moon.

The colossal task of analyzing, correlating, and interpreting the vast store of factual data now available is proceeding in hundreds of scientific laboratories around the world, but it has by no means been completed. Some important questions about the moon and its history still remain unanswered. Even so, the wild, free-wheeling speculations, rampant a century or more ago, are now replaced by a few carefully restricted working hypotheses, and a number of significant generalizations may be stated with great confidence.

The moon is composed of rocks and minerals nearly the same as rocks and minerals found here on earth. It came into existence approximately 4.6 billion years ago, at the same time as the earth. Most selenologists consider that it was formed by accretion of planetesimals orbiting the growing earth and others orbiting the sun. During the first 1.5 billion years of its history, its thermal processes and internal activity were probably quite similar to those of the juvenile earth. Since then, unlike the earth, it apparently has been a slowly cooling body lacking any significant deep-seated internal activity. Furthermore, because of its small size, the moon has never had sufficient gravitational force to retain an atmosphere and hydrosphere that could engender processes of erosion and sedimentation like those that have played an important role in the evolution of the earth.

Evidence from three seismometers (instruments that measure moonquakes in the same way as earthquakes) left on the moon's surface by Apollo astronauts indicates that the moon has a layered crust approximately 65 km (about 40 mi) thick, and there is some suggestion from the remanent paleomagnetism detected in "moon rocks" that the moon has an iron core which was molten during its infancy. If so, that core cannot have a radius greater than 0.2 the radius of the moon and it is therefore relatively much smaller than the earth's core. However, there is nothing to indicate that the internal structure of the moon comprises a convective mantle resembling dynamically that portion of the earth between its core and crust.

Samples of the moon's surface materials from five rather widely scattered sites now have been studied directly here on earth. The specimens from one of the five localities were scooped up and retrieved by the unmanned USSR Luna 16 spacecraft; the others were collected by the crews of Apollo 11, 12, 14, and 15. The petrologists report that the specimens they have studied represent three major types of rock and fragments derived from them. The oldest are rather coarsely crystallized igneous rocks, such as anorthosite, composed largely of plagioclase feldspar, that were formed by comparatively slow crystallization from fairly large bodies of molten magma about 4 billion years ago. They are characteristic of the moon's highlands and include David Scott's "genesis rock" (identified

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by Scott as anorthosite while he was on the moon during the Apollo 15 mission; the designation "genesis rock" was promptly coined by a reporter in Houston and has since been widely used). They come as close to representing the components of the original lunar surface as we are likely to get. Intermediate in age is a basaltic type of fine-grained igneous rock, notably rich in potassium (symbol K), rare earth elements (symbol REE), and phosphorus (symbol P), and hence called "KREEP basalt." Many fragments of this kind of basalt were scattered around by the impact of incoming meteorites, most of which were much smaller than the huge projectile responsible for forming the Imbrium Basin, just beyond the rim of which Apollo 15 landed. The third major type of rock consists of basalts much more similar to those at many places on the earth's surface; they are sometimes referred to as "normal basalts" in contrast to the older "KREEP basalts." All of the rocks thus far dated by radioactive methods are between 3.1 and 3.7 billion years old. They occur characteristically as lava flows that flooded pre-existing basins -- most, if not all of which were formed by impacting meteorites -- to produce the existing maria.

Fragments of these ancient rocks were scattered by the explosive impact of meteorites bombarding the face of the moon during the last 3 billion years, in general in decreasing numbers as the millenia went by. In some places their distribution is in a pattern of rays, radiating from craters like Copernicus. In many places where they accumulated to a considerable thickness, the fragments form breccias, solidified by compaction under the weight of the overburden or by cementation by shock-melted glass. Some of the loose fragments in the rock collections are glazed on one or more sides by such glass. This material is particularly abundant in the "fines" of the lunar samples.

In general the relative age of the craters that pockmark the moon's surface can be inferred from the extent of rounding or softening of their originally sharp peripheral rims. Rocks are fractured and shattered by expansion and contraction due to the great changes in surface temperature between the excessive heat of the long days and the deep freeze of the long nights (each equal in length to 14 earth days). Gravity pulls the loosened particles down slope, even though its force on the moon is about one-fifth of its force at the surface of the earth. Lunar talus slopes and cones are similar to analogous landforms on earth. The impact of micrometeorites may move dust particles from place to place in much the same way as they are moved about by terrestrial breezes. Almost everywhere the solid rock of the lunar crust is veneered with lunar "soil" -- better designated as regolith -- from a few centimeters to many meters thick. Fortunately the loose particles of the lunar regolith are compacted rapidly under their own weight so that "moon walkers" and their vehicles leave footprints and tracks but do not sink far into the regolith.

The overwhelming majority of the lunar craters were formed by impact of meteorites or planetesimals; they are definitely not of volcanic origin. In fact, outpouring of lava and other kinds of volcanic activity seem to have ceased, for all practical purposes, some 3 billion years ago. Even so, there is still a slight possibility that some volcanic cones and/or craters may yet be identified as exploration of the moon continues, and that recent or even currently active volcanism may be detected somewhere on its surface. The report from the Soviet Union that an emission of gas from the crater Alphonsus was observed in 1958 should not be totally discarded as an aberration of instruments or men, even though that observation has never been confirmed or repeated elsewhere.

The age-old question as to whether there is life on the moon, even though it might be some kind of living creature wholly different from any known on earth, has now been answered quite definitely in the negative. According to N.W. Hinners (1971, p. 448): "...no life forms have been found, nor have organic molecules been unambiguously identified as being indigenous to the moon. The virtually complete lack of water and the four-plus billion years of exposure to a harsh space environment make eventual detection of lunar life unlikely."

ACKNOWLEDGMENTS

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Taxonomic Note on Fossil *Glyptostrobus* in Northeastern Arkansas

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ABSTRACT

Two papers by Brown (1936, 1962) are reviewed and discussed in relation to the validity of specific names applied to the fossil *Glyptostrobus* as found in North American deposits. Evidence is presented supporting the contention that *G. nordenskioldi* Brown n. comb. is the valid name for *Glyptostrobus* specimens from the Hooker site of northeastern Arkansas.

Numerous specimens of a fossil *Glyptostrobus* have been described from the Hooker site and designated as *G. europaeus* (Brongn.) Heer (Wittlake, 1970). As the study of these specimens proceeds, more and more characteristics are found of androstrobili, gynostrobili, cone-scales, and seeds which vary considerably from those of *G. pensilis* Koch, the living species, and *G. europaeus*. *G. europaeus* is the species assigned by several authors to remains found in Eocene formations of North America.

Two papers by Brown (1936, 1962) regarding the validity of specific names applied to the genus *Glyptostrobus* in North America have come to the attention of the author. In his earlier work, Brown (1936) assigned the name *G. dakotensis* to androstrobili and foliage of Eocene specimens found near Elbowoods, North Dakota, and suggested that all American Eocene species of this genus should be included in this taxon. He based this recommendation on the following characteristics: "1. the cone-scales are, on the average shorter and broader, 2. The cone-scales occur scattered and detached, a characteristic apparently not shown by *G. europaeus* or the present day *G. pensilis*, whose cones remain intact and do not disintegrate readily after ripening, 3. The species occur in the lower part of the American Eocene, a considerable time interval from the typical *G. europaeus* of the European Miocene."

In his 1962 work, Brown stated that Heer (1871) assigned seeds and perhaps some cone-scales possessing the characteristics cited in his 1936 work under *G. dakotensis* and associated with *Glyptostrobus* foliage (called at the time *Sequoia nordenskioldi*) to a Taxodium species from Spetzenbergen. He placed in synonomy *G. dakotensis* under *G. nordenskioldi* (Heer) Brown. This taxon includes then *Glyptostrobus* remains found in Paleocene and Eocene localities of North America.

The Hooker deposit specimens of cone-scales are shorter and broader than those of other species. The cone-scales and microsporophylls are numerous and scattered through the clay-shale of this site, indicating a rapid and general disintegration of both male and female cones. The deposit itself is of Early Eocene age. Therefore, the *Glyptostrobus* from Hooker agrees with all characteristics for *G. dakotensis* outlined by Brown (1936). He suggested that *G. oregonensis* Brown should be applied to *Glyptostrobus* remains in the American Miocene.

In conclusion, the positive identification of *Glyptostrobus* twigs from any fossil site not associated with seeds or gynostrobili is a very tenuous exercise. Because numerous seeds, gynostrobili, and androstrobili are associated with cupressoid, cryptomeriod, and taxodioid foliage at the Hooker locality, there is no problem as to the generic identity of these specimens. Further, with the variations noted, there is no problem for their proper specific disposition. Henceforth, *G. europaeus* as reported by Wittlake (1970) from the Upper Wilcox Formation, Lower Eocene of northeastern Arkansas, will be designated as *G. nordenskioldi* (Heer) Brown.

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Trypanosoma lewisi Kent (Protozoa: Mastigophora): Ultrastructure and Theory of Locomotion

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ABSTRACT

Trypanosoma lewisi Kent is a nonpathogenic hemoflagellate of rats (*Rattus* spp.). After briefly reviewing its ultrastructure, the writers postulate that inside the flagellum the change in shape of kinetosomal plate 1 may cause one of the central microtubules and the helical-like structure to contribute to flagellar movement. The energy to run this system may be transferred from the kinetoplast with its associated mitochondrion.

INTRODUCTION

Trypanosoma lewisi Kent is a nonpathogenic hemoflagellate of the black rat, Norway rat, and other *Rattus* spp. It is transmitted in nature by the rat flea, *Nosopsyllus fasciatus* (Bosc, 1801) Jordan, 1933.

The purpose of this study is to confirm the findings of a similar investigation by Anderson and Ellis (1965) and to contribute further to their postulation concerning the mechanism of flagellar movement.

MATERIALS AND METHODS

White rats (*Rattus* sp.) about 1-2 months old were injected intraperitoneally with *Trypanosoma lewisi* (Wotton and Becker, 1963).

The trypanosomes freed from contaminating host tissue cells were pelleted by the method of Lincicome and Watkins (1963). The pellet of trypanosomes was fixed in 6.25% glutaraldehyde in 0.2 M cacodylate-buffer at pH 7.2-7.4 for 2 hr at 0-4C. The pellet then was washed with the same buffer three times for 10-20 min each time. Before osmication, the pellet was teased apart to make 1-mm^3 blocks. Osmication was carried out for 2 hr at 0C in a 1% solution of veronal-buffered osmium tetroxide at pH 7.4 (Palade, 1952).

The blocks were dehydrated through a graded series of ethanol, treated in two changes of propylene oxide for 1 hr each, and embedded in Epon 812 (Pease, 1964). The blocks were sectioned with an LKB Ultrotome at 600-800 Å. Sections were double stained in 2% aqueous uranyl acetate for 2 hr (Watson, 1958) and lead citrate for 10-20 min (Reynolds, 1963) before examination with a Siemens Elmiskop 1A.

RESULTS AND DISCUSSION

The cell membrane is typically trilaminar with longitudinal subpellicular microtubules running parallel beneath it (Figs. 1, 2). The cell membrane invaginates near the posterior end of the organism to form two flagellar pockets, and the area where the flagellar membrane and the cell membrane meet is the attachment zone (Figs. 1, 2.). The attachment zone may have the same morphological characteristics as the desmosome in vertebrate epithelial cells (Anderson and Ellis, 1965).

The flagellum consists of nine peripheral and two central longitudinal microtubules, the typical 9 + 2 pattern (Fig. 2). One of the central microtubules, along with a helical-like structure, arises form kinetosomal plate 1 and traverses the length of the flagellum (Fig. 1); the other central microtubule originates at the disc-like kinetosomal plate 2, passes through kinetosomal plate 1, and parallels the other central microtubule (Fig. 1) as described by Anderson and Ellis (1965). The nine paired peripheral microtubules are embedded in the cytoplasm forming the primary kinetosome. Each of these nine peripheral microtubules consists of two subunits; subtubule A has an arm-like structure; subtubule B is without this structure but may contain a lateral arm which bisects subtubule B forming a doublet pattern (Fig. 2), thus confirming the original observations of Anderson and Ellis (1965).

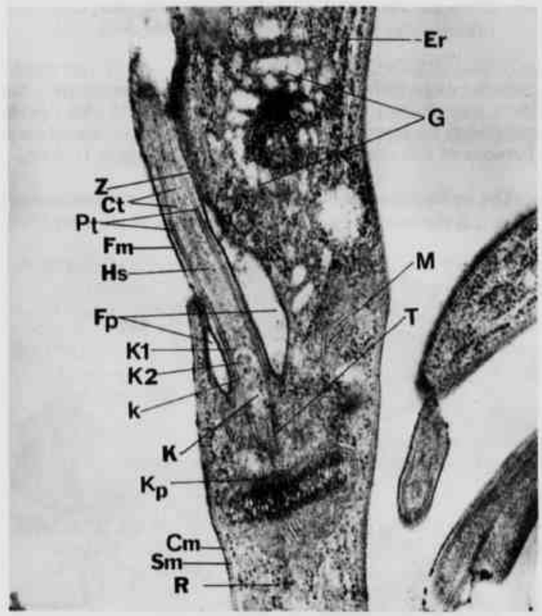

Figure 1. **Longitudinal section through posterior of organism.** Cell membrane (Cm), central microtubules (Ct), endoplasmic reticulum (Er), flagellar membrane (Fm), flagellar pocket (Fp), Golgi complex (G), helical-like structure (Hs), primary kinetosome (K), secondary kinetosome (k), curved kinetosomal plate 1 (K1), kinetosomal plate 2 (K2), kinetoplast (Kp), mitochondrion (M), peripheral microtubules (Pt), ribosome (R), Subpellicular microtubules (Sm), triplet microtubule (T), and attachment zone (Z). 18,000x.

According to Anderson and Ellis (1965), the proximal end of the primary kinetosome consists of nine peripheral triplet

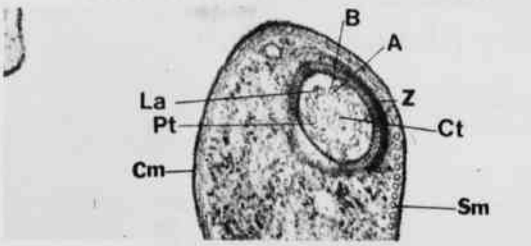

Figure 2. Oblique section through attachment zone (Z). Subtubule A (A) with arm-like structure, subtubule B (B), cell membrane (Cm), two central microtubules (Ct), lateral arms (La) in some peripheral microtubules (Pt), and subpellicular microtubules (Sm). 30,000x.

microtubules which surround a dense central core, whereas the distal end of the primary kinetosome consists of nine double peripheral microtubules surrounding a less dense central core. Portions of this ultrastructure are shown in Figure 1.

The region between the primary kinetosome and kinetosomal plate 2 is the secondary kinetosome (Fig. 1).

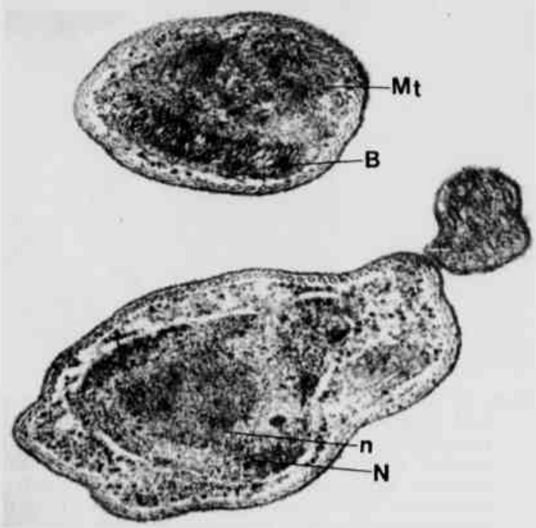

Figure 3. Cross section through kinetoplast showing tubular structure of electron dense band (B) and less dense matrix (Mt). The other cross section shows the nucleus (N) and the nucleolus (n). 30,000x.

Posterior to the primary kinetosome is the disc-like kinetoplast which is surrounded by a double membrane (Figs. 1, 3). The dense band inside the kinetoplast presents a tubular appearance and is thought by many investigators to contain DNA (Figs. 1, 3). Mitochondrial extension of the kinetoplast is demonstrated in Figure 4, and there is no membrane or other structure separating the mitochondrial matrix from the interior of the kinetoplast. Steinert (1960) suggested that the kinetoplast functions in the ontogenesis of mitochondria. The presence in the kinetoplast of DNA, generally considered to store and transmit genetic information, makes its intimate

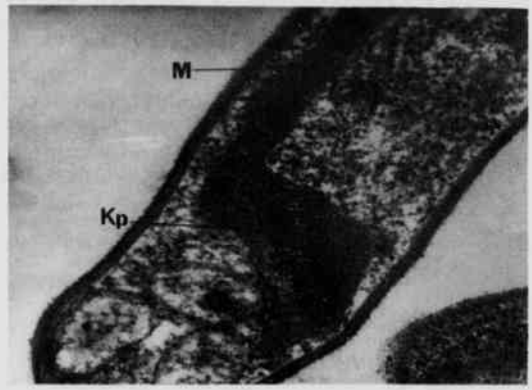

Figure 4. Longitudinal section through posterior of organism. Kinetoplast (Kp) and its mitochondrial extension (M). 20,000x.

association with mitochondria of considerable physiological significance (Steinert, 1960). The kinetoplast therefore could possess the ability of independent reproduction, and its division ordinarily precedes that of the nucleus as suggested by others (Hoare, 1954; Meyer et al., 1958).

The atypical Golgi complex is near the flagellar pocket, and commonly is associated closely with the well developed rough endoplasmic reticulum (Fig. 1). Free ribosomes can be seen in the cytoplasm, and are especially numerous near the kinetoplast (Fig. 1).

Dense bodies, which are near the flagellar pocket, are shown in Figure 5. Anderson and Ellis (1965) indicated that the dense bodies are structurally similar to hemosiderin and other blood degradation pigments, although their enzymatic activity is not yet clear.

Droplet-like structures lie near the posterior of the organism (Fig. 5). They may be the dense cell products, but apparently are not enveloped by a single membrane as described by Anderson and Ellis (1965), and may be lipid globules. Dense cell products are thought by many investigators to be volutin granules.

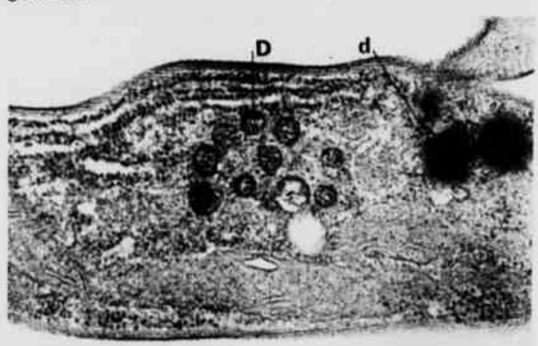

Figure 5. Longitudinal section through posterior of organism. Dense body (D) and possible dense cell product (d). 22,000x.

The nucleus, bounded by a typical double membrane and containing a prominent nucleolus, is near the middle of the organism (Fig. 3). The presence of two nuclei may be indicative of occasional binucleate forms, but probably indicates approaching binary fission.

These morphological investigations led to the postulation of the mechanism of flagellar movement. If the curved appearance of kinetosomal plate 1 is not the result of fixation, and one of the central microtubules is attached to kinetosomal plate 1, the differences observed in the shape of kinetosomal plate 1 may be associated with flagellar movement. If the distal ends of the central microtubules are embedded in a firm matrix or attached to the flagellar membrane at the distal end of the flagellum, then the diaphragm-like kinetosomal plate 1 may change from the curved to the flattened position and vice versa, causing the flagellum to move. Anderson and Ellis (1965) suggested that the helical-like structure associated with the central microtubules may play a role in the movement of the flagellum. If the helical-like structure is attached to kinetosomal plate 1, then the change in shape of the plate may cause the helical-like structure to contribute to flagellar movement. The energy for changing the shape of kinetosomal plate 1 may be transferred from the kinetoplast with its associated mitochondrion. Judge and Anderson (1964) and Anderson and Ellis (1965) suggested that since there is no structural continuity between the kinetosome and kinetoplast, the energy-containing material used in flagellar movement may be a humoral substance which may be diffusible through the double membrane of the kinetoplast. Thus the mechanism of flagellar movement is still under discussion.

ACKNOWLEDGMENTS

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Some Physicochemical Parameters and Phytoplankton Standing Crop in Four Northeast Arkansas Commercial Fish Ponds

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ABSTRACT

Physicochemical conditions and chlorophyll *a* standing crop were studied from July 1970 through June 1971 in four commercial catfish ponds at the Arkansas State University Experiment Farm near Walcott, Greene County, Arkansas. Determinations of dissolved oxygen, free carbon dioxide, total alkalinity, temperature, pH, transparency, and chlorophyll *a* standing crop were made at two-week intervals except during fish harvesting operations. One diurnal measurement of dissolved oxygen, free carbon dioxide, and temperature was conducted 25-26 June 1971. Increased oxygen concentrations coincided with increased chlorophyll *a* concentrations. Free carbon dioxide and chlorophyll *a* values varied inversely throughout the study. Diurnal concentrations of free carbon dioxide were greatest between 0300 and 0700 hours. Phenolphthalein and total alkalinity values fluctuated throughout the study period, and could not be correlated with other parameters measured. Thermal stratification occurred during the summer and was more pronounced in the more turbid ponds. Diurnal temperature measurements indicated that stratification was diurnal. An inverse relationship was found between carbon dioxide and hydrogen-ion concentrations, and all ponds were essentially alkaline. Transparency was relatively constant before the ponds were drained but increased when the ponds were refilled. Suspended particulate matter contributed significantly to turbidity. Peaks of chlorophyll *a* concentration were found in summer, early autumn, and late winter.

INTRODUCTION

Farm ponds are becoming increasingly important as inland fisheries. Because water is the medium of fish, knowledge of its natural properties is of utmost significance to the fish culturist. Such factors as light, turbidity, depth, pH, dissolved minerals, concentration of respiratory gases, and phytoplankton abundance determine the quality of water and thereby affect its productivity (Odum, 1959). Studies of productivity and related physicochemical conditions of farm ponds are few and widely scattered. Butler (1964) reported that the interactions of turbidity, dissolved solids, temperature, and surface light intensity influence productivity. Swingle (1966) reported that an increase in primary productivity is influenced by inorganic fertilizers and that an increase in fish production results. Excessive use of inorganic fertilizers increases productivity in the upper layers of water where light conditions are favorable, but production decreases in lower layers where overshading by plankton causes reduced light penetration (Hepher, 1962).

Chlorophyll concentration and its relationship to productivity have been assessed for ponds and other ecosystems in various parts of the world (Brock and Brock, 1967; Manning and Juday, 1941; McConnell and Sigler, 1959; Moss, 1967; Odum, 1956; Verduin, 1956; Yentsch and Ryther, 1957). In ponds, chlorophyll concentration appears to be correlated closely with light intensity and water temperature (Copeland et al., 1964). The writers' study describes seasonal variations in some physicochemical parameters and their effect on phytoplankton productivity as measured by chlorophyll *a* standing crop in four northeast Arkansas commercial catfish ponds.

DESCRIPTION OF AREA

The four ponds studied are at the Arkansas State University Experimental Farm (T16N, R4E, Sec. 7, NW ¼) 1.61 km west of Walcott, Greene County, Arkansas. Greene County is within the alluvial valley of the Mississippi River, which begins near Cape Girardeau, Missouri, and extends south as far as the head of the Atchafalaya River in Louisiana, where the delta plain begins. A thick veneer of loess overlies the bedrock of the valley walls, particularly on the east side of the valley (Thornbury, 1965). The ponds are in soil classified as Falaya silt loam on the loessal plain adjacent to Crowley's Ridge (Robertson, 1969). The four rectangular ponds are easternmost in a series of eight ponds which are numbered from east to west, and are separated only by earthen levees approximately 6.2 m thick. The levees have a minimum distance of 0.76 m between the water surface and top of the levee. The levees are covered with Bermuda grass (*Cynodon dactylon*). Ponds 1 and 2 are 0.53 ha each in surface area, whereas ponds 3 and 4 are 0.26 ha each in surface area. The usual depth ranges from 0.6 m at the north end to 1.36 m at the south end. The water source for the ponds is a well. Maximum wind action is insured by the absence of trees and other obstructions in the surrounding vicinity.

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METHODS AND MATERIALS

Samples were taken from the deep end of the ponds between 0800 and 1100 hours at approximately two-week intervals from July 1970 through June 1971. Diurnal measurements of dissolved oxygen, free carbon dioxide, and temperature were made at four-hour intervals on 25-26 June 1971. All water samples were taken with a Kemmerer sampling bottle. During late winter all ponds were drained to facilitate fish harvesting. Afterward three were refilled. Pond 2 was dry from July until February 1971.

Physicochemical Methods. On each occasion the following determinations were made on surface and bottom water samples. Dissolved oxygen was determined by the sodium azide modification of the Winkler method (APHA, 1960) and by a Yellow Springs Instrument Company Model 54 oxygen meter;

analysis of carbon dioxide and alkalinity followed standard limnological methods (Welch, 1948). A Thermistor and a Yellow Springs Instrument Company Model 54 oxygen meter were employed to determine water temperature. Mean hydrogen-ion concentration was obtained by the Chemtrex Type 40, Beckman Expandomatic, and Coleman Metrion III pH meters. Transparency was determined by use of a 20-cm Secchi disk.

Biological Methods. Arnon's (1949) method was used to analyze water samples for chlorophyll *a* content. Samples for chlorophyll a analysis were placed on ice in a dark container and returned to the laboratory. Aliquots of 100 ml were filtered, and residues were extracted in 20 ml of a chilled aqueous solution of 80% acetone in the dark for 24 hrs at about 5 C. The solution was refiltered and brought to a final concentration of 20 ml. The optical density of the liquid was determined with a Bausch and Lomb Spectronic 20 photoelectric colorimeter at wavelengths of 645 and 663 nm. Chlorophyll *a* concentrations were determined by the equation

$$\text{chlorophyll } a \text{ in mg} = 12.7D_{663} - 2.69D_{645}$$

where 12.7 and 2.69 are specific absorption coefficients for chlorophyll *a* and *b* respectively. D_{663} and D_{645} are optical density at wavelengths 663 and 645 nm.

RESULTS AND DISCUSSION

Oxygen. Vertical distribution of dissolved oxygen was essentially homogeneous for each pond (Figs. 1-4); however, varying differences between surface and bottom concentrations (4-11 ppm) were noted during summer and were attributed to thermal stratification, which was accentuated by increased phytoplankton standing crop. Oxygen concentration was low at the bottom of ponds 3 and 4 during the summer, reaching a low of 0.3 ppm in pond 4 on 12 and 26 June 1971 and 1.2 ppm in pond 3 on 12 June 1971. Surface concentrations on the same dates ranged from 5 to 13 ppm.

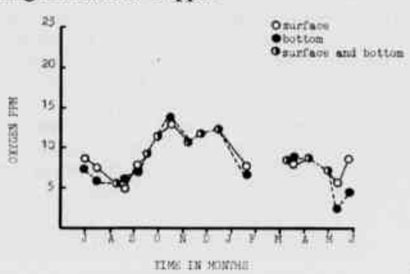


Fig. 1. Seasonal variation of oxygen in Pond 1.

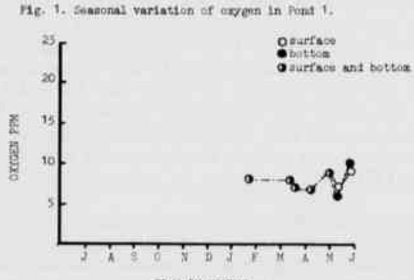


Fig. 2. Seasonal variation of oxygen in Pond 2.

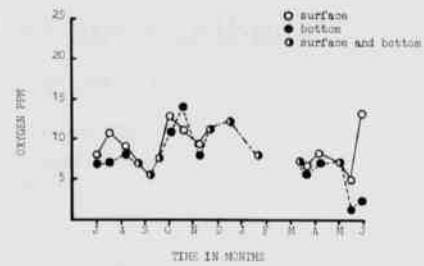


Fig. 3 Seasonal variation of oxygen in Pond 3.

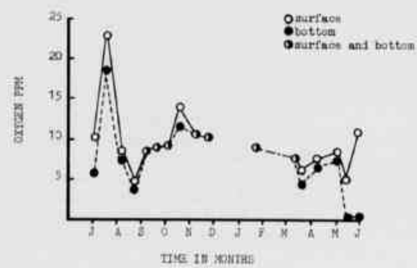


Fig. 4. Seasonal variation of oxygen in Pond 4.

Diurnal oxygen measurements were made on 25-26 June 1971 (Figs. 5-8). Surface concentrations were found to be lowest between 0300 and 0700 hours and increased to a maximum during midday and afternoon when oxygen accumulation from photosynthesis would be expected to reach a maximum. There was a gradual decrease during the night due to decomposition and respiration by aquatic organisms in the absence of photosynthetic activity. Bottom concentrations remained relatively constant (Figs. 5, 7, 8) in a range from 0 to 4 ppm. The difference between surface and bottom concentrations was greatest in pond 4 because of more pronounced thermal stratification (Figs. 9-12). Pond 2 showed the least difference between surface and bottom concentrations as it was the shallowest and clearest.

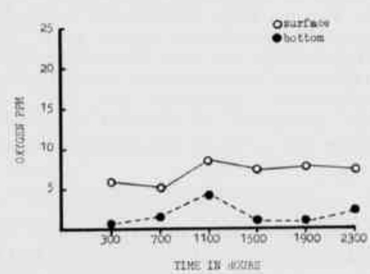


Fig. 5. Diel variation of oxygen in Pond 1.

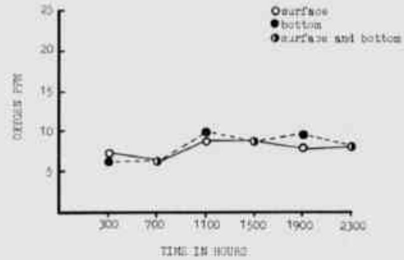


Fig. 6. Diel variation of oxygen in Pond 2.

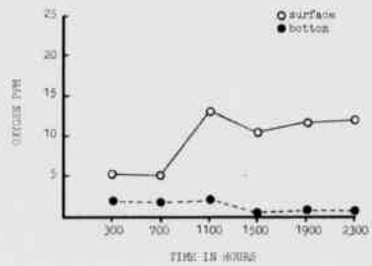


Fig. 7. Diel variation of oxygen in Pond 3.

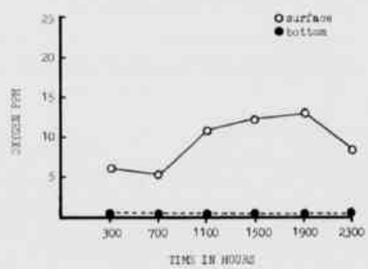


Fig. 8. Diel variation of oxygen in Pond 4.

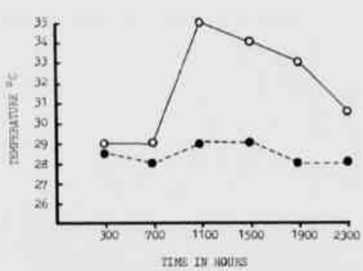


Fig. 9. Diel variation of temperature in Pond 1.

O surface ● bottom ◑ surface and bottom

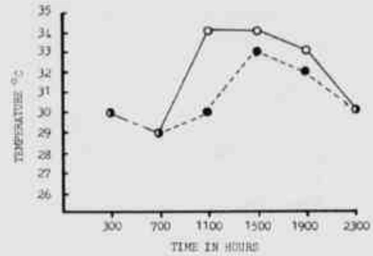


Fig. 10. Diel variation of temperature in Pond 2.

O surface ● bottom ◑ surface and bottom

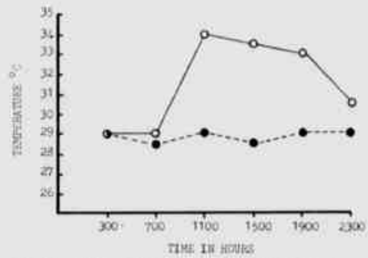


Fig. 11. Diel variation of temperature in Pond 3.

O surface ● bottom ◑ surface and bottom

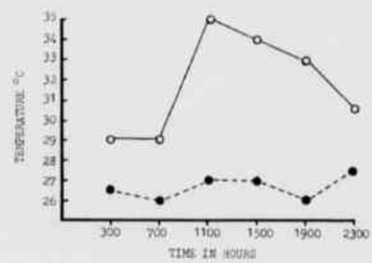


Fig. 12. Diel variation of temperature in Pond 4.

O surface ● bottom ◑ surface and bottom

In all ponds oxygen concentrations were highest in summer and fall. Increased oxygen concentrations in the fall coincided with decreased temperatures (Figs. 13-16) and increased chlorophyll a concentrations (Figs. 17-20). Chlorophyll *a* concentrations (Figs. 17-20) increased during the summer and coincided with increased temperature, causing dissolved oxygen supersaturation of the surface waters. Maximum saturation occurred in pond 4 on 26 June 1971, reaching a value of 180 ± 5% Smrchek (1970) found that oxygen concentration in ponds increased in the fall coincidentally with decreased temperatures and presumed water circulation.

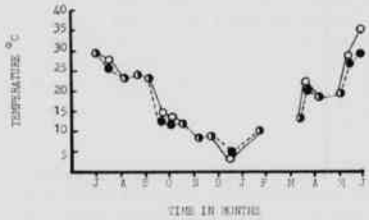


Fig. 13. Seasonal variation of temperature in Pond 1.

O surface ● bottom ◑ surface and bottom

Fig. 17. Seasonal variation of chlorophyll a in Pond 1.

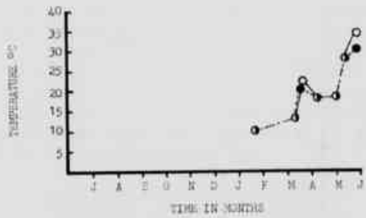


Fig. 14. Seasonal variation of temperature in Pond 2.

O surface ● bottom ◑ surface and bottom

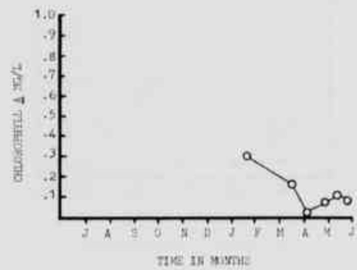


Fig. 18. Seasonal variation of chlorophyll a in Pond 2.

Fig. 15. Seasonal variation of temperature in Pond 3.

O surface ● bottom ◑ surface and bottom

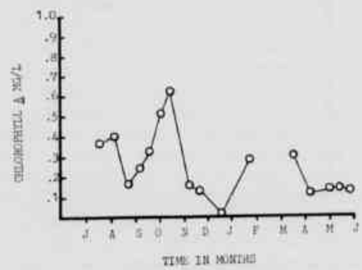


Fig. 19. Seasonal variation of chlorophyll a in Pond 3.

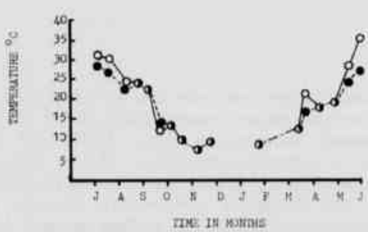


Fig. 16. Seasonal variation of temperature in Pond 4.

O surface ● bottom ◑ surface and bottom

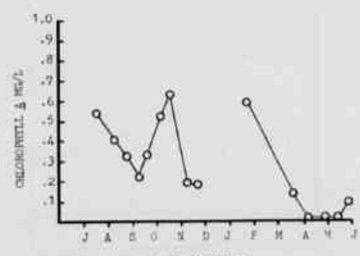


Fig. 20. Seasonal variation of chlorophyll a in Pond 4.

Carbon Dioxide. The vertical distribution of free carbon dioxide in all ponds was basically homogeneous except during the summer when surface values were usually lower than bottom values because of greater uptake by phytoplankton near the surface (Figs. 21-24). The highest surface and bottom carbon dioxide readings were recorded in pond 1 on 28 July 1970 (Fig. 21). This anomaly probably occurred because pond 1 was sampled earlier in the morning before appreciable photosynthesis had begun.

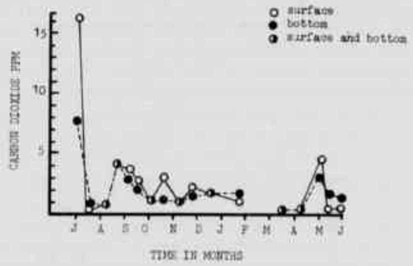


Fig. 21. Seasonal variation of carbon dioxide in Pond 1.

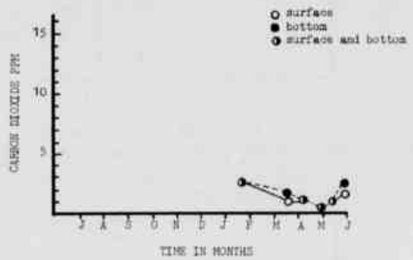


Fig. 22. Seasonal variation of carbon dioxide in Pond 2

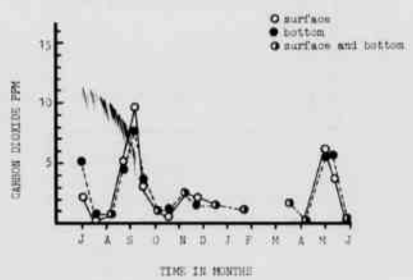


Fig. 23. Seasonal variation of carbon dioxide in Pond 3.

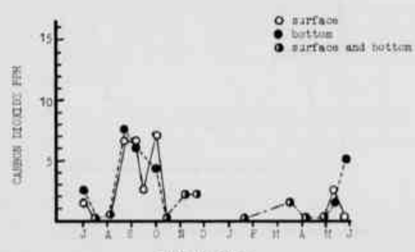


Fig. 24. Seasonal variation of carbon dioxide in Pond 4

Diurnal measurement of carbon dioxide on 25-26 June 1971 showed that free carbon dioxide concentration decreased during the day and increased at night (Figs. 25-28).

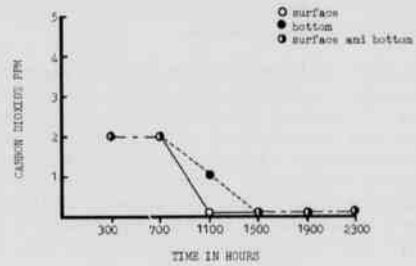


Fig. 25. Diel variation of carbon dioxide in Pond 1.

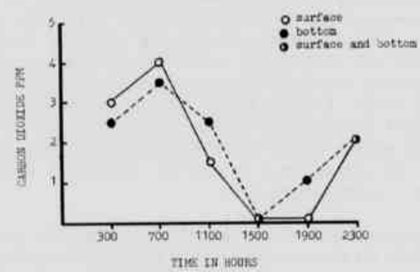


Fig. 26. Diel variation of carbon dioxide in Pond 2.

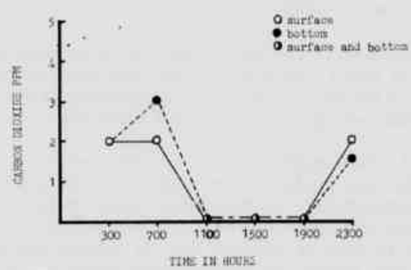
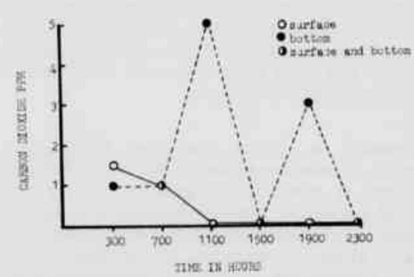


Fig. 27. Diel variation of carbon dioxide in Pond 3.



Diel variation of carbon dioxide in Pond 4.

Seasonal free carbon dioxide concentrations were highest during summer and fall, coinciding with increased water temperatures (Figs. 13-16). An inverse relationship was found between carbon dioxide and chlorophyll *a* concentrations (Figs. 17-20). Presumably, the primary source of free carbon dioxide was respiration by aquatic organisms, as the clay bottom was virtually free of organic material.

Total Alkalinity. Phenolphthalein alkalinity was recorded on a few occasions during the study period and indicated the presence of dissolved hydroxides and carbonates. Total alkalinity was highest in the summer, possibly because of addition of well water, and lowest in winter in all ponds, with no appreciable differences between surface and bottom concentrations (Figs. 29-32). The range of alkalinity in all ponds was between 25 and 91 ppm. The alkalinity of the well water with which the ponds were refilled ranged from 60 to 69 ppm.

Temperature. Because of shallowness and fetch the ponds were comparatively homothermal except during the summer (Figs. 13-16). Thermal stratification occurred because of increased air temperature and decreased light penetration, which caused the upper strata to warm more quickly than the bottom strata. Diurnal temperature measurement on 25-26 June 1971 indicated that temperatures of surface and bottom differed most at midday and converged during the night (Figs. 9-12). All ponds were essentially unithermal because of similarity in depth and fetch.

Hydrogen-Ion Concentration. The pH of all four ponds was essentially alkaline, ranging from a single acidic reading of 6.8 in pond 3 to 9.4 in pond 1 (Table I). An inverse relationship between pH and free carbon dioxide was found (Table I; Figs. 21-24), and these results closely agree with the findings of Irwin and Stevenson (1951).

Transparency. The transparency of water determines the depth to which light will penetrate, and thus establishes the depth of the euphotic zone. The temperature of the strata is dependent on light penetration and absorption.

Irwin (1945) emphasized that turbidity due to silt decreases the total food production and affects the general economy of the impoundment. In the writers' study turbidity did not correlate with chlorophyll a concentrations (Table I; Figs. 17-20). It must be assumed that the relative abundance of particulate matter and phytoplankton fluctuated throughout the year. Pond 2 was the clearest and light penetrated to the bottom on all sampling dates (Table I). Secchi-disk readings in ponds 1, 3, and 4 varied greatly during the study but were relatively constant prior to the addition of water to the ponds in March 1971. No seasonal trends could be established. In most cases the high transparency values were recorded shortly after the ponds had been filled with new water and suspended particulate matter was minimal.

Chlorophyll a. Three quantities related to primary production in lakes are measured by the aquatic biologist: (1) the volume of autotrophic organisms, (2) the ash-free dry weight of suspended particles (organic seston), and (3) the concentration of chlorophyll. Each is expressed per unit volume of water. These are measures of standing crop and they represent quantitative estimates of autotrophic organisms on which primary production is based (Verduin, 1956).

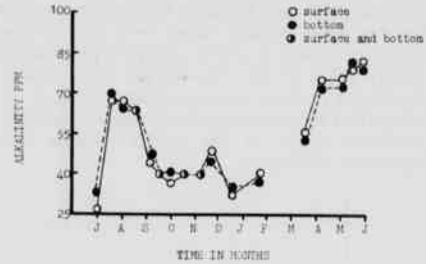


Fig. 29. Seasonal variation of total alkalinity in Pond 1.

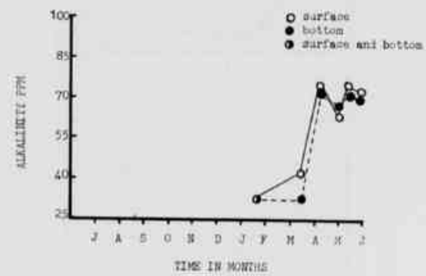


Fig. 30. Seasonal variation of total alkalinity in Pond 2.

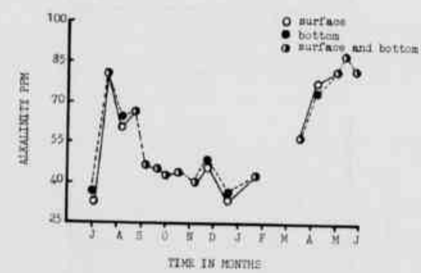


Fig. 31. Seasonal variation of total alkalinity in Pond 3.

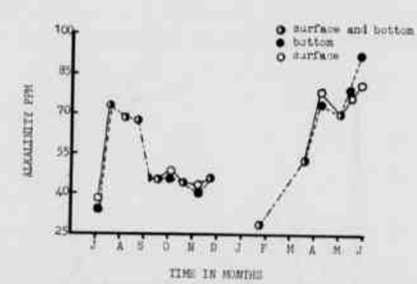


Fig. 32. Seasonal variation of total alkalinity in Pond 4.

Chlorophyll *a* concentrations ranged from 0.0 to 0.7 mg/l in pond 1, from 0.02 to 0.3 mg/l in pond 2, from 0.0 to 0.62 mg/l in pond 3, and from 0.0 to 0.63 mg/l in pond 4 (Figs. 9-12). The results obtained in this study were within the range of those found by Copeland (1963), Minter (1964), and Wright (1959).

In this study, chlorophyll *a* was used as an index of variation for phytoplankton standing crop. Chlorophyll *a* representing phytoplankton standing crop might be utilized as an index for predicting oxygen depletion during spring and summer months. Ponds 1, 3, and 4 showed an increase in phytoplankton standing crop during August 1970 (Figs. 17, 19, 20). Phytoplankton standing crop increased in ponds 1, 3, and 4 during September, October, and November 1970 (Figs. 17, 19, 20). An increase in phytoplankton was shown in ponds 1 and 3 during January and February 1971 (Figs. 17, 19); however, the ponds were drained during the latter part of February. Well water was added in March 1971, and from April to June quantitative fluctuations in phytoplankton were observed.

Even though the ponds were separated only by an earthen levee approximately 6.2 m thick, the recorded data show that they were separate ecosystems. Any treatment applied to ponds in the same locality and in the same manner for algae, lack of oxygen, pH, and turbidity may have a decimating effect on the fish population.

ACKNOWLEDGMENTS

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TABLE 1. Hydrogen-ion concentration and transparency (Secchi disk) in Ponds 1 through 4 from 28 July 1970 to 26 June 1971.

Date	Pond	pH	Transparency (cm)
July 28	1	---	--
	2	---	--
	3	---	--
	4	---	--
August 15	1	---	27
	2	---	--
	3	---	25
	4	---	20
September 5	1	7.5	35
	2	---	--
	3	8.3	28
	4	7.1	27
September 19	1	---	--
	2	---	--
	3	---	--
	4	---	--
October 3	1	7.5	33
	2	---	--
	3	6.8	33
	4	7.3	48
October 17	1	7.4	27
	2	---	--
	3	7.2	20
	4	7.4	31
November 1	1	7.3	38
	2	---	--
	3	7.1	20
	4	7.2	30
November 14	1	8.1	38
	2	---	--
	3	8.1	28
	4	8.7	33
December 4	1	7.8	46
	2	---	--
	3	7.2	26
	4	7.4	28
December 19	1	7.2	61
	2	---	--
	3	7.1	25
	4	7.2	31
January 16	1	7.6	79
	2	---	--
	3	7.8	28
	4	---	--
February 20	1	7.3	28
	2	7.4	41
	3	7.9	28
	4	8.6	20
April 10	1	---	--
	2	---	--
	3	---	--
	4	---	--
April 17	1	9.0	76
	2	8.1	68
	3	7.7	56
	4	8.1	61
May 4	1	9.4	122
	2	7.8	91
	3	8.6	20
	4	8.6	31
May 29	1	7.8	91
	2	8.6	76
	3	7.5	38
	4	8.5	23
June 12	1	7.8	21
	2	7.8	61
	3	7.4	25
	4	7.6	25
June 26	1	---	41
	2	---	82
	3	---	31
	4	---	53

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Failure to Establish Feral *Coturnix* Quail Populations in Arkansas in the Late 1950's

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ABSTRACT

Although *Coturnix* introductions failed in the late 1950's, it was learned in Arkansas that birds survived longest after autumn releases especially where fallow fields were numerous, that *Coturnix* favored grasslands whereas the bobwhite preferred shrublands, and that *Coturnix* occurred singly, pairing only in the breeding season.

INTRODUCTION

Dry years and intensification of agriculture in the early 1950's seemed to reduce considerably the lush grassy shrublands preferred by the bobwhite (*Colinus virginianus*). Thus many states tried massive introductions of the exotic *Coturnix* quail (*Corturnix coturnix japonica*) in the late 1950's in hope of providing a game bird that would occupy impoverished open upland habitats (Cottam and Stanford, 1958; Stanford, 1957, 1958; Wetherbee, 1961). These introductions were unsuccessful (Cottam and Stanford, 1958). Nevertheless, investigations of *Coturnix* released in Arkansas yielded information on its survival, habitat, and social behavior in the new environment. These findings could be useful in evaluating the potentialities of *Coturnix* in connection with possible future attempted introduction.

RELEASES

A total of 1,633 yearling *Coturnix* raised in captivity for the Missouri Conservation Commission (Stanford, 1957) were liberated in five releases in each of three study areas in northwestern Arkansas during 1957 and 1958 (Table I). The areas ranged from 1 to 4 sq mi. Nearly equal numbers of both sexes were released. The birds dispersed slowly from opened carrying cartons placed on the ground. Often they crouched motionlessly, commonly in small groups, a short distance from the cartons and even could be touched by the investigators before moving. Yet the exodus from the vicinity of the release site nearly was complete the next day.

The Osage Springs and Robinson Farm study areas, both in central Benton County, appeared to have prime bobwhite habitat consisting of a very diverse mixture of pastures, cultivated fields, many grassy and shrubby old fields, and scattered small woodlands. The proportion of fallow grassy-shrubby old fields was much greater at Osage Springs than at Robinson Farm. The Wedington study area in northern Washington County seemingly was poor bobwhite habitat. There were vast unbroken woodlands and most of the open land was utilized agriculturally, primarily as pasture.

SURVIVAL

After all releases except one, the feral *Coturnix* populations persisted only one or two weeks. Both the *Coturnix* and bobwhite population levels, determined by using one to three bird dogs with one to five investigators approximately every five days, are shown in Table II for the first four releases. After the fifth release in February, done only at Robinson Farm and Wedington, four censuses yielded nine *Coturnix* and one bobwhite, all at Robinson Farm. The *Coturnix* disappeared after nine days.

Population levels represented by numbers of birds per census (Table II) were not significantly different among study areas in either quail (χ^2 test, 1 d.f., α=0.05). This finding suggests that all three areas actually were similar in quail-habitat quality. Duration of occupancy also can reflect habitat favorability. Summing all *Coturnix* releases shows that the total duration of occupancy was 113 days at Osage Springs, 49 at Robinson Farm, and 74 days at the Wedington study area. The long survival at Osage Springs was significantly different from that at the other two areas (χ^2 = 12.64 and 4.07, 1 d.f., α = 0.05), but the longest survivals at Robinson Farm and Wedington did not differ significantly (χ^2 = 2.54). Apparently conditions were best for *Coturnix* at Osage Springs, the area with the greatest proportion of overgrown fields.

Fall and early winter were best for *Coturnix* introductions as the birds remained longest then, even persisting 100 days at Osage Springs (Table II). Regardless of the length of occupancy signs of mortality were unexpectedly few, particularly

Table I. Releases of *Coturnix* Quail in Northwestern Arkansas in 1957 and 1958

Study Area	No. Birds Released: Apr. 17 1957	Apr. 30 1957	July 2 1957	Nov. 5 1957	Feb. 25 1958	Total
Osage Springs	56	60	100	140	0	356
Robinson Farm	60	71	99	150	194	574
Wedington	60	85	199	160	199	703
Total	176	216	398	450	393	1633

considering the initial tameness. Only 48 instances of predation were found, representing merely 3% of the total releases. Thus, the small resulting populations apparently were the few birds remaining after widespread dispersal elsewhere, a well documented phenomenon in banded *Coturnix* (Cottam and Stanford, 1958; Jacobs et al., 1959).

HABITAT

Birds as closely related as *Coturnix* and the bobwhite probably would compete for the same food if they were present in the same vegetational habitat. The desirability of introducing *Coturnix* thus depends on its not occupying prime

Table II. Census Results for *Coturnix* and Bobwhite After First Four Releases of *Coturnix*

	Combined 3 Releases in April and July			November Release		
	Total Days Present[1]	Total Birds Counted	Birds Per Census[2]	Total Days Present	Total Birds Counted	Birds Per Census[2]
COTURNIX						
Osage Springs	13	28	7.0	100	35	2.1
Robinson Farm	12	20	6.7	37	13	2.6
Wedington	39	40	6.7	35	17	2.1
BOBWHITE						
Osage Springs	*	39	4.9	*	31	2.1
Robinson Farm	*	43	6.1	*	51	7.3
Wedington	*	23	2.1	*	31	3.1

[1] The figures in this column are the cumulative sums for three releases. Thus the duration of occupancy after each release was less than these totals.

[2] Based on the number of censuses through the last occurrence of *Coturnix* in each area, but based on all censuses in each area with respect to the bobwhite.

* The indigenous bobwhite was present throughout the study.

Table III. Habitat Utilization by *Coturnix* and Bobwhite

Habitat	*Coturnix* No. Encounters[1]	*Coturnix* Percent	Bobwhite No. Encounters[1]	Bobwhite Percent
Forest	1	1	3	6
Shrubland	46	36	36	72
Grassland	78	61	10	20
Agriculture	2	2	1	2
Total	127		50	

[1] An encounter involved either a single bird or a group of birds at one place.

bobwhite habitat. Therefore, each encounter with either quail, whether a single bird or a group per encounter, was categorized according to habitat (Table III). Forest habitat was any woodland with a well developed tree-leaf canopy. Shrublands were bushy forest margins and fence-rows, and also extensive shrubby old fields. Grasslands were dense relatively tall grasses and weeds without trees or shrubs. Agricultural areas included cultivated crops and closely grazed pastures. Both species avoided forest and agricultural lands but overlapped considerably percentagewise in shrublands and grasslands (Table III). Still the bobwhite was found in shrublands twice as often as *Coturnix*, and *Coturnix* occupied grasslands three times as much as the bobwhite. This habitat difference is highly significant ($\chi^2 = 21.15$, d.f. $= 1$, $\alpha = 0.001$) if one considers just the shrubland and grassland encounters for both species in a 2 x 2 contingency table. The preference of grassland by *Coturnix* corresponds to its behavior in its original range (Wetherbee, 1961) and would reduce the amount of habitat overlap with the bobwhite.

The most successful wintering *Coturnix* population, the one at Osage Springs (Table II), utilized a 25-acre grassy old field dominated by broom sedge (*Andropogon virginicus*) but heavily invaded by blackberry (*Rubus*) thickets and some sumac (*Rhus*). The *Coturnix* generally were found in or near the low leafless blackberry thickets where the ground was barer than in the adjoining dense grasses. Panic grass (*Panicum*) growing in these barer areas had many seeds all winter and may have attracted the *Coturnix*. The quickly vacated release field nearby was almost devoid of the blackberry thickets and panic grass.

SOCIAL BEHAVIOR

Field data on the social unit of *Coturnix* were obtained from November through May (Table IV). Clearly *Coturnix* is essentially solitary, avoiding coveys. Field observations indicated that the increase in two-bird groups in May was due to courtship pairings.

ACKNOWLEDGMENTS

The investigation was supported by the Arkansas Game and Fish Commission through Federal Aid Project W-50-R-1 and was coordinated by Harold E. Alexander, then with the Commission. John Preston, Ned Fogle, Douglas Jester, and the late Clyde Goddard with his dogs assisted in the field work. James K. Patrick also provided a dog for use in the quail surveys.

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Table IV. Social Behavior of Feral *Coturnix*

	No. Individuals Encountered						
	1	2	3	4	5	6	
	No. Encounters						Total
November	32	2	2	1			37
December	6	1					7
January	5	2					7
February	1						1
March	6		1				7
April	6						6
May	26	16	3			1	46
Total	82	21	6	1	0	1	111

Build-up of Ions in Areas of Lake Dardanelle as Affected by Stream Flow

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ABSTRACT

The poultry industry in the Lake Dardanelle watershed annually introduces large amounts of poultry effluents into the system. This, plus the large concentrations of chloride ions that are introduced into the lake from salt deposits in the upper Arkansas River watershed, has definite effect on the limnological conditions of the lake. The buildup of chloride ions in areas of the lake depends on the amount of flow from streams into these parts of the lake. This stagnation phenomenon is especially noticeable in pocket areas which are generally cut off from the major influence of the river as it flows in its channel and through the dam.

INTRODUCTION

Lake Dardanelle is a manmade flow-through lake, completed by the U.S. Army Corps of Engineers in 1969 as a major unit in the mulitple-purpose project for the improvement of the Arkansas River and its tributaries in Arkansas and Oklahoma.

The Dardanelle Lock and Dam is between the cities of Dardanelle and Russellville in west-central Arkansas. The lake is 50 mi long and 2 mi wide at its maximum width. The shoreline is 315 mi long. The top of the conservation pool is 338 ft above mean sea level. The surface area of the reservoir is 34,300 acres and storage capacity is 486,200 acre-feet. The mean stream flow rate is 35,620 cfs. The 153,703 sq mi of drainage area above the dam includes parts of both the Ozark and Ouachita National Forests.

The watershed area of the Illinois Bayou, which includes drainage of Baker's Creek, Mill Creek, Prairie Creek, and Shiloh Creek, totals 391 sp mi (Sullavan and Terry, 1970). Most of the poultry houses and turkey ranges of Pope County are in this area. The total poultry population in 1970 for Pope County, 13,290,000, included birds in five catagories (USDA, 1970).

1. Birds in commercial table egg flocks	408,000
2. Broilers	11,788,000
3. Birds in broiler hatchery supply flocks	339,000
4. Turkeys	705,000
5. Birds in table egg hatchery supply flocks	50,000

The concentrations of poultry effluents introduced into the lake are varied and depend on several factors which include:

1. Time of year - poultry populations vary greatly, especially turkey populations, according to the time of year.
2. Amount of rainfall and the area affected - whether localized or general, whether the amount is sufficient to produce runoff.
3. Location of litter - whether litter is intact in the poultry houses or if it has been spread on pasture lands.
4. Amount of stream flow - whether stream flow (particularly in certain streams) is sufficient to cause flushing action from various isolated areas of the lake.

MATERIALS AND METHODS

Sampling for the first year of testing ran from 3 June to 21 October 1970. During the second year the sampling period ran from 1 June to 18 November 1971. Collections were on a weekly basis during June, July, and August, and thereafter were generally on a biweekly schedule. The same plan was followed each year.

Surface samples were collected at all stations during both years of testing. Bottom samples were collected during the second year of testing at stations C, D, E, G, I, and N for chemical analysis only.

In this study only flows at stations A and D (Table I) were checked regularly; others were checked occasionally. The flowmeter available to the project was incapable of measuring the very small amounts of flow at times in the streams. Only visible stream flow was recorded.

A Kemmerer water bottle was used to collect the bottom samples. Part of the water sample was filtered by a Millipore filtration apparatus with a 0.45-micron pore size filter. The filtrate was refrigerated at 4C until it was analyzed.

Plankton samples were collected by two methods. In both methods only net plankton (Welch, 1948) were collected, by means of a plankton net with a No. 25 silk bolting cloth equipped with an adaptor and a 30-cc bottle. Stations in the lake proper were sampled by the horizontal drag method. With the use of the standard formula for the volume of a cylinder ($V = \pi r^2 h$), a 4.383-m horizontal drag would represent a 200-l sample. No vertical samples were taken. Plankton samples were collected from an area that ranged from surface to approximately 46 cm below the surface. At all other stations a sample representing a 10 or 20 l concentration was collected by means of a plankton net with bottle and precalibrated bucket. The size of this sample was dependent on the turbidity and/or debris in the water.

Plankton samples were fixed and preserved with approximately 3 ml of formaldehyde in the laboratory. They were analyzed for zooplankton both quantitatively and qualitatively. In this project the identification of zooplankton was taken only to genus. The taxonomic scheme of Pennak (1953) was used to place those flagellated organisms which possess both plant and animal characteristics. Other sources used in identification were works by Hyman (1951), Needham and Needham (1966), Eddy and Hodson (1967), and Ward and Whipple (1959).

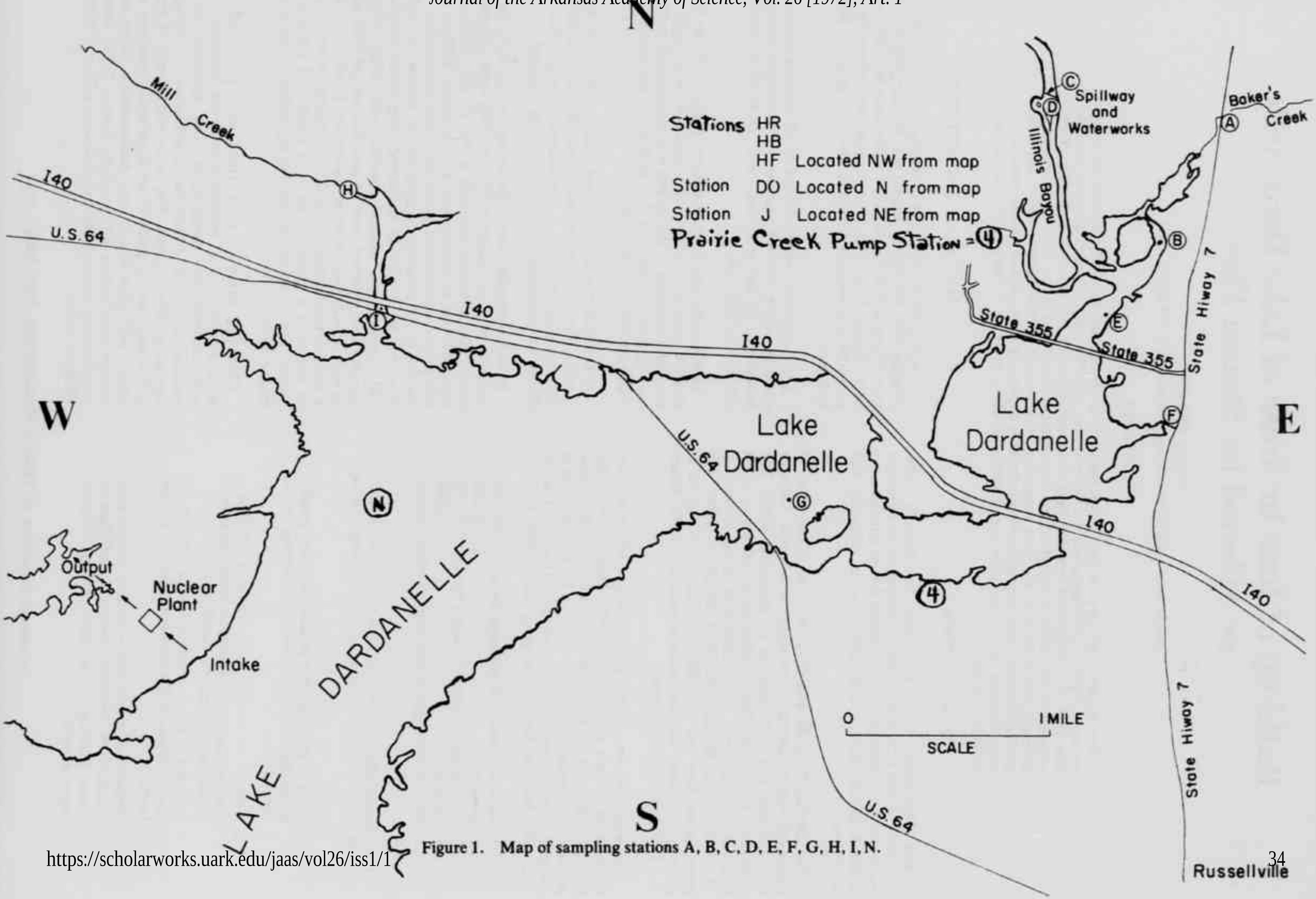

Figure 1. Map of sampling stations A, B, C, D, E, F, G, H, I, N.

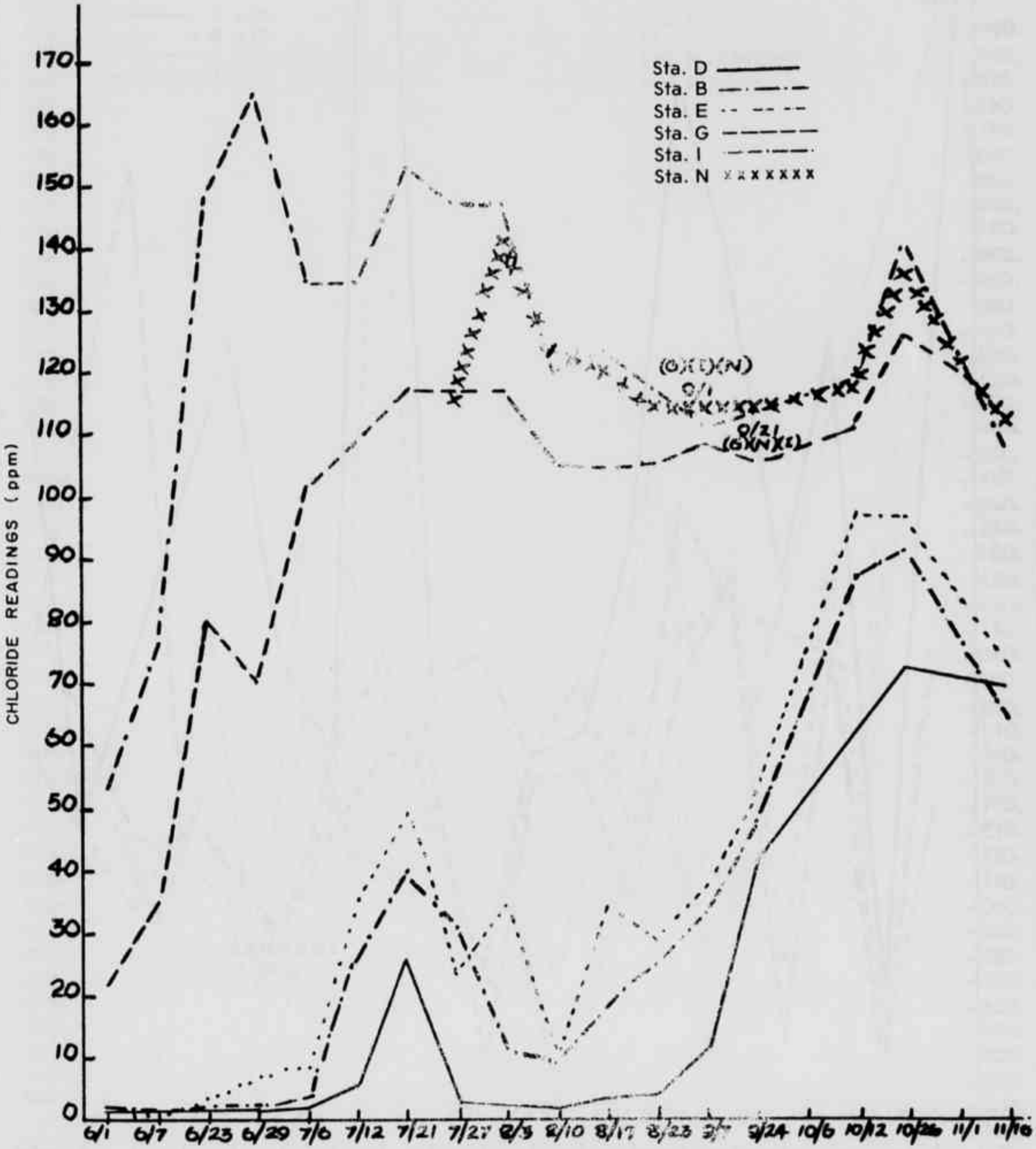

Figure 2. Surface concentrations of Cl^- in ppm at stations D, B, E, G, I, and N recorded during 1971 testing period.

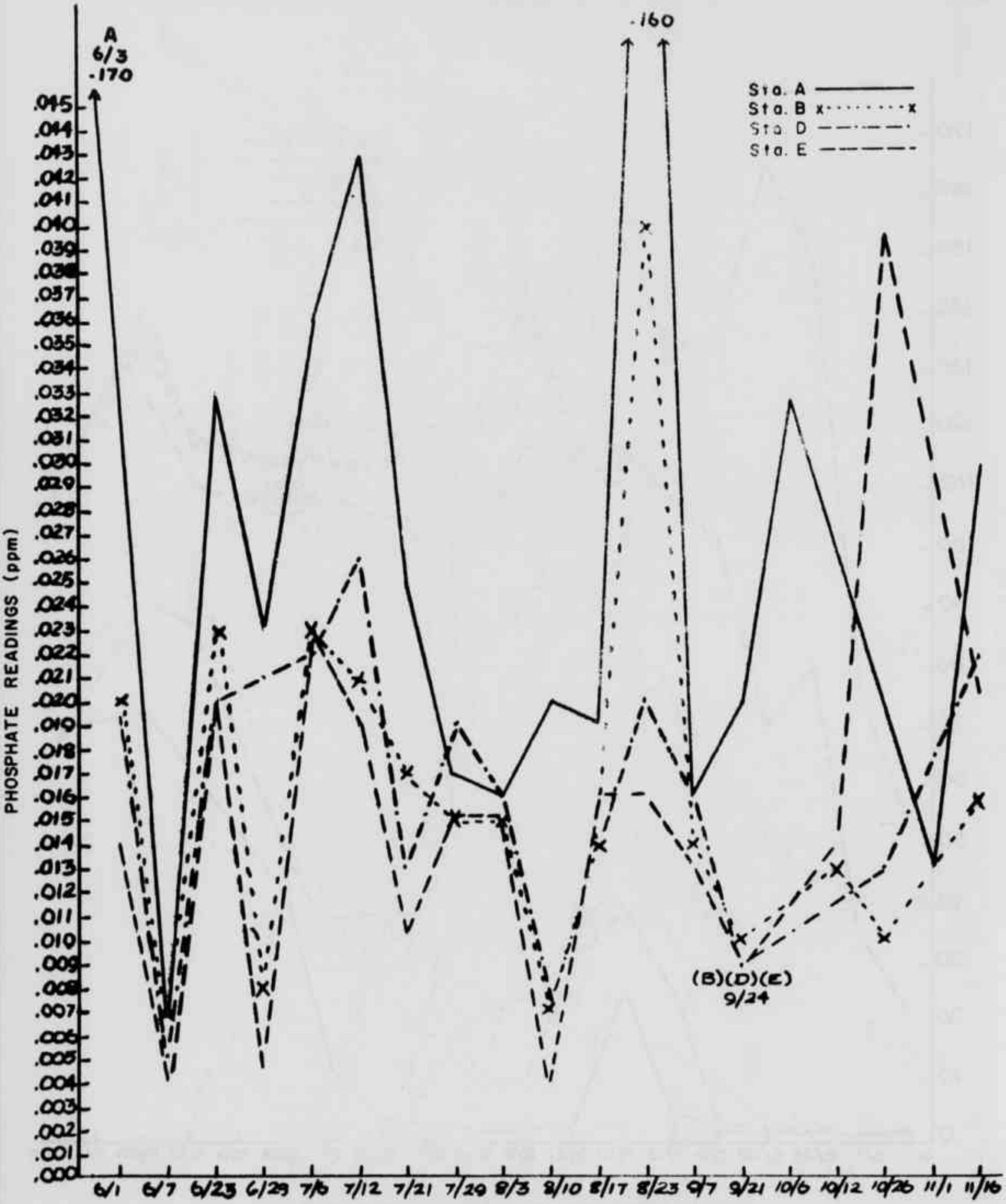

Figure 3. Surface concentrations of PO_4^{---} in ppm at stations A, B, D, and E recorded during 1971 testing period.

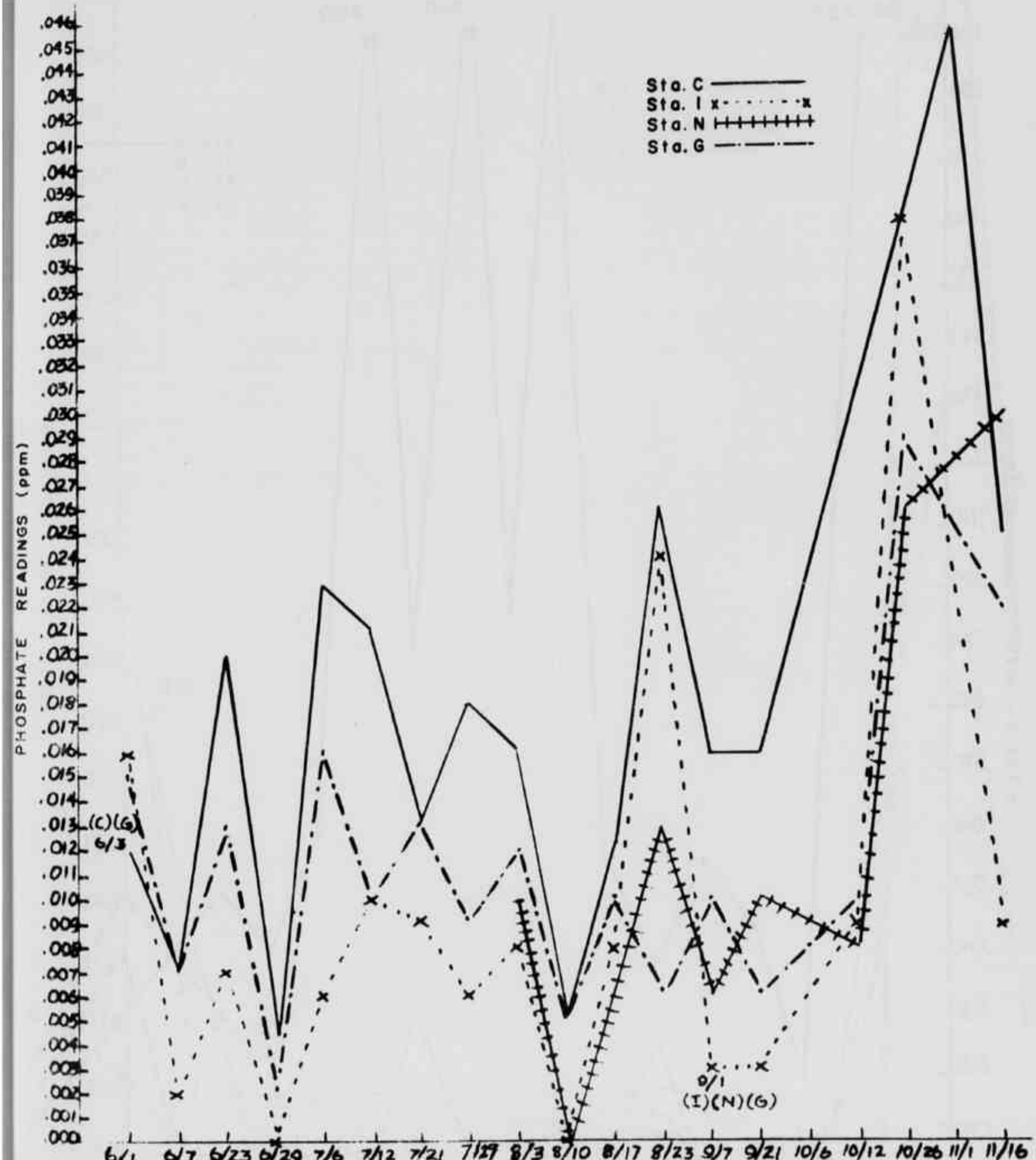

Figure 4. Surface concentrations of PO_4^{---} in ppm at stations C. I. N. and G recorded during 1971 testing period.

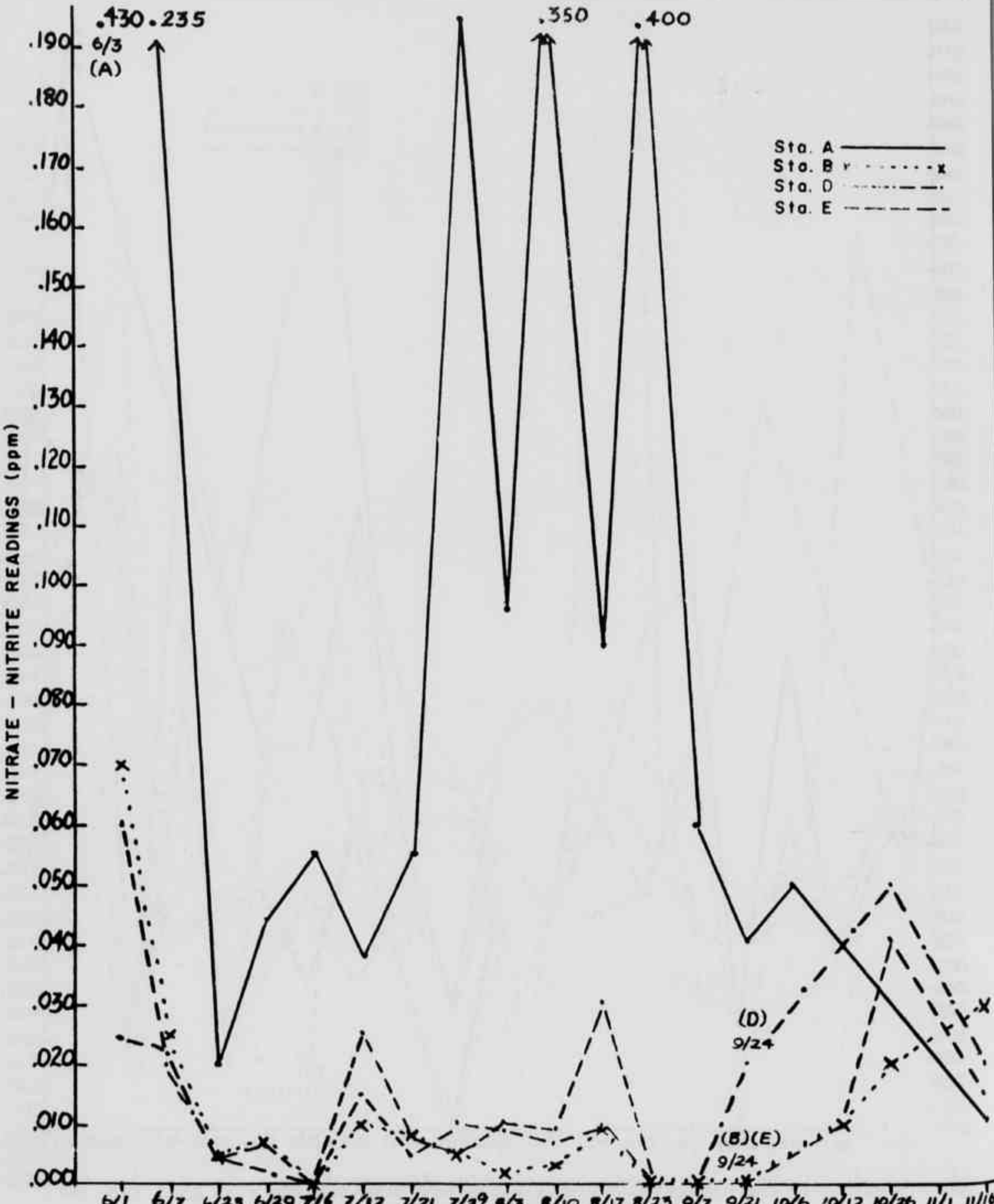

Figure 5. Surface concentrations of NO_3^-—NO_2^- in ppm at stations A, B, D, and E recorded during 1971 testing period.

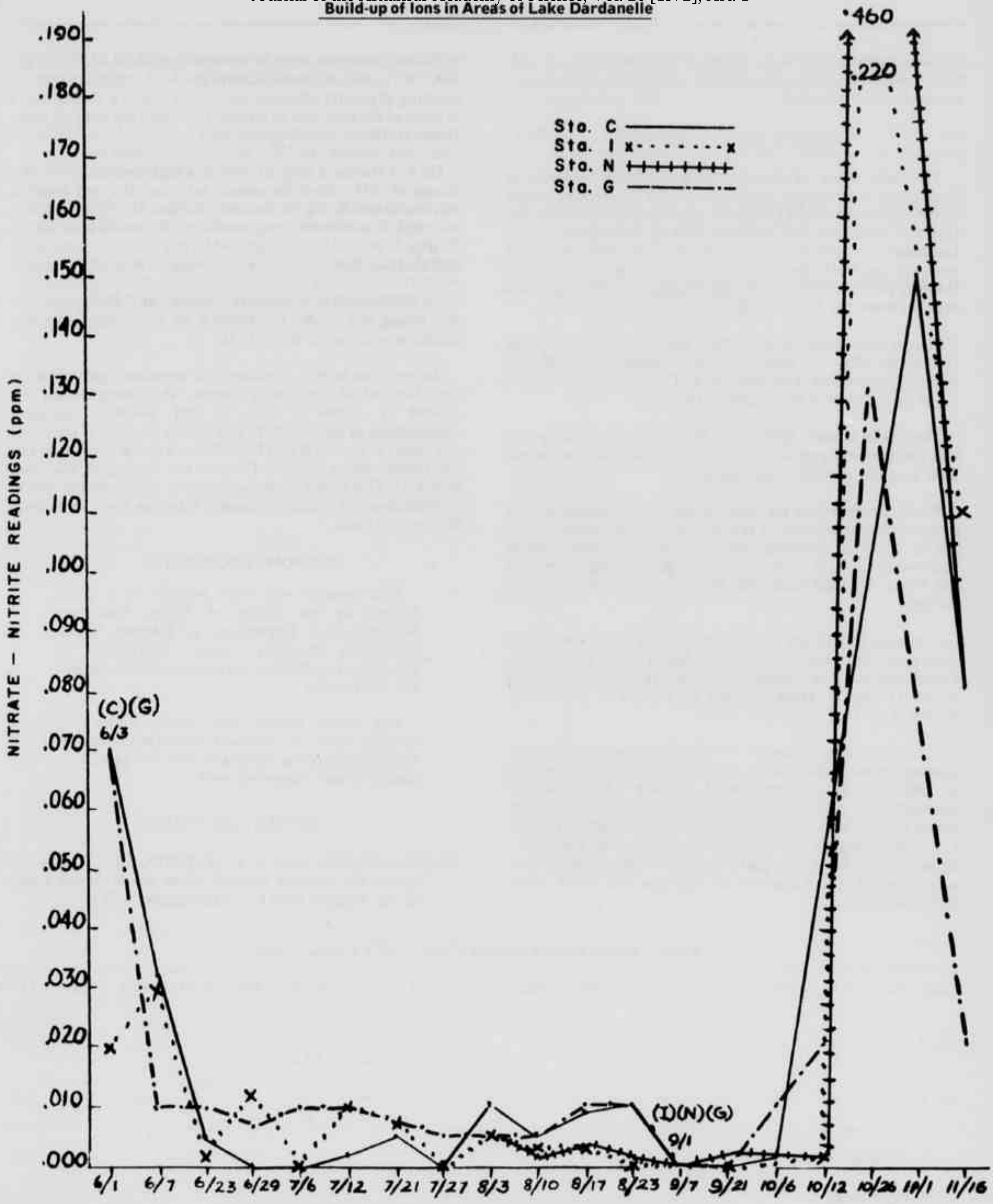

Figure 6. Surface concentrations of NO_3 —NO_2 in ppm at stations C, I, N, and G recorded during 1971 testing period.

Tests performed on water samples included turbidity, pH, CO_2, nitrate-nitrite, ortho-phosphate, chloride, total hardness, ammonia, and uric acid.

RESULTS AND DISSCUSSION

The stabilization of concentrations of certain materials in backwaters of the lake is related directly to the amount of flow of the tributaries feeding the lake in those areas (Veatch and Huphrys, 1966). The best indicator of this phenomenon in Lake Dardanelle is chloride-ion buildups. Chloride levels are generally very low in the tributaries proper, whereas in the river channel the levels are very high because of concentrations brought down the Arkansas River.

Five regular water sources feed the study area of Lake Dardanelle (Fig. 1): Baker's Creek, Shiloh Creek, Illinois Bayou, Prairie Creek, and Mill Creek. The Illinois Bayou is the major contributor in this sector of the lake.

The flow in Baker's, Shiloh, and Mill Creeks is generally very low, and frequently ceases during periods in the summer except after sporadic periods of precipitation.

Prairie Creek waters are added to the lake by means of a lift pump station at the edge of the lake at the Dike Road (Fig. 1, station 4). This pumping system is an automated device operated by the U. S. Army Corps of Engineers. The water from this system is added to the lake directly opposite the pumping station.

A change in chloride concentrations can be observed in a short period of time when the Illinois Bayou ceases to introduce waters into the lake (except for seepage through the dam) at station D (Fig. 1). These changes are evident in Figure 2 at station D on 7/12, 7/21, and 7/27.

Even strong flow in Baker's Creek is not effective in flushing concentrations of chloride out into the major body of the lake, as indicated by the continuous buildup of chloride-ion concentrations on 8/23 at station B (Fig. 2), in spite of the strong flow at station A at that time (Table I). Station E (Figs. 1, 2), approximately one-half mile from station B, did show a slight decrease during this period, probably because most of the water flows in the channel on the opposite side of the island from station B.

When a sharp increase in the concentrations of NO_3^- and PO_4^{---} is noted in the streams (Figs. 3-6), resulting from the leaching of poultry effluents, one would expect a similar result in areas of the lake near or adjacent to where the streams enter. However, this is not always the case.

On 6/3 station A (Fig. 5) showed a high level of NO_3^-; this deluge of NO_3 from the stream into the lake was noted at stations B and E (Fig 5), but with far less magnitude than at station A. This decrease may be due to dilution factors. Station D. (Fig. 5) seemed to be influenced by this influx, in spite of the fact that the Illinois Bayou was flowing on that day (Table I).

On 8/23 the station A nitrate reading was 0.400 ppm with a very strong flow (Table I). Station B on 8/23 registered a zero nitrate concentration (Figs. 1, 5).

An elevation in NO_3^- readings was recorded again on 10/26 near the end of the testing period. The concentration was highest at station N (Fig. 6) and generally decreased consecutively at stations G, E, and B (Figs. 4, 5, 6). A lag factor was noted at station B on 11/16. Baker's Creek (station A) and the Illinois Bayou (station D) were not flowing at that time (Table I). This influx in concentrations was probably due to introductions of poultry effluents into the river at a point farther upstream.

ACKNOWLEDGEMENTS

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Table I. Stream Flow at Stations A and D, 1971 Testing Period

Date	6/1	6/8	6/22	7/5	7/12	7/20	7/26	8/2	8/9	8/17	8/24	9/8	9/21	10/6	11/1	11/16
Sta. A	+	+ S	—	—	—	—	—	—	+	+ S	+ VLA	+ S	—	—	—	—
Sta. D	+	+	+	+	+ D	—	+	+	+	+	+ D	+	9/24 —	—	—	—

\+ Flowing.

— Not flowing

Station D is in Illinois Bayou and Station A is in Baker's Creek. The letter D appears below the + sign if a very noticeable decrease had occurred at Station D since the last collection date. The letter S is used to describe a very small flow (trickle) and VLA indicates a very large amount of flow at Station A.

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Fracture Pattern Analysis Employing Remote Sensing Techniques for Groundwater Movement with Environmental Applications: Preliminary Report

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ABSTRACT

The study will consist of determining the relationship between fracture patterns and porosity-permeability changes in carbonate rocks with emphasis on groundwater movement. These porosity-permeability changes will be measured by relative groundwater movement, in the form of either springs, artesian wells, municipal supplies, or private wells. Relationships will be determined by plotting the positions of the measuring sites and correlating these sites with mapped fractures. Water yield is expected to be markedly greater for sites along fracture traces than for those located at random.

RECENT STUDIES

Several fracture pattern-groundwater studies completed in recent years provided the impetus and background information for this study. For example, in northern Alabama, Sonderegger (1970) used fracture traces in a carbonate terrain to interpret the occurrence and movement of groundwater. He concluded that the use of the fracture trace method for the location of high-yield water wells in carbonate aquifers is substantially more effective than a random approach. He noted also that wells drilled along fracture traces yielded greater quantities of water than the average of the randomly located wells. Lattman and Parizek (1964) concluded that the capacity of wells and the frequency of cavities in the rock increased for wells drilled along fracture traces and were maximized where fracture traces intersect. Methods similar to those of Lattman and Parizek were employed in Brazil where municipal wells were developed by drilling on photo-lineament sites suspected to reflect faults and fracture zones in the crystalline basement complex (Setzer, 1966). Artesian conditions were encountered at the more successful wells having recorded capacities in excess of 660 gal/min.

INTRODUCTION

Carbonate rocks are erratic aquifers in most areas. Wells drilled a few feet apart into a limestone aquifer may differ in specific capacity by a factor of ten or more because generally these rocks have very low primary porosity and permeability. Both surface and subsurface zones of fracture concentration should provide avenues for greater solution and weathering, thereby causing an increase in porosity and permeability. These solution conduits in turn facilitate vertical and lateral groundwater movement. Therefore, the capacity of dolomite and limestone aquifers to transmit groundwater to wells depends largely on the size, number, and interconnection of water-yielding joints, fractures, and solution cavities intersected during the drilling operation. Furthermore, if fracture traces are the surface reflection of a concentrated zone of subsurface fractures, they also should delineate zones of increased porosity and permeability. The position for a maximum-yield well, therefore, is directly on fracture traces; the optimum position is at the intersection of two or more lineations.

Lineations include both fracture traces and lineaments mapped or inferred on aerial photographs. Fracture traces are lineations less than 1 mi long; they generally represent bedrock joints or small faults. Lineaments are lineations more than 1 mi. long; they generally represent regional zones of shatter or faults of deep-seated origin. These differentiations, taken from Lattman (1958), are recognized in most of the literature, the distinguishing characteristic being length. In any case, lineations are linear trends of topographic features, soil tones, stream courses, and vegetation visible on aerial photographs. Nonrelated photo lineations would include such things as outcrop patterns of inclined strata, stratigraphic contacts, and man-made features such as railroads or highways.

TECHNIQUE

The method of study involves intital mapping of lineations from high-altitude photo mosaics for Benton, Boone, Carroll, Marion, and parts of Baxter, Izard, Madison, Newton, Searcy, Stone, and Washington Counties of northern Arkansas. Whether a lineation represents a zone of regional shear or a bedrock joint, it represents a fracture in the rock. If the surface bedrock is a carbonate, the fracture undergoes rapid weathering and solutioning, and if the solutioned fracture lies within a drainage basin, it will be accentuated by the drainage pattern. Initially, the drainage is used as a guide for mapping the major lineations.

Not all mapped lineations were reflected by the drainage patterns, however, and Figure 1 illustrates the results when the superimposed drainage pattern is removed. On general observation, two major sets of linear trends are expressed, one in the northeast direction and the other in the northwest direction. Two minor sets, E-W and N-S, also are represented. The regional fracture pattern for northwest Arkansas found in the field consists of five sets of fractures: N70° W, N30° W, N5° W, N7° E, and N55° E. (Gibbons, 1962). Radar lineaments mapped for the Ozark Province (Kirk and Walters, 1968) generally show trends similar to those reported by Gibbons. Several smaller lineaments are actually discontinuous segments of larger reional trends. For example, the discontinuous lineament at points "x" in Figure 1 represents the White River fault which is an extensive fault zone extending from northwest Mississippi, through northern Arkansas, and terminating in southern Missouri (Fig. 2).

Figure 1. Lineations mapped from high-altitude photo mosaics.

APPLICATIONS

The results of this investigation could have applications for such diverse fields as economic geology, hydrology, and environmental geology. Fresh water in many areas is in critically short supply. Urban development and groundwater utilization would be enhanced greatly by accurate prediction of groundwater movement and sites for high-yield wells. Other environmental applications include pollution control. Groundwater sources which ultimately feed a public water supply or a recreational area may be in proximity to garbage dumps, landfills, or sewage treatment basins. Because the mapped lineations represent zones of increased porosity and permeability, they may also represent zones of natural groundwater recharge. Consequently, the exact location of these zones provides not only a tool for locating sites for optimum groundwater discharge, but also invaluable information for land use planning.

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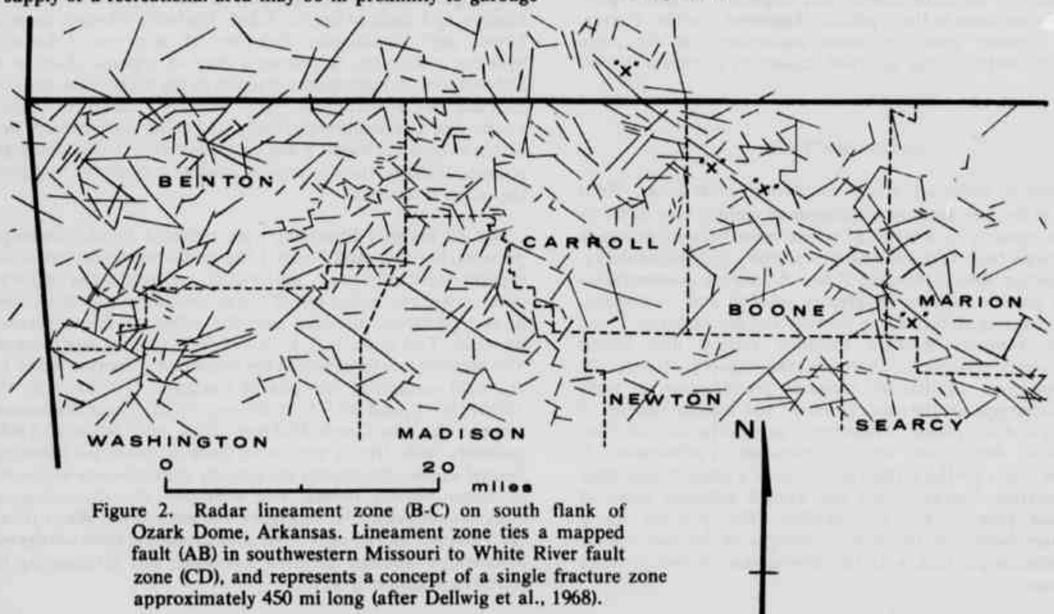

Figure 2. Radar lineament zone (B-C) on south flank of Ozark Dome, Arkansas. Lineament zone ties a mapped fault (AB) in southwestern Missouri to White River fault zone (CD), and represents a concept of a single fracture zone approximately 450 mi long (after Dellwig et al., 1968).

Population Profiles by Factor Analysis: Study of a Rural Arkansas Community

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ABSTRACT

Factor analysis was used as a preliminary data analytic technique to delineate population profiles in a rural, poverty-level community. The technique was useful in defining the nature of sociological interdependencies in the population so that the heterogeneity in the community could be understood. Four factors identified as representing socio-economic status, age-work attitudes, morality, and participation dimensions were extracted from the correlation matrix.

INTRODUCTION

Changes in agricultural technology have had destabilizing effects which often rest heavily upon minority groups. In eastern Arkansas, a commercial agricultural area, decades of rapid adjustment have resulted in black Americans changing from agricultural to industrial employment. Many social and economic problems have been associated with this process. The writers' research was designed to learn more about living conditions and employment opportunities in a predominantly black community in eastern Arkansas. Data obtained were to be used to test hypotheses posited by other investigators concerning the sociological correlates of poverty and racial discrimination. Information was provided by an adult member of each household in the study community who was administered a 30-min questionnaire. The questionnaire included objective census information as well as items taken from Rotter's (1966) Internal-External Control Scale and an Attitudes Toward Deviance Scale designed by Jessor et al. (1968) for use in a study in a tri-ethnic Colorado community. Both black and white interviewers canvassed the community.

The study yielded a mass of data which needed to be ordered so that the complexities of social life in the community could be understood. The heterogeneity and variation in the population needed to be structured so that meaningful theory could be developed. Factor analysis thus was used as a preliminary technique to gain insight into the nature of the interdependencies of sociological variables and to develop structures which differentiated groups within the population.

POPULATION STUDIED

Madison, Arkansas, is an agriculturally based community of less than 1000 population in the eastern part of the state. Although about 75% of the population is black, whites in the community control much of the wealth and have substantially higher mean income ($6257 compared with $3264). The community has a high percentage of older residents, largely composed of couples or individuals who have left the plantations to retire. Many of the older residents have spent their lives as agricultural workers, and it has been only within the last decade that substantial industry has come into the area. The population, with relatively little education and few skills, remains generally poor.

Census statistics indicate that demographically Madison is representative of the Mississippi Delta region. Fifty-one percent of the respondents in the writers' sample had attained an educational level of less than 9 years; 48% of the households had total 1970 take-home income of under $3000. Today Madison is somewhat unusual among southern towns in having a city council composed entirely of black members and a black mayor. Black participation in community activities and voting is relatively high. Although the political activity of blacks may tend to separate the community from other towns, there is evidence of a trend throughout the South for blacks to become increasingly active in local politics. Recent studies have shown a growing feeling among blacks that through the election of local black representatives day-to-day living conditions can be improved.

There is great income and socio-economic variation within both the black and white segments of the community. For example, Madison has a history of a black bourgeoise. For several generations a black millionaire family has exerted great influence on local affairs. The family has made a sizable fortune by farming, lumbering, operating a cotton gin and wooden casket factory, and most recently by preparing an embalming fluid that is distributed to black mortuaries. Black solidarity is certainly not manifested economically, nor is it manifested attitudinally. What attitudinal and socio-economic traits correlate with one another? What are the bases upon which population groupings cluster? Such questions can be answered by factor analysis of the data.

METHOD OF FACTOR ANALYSIS

Social scientists are increasingly turning toward the statistical technique known as factor analysis to uncover major social patterns. The social scientist who is faced with large amounts of data and unknown interdependencies may profitably use factor analysis because the technique can manage simultaneously more than 100 complexly interrelated variables and can disentangle their linear relationships.

The method of generalized factor analysis utilizes the correlation matrix which expresses the linear relationships between all possible pairs of n variables. This matrix is factored or partitioned into orthogonal, independent components which geometrically represent axes that are associated with underlying patterns of relationships in the original matrix. The first factor isolated represents the axis which accounts for the most variance of the data in n-dimensional space. Each successive factor accounts for a lesser amount of this variance. This method of analysis allows one to delineate objectively patterns of co-occurrence of variables, and thereby to isolate the major dimensions in the data.

The writers' application of factor analysis was intended to be a multipurpose approach. Survey data gathered by questionnaire were amenable to a factor analytic approach for several possible objectives. First, the primary independent dimensions of attitudinal and/or behavioral characteristics of the population were isolated. The nature of the dimensions delineated is dependent on the type of variables included in the analysis. The factors represent derived artificial variables, each composed of a cluster of the original variables, and the derived variables characterize the units of observation.

Factor analysis also reduced a mass of information, based on a large number of variables, to an eminently smaller number of variables allowing an economical description. In the writers' study the raw data from 89 variables and 257 observational units defy summary description and interpretation. Factor analysis, however, reduced this data mass to four interpretable dimensions.

ANALYSIS AND RESULTS

Eighty-nine questionnaire items were selected for the factor analysis. Items chosen reflect a wide range of information pertaining to socio-economic status, participation in various community and national institutions, job patterns, and attitudes. The questions used were those involving a ratio or interval scale of measurement or those which were or could be dichotomized. Four factors were extracted from the inter-item correlation matrix: a socio-economic factor, an age-work attitude factor, a morality factor, and a participation factor.

Both a rotated and an unrotated solution were obtained. It was believed that the unrotated solution yielded a more general and complete picture of the factors. With rotation some loadings were higher, but fewer items loaded on the dimensions since some moderate loadings were lessened. Factor identification was unchanged by the rotation.

Factor I. Socio-economic Status (SES). A dimension representing socio-economic status was obtained from items having high loadings on Factor I. The relative directions of loadings represent configurations of correlated variables, indicating either high or low socio-economic status.

Factor I. Socio-Economic

Variable	Loading
Black	-0.41180
Own or buying house	0.52127
Over 40 years old	-0.30006
10th grade or less education	-0.32816
Employed full time	0.47373
3 or fewer rooms in house	-061256
Has kitchen sink	0.76981
Has inside flush toilet	0.73822
Has bath tub	0.77106
Has telephone	0.50454
Has operating car or truck	0.65328
Has record player	0.47893
Has toaster	0.42130
Has vacuum cleaner	0.62390
Has air conditioner	0.57330
Has clothes dryer	0.50012
Has health problems	-0.38045
Is employed or unemployed 6 mo or less	0.51743
Total household pay under $4000	-0.59731
Would take special training to get or better present job	0.46052
Would drive 25 mi to work	0.35827
"It's easy to have friends; a person just needs to try to be friendly"	0.21197
"You need the right breaks for a marriage to be happy"	-0.20789
"I've got plenty of time; I don't mind waiting"	-0.21865
"If the breaks are against you, you can get into trouble"	-0.25826
Has income from retirement	-0.34813
Has income from welfare	-0.51179
Has income from salary	0.59979

High SES is correlated positively with white racial identity, home ownership, age under 40, 10th grade or better education, material possessions such as running water, kitchen sink, inside flush toilet, gas or electric range, toaster, bath tub, telephone, clothes dryer, operating car or truck, vacuum cleaner, air conditioner, and home with more than three rooms. High SES is associated with an absence of health problems and a willingness to take special training to improve job skills or to travel 25 mi each day to work. A family income exceeding $4000 a year is correlated positively with the foregoing traits. Low SES is reflected by such correlated traits as black racial identity, age over 40, less than 10th grade education, absence of selected material possessions, health problems, and expressed unwillingness to make efforts to gain employment. High SES is correlated with the internal-external control statement: "It's easy to have friends; a person just needs to try to be friendly," whereas low SES is correlated positively with the statements: "You need the right breaks for a marriage to be happy,"; "I've got plenty of time; I don't mind waiting," and "If the breaks are against you, you can get into trouble."

SES apears to be an important discriminating dimension in the population. This is certainly not unexpected in light of the considerable attention that has been paid to SES as a predictor of attitudinal and behavioral traits.

Factor II. Age-Work Attitudes. A substantial part of the Madison population is old and unable to work. The social importance of this aged sector of the population was reflected in Factor II. Such variables as 10th grade or lower education, age over 40, absence of special training, and lack of full-time employment are correlated positively and represent an empirically definable and sociologically important segment of the Madison population. Such persons tend to be or to have been married, to visit friends relatively infrequently, to own or to be buying their own homes, and to have voted in the 1968 national elections. Unemployment is correlated positively with a tendency not to be looking for work and an unwillingness to take special training, drive 25 mi to work each day, move 50 mi to obtain work, or accept employment if it were offered. Variables loading on Factor II appear to be correlated because of the homogeneity in work attitudes and life patterns of the aged sector of the Madison community.

Factor 2. Age-Work Attitudes

Variable	Loading
Own or buying house	0.25692
Over 40 years old	0.59825
10th grade or less education	0.31295

Special training	-0.23964
Never married	-0.38616
Employed full time	-0.35942
Sees 2 or more friends once a week or more	0.25017
Voted national in 1968 elections	0.29246
Has health problems	0.22112
Is employed or unemployed 6 mo or less	-0.31091
Is employed or unemployed and looking for job	-0.40564
Is employed or unemployed and would accept emp.	-0.41288
Total household pay under $4000	0.15641
Has visited employment security office	-0.48277
Would take special training to get or better present job	-0.61556
Would move at least 50 mi to work	-0.51774
Would drive 25 mi to work	-0.60217
Has income from retirement	0.46770
Has income from salary	-0.28321

Factor III. Morality. All statements from the Attitudes Toward Deviance Scale loaded heavily on Factor III, indicating that a significant portion of Madison residents felt that such behavior as drinking heavily, not working, getting into fights, marital separations, not saving money, and child neglect were very wrong. Such attitudes toward deviant behavior were associated with behavioral variables such as attending church at least 45 times a year, relatively frequent get-togethers with friends, and an absence of an arrest record. There is some tendency for these attitudes and behavioral patterns to be associated with black females. Strict attitudes toward morality are associated with internal control, as there are positive loadings for the statements: "If you've got ability, you can always get a good job,"; "What's happened to me has been my own doing,"; "I prefer to have things all worked out in advance," and "It's better to put money aside so you'll have it when you really need it." Concern with morality is sociologically important and empirically manifested in the rural community where social activities center around the church, a multipurpose institution. In such a setting church membership and attendance serve to incorporate the individual into many aspects of community life.

Those individuals more tolerant of deviant behavior tended to be white males whose more moderate attitudes toward morality were reflected on the Attitudes Toward Deviance Scale statements. Such individuals tended to attend church infrequently, seldom get together with friends, and to be somewhat externally controlled as evidenced by agreement with the statement: "There's not much the average person can do about how the government runs."

Factor 3. Morality

Variable	Loading
Black	0.16578
Female	0.26512
Military service	-0.22809
Attends church at least 45 times a year	0.30622
Get-togethers once a month or less	-0.19397
Arrests other than parking violations	-0.25360
"If you've got ability, you can always get a good job"	0.21035
"What's happened to me has been my own doing"	0.18398
"I prefer to have things all planned in advance"	0.15798
"Working hard and steady is the way to get ahead in a job"	0.19294
"Not much average person can do about how the government runs"	-0.24773
"Better to put money aside so you'll have it when you really need it"	0.28226
Woman a heavy drinker is wrong	0.51125
Wrong not to work steady when he could	0.48404
Getting into fights is wrong	0.57510
Husband and wife separating is wrong	0.39103
Man a heavy drinker is wrong	0.63526
Married man fooling around with other women	0.55959
Wrong for parents to not stay home with their kids most of the time	0.57862
Not paying debts is wrong	0.54929

Factor IV. Participation. Participation in community and national-level activities is correlated with sex, education, religious attitudes, voting behavior, and attitudes toward work availability. White males tended to exemplify the nonparticipant in Madison. Such persons tended to have completed 10 or fewer grades of school, to attend church infrequently, to be non-church members, and to have little interest in voting. Black females, in contrast, best exemplify the Madison participant who is a church member, attends church regularly with her spouse, voted in the 1968 national elecions, and plans to vote again in the 1972 national elections. Participation is correlated with internal control: "What's happened to me has been my own doing." Non-participation correlates with the external statements: "Live in the present, the future will take care of itself" and "There's not much the average person can do about how the government runs."

Factor 4. Participation

Variable	Loading
Black	-0.41735
Female	-0.30420
Baptist or Methodist	-0.33249
10th grade or less education	0.23653
Attends church at least 45 times a year	-0.26879
Spouse attends church at least 45 times a year	-0.20864
Plans to vote national in 1972 elections	-0.39571
Voted national in 1968 elections	-0.40684
Feels economic conditions worse than 5 years ago	0.38197
Feels job situation is good	-0.15757
"What's happened to me has been my own doing"	-0.19332
"Live in present, the future will take care of itself"	0.18236
"Not much average person can do about how the government runs"	0.22716

SUMMARY AND CONCLUSIONS

Factor analysis served as a valuable exploratory tool by which to structure questionnaire variables and to discern important dimensions in the population. Four significant dimensions extracted from the iter-item correlation matrix provided information pertaining to the nature of population heterogeneity. The significant dimensions on which groups were distinguished related to age, sex, and racial differences as well as socio-economic standing, job experiences and job-related attitudes, participation in community and national organizations, and attitudes related to internal-external control and deviant behavior. Thus, the nature of the population was understood better by the application of factor analysis to the questionnaire data. Factors served to delineate groups of related variables which represent important dimensions in the population and demonstrated the applicability of the I-E Control and Attitudes Toward Deviance Scales. Significant dimensions were established through an objective procedure, rather than by *a priori* means. Factor analysis demonstrated that the questionnaire was valid--that it tested those dimensions that it had been designed to test. Additionally the factor analysis pointed out social inter-relationships of which the researchers were initially unaware.

ACKNOWLEDGEMENTS

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Limnology of Four Bauxite Open-Pit Lakes

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ABSTRACT

The aquatic flora and fauna and 18 physicochemical characteristics of four bauxite open-pit lakes were studied from September 1969 to August 1970. The least acid lake (pH 3.4-4.4) supported 49 different aquatic insects, plankton, and higher aquatic plants. The most acid lake (pH 2.7-3.2) supported only 26 different plants and animals. Bauxite open-pit lakes within the pH range studied appear to be as relatively unproductive as their coal strip-mine lake counterparts, with which they share physicochemical and biological characteristics. Benthic macrofaunal diversity and abundance appear to be related more closely to distribution and abundance of leaf detritus than to hydrogen-ion concentration.

INTRODUCTION

The process of open-pit mining for aluminum ore, or bauxite, commonly leaves pits which subsequently fill with water. Initially, such lakes may contain water contaminated with sulfuric acid formed from the oxidation of sulfur compounds associated with the bauxite. To date, 2,835 ha near Bauxite, Saline County, and Little Rock, Pulaski County, Arkansas, have been mined for bauxite. As recently as 1966, 96.6% of the bauxite mined in the continental United States came from Arkansas (Stroud et al., 1969).

No investigation has been conducted previously concerning the physicochemical or biological characteristics of open-pit lakes resulting from bauxite mining (Spaulding and Ogden, 1968). A preliminary survey in Saline County, Arkansas, concerning acid water drainage from bauxite pits into nearby streams was conducted by the Arkansas Pollution Control Commission in 1964, but the resulting report had a limited distribution.

The purpose of this study is to describe qualitatively and quantitatively the physicochemical characteristics and the aquatic flora and fauna of four open-pit lakes resulting from bauxite mining. The lakes studied are 40 km southwest of Little Rock in Saline County, Arkansas. Lake 1 is in the NE ¼ Sec. 26, T2S, R15W; lake 2 is in the NE ¼ Sec. 24, T2S, R14W; lakes 3 and 4 are in the SE ¼ Sec. 11, T2S, R14W.

MATERIALS AND METHODS

Surface samples for physicochemical analysis and qualitative samples of the aquatic insects were collected monthly from each lake from September 1969 through August 1970. In addition, during June-August 1970, monthly quantitative samples of benthos and plankton and vertical series for physicochemical analysis were taken from each lake. The vertical series consisted of a surface sample, one at a depth one-half the distance of the bottom, and one near the bottom.

Potential free acidity of 59 water samples was determined by hot titration (Rainwater and Thatcher, 1960); pH by Beckman Expandomatic pH meter; specific conductance by wheatstone bridge; NO_3 by phenoldisulfonic acid method, SO_4 by turbidimetric method, and Al by spectrophotometric method (APHA, 1965); and Ca, Co, Cu, total Fe, K, Mg, Na, Ni, Sr, and Zn by atomic absorption (Reid, 1970).

Bottom samples (48) were secured from the shallow and deep parts of each lake with a 15.2 x 15.2-cm Ekman dredge, washed through a screen of 11.8 sq/linear cm, preserved in 5% formalin, and later sorted mechanically and transferred to 70% ethanol. Qualitative samples were procured with a dip net. Sample size for net plankton was 100 l, obtained by a Kemmerer water bottle and strained through a standard Wisconsin net of No. 25 nylon bolting cloth. Preservtion was by 70% ethanol. Plankton enumeration was by the differential count method (Welch, 1948). Triplicate determinations of primary production in lakes 3 and 4 on 18-19 July were by a modification (McConnell, 1962) of the diel oxygen curve procedure of Odum (1956) and Odum and Hoskin (1958), which are methods especially applicable to small, quiet bodies of water.

RESULTS AND DISCUSSION

The salient physicochemical feature of the four lakes studied is the clear, highly acid nature of their waters. The source of acidity is apparent inasmuch as the sulfate ion is the predominant anion, 106-1130 ppm (Table I). The acid nature of these waters is reflected further in the pH values, range 2.7 to 4.4, and potential free acidity, range 11 to 497 mg/l. The acid condition facilitates the solution of many other minerals. Aluminum, calcium, magnesium, and sodium are present in high concentrations. The heavy load of dissolved materials results in high specific conductance values, range 180 to 1940 mhos at 25 C. The high hydrogen-ion concentration flocculates the naturally occurring suspended clay particles of waters in the study area, resulting in such clarity that objects on the lake bottom may be seen at depths of up to 7.5 m.

The morphometry of these lakes augments both degree and duration of acid pollution. Steep slopes and restricted watershed, consisting largely of spoil banks, are characteristic of all four lakes.

Seasonal fluctuations in the ionic concentrations of the bauxite-lake surface waters were not great and their patterns were not discernable. Whereas some ions decreased during the winter, others increased or remained relatively constant. Also, the pattern for a specific ion varied between lakes. Although thermal stratification occurred during the summer, vertical distribution of the ionic concentrations was essentially constant, suggesting a homogenous condition for these waters.

Table I. Mean Values for Physicochemical Characteristics of Four Bauxite Open-Pit Lakes, Saline County, Arkansas, September 1969-August 1970 (sample numbers were 12 for lakes 1 and 2, 18 for lakes 3 and 4).

Item	Lakes 1	2	3	4
Approximate year formed	1960	1948	1948	1948
Maximum depth (m)	2.5	8	18	8
Specific conductance (υmhos@25C)	302	1198	1044	1564
pH	3.9	2.9	3.4	2.9
Potential free acidity (mg $CaCo_3$/1)	44	282	194	433
Sulfate (ppm)	132	443	575	879
Nitrate[1] (ppm)	0.08	0.12	0.13	0.13
Aluminum (ppm)	5.2	24.3	23.5	49.7
Calcium (ppm)	18	47	110	120
Cobalt (ppm)	0	0.4	0	0.3
Copper (ppm)	0.04	0.1	0.3	0.2
Total iron (ppm)	0.2	10.3	0.4	13.9
Magnesium (ppm)	6.2	13.4	31.2	29.5
Nickel[1] (ppm)	0	0	0	0
Potassium (ppm)	2.9	3.9	5.4	3.87
Sodium (ppm)	6.1	7.1	18	13.8
Strontium (ppm)	0.9	1.8	4.0	4.0
Zinc (ppm)	0.21	0.27	0.45	0.78

[1] One or two determinations only.

If decline in potential free acidity is used as a criterion for ecological age of an acid lake, lake 4 appears to be the youngest, followed in order by lakes 2, 3, and 1. As noted in acid coal strip-mine lakes (Campbell and Lind, 1969), a distinct reduction in specific conductance is associated with a decrease in acidity; ionic concentrations in general diminish with decreasing acidity (Table I).

It has long been recognized that species diversity decreases with increased pollution (Patrick, 1950). In this study, lake 1 supported 35 different aquatic insects (Table II). Four species of higher aquatic plants (*Typha angustifolia* Linnaeus, *Juncus diffusus* Bulk., *Scirpus atrovivens* Willd, and *Sphagnum magellanicum* Brid.) and 10 plankton taxa (Table III) also were described from lake 1. It was the least acid lake (Table I). Conversely, the most acid lake, lake 4, supported only 16 different aquatic insects, one higher aquatic plant, *Typha angustifolia*, and nine plankton taxa (Tables I-III).

Table II. Aquatic Insects in Four Bauxite Open-Pit Lakes: Frequency of Occurrence in 12 Monthly Samples, September 1969-August 1970

Taxa	Lake 1	2	3	4
DIPTERA				
Ceratopogonidae	0	3	0	0
Chironomus n. sp.	9	11	6	7
Culex territans Walker	1	0	0	0
Tabanus sp.	1	0	0	0
COLEOPTERA				
Onychylis nigrirostris (Boh)	2	1	0	0
Agabus disintegratus (Crotch)	0	1	0	1
Coptotomus interrogatus obscurus Sharp	5	9	2	0
Cybister fimbriolatus crotchi Wilke	0	0	0	1
Cybister L.[1]	2	0	0	0
Graphoderus sp.	0	1	0	0
Hydroporus consimilis LeConte	0	9	0	0
H. pilatei Fall	0	5	0	1
Ilybius confusus Aubé	2	0	0	0
Ilybius L.[1]	1	1	0	0
Laccophilus maculosus maculosus Say	3	0	9	2
Laccophilus L.[1]	1	0	2	1
Thermonectus basillaris Harris	1	4	0	2
T. ornaticollis Aubé	2	0	1	0
Dineutus assimilis (Kirby)	12	11	11	6
D. carolinus LeConte	1	0	0	0
Dineutus L.[1]	2	4	3	1
Gyrinus affinis Aubé	0	3	4	3
Haliplus triopsis Say	1	4	0	0
Peltodytes dunavani Young	0	2	0	0
Berosus fraternus LeConte	0	1	0	0
B. infuscatus LeConte	1	1	3	0
B. pallescens LeConte	0	3	2	0
B. pennsylvanicus Knisch	10	7	9	5
Berosus L.[1]	5	3	4	0

Enochrus ochraceus (Melsh.)	1	1	1	0
Helophorus sp.	1	0	0	0
Paracymus subcupreus (Say)	1	0	1	0
Tropisternus lateralis nimbatus (Say)	5	6	5	3
Hydrocanthus iricolor atripennis Say	0	1	0	0
Suphisellus bicolor (Say)	0	1	0	0
MEGALOTA				
Chauliodes	2	1	0	0
Sialis	6	10	0	0
ODONATA				
Anax junius (Drury)	7	2	2	3
Celithemis elisa (Hagen)	2	0	0	0
Ladona sp.	1	0	0	0
Libellula luctosa Burmeister	1	0	0	0
Sympetrum madidum (Hagen)	2	0	0	0
Tramea lacerata Hagen	8	0	0	0
Enallagma	1	0	0	0
Ischnura	5	0	0	0
HEMIPTERA				
Lethocerus griseus (Say)	0	0	0	1
Hesperocorixa sp.	0	1	0	0
Sigara pectinata (Abbott)	0	5	6	10
Gerris marginatus Say	3	1	1	1
Trepobates inermis Esaki	1	0	0	0
Hydrometra martini Kirkaldy	1	2	4	0
Buenoa confusa Truxal	5	1	0	0
B. scimitra Bare	0	1	2	0
Notonecta indica Linnaeus	9	1	2	1
Mesovelia mulsanti White	3	0	4	5
Total Taxa	35	32	19	16

[1] L=larval beetle.

Typha angustifolia was the only higher aquatic plant in lakes 1, 2, and 3, and in each instance it was limited to a small delta which was caused by erosion and covered by shallow water. The senior author has observed that this cattail species is the first higher aquatic plant to invade coal strip-mine lakes with an approximate pH value of 3.6 or less. Only with diminished acidity do other species appear.

Qualitatively and quantitativley the plankton community was limited in all four lakes. Each lake supported 9-10 taxa and a standing crop of 0.5-29 organisms per liter (Table III). Nelson and Harp (in press), studying the new plankton of a relatively unproductive lake, reported a mean summer standing crop of 284 organisms per liter, representing 55 genera. In lakes devoid of limiting factors, mean annual standing crop values commonly reach several hundred thousand organisms per liter or more (Harris and Silvey, 1940; Pennak, 1946, 1949).

The most diverse community in these acid lakes was the benthic macrofauna. Even their diversity was limited in comparison with unpolluted lentic communities of similar size. Harp and Campbell (1964) reported 79 benthic macroinvertebrate taxa from a Missouri pond. Kenk (1949) recorded 79-127 benthic faunal forms from four ponds in Michigan.

The paucity of benthic macroinvertebrate species in the acid bauxite lakes is emphasized when one realizes that most species found were not present throughout a given lake. Characteristically, many were found only in the restricted stands of cattails. The quantitative data further support this observation. The benthic fauna ranged from 511 (lake 1) to 5479 organisms per square meter (lake 2). The larger populations were invariably in the deep water and were composed almost entirely of *Chironomus* n. sp. Presumably this species is favored by an acid environment. Because it can develop in these acid waters, it profits from the lack of competition (e.g. other chironomids) and predation (fish) and builds these characteristically dense populations (Harp, 1969).

The absence of benthic macrofauna other than insects is due to the absence of calcium carbonate for shell development in mollusks. Also, the epidermis of soft-bodied forms is susceptible to potential coagulation in this mineral-acid environment.

Species diversity did not correlate precisely with hydrogen-ion concentration. The second most acid lake supported the second largest number of species, 42, whereas only 29 taxa were identified from the less acid lake 3. The writers observed a closer relationship between species diversity and the distribution and abundance of leaf detritus. Lakes 1 and 2 have trees around significant portions of their shorelines, whereas lakes 3 and 4 have practically none. The leaf detritus apparently provides shelter and a direct or indirect food source for the aquatic insects in an otherwise barren habitat. Harp and Campbell (1967) first reported this correlation between leaf detritus and a midge larva which was identified mistakenly as *Tendipes plumosus* Linne'. In fact it is a still undescribed species, which was taken from the acid bauxite lakes by the writers and is designated as *Chironomus* n. sp. (Table II).

The primary production in lakes 3 and 4 on 18-19 July 1970 was nonexistent. Differences in dissolved oxygen values never varied more than 0.5 ppm in triplicate series, and dawn values

Table III. Net Plankton Collected in Surface Samples from Four Bauxite Open-Pit Lakes, Saline County, Arkansas, June-August 1970

Taxon	Lake 1		Lake 2		Lake 3			Lake 4		
	6/27	8/15	6/27	8/15	6/27	7/18	8/15	6/27	7/18	8/15
Cladophora			X							
Mougeotia			X					X	X	
Zygnema			X							
Arcella	X	X	X	X		X	X	X	X	
Difflugia	X				X	X			X	
Ceratium		X	X	X		X		X		
Diatoma	X									
Brachionus	X	X	X	X	X	X	X	X	X	X
Keratella					X	X		X		
Notholca		X	X							
Tetramastix	X				X	X	X	X	X	
Tardigrada		X								
Ostracoda						X				
Calanoida									X	
Cyclopoida	X					X				
Nauplii	X		X	X		X				
Ceriodaphnia	X	X	X	X	X	X	X	X	X	X
Hydracarina		X								
Total No./Liter	11	2	5	0.5	8	3	29	3	1	4
Total Taxa/Lake	10		9			9			9	

after presumed respiration all night were on occasion higher than the preceding dusk values. Minute changes in dissolved oxygen content were probably due to temperature change and simple diffusion.

In conclusion, the four bauxite open-pit lakes appear to be relatively unproductive. They can be compared with coal strip-mine lakes of similar pH, with which they share physicochemical and biological characteristics (Campbell and Lind, 1969; Harp, 1969). Finally, within the pH range studied, benthic macrofaunal diversity and abundance appear to be more responsive to distribution and abundance of leaf detritus than to hydrogen-ion concentration.

ACKNOWLEDGMENTS

The writers are most grateful for specific identification of the insects to: Russel D. Anderson, Dytiscidae; James R. Zimmermann, *Laccophilus;* Frank N. Young, Haliplidae, Hydrophilidae, Noteridae; F.E. Wood, Gyrinidae; James E. Sublette, *Chironomus* n. sp.; Vasco M. Tanner, Curculionidae; Fred S. Truxal, Notonectidae; and J.L. Herring, Corixidae, Gerridae. J. Edward Bennett determined specific conductance values. Richard S. Mitchell supervised the determination of certain ions.

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Anatomical and Behavioral Aspects of Killing and Feeding by the Least Weasel, *Mustela nivalis* L.

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ABSTRACT

The least weasel (*Mustela nivalis*) is a remarkably well adapted predator of mice and other small animals. Each kill is rather stereotyped, in that the weasel grabs the prey by the nape of the neck and bites through the base of the skull and/or throat, using its lithe body to "wrap up" and hold the prey. The least weasel will kill mice successively until it is too exhausted physically to kill more. Mice are always eaten from the head posteriorly until completely consumed.

The least weasel (*Mustela nivalis* L.), the smallest living carnivore, is an extremely well adapted and efficient predator. Its chief food item is mouse-size mammals; small invertebrates and birds also are eaten (Allen, 1940; Day, 1966, 1968; Hurrell, 1966). The weasel is long and slender (140-210 mm); males weigh between 60 and 90 g and females between 40 and 70 g. The short legs, tail, and ears allow it to travel freely along surface runways and burrows constructed by small mice. It is very agile and quick, with great variation in body movements and positions.

The observations and conclusions contained herein are the result of numerous observations of killing and feeding by members of a colony of least weasels maintained in the Michigan State University Live Animal Colony between 1966 and 1970 (see Heidt, 1970, for details of the colony). Llewellyn (1942) described killing and feeding; however, his observations were limited to only one weasel over a period of several days. Several additions and differences were found by the writer. Short (1961), Allen (1940), East and Lockie (1964), and Polderboer et al. (1941) described various aspects concerning the amounts of food consumed by least weasels.

The killing behavior of the weasel is rather stereotyped. The weasel generally seizes the prey at the nape of the neck and bites through the base of the skull and/or throat area. The weasel may first grasp a prey item almost any place on the prey's body in order to gain leverage for the neck bite, using its feet to manipulate the prey and commonly wrapping its long, slender body around the victim for more leverage. Llewellyn (1942) never observed his weasel to release its grip until the mouse was dead. However, in our colony the weasels commonly would drop a mouse after immobilizing it. At times they would play with the mouse much as a house cat might. If a second mouse was placed in the cage the weasel usually would immobilize the first and then catch and kill the second, returning to kill the first if it had not already died. The entire killing procedure is generally very rapid, ranging from 10 to 60 sec. The attack stimulus seems to be movement by the mouse, as weasels have been observed to pass within inches of a completely still mouse without seeming to see it. The weasel is a voracious killer in that it will kill one mouse after another until too exhausted physically to kill more. At one time when seven mice were placed in a cage with one weasel, the weasel immediately and systematically killed all seven and began a search pattern of the cage for more mice.

As stated previously (Heidt, 1970), killing in the least weasel appears to be innate, because young separated from their mother and litter mates before their eyes were open could kill mice at 50-60 days of age with no previous experience. However, these animals made several attempts before they were successful. In several cases it was observed that young were "trained to kill" by their mother (Heidt et al., 1968), and as a result these young were more efficient at an earlier age (40-45 days) in capturing and killing mice.

When feeding, a least weasel always begins by eating the brain and head, and then proceeds posteriorly until the entire mouse is consumed. Llewellyn (1942) found that if blood was present on the fur of a freshly killed mouse, the weasel would lick it off, but in no case did the weasel "suck the blood" from the prey. This finding is consistent with the writer's observations, and deserves to be emphasized because of misinformation concerning weasel feeding and blood sucking. It does not tear meat from the prey as many other carnivores do, but uses well developed carnasial teeth to slice meat from the food source. In addition, the weasel occasionally uses its front feet to manipulate the prey while feeding, an observation which is in contrast to Llewellyn's. Llewellyn also observed that if more than one mouse was present the weasel would finish eating the first before starting on another. The writer observed that in most cases the weasel would eat the head and brain of all available mice and then return to one of them and finish it. As in Llewellyn's study, if a great quantity of food was available, the nose, teeth, and tails were not eaten. Mice killed 24 hours earlier which had begun to decompose and smell were not touched unless the weasel had been deprived of food for some time.

On five different occasions large grasshoppers were given to five different weasels. In all cases the insects were killed either by a quick bite through the thorax or by beheading. In two cases the grasshoppers were ignored after being killed, whereas in the other three they were consumed totally or partially. In no case were the wings or legs eaten.

The weasel is very jealous of its kills and will readily chirp warnings and attack an intruder attempting to remove the killed prey. That it is extremely tenacious can be illustrated by the fact that if a dead mouse is held off the ground, a weasel will hang on with its mouth to the point of being lifted and swung back and forth several inches above the floor of the cage.

These observaions show that the least weasel is highly adapted for capturing and killing prey items. It often is maligned for alleged attacks on chickens and other small domestic animals, but actually benefits the farmer by annually killing and destroying numerous small rodents which, if not controlled, can cause large economic losses.

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Bioclimatic Chambers for Poultry Research: Design and Preliminary Results of Testing

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ABSTRACT

The 12 new environmental chambers for poultry research recently completed at the University of Arkansas feature solid state electronic systems to control dry bulb temperature and dew point of the chamber air. Dry bulb temperature is controlled by reheating previously cooled and dehumidified air by an electric heater installed in each supply air duct. Solid state controls proportion the flow of electricity to the heater to match the demand. The system is arranged to maintain constant temperature on a diurnal temperature cycle. A solid state time-proportioning control maintains a pre-selected dew point in each chamber. The control operates a solenoid valve to admit steam in regular pulses of varying duration to add moisture to the supply of air as needed. Automatic systems to control drinking water temperature and air flow rate also are included. The use of electronic controls, with electric heat, has resulted in environmental control systems of high precision with minimal mechanical complexity. The chambers are being used to study the response of broilers to different brooding temperature schedules and drinking water temperatures.

INTRODUCTION

Dependable facilities, capable of maintaining desired environmental conditions, are essential for research in environmental effects on animals and poultry. With financial aid from the poultry industry and allied industry, a laboratory for environmental research with poultry was constructed at the University of Arkansas. The major feature of this laboratory is a set of 12 environmental chambers in which the environmental variables of dry bulb temperature, dew point, light quality and duration, and water temperature can be controlled.

The environmental chambers, designed by the Agricultural Engineering Department, incorporate novel control systems which are expected to provide improved performance and dependability. The purpose of this paper is to describe the control methods used.

CHAMBER DESIGN CRITERIA

To provide for a broad spectrum of research environments, the following criteria were established.

1. Dry bulb temperature range 35 to 105 F (2 to 41 C).
2. Dew point temperature range 35 to 95 F (2 to 35 C).
3. Air movement not to exceed 300 fpm at floor.
4. Air exchange rate fixed at 300 cfm.
5. Size approximately 8 ft wide x 12 ft deep x 7 ft high.
6. Chamber ambient conditions - design value of 80 F (27 C) maximum dry bulb; 69 F (20 C) maximum wet bulb in summer to 70 F (21 C) dry bulb minimum in winter.
7. Automatically controlled lighting schedule.
8. Controlled drinking water temperature.

PHYSICAL ARRANGEMENTS

The 12 chambers are arranged in two continuous rows of six each, as shown in Figure 1. Each chamber is controlled independently but has airtight insulated partitions in common with its neighbors. Control of environment is achieved by continuous flow of temperature- and moisture-controlled air. No air is recirculated, and no control equipment except sensors is in the chambers. The chambers are organized further into four groups. One group of four chambers is equipped for dry bulb temperatures and dew points down to 36 F, another group of four is equipped to go down to 50 F, and two groups of two chambers are equipped for 60 F minimum operation. All the chambers within a group have common air filtration, cooling and dehumidifying, and exhaust systems. Within each group air from the room passes through a filter, across a direct-expansion coil where it is cooled and dehumidified, and then is discharged into a supply plenum. Cold air (300 cfm) enters a separate branch to each individual chamber, passing first through a measuring orifice, then over an electrical duct heater and a steam-jet humidifier, and through a manually adjusted damper before entering the chambers. Exhaust air is removed from the chamber through a system of ducts by an exhaust fan and is discharged above the roof of the building. Conditions in the plenum are maintained constant. Control of the chamber conditions is accomplished by controlling the inputs to the electric heater and to the humidifier, to reheat and rehumidify air from the plenum to the desired condition. A schematic diagram of the system is shown in Figure 2.

CONTROL SYSTEM DESIGN

The control functions of the air-handling system are fourfold.

1. Cooling and dehumidification of the room air entering the system by a direct-expansion coil. Control is by automatic by-pass valves supplying hot refrigerant gas to the low side of the refrigerant circuit to maintain constant suction pressure.

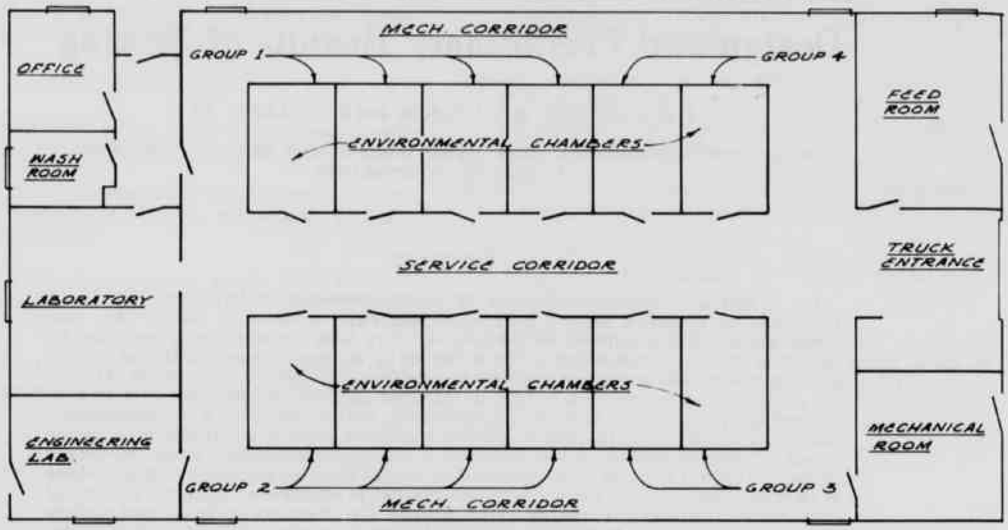

Figure 1. University of Arkansas Poultry Environmental Research Laboratory.

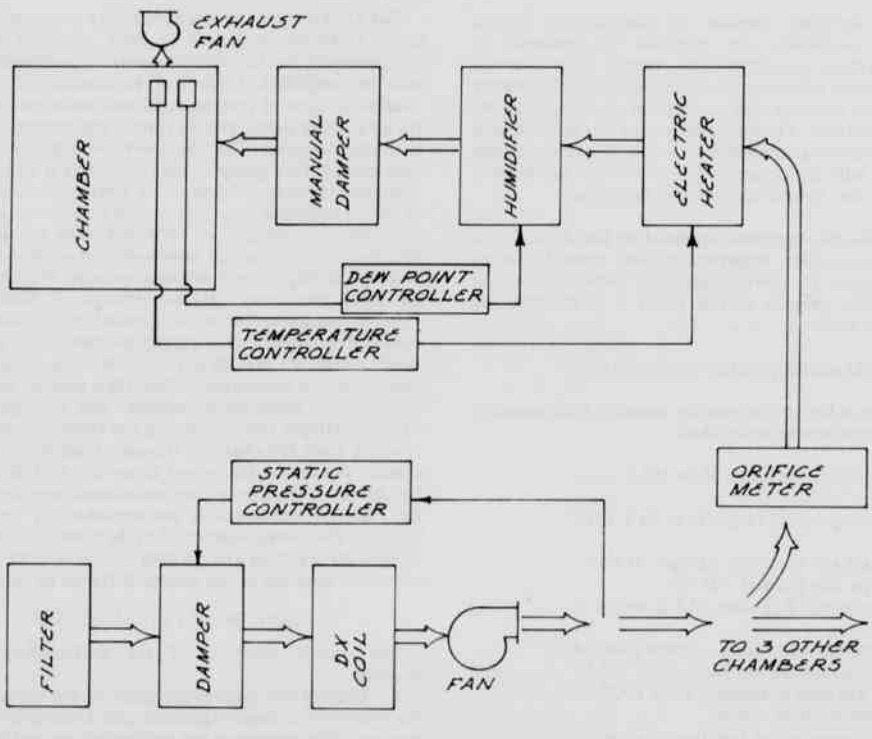

Figure 2. Air handling system for environmental chambers.

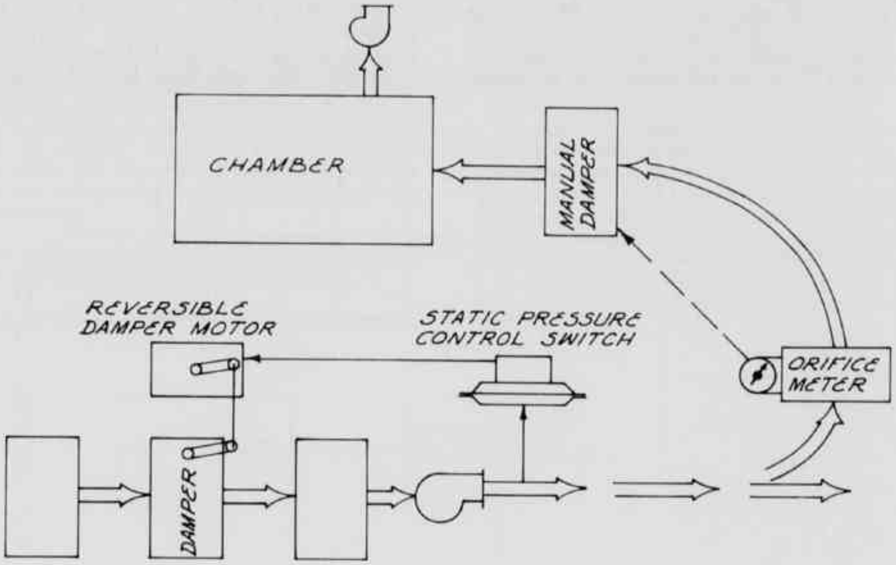

Figure 3. Air flow rate control system.

2. Control of air volume to each chamber. Volume is adjusted by a manual damper in conjunction with a measuring orifice in each branch. Static pressure in the supply plenum is maintained constant by a slack-diaphragm pressure controller operating in conjuction with a reversing slow-speed damper motor to position a restricting damper in the inlet to the plenum. This system is shown schematically in Figure 3.

3. Control of air temperature is by reheating of the cold supply air to the required level by an electric duct heater in each branch. A thermocouple near the exhaust outlet from the chamber senses the chamber temperature. A temperature controller (Honeywell R7272B) senses the departure of the thermocouple temperature from the set point (which may be established internally or by an external programmer, one-half of a Honeywell W806A two-cam programmer, at the user's option) and provides a signal voltage to control the power supply to the heater. The power supply is a 240-v, 6-kw, solid-state controller (Honeywell R7291A) which supplies a variable-length pulse of energy, typically consisting of several complete cycles of electric power, at a constant time interval. Typically the interval is 2 sec, but is adjustable. The power-pulse duration may range from 0 to 100% of each time interval, as shown in Figure 4. Arrangement of the system is shown in Figure 5.

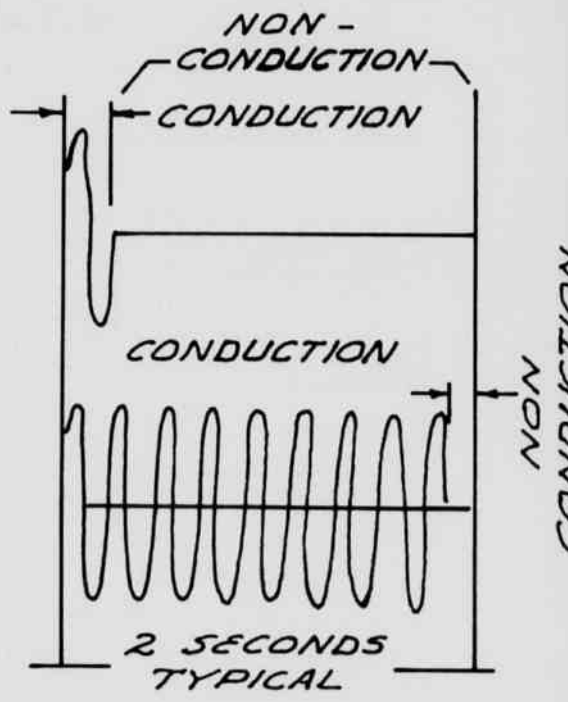

Figure 4. SCR power supply outlet wave form.

4. Control of dew point is by adding low-pressure steam as required to the air stream before it enters the chamber. The dew point of the air in the chamber is sensed by a Dew Probe sensor near the exhaust outlet. A Thermistor sensor in the probe cavity senses the cavity temperature. A solid-state time-proportioning temperature controller (Honeywell R7113A) controls at 25-sec intervals (intervals are adjustable) by opening a solenoid valve admitting steam to a nozzle in the air duct. The system thus admits pulses of steam of varying duration to maintain the temperature of the Dew Probe cavity constant. With frequent pulses the dew point of the comparatively large chamber is maintained essentially constant, although there must be some cyclic effect. A diagram of the dew-point control system is shown in Figure 6.

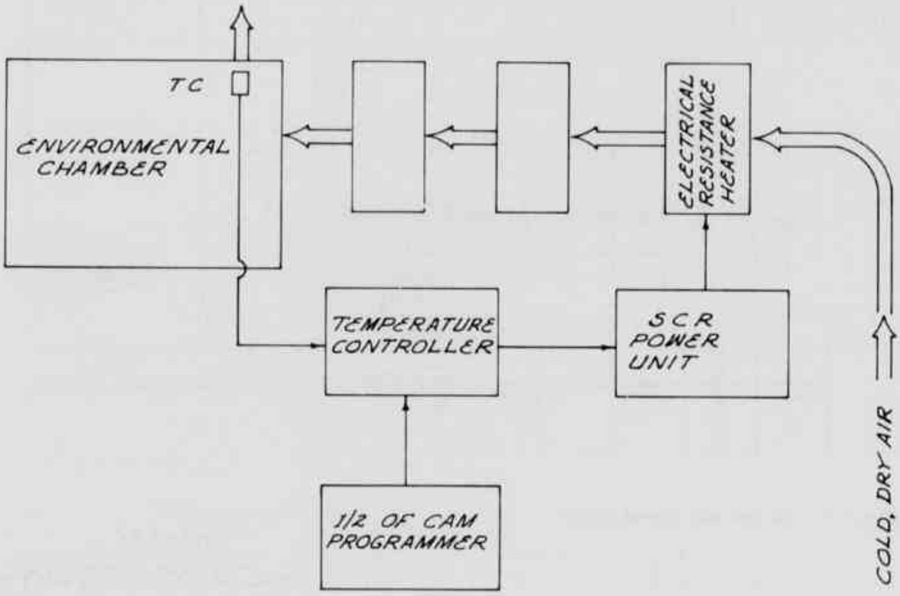

Figure 5. Temperature control system.

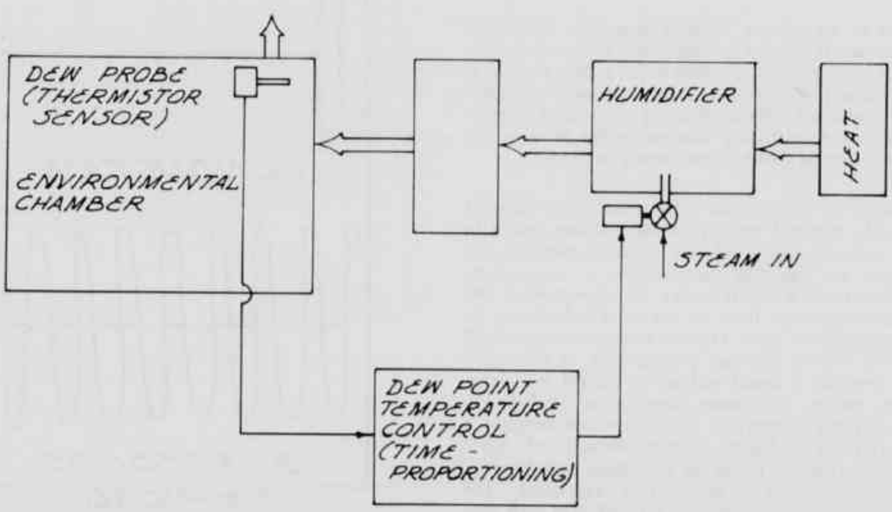

Figure 6. Dew point control system.

PERFORMANCE

Experience in raising the first flock of broilers in the chambers indicated that the control systems will nearly attain design performance. The temperature-control system performed very successfully but some failures occurred in electronic components, which necessitated careful supervision and occasional repair. The air-flow control system required no maintenance. Adjustments to the dew-point control system were needed to increase sensitivity and to eliminate condensation within the ducts. Some shakedown problems developed in the refrigeration equipment but have been corrected satisfactorily.

The time-proportioning action of the Honeywell Burst-Fire regulator gave exceptionally good temperature control.

Major problems developed with the water systems, mainly because of the need for continuous flow to maintain the drinking water at the desired temperature. Litter would get into the system and stop up the waste-water lines. Some problems also occurred with the temperature-control units. Redesign of the water systems and replacement of the mechanical controls with electronic controls has reduced these problems but has not eliminated them entirely.

The first year of operation was spent in investigating the response of broiler chickens to various brooding temperature regimes and drinking water temperatures. Different initial brooding temperatures, different rates of temperature decline with age, and different water temperatures were investigated. Analysis of results is incomplete, but indicates that growth and feed conversion are best with initial brooding temperature of 89 F (32 C), and that cooling the drinking water can help the chicken to adapt to higher ambient temperatures.

Herpetofauna of Sylamore Ranger District Ozark National Forest, Arkansas: Preliminary Report

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ABSTRACT

A survey of the amphibians and reptiles of the Sylamore Ranger District, Ozark National Forest, Arkansas, was conducted from May 1969 through May 1972. The district is composed of 170,000 acres and includes parts of Stone, Baxter, Marion, and Searcy Counties. A total of 533 specimens was collected during the study. An additional 72 specimens in the collections of Memphis State University and Arkansas State University were examined. Forty-nine species were recorded from the study area. These consisted of 8 salamanders, 12 frogs and toads, 4 turtles, 6 lizards, and 19 snakes. Two species collected during the study, *Scaphiopus holbrooki* and *Rana sylatica*, were not previously indicated by published range maps and range descriptions as occurring in north-central Arkansas.

INTRODUCTION

The purpose of this study was to determine the species of amphibians and reptiles present in the Sylamore Ranger District of the Ozark National Forest (Figs. 1, 2). The district is in north-central Arkansas approximately 30 mi south of the Arkansas-Missouri state line. The area consists of 170,000 acres of mountainous terrain, 80% of which is forested. The major part of the district includes northern Stone County and most of Baxter County south of the White River. The remaining part includes northeastern Searcy County east of Big Creek and southeastern Marion County east of the Buffalo River. The White River bounds the district on the north and east. The Buffalo River and Big Creek form the western boundary.

The district is in the southern part of the Salem Plateau and the northern part of the Springfield Plateau. It is in the area of a 60-mi-wide limestone belt that extends across three-fourths of northern Arkansas. The area is in the mature stage of the geomorphic cycle of erosion. Ridges are narrow and rounded. Rocks of the region are primarily limestone, sandstone, and shale in horizontal beds. Caves are numerous in the district. The area is cut deeply and intricately by many spring-fed streams, most of which are intermittent. The major stream within the district is North Sylamore Creek which flows into the White River. Elevation ranges from 320 ft on the White River to 1,250 ft in the southwestern part of the district.

Through normal ecological succession, the predominating deciduous forest has reached the oak-hickory climax. Thirty-six percent of the area, however, is in shortleaf pine.

The mean annual precipitation is approximately 46 in. Precipitation during the growing season, April to September, averages 23.8 in. Temperatures range from -2 to 105 F in an average year. The mean annual temperature is 58 F. The prevailing winds are out of the southwest and average 5 mph.

MATERIALS AND METHODS

A few preliminary collecting trips were conducted in May 1969. Daily collections were begun 8 June 1969 and continued through 15 August 1969. Subsequent weekend trips were made during the following 33 months. The number of trips varied seasonally, the more concentrated effort being made during the spring seasons.

Figure 1. Map of Arkansas indicating location of Sylamore Ranger District, Ozark National Forest, and general physiographic regions which appear to influence distribution of amphibians and reptiles in the state (modified from Dowling, 1957).

Collection sites were selected systematically to sample the various habitats of the district, with emphasis on areas adjoining recreational facilities. Although diverse habitats were sampled, intense investigation of more productive areas included repeated trips to these areas with concentrated day and night collecting.

Standard techniques for collecting, preserving, and storing specimens were employed. All specimens collected were placed in the Memphis State University Museum of Zoology. Specimens from the study area in the herpetological collections of Arkansas State University and Memphis State University

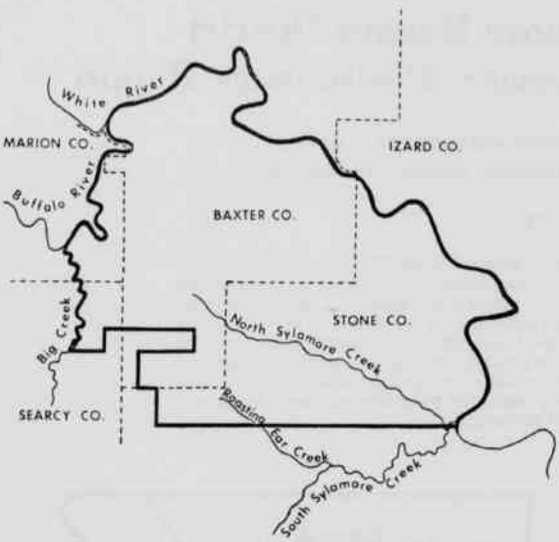

Figure 2. Map of Sylamore Ranger District, Ozark National Forest, Arkansas, indicating boundary and county line distinctions.

were examined and the results were included in the species accounts.

Questionnaires sent to 37 other colleges and universities and five museums resulted in no additional records of specimens from the study area.

No published records of herpetofauna from the district were found. Relatively few records concerning the distribution of amphibians and reptiles of the southern highlands of the Ozark Mountains were available. Stone (1904) and Hurter and Strecker (1909) published lists of amphibians and reptiles found in Arkansas but provided no records of herptiles from the counties within or adjacent to the Sylamore Ranger District. Taylor (1935) cited the presence of *Typhlotriton spelaeus* in Stone County, Arkansas, a part of which is in the district. Black and Dellinger (1938) and Dellinger and Black (1938) wrote the first general papers on the distribution of amphibians and reptiles in Arkansas, but neither paper gave data on species from the north-central part of the state. Dowling (1956) correlated the zoogeographic distributions of many species of salamanders on the Ozark Plateau with those of some of the endemic forms of the Interior Highlands. The latter included *Eurycea multiplicata multiplicata* and *Typhlotriton spelaeus,* both of which are present in the study area. Dowling (1957) reviewed the ranges, relationships, and numerous changes of nomenclature of Arkansas amphibians and reptiles. No specific records from the study area were cited.

RESULTS AND DISCUSSION

A total of 533 specimens was collected during the study. An additional 72 specimens from the study area in the collections of Memphis State University (MSUMZ) and Arkansas State University (ASU) were examined. Forty-nine species were recorded from the district. These consisted of 8 salamanders, 12 frogs and toads, 4 turtles, 6 lizards, and 19 snakes.

Two species collected during this study, *Scaphiopus holbrooki* (Harlan) and *Rana sylvatica* LeConte, had not been indicated previously by published range maps and range descriptions as occurring in north-central Arkansas (Schwardt, 1938; Bishop, 1943; Smith, 1946; Wright and Wright, 1949, 1957; Carr, 1952; Conant, 1958; Klauber, 1956; Dowling, 1957; Stebbins, 1966).

Several (26) additional species possibly are present in the Sylamore Ranger District, as indicated by these range maps and published range descriptions.

SPECIMENS EXAMINED

The following scientific names, through subspecies, are according to Schmidt (1953) except for recent revisions in nomenclature according to the Herpetological Information Search Systems of the American Museum of Natural History (1970). Common names were adopted from Conant (1956).

Ambystoma maculatum (Shaw), Spotted Salamander - **Stone Co.:** Tarwater Spring (T16N R11W S23), 1.

Ambystoma tigrinum tigrinum (Green), Eastern Tiger Salamander - **Stone Co.:** 2 mi S Calico Rock (T17N R11W S28),1.

Plethodon dorsalis augusticlavus Grobman, Ozark Red-Backed Salamander.-**Baxter Co.:** Farris Spring (T17N R13W S2), 1; sinkhole, Culp (T17N R12W S14), 1; hillside, Push Mtn. (T17N R13W S28), 1. **Stone Co.:** Mill Creek below dam, Blanchard Springs (T15N R11W S5), 1; Tarwater Spring (T16N R11W S23), 1; Partee Spring (T16N R11W S26), 1; Old Chimney, 2 mi N Fifty Six (T16N R12W S25), MSUMZ A-1586, 3.

Plethodon glutinosus glutinosus (Green), Slimy Salamander - **Baxter Co.:** Tassel Spring (T17N R13W S33), 1; sinkhole, Culp (T17N R12W S14), 1. **Stone Co.:** N Sylamore Creek, 1 mi E Blanchard Springs (T15N R11W S5), 5; Roasting Ear Creek near Clark Spring (T15N R12W S7), 1; Mill Creek below Clark Spring (T15N R12W S8), 1; Mud Spring, 3 mi SE Green Mtn. Tower (T16N R11W S20), 6; Partee Spring (T16N R11W S26), 1; spring, 3 mi E Cole Fork Rd. at Forest Rt. 1108-1 (T16N R12W S8), 2; N Sylamore Creek at Barkshed (T16N R12W S15), 2; Sandstone Creek, 1 mi NE Gunner Pool (T16N R12W S25), 5; Old Chimney, 2 mi N Fifty Six (T16N R12W S25), 2; Gunner Pool (T16N R12W S25), MSUMZ A-1011, A-1078, 2; Gunner Creek, 1 mi W Gunner Pool (T16N R12W S26), 6; 4 mi S Calico Rock (T17N R11W S28), 2.

Typhlotriton spelaeus Stejneger, Grotto Salamander - **Stone Co.:** S Prong Roasting Ear Creek at Forest Rt. 1106 (T15N R11W S2), 1; Slick Rock Hollow Cave, 1 mi N Sylamore Exp. Station (T16N R11W S17), 2; Livingston Creek at Forest Rt. 1139 (T16N R11W S21), 2; spring box, Gunner Pool (T16N R12W S25), MSUMZ A-981, 4; Gunner Cave, 2 mi W Gunner Pool (T16N R12W S27),1.

Eurycea lucifuga Rafinesque, Cave Salamander - **Stone Co.:** Mill Creek below dam, Blanchard Springs (T15N R11W S4), 1; natural entrance Blanchard Springs Caverns (T15N R11W S5), ASU-55, 2; Roasting Ear Creek near Clark Spring (T15N R12W S7), 1; Mud Spring, 3 mi SE Forest Rt. 1113 at 1102 (T16N R11W S20), 4; Hidden Spring, ½ mi N Sylamore Exp. Station (T16N R11W S20), 1; Tarwater Spring (T16N R11W S23), 1; Livingston Creek at Ark. Hwy. 5 (T16N R11W S26), 2; spring box, Gunner Pool (T16N R12W S25), 2; 1 mi W Gunner Pool (T16N R12W S26), 1; Gunner Cave, 2 mi W Gunner Pool (T16N R12W S27), 5; Branscum Cave, 3 mi SE Culp (T17N R11W S19), 1.

Eurycea longicauda melanopleura (Cope), Dark sided Salamander - **Baxter Co.:** spring, Cataract Creek at Forest Rt. 1105 (T17N R12W S23), 1; Farris Spring (T17N R13W S2), 1. **Marion Co.:** Middle Creek, ¾ mi from Buffalo River (T17N R14W S25), 1. **Searcy Co.:** spring, Spring Creek at Forest Rt. 1111 (T16N R14W S11), 5. **Stone Co.:** Wolf Pen Hollow, 2 mi E Blanchard Springs (T15N R11W S3), 1; Mill Creek below dam, Blanchard Springs (T15N R11W S4), ASU-60, ASU-737, ASU-747, 5; Roasting Ear Creek near Clark Spring (T15N R12W S8), 9; Clark Spring (T15N R12W S8), 4; spring, Ramsey Rd. at Forest Rt. 1106 (T15N R13W S2), 5; S Prong Roasting Ear Creek at Forest Rt. 1106 (T15N R13W S2), 4; Roaring Spring (T16N R11W S4), 4; Big Spring, adjacent to Sylamore Exp. Station (T16N R11W S16), 6; Hidden Spring, ½ mi N Sylamore Exp. Station (T16N R11W S20), 1; spring, Livingston Creek at Forest Rt. 1139 (T16N R11W S21), 2; Tarwater Spring (T16N R11W S23), MSUMZ A-1592, 2; Partee Spring (T16N R11W S26), 9; Livingston Creek at Ark. Hwy. 5 (T16N R11W S35), 2; spring, ½ mi N Forest Rt. 1101 at 1102 (T16N R12W S1), 1; spring, 3 mi E Cole Fork Rd. at Forest Rt. 1108-1 (16N R12W S8), 3; spring near Barkshed (T16N R12W S16), 2; N Sylamore Creek, ½ mi SE Gunner Pool (T16N R12W S25), 1; 1 mi W Gunner Pool (T16N R12W S26), 2; Branscum Cave, 3 mi SE Culp (T17N R11W S19), 3; spring, 3 mi S Calico Rock (T17N R11W S28), 2.

Eurycea multiplicata multiplicata (Cope), Many-Ribbed Salamander - **Baxter Co.:** spring, Cataract Creek at Forest Rt. 1105 (T17N R12W S13), 9; Farris Spring (T17N R13W S2), 7; spring, Push Mtn. (T17N R13W S28), 1; Tassel Spring (T17N R13W S33), 4; Lone Rock Spring (T18N R13W S22), 1; Martin Spring (T18N R13W S24), 1; Cantrill Spring, Advance (T18N R13W S32), 4. **Searcy Co.:** spring, Spring Creek at Forest Rt. 1111 (T16N R14W S11), 2. **Stone Co.:** S Prong Roasting Ear Creek at Forest Rt. 1106 (T15N R13W S2), 1; spring, Ramsey Rd. at Forest Rt. 1106 (T15N R13W S2), 1; N Sylamore Creek, 1 mi E Blanchard Springs (T15N R11W S4), 20; Blanchard Springs (T15N R11W S5), MSUMZ A-1114, 1; Mill Creek below dam, Blanchard Springs (T15N R11W S5), 9; Roaring Spring (T16N R11W S4), 11; Big Spring, adjacent to Sylamore Exp. Station (T16N R11W S16), 3; Hidden Spring, ½ mi N Sylamore Exp. Station (T16N R11W S20), 2; Tarwater Spring (T16N R11W S23), 4; spring, ½ mi N Forest Rt. 1101 at 1102 (T16N R12W S1), 6; spring near Barkshed (T16N R12W S15), 1; spring box, Gunner Pool (T16N R12W S25), MSUMZ A-1117, A-1158, A-1410-12, A-1593-95,10; 1 mi W Gunner Pool (T16N R12W S26), 5; Hambies Spring, 4 mi S Calico Rock (T17N R11W S28), 2; spring, 3 mi S Calico Rock (T17N R11W S28), 2.

Scaphiopus holbrooki hurteri Strecker, Western Spadefoot - **Stone Co.:** 2 mi S Calico Rock (T17N R11W S28), 12.

Gastrophryne carolinensis carolinensis (Holbrook), Eastern Narrow-Mouthed Toad - **Stone Co.:** pond, 3½ mi E Optimus (T16N R10W S8), 7; 4 mi S Calico Rock (T17N R11W S33), ASU-503, 1.

Bufo woodhousei fowleri Hinckley, Fowler's Toad - **Baxter Co.:** Sneeds Creek at Forest Rt. 1105 (T17N R12W S4), 2; Lone Rock Spring (T18N R13W S22), 1; Martin Spring (T18N R13W S24), 1. **Stone Co.:** N Sylamore Creek at Barkshed (T16N R12W S15), 3; N Sylamore Creek, 1 mi SE Gunner Pool (T16N R12W S25), 3; Gunner Pool (T16N R12W S25), MSUMZ A-1623, A-1632-33, 3.

Bufo americanus americanus Holbrook, American Toad - **Baxter Co.:** Forest Rt. 1101 2½ mi E Forest Rt. 1100 (T17N R12W S18), 1; Lone Rock Spring (T18N R13W S22), 1. **Stone Co.:** Roaring Spring (T16N R11W S4), 3; N Sylamore Creek, 1 mi SE Gunner Pool (T16N R12W S25), 1; Blanchard Springs (T15N R11W S5), 1; Partee Spring (T16N R11W S26), 1; Ark. Hwy. 14 at Livingston Creek (T16N R11W S35), 1; pond, 2 mi N Fifty Six (T16N R12W S35), 1; 4 mi S Calico Rock (T17N R11W S28), 1.

Hyla versicolor versicolor LeConte, Eastern Gray Treefrog.-**Baxter Co.:** pond, ½ mi S Forest Rt. 1106 at Ark. Hwy. 14 (T16N R13W S27), 1. **Stone Co.:** pond, 3½ mi E Optimus (T16N R10W S8), 10; pond, 2 mi N Fifty Six (T16N R12W S35), 4; Partee Spring (T16N R11W S26), 1.

Hyla crucifer crucifer Weid, Northern Spring Peeper.-**Baxter Co.:** pond, ½ mi S Forest Rt. 1106 at Ark. Hwy. 14 (T16N R13W S27), 5;**Stone Co.:** pond, 2 mi N Fifty Six (T16N R12W S35), 1.

Pseudacris triseriata feriarum (Baird), Upland Chorus Frog - **Stone Co.:** Blanchard Springs (T15N R11W S5), ASU-746, 1.

Acris crepitans blanchardi Harper, Blanchard's Cricket Frog - **Baxter Co.:** pond, ½ mi S Forest Rt. 1106 at Ark. Hwy. 14 (T16N R13W S27), 1; Sneeds Creek at Forest Rt. 1105 (T17N R12W S3), 3; Lone Rock Spring (T18N R13W S22), 4; Martin Spring (T18N R13W S24), 1. **Marion Co.:** Buffalo River, 4 mi SW Advance (T17N R14W S2), 1; Middle Creek, ½ mi SE Buffalo River (T17N R14W S2), 1. **Searcy Co.:** Spring Creek, 4 mi NNW Big Flat (T16N R14W S11), 1. **Stone Co.:** Roasting Ear Creek at Forest Rt. 1106 (T15N R13W S2), 1; N Sylamore Creek, ½ mi N Blanchard Spring (T15N R11W S5), 1; Blanchard Springs (T15N R11W S5), MSUMZ A-1479-80, 2; Clark Spring (T15N R12W S8), 1; Mill Creek below Clark Spring (T15N R12W S8), 1; convergence of N and S Sylamore Creeks (T15N R11W S12), 3; Roaring Spring (T16N R11W S4), 3; Big Spring (T16N R11W S16), 1; Tarwater Spring (T16N R11W S23), MSUMZ A-1605-06, 2; Partee Spring (T16N R11W S26), 1; Livingston Creek at Ark. Hwy. 5 (T16N R11W S26), 1; N Sylamore Creek, 1 mi SE Gunner Pool (T16N R12W S25), 1; Gunner Pool (T16N R12W S25), MSUMZ A-1337-41, A-1604, 6; 1 mi W Gunner Pool

(T16N R12W S26), 2; Harkelroad's Lake, 2 mi NW Fifty Six (T16N R12W S34), 1; 4 mi S Calico Rock (T17N R11W S28), 5.

Rana pipiens sphenocephala Cope, Southern Leopard Frog - **Baxter Co.:** pond, ½ mi S Forest Rt. 1106 at Ark. Hwy. 14 (T16N R13W S27), 1; Sneeds Creek at Forest Rt. 1105 (T17N R12W S4), 1; spring, Cataract Creek at Forest Rt. 1105 (T17N R12W S23), 1; Tassel Spring (T17N R13W S33), 1; Lone Rock Spring (T18N R13W S22), 2; Martin Spring (T18N R13W S24), 1. **Stone Co.:** Mill Creek below dam, Blanchard Springs (T15N R11W S5), 2; Clark Spring (T15N R12W S8), 1; S Prong Roasting Ear Creek at Forest Rt. 1106 (T15N R13W S2), 1; Livingston Creek at Forest Rt. 1139 (T16N R11W S21), 1; Roaring Spring (T16N R11W S4), 1; Partee Spring (T16N R11W S26), 1; N Sylamore Creek, 1 mi SE Gunner Pool (T16N R12W S25), 2; Gunner Pool (T16N R12W S25), MSUMZ A-749, A-765, A-779, 3; 1 mi W Gunner Pool (T16N R12W S26), 1; pond, 2 mi N Fifty Six (T16N R12W S35), 1; 4 mi S Calico Rock (T17N R11W S28), 1.

Rana sylvatica sylvatica LeConte, Eastern Wood Frog. - **Stone Co.:** Partee Spring (T16N R11W S26), 2; Old Chimney, 2 mi N Fifty Six (T16N R12W S25), 1.

Rana catesbeiana Shaw, Bullfrog - **Baxter Co.:** pond, ½ mi S Forest Rt. 1106 at Ark. Hwy. 14 (T16N R13W S27), 3; Sneeds Creek at Forest Rt. 1105 (T17N R12W S4), 3. **Stone Co.:** N Sylamore Creek, ½ mi N Blanchard Springs (T15N R11W S5), 1; Mirror Lake, Blanchard Springs (T15N R11W S5), MSUMZ A-1453, A-1484, 2; White River, 1½ mi N Allison (T15N R11W S12), 2; Clark Spring (T15N R12W S7), 1; Roasting Ear Creek at Forest Rt. 1106 (T15N R13W S2), 6; Livingston Creek at Forest Rt. 1139 (T16N R11W S21), 1; Partee Spring (T16N R11W S26), 1; N Sylamore Creek, 1 mi SE Gunner Pool (T16N R12W S25), 2; Gunner Pool (T16N R12W S25), MSUMZ A-686, A-699-701, A-729, A-1558-59, A-1578, 8; 1½ mi W Gunner Pool (T16N R12W S26), 2; pond, 2 mi N Fifty Six (T16N R12W S35), 1.

Rana clamitans melanota (Rafinesque), Green Frog - **Baxter Co.:** Lone Rock Spring (T18N R13W S22), 1; Cantrill Spring, Advance (T18N R13W S32), 1. **Stone Co.:** natural entrance Blanchard Springs Caverns (T15N R11W S5), 1; Mirror Lake, Blanchard Springs (T15N R11W S5), MSUMZ A-1613, 1; Clark Spring (T15N R12W S8), 1; Partee Spring (T16N R11W S26), 1; Gunner Pool (T16N R12W S25), MSUMZ A-1577, 1; Bontreger's Spring, 3 mi NW Optimus (T17N R11W S33), 1.

Chelydra serpentina (Linnaeus), Snapping Turtle - **Stone Co.:** Forest Rt. 1106 at S Prong Roasting Ear Creek (T15N R13W S2), 1; Gunner Pool (T16N R12W S25), MSUMZ R-874, 2.

Terrapene carolina triunguis (Agassiz), Three-Toed Box Turtle **Baxter Co.:** Forest Rt. 1100, 1 mi N Ark. Hwy. 14 (T16N R13W S15), 1 Twin Creek, 2 mi SE Advance (T17N R13W S2), 1; ½ mi NE Advance (T18N R13W S32), 1. **Stone Co.:** Forest Rt. 1113, 1 mi NW Ark. Hwy. 5 (T15N R11W S2), 1; 2 mi NW Allison (T15N R11W S10), 2; 3 mi SE Blanchard Springs (T15N R11W S11), 2; Forest Rt. 1102, 7 mi N Fifty Six (T16N R12W S12), 1; 1 mi S Calico Rock (T17N R11W S15), 1.

Graptemys geographica (Le Sueur), Map Turtle - **Stone Co.:** White River, ½ mi N Allison (T15N R11W S10), 2; N Sylamore Creek, 2 mi SE Gunner Pool (T16N R11W S31), 1; Ark. Hwy. 5 at Livingston Creek (T16N R11W S35), 2.

Trionyx spinifer spinifer (Le Sueur), Eastern Spiny Softshell - **Stone Co.:** Gunner Pool (T16N R12W S25), 1.

Crotaphytus collaris collaris (Say), Eastern Collared Lizard - **Stone Co.:** City Rock Bluff (T17N R11W S19), 1; 5 mi S Calico Rock by White River (T17N R11W S35), ASU 63, ASU 93-94, ASU 500-502, 6.

Sceloporus undulatus hyacinthinus (Green), Northern Fence Lizard. **Baxter Co.:** Forest Rt. 1101, 3 mi E Forest Rt. 1100 (T17N R12W S20), 2; Lone Rock (T18N R13W S22), 2; Martin Spring (T18N R13W S13), 2; ½ mi NW Advance (T18N R13W S32), 1. **Marion Co.:** Forest Rt. 1111 at Middle Creek (T17N R14W S25), 2. **Stone Co.:** Blanchard Springs (T15N R11W S5), MSUMZ R-756-757, 3; Clark Spring (T15N R12W S8), 2; Roaring Spring (T16N R11W S4), 1; 10 mi NE Fifty Six (T16N R11W S8), 1; Barkshed (T16N R12W S15), 1; Gunner Pool (T16N R12W S25), MSUMZ R-725, 1; ¼ mi SE Gunner Pool (T16N R12W S25), 2; 4 mi S Calico Rock (T17N R11W S28), 1.

Cnemidophorus sexlineatus sexlineatus (Linnaeus), Six-Lined Racerunner - **Stone Co.:** Slick Rock Hollow, ¼ mi S Forest Rt. 1113 (T15N R11W S2), 2; Gunner Pool (T16N R12W S25), 1.

Scincella laterale (Say), Ground Skink - **Baxter Co.:** Forest Rt. 1101, 1½ mi E Forest Rt. 1100 (T17N R12W S20), 1. **Stone Co.:** Slick Rock Hollow, ¼ mi S Forest Rt. 1113 (T15N R11W S2), 1; Blanchard Springs (T15N R11W S5), 2; 3 mi SE Blanchard Springs (T15N R11W S11), 1; Clark Spring (T15N R12W S8), 1; Roaring Spring (T16N R11W S4), 2; Big Spring (T16N R11W S16), 1; 2 mi W Gunner Pool (T16N R12W S27), 2; Gunner Pool (T16N R12W S25), MSUMZ R-993, 1; 4 mi S Calico Rock (T17N R11W S28), 1; Push Mountain (T17N R13W S32), 1.

Eumeces fasciatus (Linnaeus), Five-Lined Skink - **Baxter Co.:** Lone Rock (T18N R13W S22), 3. **Stone Co.:** Blanchard Springs (T15N R11W S5), 1; Roaring Spring (T16N R11W S4), 4; Gunner Pool (T16N R12W S25), MSUMZ R-729, 1; N Sylamore Creek, ¼ mi SE Gunner Pool (T16N R12W S25), 1; Gunner Creek, ¼ mi W Gunner Pool (T16N R12W S26), 1.

Eumeces anthracinus pluvialis Cope, Southern Coal Skink - **Stone Co.:** Roaring Spring (T16N R11W S4), 1; N Sylamore Creek, ¼ mi SE Gunner Pool (T16N R12W S25), 1.

Natrix sipedon pleuralis Cope, Midland Water Snake - **Baxter Co.:** 3 mi E Optimus (T16N R10W S8), 1; Forest Rt. 1106, ½ mi S Ark. Hwy. 14 (T16N R13W S27), 1. **Stone Co.:** Blanchard Springs (T15N R11W S5), MSUMZ R-753, 1; Mirror Lake (T15N R11W S5), 1; N Sylamore

Creek, ½ mi NW Blanchard Springs (T15N R11W S5), 1; N Sylamore Creek, 1 mi SE Gunner Pool (T16N R11W S30), 2; N Sylamore Creek, ½ mi N Barkshed (T16N R12W S15), 1; Barkshed (T16N R12W S15), 1; Gunner Creek, ½ mi W Gunner Pool (T16N R12W S25), 2; 1½ mi NW Fifty Six (T16N R12W S34), 1.

Storeria dekayi wrightorum Trapido, Midland Brown Snake - **Stone Co.:** 1 mi SE Gunner Pool (T16N R12W S25), 1.

Storeria occipitomaculata occipitomaculata (Storer), Northern Red-Bellied Snake - **Stone Co.:** Blanchard Springs Caverns (T15N R11W S5), 1; N Sylamore Creek, ½ mi SE Gunner Pool (T16N R12W S25), 1; 2 mi N Fifty Six (T16N R12W S35), MSUMZ R-846, 1.

Thamnophis sirtalis sirtalis (Linnaeus), Eastern Garter Snake - **Baxter Co.:** Forest Rt. 1106, ½ mi S Ark. Hwy. 14 (T16N R13W S27), 1. **Stone Co.:** Blanchard Springs (T15N R11W S5), MSUMZ R-760, 1; Forest Rt. 1110, 1½ mi N Ark. Hwy. 14 (T15N R11W S6), 8; N Sylamore Creek, 3 mi SE Blanchard Springs (T15N R11W S11), 1; Roaring Spring (T16N R11W S4), 1.

Virginia striatula (Linnaeus), Rough Earth Snake - **Baxter Co.:** Forest Rt. 1105 at Sneed's Creek (T17N R12W S4), 1. **Stone Co.:** Roaring Spring (T16N R11W S4), 3; Gunner Pool (T16N R12W S25), MSUMZ R-720, 1; 4 mi S Calico Rock (T17N R11W S33), ASU 97, ASU 801, 2.

Virginia valeriae elegans Kennicott, Western Earth Snake - **Stone Co.:** Roaring Spring (T16N R11W S4), 1; 4 mi S Calico Rock (T17N R11W S33), ASU 798-800, 3.

Heterodon platyrhinos Latreille, Eastern Hognose Snake - **Stone Co.:** N Sylamore Creek, ½ mi SE Gunner Pool (T16N R12W S25), 1; Gunner Pool (T16N R12W S25), MSUMZ R-741, 1.

Diadophis punctatus arnyi Kennicott, Prairie Ringneck Snake **Baxter Co.:** Tassel Spring (T17N R13W S33), 1. **Stone Co.:** Blanchard Springs (T15N R11W S5), 1; Clark Spring (T15N R12W S8), 1; Forest Rt. 1113, 3 mi NE Allison (T16N R11W S34), 1; Gunner Pool (T16N R12W S5), 2; N Sylamore Creek, ½ mi SE Gunner Pool (T16N R12W S25), 1.

Carphophis vermis (Kennicott), Western Worm Snake - **Baxter Co.:** Forest Rt. 1105 at Sneed's Creek (T17N R12W S4), 1. **Stone Co.:** Big Spring (T16N R11W S16), 1.

Coluber constrictor priapus Dunn and Wood, Southern Black Racer - **Baxter Co.:** Forest Rt. 1105 at Sneed's Creek (T17N R12W S4), 1. **Stone Co.:** Roaring Spring (T16N R11W S4), 1; Ark. Hwy. 14, 4 mi NW Fifty Six (T16N R12W S29), 1.

Masticophis flagellum flagellum (Shaw), Eastern Coachwhip - **Baxter Co.:** Ark. Hwy. 14. 2½ mi E Big Flat (T16N R13W S22), 1. **Stone Co.:** N Sylamore Creek, ½ mi SE Gunner Pool (T16N R12W S25), 1.

Opheodrys aestivus (Linnaeus), Rough Green Snake - **Stone C0.:** N Sylamore Creek ½ mi SE Gunner Pool (T16N R12W S25), 1.

Elaphe obsoleta obsoleta (Say), Black Rat Snake - **Stone Co.:** Gunner Pool (T16N R12W S25), 2; Forest Rt. 1102, 7 mi N Fifty Six (T16N R12W S12), 1.

Lampropeltis getulus holbrooki Stejneger, Speckled Kingsnake. - **Baxter Co.:** Forest Rt. 1111 at Middle Creek (T17N R14W S25), 1. **Stone Co.:** Gunner Pool (T16N R12W S25), 2.

Tantilla gracilis hallowelli Cope, Northern Flat-Headed Snake - **Searcy Co.:** Forest Rt. 1111 at Spring Creek (T16N R14W S11), 1.

Agkistrodon contortrix contortrix (Linnaeus), Southern Copperhead - **Baxter Co.:** Forest Rt. 1106, ½ mi S Ark. Hwy. 14 (T16N R13W S27), 1. **Stone Co.:** Ark. Hwy. 14, 2 mi NW Allison (T15N R11W S10), 1; 3 mi SE Blanchard Springs (T15N R11W S11), 1; Ark. Hwy. 5, ½ mi N Allison (T15N R11W S12), 1; Blanchard Springs (T15N R11W S5), ASU 248, ASU 577, 2; Big Spring (T16N R11W S16), 1; 5 mi N Fifty Six (T16N R12W S13), ASU 390, 1; ¼ mi SE Gunner Pool (T16N R12W S25), 2; Ark. Hwy. 14, 5 mi NW Fifty Six (T16N R12W S30), 1.

Agkistrodon piscivorus leucostoma (Troost), Western Cottonmouth - **Stone Co.:** 5 mi E Fifty Six (T15N R11W S11), ASU 202, 1; Partee Spring (T16N R11W S26), 2; ¾ mi SE Gunner Pool (T16N R12W S25), 2; Gunner Pool (T16N R12W S25), MSUMZ R-736-37, 3; ¼ mi SE Gunner Pool (T16N R12W S25), 1; ¼ mi NW Gunner Pool (T16N R12W S26), 1.

Sistrurus miliarius streckeri Gloyd, Western Pigmy Rattlesnake - **Stone Co.:** Forest Rt. 1113, 1¼ mi NW Barkshed Campground (T16N R12W S17), 1.

Crotalus horridus horridus Linnaeus, Timber Rattlesnake - **Baxter Co.:** Forest Rt. 1107, 4 mi E Forest Rt. 1100 (T17N R12W S21), 1. **Stone Co.:** Tassel Spring (T17N R13W S33), 1; ½ mi SE Gunner Pool (T16N R12W S25), 1.

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Histological Study of Liver of Channel Catfish, *Ictalurus punctatus*

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ABSTRACT

Histologically the liver of the channel catfish, *Ictalurus punctatus*, was found to consist of many lobules. Though not surrounded by a connective tissue sheath as they are in some animals, the lobules were discernable because all the hepatic cells in a particular area radiated from a central vein. Portal triads were scattered throughout the liver. The lobule tissue consisted of radiating cords of cells alternating with sinusoids. Glycogen was condensed into large vacuoles within these cells. Pancreatic tissue was found in the liver, always surrounding a capillary or venule. Morphologically the pancreatic cells were exocrine. Functionally, however, they may be endocrine cells because no ducts were found leading away from them. Connective tissue in the liver was scanty.

INTRODUCTION

The histological appearance of the mammalian liver has been studied for many years with particular emphasis on the histology of the human liver. However, as Patt and Patt (1969) pointed out, very little work has been done on the histology of the liver of other vertebrate types. A few good papers have been written concerning this topic. For example, Ells (1954) described the microscopic anatomy of the liver and gallbladder of the lizard *Sceloporus occidentalis biseralis.* Heider (1966) investigated the histology of the liver of the crucian carp and tench. Finally, Simon et al. (1967) described the histology of the trout liver.

The purpose of the writer's study was to describe the histology of the liver of the channel catfish, *Ictalurus punctatus.*

MATERIALS AND METHODS

All of the tissues used to study the histology of the catfish liver were collected from the warm-water fish cultural research laboratories at Stuttgart, Arkansas. These tissues were rinsed in saline and sliced into sections approximately 2 mm thick. The slices of liver were distributed evenly among three fixatives: AFA, Zenker's, and a solution consisting of nine parts absolute ethyl alcohol and one part formalin (Humason, 1967).

After the tissues had been fixed for 72 hours, they were dehydrated with alcohol, cleared in xylene, and embedded in paraplast. Sections were cut by a rotary microtome to 12 micron thickness. The sections were affixed to slides and stained with hematoxylin and eosin, or Mallory's or Schiff's reagent (Humason, 1967).

RESULTS AND DISCUSSION

Histologically the catfish liver was found to consist of many lobules. These lobules were poorly defined because they were not surrounded by a connective tissue sheath as they are in some animals, such as the pig (Bevelander, 1970). The lobules were discernable only because all of the liver cells in a particular area radiated from central vein (Fig. 1).

Scattered throughout the liver were portal triads (Fig. 2), which consisted of a branch of the hepatic artery (A), a branch of the portal vein (B), and a branch of the bile and/or pancreatic duct (C) as will be explained. The vessels were lined by squamous endothelium and the ducts were lined by simple columnar epithelium. Some of the larger ducts contained a few goblet cells scattered among the columnar cells.

The tissue of the lobule contained radiating cords of hepatic cells alternating with sinusoids (Fig. 3). Each cord seemed to be

Figure 1. Lobule of liver outlined by hash marks. Central vein (A) is shown. 450x.

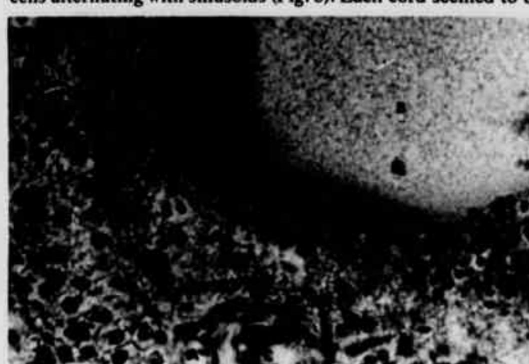

Figure 2. Portal triad consisting of branch of hepatic artery (A), portal vein (B), and bile duct (C). 450x.

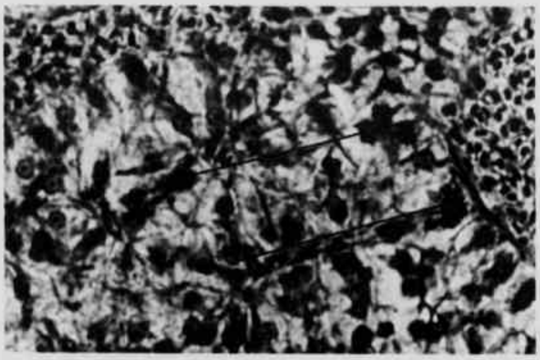

Figure 3. Parenchymal tissue within lobule. One hepatic cord is outlined. 450x.

two cells thick, although on many slides it was hard to tell because of the plane of section. The hepatic cells were cuboidal and showed an eosinophilic cytoplasm and prominent nucleoli. Within the cytoplasm of the hepatic cells glycogen was concentrated into one or two large vacuoles, as was demonstrated by the periodic acid-Schiff (PAS) reaction (Fig. 4).

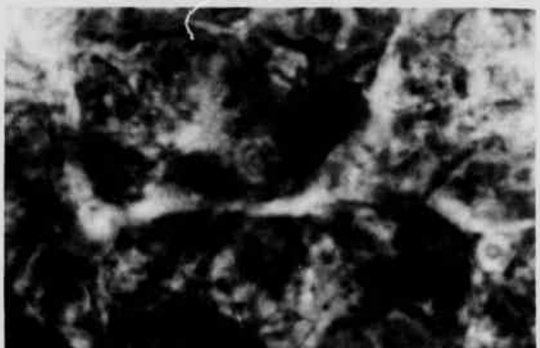

Figure 4. Glycogen deposition within hepatic cells (A). 1000x.

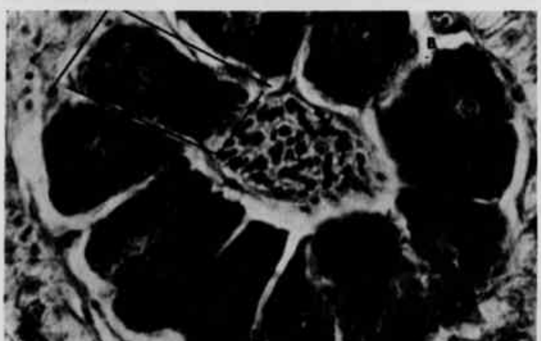

Figure 5. Exocrine pancreatic tissue surrounding capillary (A). An acinus is outlined. Centroacinar cells (B) are present. 450x.

One of the most interesting features of the catfish liver was the presence of exocrine pancreatic tissue (Fig. 5). These pancreatic cells always surrounded a large capillary or venule (A) and collected together in the form of an acinus. Centroacinar cells were present (B). The cytoplasm of the pancreatic cells was much more basophilic than the cytoplasm of the hepatic cord cells. The pancreatic cells were of the serous variety. The cells were more columnar than any other shape, although some tended to be pyramidal. The basal part of the cytoplasm of the exocrine cells appeared to be much darker than the apical part, possibly because of the accumulation of zymogen granules.

Though the pancreatic cells were exocrine in appearance, they may be endocrine cells in function. One of the basic differences between exocrine and endocrine tissues is that exocrine cells secrete their products into some type of duct system, whereas endocrine cells secrete their products directly into the blood stream. The author could not observe any ducts leading away from the pancreatic tissue. However, it is possible that intercalary ducts were present. Intercalary ducts have been known to show squamous epithelium, which would make them look very much like the sinusoids that were prevalent in the liver. Also, the pancreatic cells could use the same biliary ducts that the hepatic cells use. Nevertheless, the fact remains that the pancreatic tissue always surrounded a capillary or venule. The author, therefore, believes that the pancreatic cells may pour their products directly into the blood stream. Thus, morphologically the pancreatic cells were of an exocrine nature but functionally they may be of an endocrine nature.

By using Mallory's triple connective tissue stain, the author was able to determine the various locations of connective tissue in the liver (Fig. 6). As in other vertebrates, there was an abundance of connective tissue in the walls of the vessels (A). A small amount of connective tissue also was present surrounding the sinusoids. Very little connective tissue appeared to be present intercellularly between the hepatic and pancreatic cells.

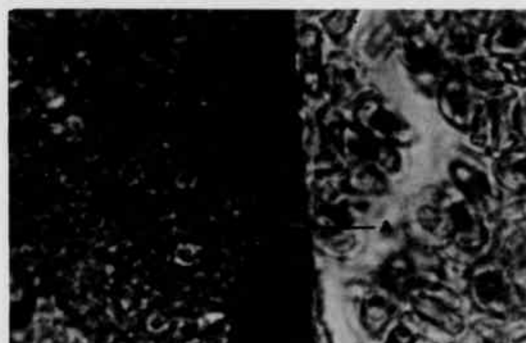

Figure 6. Connective tissue (A) within walls of vessel. 1000x.

SUMMARY AND CONCLUSIONS

The basic morphological unit of the catfish liver was the lobule. These lobules were poorly defined because they were not surrounded by a connective tissue sheath as they are in some animals. Nevertheless, the lobules could be discerned because all of the hepatic cells in a particular area radiated from a central vein.

The tissue of the lobule was made up of radiating cords of cells alternating with sinusoids. Within these cells, the glycogen was condensed into large vacuoles.

Pancreatic tissue was found in the liver. The pancreatic cells always surrounded a capillary or venule. Morphologically the cells were exocrine in nature. Functionally, however, the cells may be of an endocrine nature because no ducts could be seen leading away from them and they may secrete their products directly into the blood stream.

Connective tissue in the liver was scanty.

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Geoelectrical Possibilities of Detecting Stream Channels in Carbonate Rocks

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ABSTRACT

Several geoelectrical resistivity methods that may be used to determine the position and flow characteristics of underground water associated with carbonate bedrock and karst development are considered. The most promising method studied employs depth soundings patterned after Schlumberger. The plotting of half electrode separation against apparent resistivity yields a curve which may be used to discriminate between lateral and vertical inhomogeneities in bedrock. A network of depth soundings of this type ultimately may lead to a map that will show geoelectrical anisotropies that may be used to analyze subsurface water courses in carbonate rock.

Karst water is characterized by two properties, one good and the other bad. The good one is abundance. The bad one is that the carbonate host rock has almost no filtering potential. Once the water is polluted, the chances of its being cleaned by natural processes are very limited. For this reason as well as to understand karst hydrogeology in general, it is a challenge to find methods which would make it possible to detect underground stream channels and to determine the velocity of stream flow and the origin of springs.

The use of dye and radioactive tracers can be helpful for detecting the source of spring water which has disappeared into the ground somewhere upstream. Yet no one has found a satisfactory method by which to determine where the water flows below the surface, the characteristics of the channels in terms of average diameter and number, and whether the water is confined to narrow fissures or flows through moderate-size channels.

A geoelectrical resistivity method commonly is used to find resistivity contrasts which are based on water infiltration of rocks. An electrical current is fed into the soil. The resulting electrical field, measured between two potential electrodes, is a function of the resistivity of the rock material and its distribution. Two electrode arrangements commonly are used. One patterned after the method of Wenner generally is used in the U.S.A.; the other is after Schlumberger. One of the main problems of either method is the interpretation of the resistivity measurements. In many cases it is most difficult to determine whether an anomaly is caused by a vertical or a horizontal boundary between materials of different resistivity. The organization of the measurements can overcome this problem only partly. In the horizontal profiling method, all four electrodes are kept at a constant separation while the center of the arrangement is moved along a profile. This method responds to lateral resistivity changes, which occur at a certain depth according to the constant electrode separation. In another method, known as "depth sounding," the electrode separation is expanded successively over the same center. This arrangement forces the current deeper into the ground and makes the method responsive to vertical changes of resistivity. However, expansion of the electrode spacing may very well cause the current to cross deeply buried lateral inhomogeneities. It therefore becomes increasingly difficult to distinguish between lateral and vertical discontinuities of resistivity. Theoretical considerations as well as practical results have shown that depth sounding after Schlumberger is affected least by lateral resistivity changes, which are most disturbing in the upper layers of the overburden.

Several Schlumberger depth soundings were made at a location where the hydrogeology and the geoelecrical results are fairly unambiguous. About 20 mi south of Rolla, Missouri, is Lane Spring, in the valley of the Little Piney River. Lane Spring flows south and turns, after about 800 ft, toward the north to join the Little Piney, which flows north (Fig. 1). There is reason to assume that a large part of the water feeding Lane Spring flows underground from the eastern side of the valley, in a direction which is in alignment with the first 800 ft of exposed flow.

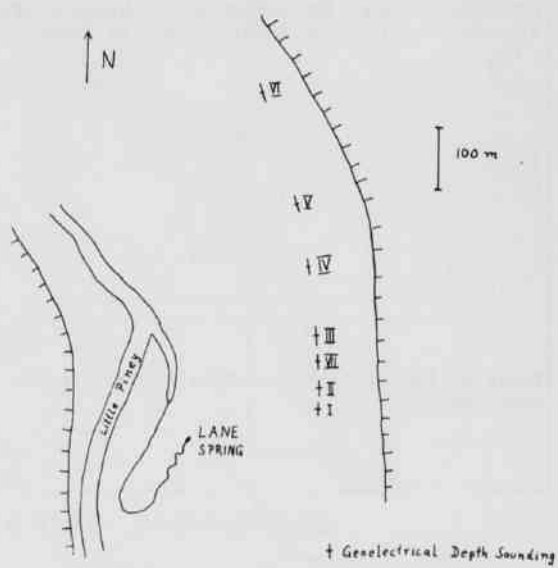

Figure 1. Location of geoelectrical depth soundings near Lane Spring, Missouri.

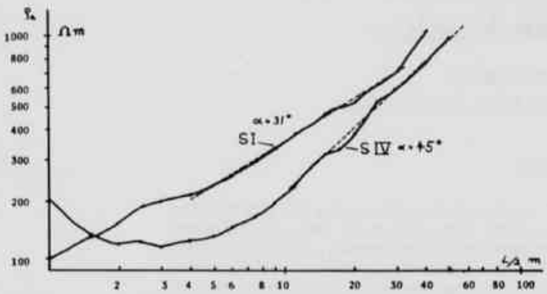

Figure 2. Geoelectrical depth soundings over Limestone; two-layer example near Lane Spring, Missouri.

Two types of depth-sounding curves are shown in Figure 2. The results are presented on bilogarithmic paper on which the half electrode separation is on the abscissa and the apparent resistivity is on the ordinate. Both curves represent a typical two-layer example which has an overburden (clay, gravel) of low resistivity and a carbonate bedrock of high resistivity. The slope of the right side of the depth sounding is characteristic for the resistivity of the bedrock. If the relation of bedrock resistivity, ρ_2, to over burden resistivity, ρ_1, approaches infinity, this slope must have an angle of 45 degrees. This condition indicates a nonconducting bedrock. Such bedrock was found in depth soundings at the three northern locations shown in Figure 1 (SIV, V, VI). Location SIV is represented in Figure 2. The other depth soundings were in an area where the water most likely flows through stream channels which feed Lane Spring. The right side of the depth soundings in Figure 2 shows a lower slope of ascent, which indicates a finite resitivity of the bedrock. The results of a total of seven depth soundings are represented in Figure 3. The resistivity of the bedrock (Fig. 3A) was interpreted from the depth soundings by means of

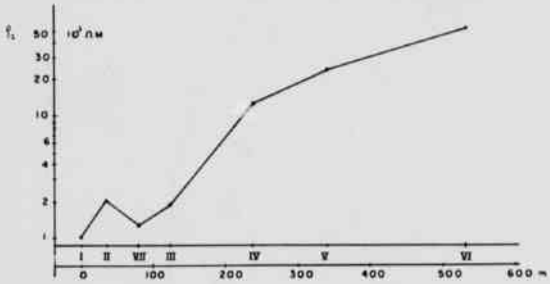

Figure 3A. Bedrock resistivity along a traverse near Lane Spring, Missouri.

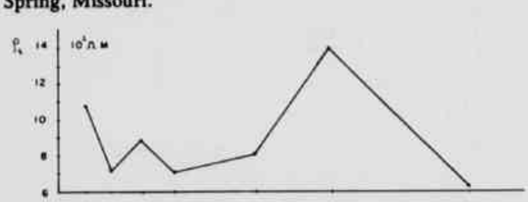

Figure 3B. Apparent resistivity of a Schlumberger profile with an electrode separation of 80 m.

two-layer interpretation master curves. Figure 3B shows the apparent resistivity one would obtain by using horizontal profiling with a constant separation of 80 m between current electrodes.

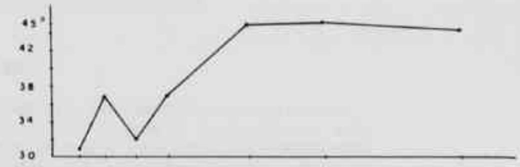

Figure 3C. Slope angle of ascending branch of depth soundings.

Horizontal profiling is a conventional way of finding lateral changes of resistivity. Figure 3B shows that, with the exception of location SV, there is no indication of an increase of bedrock resistivity on the north. The exception of SV must be considered a random value. Horizontal profiling in this case does not allow for a discrimination between lateral and vertical inhomogeneities. Finally, in Figure 3C, the slope angle of the ascending branch is plotted over each depth sounding. The slope angle is sufficiently sensitive to discriminate resistivity variations of bedrock material.

The investigations at Lane Spring will be continued with the goal of establishing a close network of depth soundings which will make it possible to draw a map of low bedrock resistivity. This map might lead to an estimate of water flow. The measurements are planned in a modified way to determine the slope angle of the right side of the sounding curve. Finally, in rotating the basis of the electrical current flow, an attempt will be made to measure the geoelectrical anisotropy, which should make it possible to draw conclusions on the direction of water flow in the stream channels.

ACKNOWLEDGEMENT

This work was supported by the Water Resources Research Center, Columbia, Missouri, under a grant (OWRR-A046-M0).

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Stratigraphy and Sedimentary Structures of a Middle Bloyd Fluvial Sandstone Washington and Madison Counties, Arkansas

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ABSTRACT

A prominent quartz-pebble-bearing sandstone unit crops out at stream level along the East Fork of the White River in Madison County. Detailed geologic mapping indicates that the unit is stratigraphically positioned between the Brentwood and Dye Shale Members of the Bloyd Formation and is not the Greenland Member of the Winslow Fromation as previously supposed. Sedimentary textures and structures of the unit indicate that it was deposited by competent, unidirectional currents flowing in a southerly direction. These currents were related to a broad braided stream system.

INTRODUCTION

A prominent quartz-pebble-bearing sandstone unit crops out near stream level along the East Fork of the White River and along Lollars Branch in eastern Madison County, Arkansas (Fig. 1). This unit generally has been assumed to be the Greenland Member of the Winslow Formation. Detailed mapping of the Greenland Sandstone from the type area near Greenland and Brentwood, Arkansas, into the valley of the East Fork of the White River near Delaney indicates that the

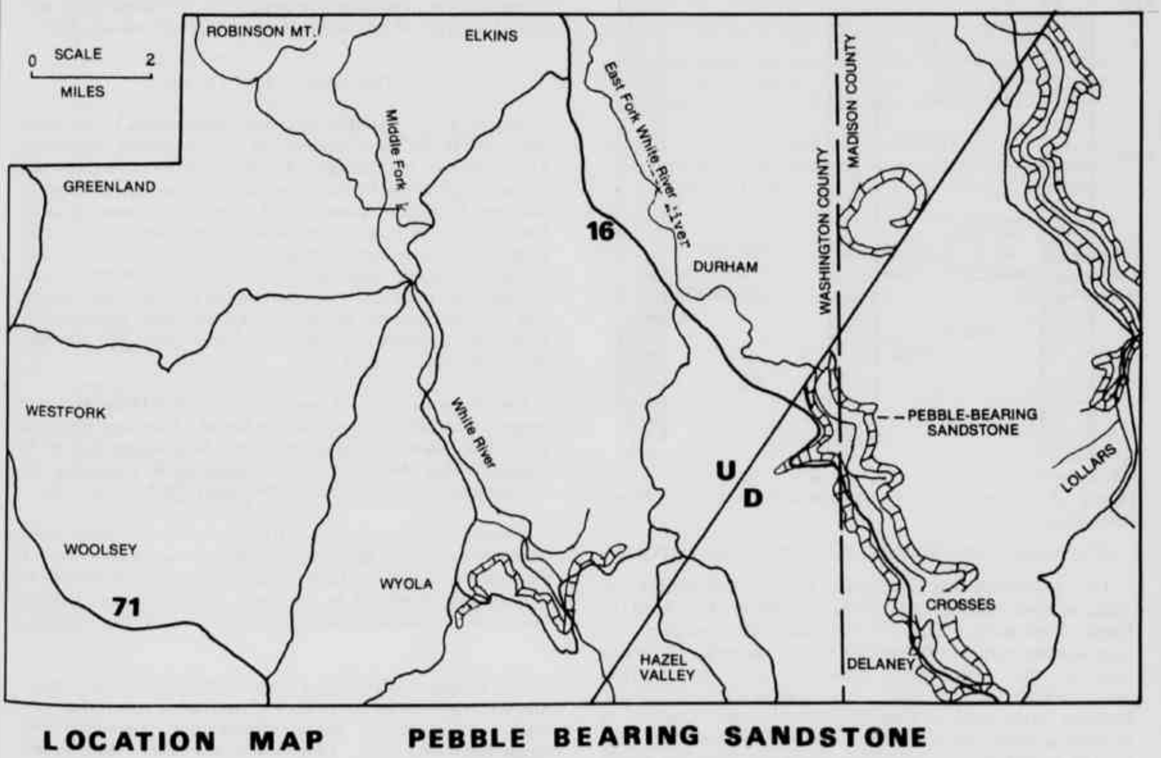

Figure 1. Location map of pebble-bearing sandstone.

Greenland Sandstone of the East Fork lies 130-150 ft stratigraphically above the quartz-bearing sandstone formerly considered to be Greenland.

The quartz-pebble-bearing sandstone overlies the Brentwood Member and is overlain by the Dye Shale Member of the Bloyd Formation (Fig. 2). It is characteristically coarse-grained and near the base shows several types of cross-stratification and preserved bed forms. Cross-stratification and bed-form types, paleocurrent data, and textural aspects of the rock indicate that the basal part of the unit was implaced by competent, unidirectional currents flowing in a southerly direction. These currents were confined loosely to broad channels on a near-strand coastal plain.

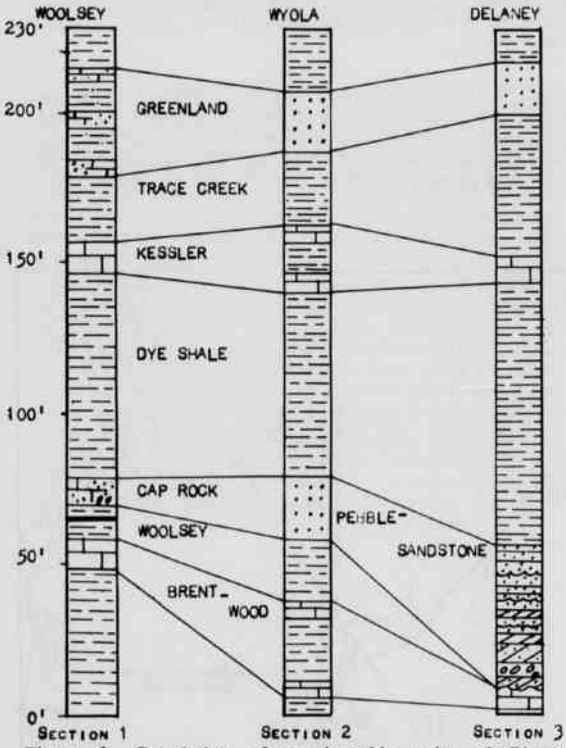

Figure 2. Correlation of stratigraphic units of Bloyd Formation.

STRATIGRAPHY OF PEBBLE-BEARING SANDSTONE

The pebble-bearing sandstone lies unconformably on siltstone, shale, and limestone of the Brentwood Member of the Bloyd Formation. Near Wyola the unit occupies the approximate stratigraphic position of the "caprock," the lowest unit of the Dye Shale Member, and is generally quartz-pebble-bearing, sandy to conglomeratic limestone. However, to the north on Robinson Mountain the "caprock" is medium-grained quartz arenite, with no quartz pebbles (Fig. 1). The pebble-bearing sandstone crops out from the Wyola area east, and the Baldwin Coal and "caprock" are present from the Wyola area west (Fig. 2).

Fifty to 100 ft of shale assigned to the Dye Shale Member overlies the pebble-bearing sandstone. In most locations 1-15 ft of Kessler Limestone overlies the Dye Shale. Thirty to 50 ft of Trace Creek strata separates the Kessler from the Winslow Formation (Fig. 2).

BED FORMS AND STRATIFICATION

Exposures of primary sedimentary structures are unusually good and varied in the pebble-bearing sandstone. Recent studies by other workers indicate that certain suites of sedimentary structures are characteristic of certain depositional conditions and environments. For sedimentary structures to be useful in environmental interpretations, it is necessary to recognize certain stratification types and to have an understanding of the flow phenomena and bed forms that produce them.

Stratification is the product of bed forms, and bed forms are related to flow regime. Flow regime is the generalized, integrated result of all variables such as velocity, depth, and slope.

In controlled experiments with flumes transporting sand, a sequence of bed forms is noted as flow is increased. Ripples are the bed form first developed after initiation of sand-size particle movement and belong to the lower flow regime. With increasing flow, the sequence progresses to include dune and plane bed types of bed forms (Harms and Fahnestock, 1965).

STRATIFICATION TYPES

Tabular Sets. Tabular sets are volumetrically the most important in the lower third of the pebble-bearing sandstone. These sets have basically planar upper and lower surfaces and contain high-angle foreset cross-laminations. They range in thickness from a few inches to 6 ft or more and generally are a few tens of feet long. Most tabular sets have non-erosional bounding surfaces that converge upstream. Downcurrent, some grade into ripple laminations. Foreset cross-bedded sand laminations are formed when particles avalanche down the slip face of a transverse bar or dune. This occurs most commonly in high-energy alluvial systems and forms point-bar deposits (McGowen and Groat, 1971).

Conglomerate Beds. Conglomerate beds 3-14 in. thick are present near the base of the sandstone. They are bounded above and below by tabular sets. Such deposits are formed at highest energy levels where finer material is bypassing the depositional site, concentrating the quartz and clay pebbles.

Ripple-Laminated Sets. Ripple-laminated sand units generally overlie the tabular sets and form as much as half of the volume of the sandstone. These sets are interpreted as having been deposited in the lower flow regime as current velocity decreased after deposition of the underlying foresets.

Clay Drapes. Clay drapes mantle other stratificaiton types and are deposited by the settling of suspended material as flow slackens. Clay drapes are associated most commonly with ripple-laminated sets. Less commonly they cap foreset cross-strata.

Disturbed Beds. Two kinds of disturbed beds were noted. Heave structures are present where water or gas was injected into overlying units. They are in the lower part of the sandstone.

Some large foreset beds also are disturbed. The upper part of each lamination is overturned in a downstream direction. As the foreset units above and below are not deformed, this might be the result of forces applied to the upper part of the foreset cross-strata by flowing water during the initial part of a new high-energy depositional event.

Fossils. Plant fossils are common in the pebble-bearing sandstone. Fragments of coal also are present in the lower part. Marine fossils, mostly abraded crinoid stems, are found in places in the sandstone.

The vertical sequence of units within the basal part of the pebble-bearing sandstone consists of (1) quartz-pebble conglomerate beds, (2) thick beds characterized by tabular foreset cross-stratification, (3) thin beds characterized by ripple bed forms, and (4) thin beds of shale deposited as drapes over the ripple forms (Fig 3).

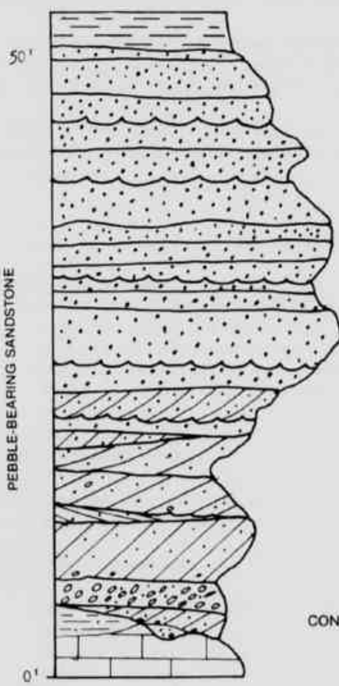

Figure 3. Sequence of stratification types in pebble-bearing sandstone.

The sandstone of the pebble-bearing unit is moderately well sorted; standard deviations range from 0.50 to 2.0 phi units. Paleocurrent directions, determined by measuring the direction of dip of prominent foreset strata, were southerly. This finding is supported by data obtained by Sandlin (1968, p. 78) east of Delaney.

CONCLUSIONS

The stratification types found in the basal part of the pebble-bearing sandstone indicate that this part of the unit was deposited in a near-strand, fluvial environment. Individual sequences record periods of extremely competent flow (quartz-pebble conglomerate), succeeded by periods of waning flow (tabular foresets and ripple bed forms). Cessation or near cessation of flow followed, as indicated by clay drapes over ripple bed forms. Most of the sediment now contained in the unit is in large, tabular foreset beds. These were deposited on dunes and transverse bars by competent, unidirectional currents that flowed in a southerly direction. Periods of waxing (flood) and waning flow produced the successive sequences of stratification types.

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Chrysomelidae of Arkansas

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ABSTRACT

A list of Chrysomelidae of Arkansas is brought up to date by inclusion of species in the reference collection in the University of Arkansas, the collection in the Zoological Institute of Leningrad, and the private collection of L. Medvedev, as well as those reported in the literature.

The list consists of 232 species, subspecies, and varieties and the ecological data where known. One new species and one new variety are included.

Current catalogues of Coleoptera list only a few Chrysomelidae from Arkansas. The specimens in the reference collections of the University of Arkansas and the Zoological Institute of Leningrad, along with those reported in the literature and those in the private collection of L. Medvedev, provide the basis for the list of species given.

The list consists of 232 species, subspecies, and varieties. Subsequent collections might increase this number to more than 300. One new species and one new variety are included.

Where known, locality by county and ecological data are given. Numbers in parentheses designate the literature sources from which the data were compiled.

Family **Chrysomelidae**

Subfamily Donaciinae

Donacia cincticornis Newn. Washington Co. (5) Beetles and larvae feed on leaves and roots of *Nymphaea, Brasenia, Nuphar, Nymphoides,* and *Potamogeton.* (1)
Donacia hypoleuca Lac. Hempstead Co., Pulaski Co., Drew Co., Desha Co., Crawford Co., Mississippi Co., Arkansas Co.

Subfamily Orsodacninae

Orsodacne atra (Ahrens). Johnson Co., Wahsington Co.; on peach.

Subfamily Megascelinae

Megascelis texana Linell. Washington Co.; on Compositae. The only specimen seems to be transitional between *A. texana* Linell and *A. suturalis* Lac. About 4.7 mm. with sutural flavous stripe dark violaceous as in *A. suturalis* Lac.

Dr. Medvedev is Entomologist of the Soviet-Mongolian Biological Expedition. He has made or confirmed all identifications and descriptions.

Mr. Rouse, Certified Entomology Taxonomist, collected all the insects and their ecology and distribution records. He also edited and presented the paper for publication.

Published with the approval of the Director, Agricultural Experiment Station, University of Arkansas.

Subfamily Criocerinae

Crioceris asparagi (L.). Washington Co., Mississippi Co.
Lema collaris Say. Arkansas Co., Washington Co.
Lema conjuncta Lac. Johnson Co.
Lema maculicollis Lac., ab. inornata nov. Logan Co., Montgomery Co.
Lema sayi Crotch. Lincoln Co.
Lema sexpunctata Oliv. Benton Co., Van Buren Co., Howard Co., Jefferson Co.; at light.

Subfamily Clytrinae

Tribe Clytrini

Anomoea hogei Jac. Washington Co., Carroll Co., Crawford Co., Logan Co.; numerous on willow; sometimes on soybeans.

Anomoea laticlavia (Forst). Washington Co., Crawford Co., Johnson Co., Arkansas Co., Lawrence Co., Garland Co., Hempstead Co., Nevada Co., Desha Co.; a few specimens were collected at black light trap.

Gynandrophthalma militaris Lec. Washington Co.

Tribe Megalostomini

Coscinoptera aeneipennis Lec. Clark Co., Dallas Co.; on Compositae.
Coscinoptera axillaris Lec. Washington Co., Crawford Co., Montgomery Co.
Coscinoptera dominicana (F.). Washington Co., Franklin Co.
Coscinoptera dominicana franciscana Lec. Benton Co., Washington Co.

Tribe Babiini

Babia quadriguttata (Oliv.) Washington Co., Franklin Co., Johnson Co., Logan Co., Hempstead Co., Clark Co.
Saxinis omogera Lac. Washington Co., Crawford Co., Sebastian Co., Johnson Co.

Subfamily Cryptocephalinae

Tribe Monachulini

Lexiphanes saponatus (F.). Crawford Co.; on soybeans.

Tribe Pachybrachyni

Griburius larvatus (Newn.). Calhoun Co.
Griburius scutellaris (F.). Washington Co., Crawford Co.
Pachybrachis atomarius (Melsh.). Washington Co., Sebastian Co., Montgomery Co., Pulaski Co.
Pachybrachis bivittatus (Say). Washington Co.
Pachybrachis carbonarius Hald. Washington Co., Crawford Co., Sebastian Co., Johnson Co., Howard Co.; on *Desmodium.*
Pachybrachis cephalicus (Melsh.). Sebastian Co.
Pachybrachis confederatus Fall. Conway Co., Jackson Co., Franklin Co., Marion Co.; on cotton.
Pachybrachis hepaticus (Melsh.). Dallas Co., Carroll Co.
Pachybrachis luridus (F.). Washington Co., Johnson Co., Arkansas Co.
Pachybrachis m-nigrum (Melsh.). Washington Co., Franklin Co.
Pachybrachis othonus (Say). Washington Co., Madison Co.
Pachybrachis pallidipennis Suffr. Jackson Co.; on evening primrose.
Pachybrachis peccans Suffr. Crawford Co., Carroll Co., Lincoln Co., Conway Co.; species collected on willow, alfalfa, cotton, soybean and *Desmodium.*
Pachybrachis pectoralis (Melsh.). Washington Co.; collected at light.
Pachybrachis pinicola, sp. n. Nevada Co.; on pine.
Pachybrachis praeclarus Weise. Washington Co., Crawford Co.; on *Desmodium.*
Pachybrachis pubescens (Oliv.). Benton Co.
Pachybrachis roboris Fall. Johnson Co., Little Rock (3); on *Clanothus* flowers.
Pachybrachis sobrinus Hald. Washington Co., Crawford Co.; on locust and soybean.
Pachybrachis subfasciatus Lec. Washington Co., Hampton; collected at light.
Pachybrachis tridens (Melsh.). Washington Co., Franklin Co., Polk Co.
Pachybrachis trinotatus (Melsh.). Washington Co. (3)
Pachybrachis vestigialis Fall. Washington Co., Hempstead Co., Franklin Co., Polk Co., Jackson Co.; on alfalfa, spanish needle and flowers of *Erigeron.*

Tribe Cryptocephalini

Cryptocephalus calidus Hald. Washington Co., Lee Co., Conway Co.
Cryptocephalus egregius Schaeff. Arkansas (6).
Cryptocephalus fulguratus Lec. Benton Co., Washington Co., Hempstead Co., Crawford Co.; on soybean.
Cryptocephalus guttulatus Oliv. Washington Co.; on loblolly pine.
Cryptocephalus leucomelas Suffr. Benton Co., Washington Co.
Cryptocephalus mucoreus Lec. Washington Co.
Cryptocephalus mutabilis Melsh. Benton Co., Washington Co., St. Francis Co., Johnson Co.
Cryptocephalus nanus F. Arkansas.
Cryptocephalus quadrimaculatus Say. Washington Co., Crawford Co., Johnson Co.
Cryptocephalus quadruplex Newn. Washington Co., Johnson Co.
Cryptocephalus schreibersi Suffr. Howard Co., Calhoun Co., Bradley Co.
Cryptocephalus tinctus Lec. Washington Co., Johnson Co.; on peach.
Cryptocephalus venustus F. Benton Co., Washington Co., Crawford Co., Conway Co., Lawrence Co., Cleburne Co., St. Francis Co., Polk Co., Montgomery Co., Pulaski Co., Grant Co., Dallas Co., Drew Co., Arkansas Co., Hempstead Co., Miller Co.
Bassareus brunnipes (Oliv.). Washington Co., Mississippi Co., Hempstead Co., Dallas Co., Jefferson Co., Lincoln Co., Lee Co., Cleburne Co., Conway Co.
Bassareus lituratus (F.). Washington Co., Polk Co.
Bassareus mammifer (Newn.). Washington Co., Logan Co., Pulaski Co.
Diachus auratus (F.). Washington Co., Crawford Co., Franklin Co., Miller Co.; on soybean and *Desmodium.*
Diachus nanus (Er.). Lawrence Co.

Subfamily Chlamisinae

Exema dispar Pierce. Washington Co., Lee Co.
Chlamisus plicata (F.). Washington Co., Drew Co., Crawford Co., Johnson Co.

Subfamily Eumolpinae

Tribe Chrysodinini

Chrysodian globosa (Oliv.). Johnson Co., Sevier Co., Washington Co., Franklin Co.; on crimson clover.
Nodonota clypealis Horn. Washington Co., Benton Co., Crawford Co., Mississippi Co., St. Francis Co., Lee Co., Arkansas Co., Saline Co., Hot Springs Co., Montgomery Co., Hempstead Co., Perry Co.; on *Desmodium.*
Nodonota puncticollis (Say). Washington Co., Carroll Co., Crawford Co., Franklin Co., Izard Co., Mississippi Co., Lincoln Co., Miller Co., Dallas Co.; on cotton.
Nodonota tristis (Oliv.). Washington Co., Crawford Co., Pulaski Co., Lee Co., Hempstead Co., Carroll Co.; on soybean, willow and *Desmodium.*

Tribe Colaspini

Colaspis brunnea (F.). Washington Co., Crawford Co., Logan Co., Mississippi Co., Benton Co., Lincoln Co., Drew Co., Arkansas Co., Cicot Co., Clay Co., Independence Co., White Co., Conway Co., Lee Co., Hempstead Co., Lawrence Co., Johnson Co., Desha Co.; on soybean, *Lespedeza,* sweet potato and cotton, also at light and black light.
Colaspis favosa Say. Benton Co., Washington Co., Arkansas Co., Sebastian Co.
Colaspis pini Barber. Logan Co., Hot Springs Co., Hempstead Co., Nevada Co., Calhoun Co., Johnson Co.; on pine, also at light.
Rhabdopterus praetextus (Say). Conway Co., Washington Co., Crawford Co., Bradley Co., Faulkner Co.; on cotton and soybean.

Tribe Scelodontini

Graphops curtipennis Blake. Green Co., Prairie Co., Arkansas Co., Drew Co.; on broom sedge.
Graphops pubescens (Melsh.). Washington Co., Mississippi Co., Crawford Co.; on soybean and oat, also at light.
Graphops simplex (Lec.) Marion Co.

Tribe Leprotini

Xanthonia decemnotata (Say). Washington Co., Logan Co.
Xanthonia villosula (Melsh.). Benton Co., Washington Co., Franklin Co., Clark Co., Bradley Co.
Fidia longipes (Melsh.). Washington Co., Madison Co., Benton Co.
Fidia viticida Walsh. Washington Co., Conway Co., Crawford Co.; on grape, soybean and cotton.

Tribe Metachromini

Metachroma aeneicolle Horn. Bradley Co., Washington Co., Dallas Co., Hempstead Co.
Metachroma interruptum (Say). Arkansas Co.
Metachroma pallidum (Say). Arkansas Co., Drew Co., Bradley Co.; on red oak.
Metachroma puncticolle Lec. Hempstead Co.; on pine.

Tribe Edusellini

Thymnes metasternalis (Crotch). Franklin Co., Yell Co.
Thymnes tricolor (F.). Washington Co., Logan Co.

Tribe Myochroini

Myochrous denticollis (Say). Washington Co., Lawrence Co., Mississippi Co., Jackson Co., Pope Co., Conway Co., Crittenden Co., Lonoke Co., Lee Co., Phillips Co., Arkansas Co., Desha Co., Hempstead Co., Little River Co., Miller Co., Jefferson Co., Lafayette Co., Randolph Co., Chicot Co., Poinsett Co.; on broom sedge, wheat, cotton, soybean, alfalfa, *Lespedeza*, also at light.
Myochrous squamosus Lec. Jackson Co.
Glyptoscelis albicans Baly. Pine Bluff (1).
Glyptoscelis cryptica (Say). Pine Bluff (1).

Tribe Typophorini

Typophorus viridicyaneus Crotch. Benton Co., Washington Co., Lawrence Co., Poinsett Co.
Paria fragariae Wilcox. Washington Co., Clay Co., Monroe Co., Jefferson Co., Drew Co., Nevada Co., Hempstead Co., Conway Co.; on strawberry and broom sedge, also at light.
Paria opacicollis Lec. Washington Co., Franklin Co.; on cotton.
Paria quadrinotata (Say). Washington Co.
Paria sellata Horn. Mississippi Co., Conway Co., Hot Springs Co., Crawford Co.; on soybean.
Paria sexnotata (Say). Clay Co., Hempstead Co., Drew Co., Craighead Co., Crawford Co., Calhoun Co., Mississippi Co.; on broom sedge and loblolly pine, also at Malaise trap.
Paria thoracica (Melsh.). Washington Co., Crawford Co.; on alfalfa and soybean.

Tribe Corynodini

Chrysochus auratus (F.). Benton Co., Washington Co., Logan Co.

Subfamily Chrysomelinae

Tribe Zygogrammini

Zygogramma heterothecae Linell. Crawford Co.
Zygogramma suturalis (F.). Washington Co., Conway Co., Pike Co., Little River Co., Ashley Co., Montgomery Co., Crawford Co., Clay Co.; on *Lespedeza*.
Zygogramma suturalis casta Rogers. Washington Co., Franklin Co.

Tribe Doryphorini

Labidomera clivicollis (Kirby). Crawford Co., Logan Co., Conway Co., Arkansas Co., Crittenden Co., Franklin Co., Washington Co.; on milkweed.
Labidomera clivicollis rogersi Lec. Crawford Co., Mississippi Co., Crittenden Co.
Leptinotarsa decemlineata (Say). Washington Co., Mississippi Co., Arkansas Co., Hempstead Co., Nevada Co., Chicot Co., Crawford Co.; at black light trap.
Leptinotarsa juncta (Germ.). Lee Co., Lincoln Co.
Calligrapha bidenticola Brown. Washington Co., Lonoke Co., Clay Co., Johnson Co.; on *Rubus*.
Calligrapha multipuncteta bigsbyana (Kby.). Washington Co., Conway Co.; on willow.
Calligrapha scalaris Lec. Franklin Co.

Tribe Chrysomelini

Chrysolina auripennis (Say). Washington Co.
Phaedon viridis (Melsh.). Washington Co.,
Gastrophysa cyanea (Melsh.). Benton Co., Washington Co., Crawford Co., Franklin Co., Newton Co., Craighead Co., Mississippi Co., Poinsett Co., St. Francis Co., Sevier Co.; on dock.
Chrysomela interrupta F. Madison Co., Franklin Co., Hempstead Co.
Chrysomela knabi Brown. Mississippi Co., Bentonville (2); on willow.
Chrysomela scripta F. Washington Co., Franklin Co., Conway Co., Mississippi Co., Pulaski Co., Lee Co., Lincoln Co., Hempstead Co., Little River Co., Arkansas Co.; on cottonwood, also at black light trap.

Tribe Prasocurini

Hydrothassa vittata (Oliv.). Izard Co.

Subfamily Galerucinae

Monocesta coryli (Say). Washington Co.
Derospidea brevicollis (Lec.). Conway Co., Pulaski Co.
Trirhabda bacharidis (Weber.). Arkansas Co.; collected by black light trap.
Trirhabda canadensis (Kirby). Baxter Co.
Galerucella nymphaeae (L.). Lincoln Co.
Pyrrhalta luteola (Mull). Washington Co., Lafayette Co., Drew Co.
Ophraela integra (Lec.). Little River Co., Hempstead Co., Lafayette Co.; on alfalfa and evening primrose.
Ophraela notulata (F.). Washington Co., Arkansas Co., Cross Co., Johnson Co., Lawrence Co.; on broom sedge.
Ophraeela sexvittata (Lec.). Conway Co.; on weeds.
Monoxia pallida Blake. Pulaski Co.; on lamb's-quarters.
Paratriarius dorsatus (Say). Arkansas (7).
Diabrotica tripennis (Say). Washington Co., Newton Co., Cleburne Co., Sebastian Co., Yell Co., Perry Co., Arkansas Co., Franklin Co.; on flowers of *Monarda*.
Diabrotica balteata Lec. Washington Co., Hempstead Co.
Diabrotica longicornis (Say). Conway Co.
Diabrotica picticornis Horn. Washington Co.; on Umbelliferae.

Diabrotica unidecimpunctata howardi Barb. Washington Co., Crawford Co., Randolph Co., Mississippi Co., Conway Co., Lonoke Co., Arkansas Co., Jefferson Co., Lincoln Co., Desha Co., Hempstead Co., Union Co.; on alfalfa, oats, corn, also at black light trap.

Acalymma vittata (F.). Washington Co., Crawford Co., Conway Co., Greene Co., Hempstead Co., Lafayette Co., Drew Co., Mississippi Co.; on watermelon, also at light.

Cerotoma atrofasciata Jac. Washington Co.; on Umbelliferae.

Cerotoma trifurcata (Forst.). Washington Co., Madison Co., Johnson Co., Randolph Co., Mississippi Co., Yell Co., Conway Co., Cross Co., Pulaski Co., Lonoke Co., Sevier Co., Hempstead Co., Hot Springs Co., Arkansas Co., Lincoln Co., Desha Co.; on cotton and young soybean.

Phyllecthris dorsalis (Oliv.). Washington Co., Franklin Co., Crawford Co.; on soybean and at Malaise trap, numerous in wooded area.

Phyllecthris gentilis (Lec.). Washington Co., Franklin Co.

Calomicrus burnneus (Cratch.). Pope Co.

Scelolyperus chautauquus Wilcox. Arkansas: Mt. Magazine top (7).

Phyllobrotica limbata (F.). Washington Co., Sharp Co.

Subfamily Alticinae

Blepharida rhois (Forst.). Washington Co., Johnson Co., Nevada Co., Franklin Co.

Pachyonychus paradoxus Melsh. Sevier Co., Lincoln Co., Johnson Co.

Distingmoptera pilosa (Ill.). Monroe Co., Calhoun Co.; on loblolly pine and broom sedge.

Oedionychus gibbitarsa (Say). Washington Co., Crawford Co., Newton Co., Benton Co.

Oedionychus miniata (F.). Washington Co., Johnson Co., Independence Co.

Oedionychus petaurista (F.). Washington Co.; on loblolly pine.

Oedionychus quercata (F.). Washington Co., Crawford Co., Stone Co., Franklin Co.; on ash and mullein.

Oedionychus scalaris Melsh. Drew Co., Hempstead Co.; collected at light.

Oedionychus sexmaculata (Ill.). Washington Co., Calhoun Co., Hempton Co., Bradley Co.

Oedionychus subvittata Horn. Franklin Co., Faulkner Co.

Oedionychus thoracica (F.). Washington Co.

Oedionychus thyamoides Crotch. Washington Co., Crawford Co., Franklin Co., Randolph Co., Clay Co., Prairie Co., Conway Co.; on *Lespedeza.*

Oedionychus vians (Ill.). Randolph Co., Craighead Co., Little River Co.

Oedionychus obsidianus (F.). Arkansas (4).

Disonycha admirabilis Blatch. Washington Co., Johnson Johnson Co., Conway Co.

Disonycha alternata (Ill.). Washington Co.

Disonycha caroliniana (F.). White Co., Calhoun Co., Little River Co.

Disonycha collata (F.). Washington Co., Crawford Co., Conway Co., Lee Co.

Disonycha discoidea (F.). Washington Co., Johnson Co., Pike Co.

Disonycha glabrata (F.). Benton Co., Washington Co., Crawford Co., Conway Co., Scott Co., St. Francis Co., Lee Co., Benton Co.; on soybean and alfalfa.

Disonycha latifrons Schffr. Grant Co.

Disonycha triangularis (Say). Washington Co., Crawford Co., Franklin Co., Faulkner Co.; on soybean.

Disonycha xanthomelas (Dalm.). Washington Co., Crawford Co., Lafayette Co.; on soybean.

Altica chalybea Ill. Washington Co.

Altica foliaceae Lec. Washington Co., Jefferson Co., Lincoln Co., Hempstead Co., Mississippi Co.; on cowpeas.

Altica ignita Ill. Crawford Co., Johnson Co., Lawrence Co., Washington Co., Polk Co.; on wheat and *Desmodium.*

Altica litigata Fall. Washington Co., Crawford Co., Conway Co., Mississippi Co., Lee Co., Polk Co., Hot Springs Co., Clark Co., Pike Co., Arkansas Co., Desha Co., Drew Co., Little River Co., Hempstead Co., Van Buren Co., Johnson Co., Yell Co., Sevier Co., Chicot Co.; on evening primrose, dock, wheat, cowpeas, soybean, tomato, cotton, sweet potato, myrtle, also at light and black light trap.

Altica nana (Crotch). Washington Co., Conway Co., Franklin Co., Mississippi Co.; on corn.

Altica punctipennis Lec. Washington Co.

Altica subplicata Lec. Faulkner Co., Pulaski Co., Arkansas Co., Desha Co.; on willow.

Luperaltica nigripalpis (Lec.). Cleburne Co.; on *Lespedeza.*

Monomacra iris (Oliv.). Benton Co., Boone Co., Washington Co.

Monomacra tibialis (Oliv.). Benton Co., Washington Co., St. Francis Co., Pulaski Co., Lincoln Co.

Strabala rufa (Ill.). Johnson Co., Lee Co., Conway Co., Howard Co., Lafayette Co., Randolph Co.; on alfalfa, tomato.

Mantura floridana Crotch. Washington Co., Crawford Co., Franklin Co., Faulkner Co., White Co., Calhoun Co., Bradley Co.

Hornaltica atriventris (Melsh.). Washington Co., Crawford Co.; on soybean.

Trichaltica scabricula (Crotch). Washington Co., Stone Co.; on ash.

Epitrix cucumeris Harris. Washington Co., Faulkner Co., Crawford Co.; on *Rumex* and *Desmodium.*

Epitrix fuscula Crotch. Benton Co., Washington Co., Baxter Co., Johnson Co., Scott Co., Yell Co., Lonoke Co., Hot Spring Co., Hempstead Co., Pulaski Co., Bradley Co., Chicot Co., Conway Co., Crawford Co., Clark Co., Franklin Co.; on *Solanum* carolinense, eggplant, mullein, cotton, soybean, also at light.

Epitrix hirtipennis (Melsh.). Washington Co., Pope Co., Craighead Co., Hempstead Co.; on tomato, eggplant.

Orthaltica copalina (F.). Washington Co., Crawford Co., Franklin Co., Van Buren Co., Polk Co.; on *Rhus,* also at light.

Orthaltica melina Horn. Washington Co.

Derocrepis erythropus (Melsh.). Washington Co., Crawford Co., Franklin Co.; on *Celtis* foliage, also at Malaise trap and black light trap.

Chalcoides chittendeni Heik. Washington Co., Mississippi Co., Conway Co., Hempstead Co., Arkansas Co., Crawford Co.; on willow.

Chalcoides violacea (Melsh.). Faulkner Co.; on honeysuckle.

Chaetocnema confinis Crotch. Washington Co., Crawford Co., Lonoke Co., Chicot Co., Yell Co.; on wheat and soybean.

Chaetocnema cribrifrons Lec. Washington Co., Lee Co., Sevier Co.

Chrysomelidae of Arkansas

Chaetocnema denticulata (Ill.). Washington Co., Crawford Co., Faulkner Co., Lonoke Co., Chicot Co., Mississippi Co., Greene Co., Pulaski Co.; on *Panicum*, sweet potato, broom sedge, alfalfa, crabgrass, soybean.
Chaetocnema pulicaria Melsh. Benton Co., Washington Co., Crawford Co., Franklin Co., Baxter Co., Randolph Co., Lawrence Co., Independence Co., Mississippi Co., Conway Co., Faulkner Co., Lonoke Co., Lee Co., Desha Co., Arkansas Co., Lincoln Co., Chicot Co., Hempstead Co., Lafayette Co.; on alfalfa and soybean.
Systena blanda (Melsh). Washington Co., Logan Co., Mississippi Co., Crittenden Co., Lonoke Co.; on sweet potato.
Systena elongata (F.). Washington Co., Crawford Co., Carroll Co., Mississippi Co., Pope Co., Conway Co., Pulaski Co., Lee Co., Lonoke Co., Lincoln Co., Hempstead Co., Lafayette Co.; on soybean, alfalfa and cotton.
Systena frontalis (F.). Washington Co., Conway Co., Crittenden Co., Pulaski Co., Arkansas Co., Desha Co., Lonoke Co.; on cotton and sweet potato.
Systena hudsonias (Forst.). Arkansas Co., Franklin Co.
Systena marginalis (Ill.). Yell Co.; on wheat.
Aphthona insolita (Melsh.). Hempstead Co.
Glyptina bicolor Horn. Washington Co., Calhoun Co., Polk Co.
Glyptina brunnea Horn. Washington Co., Conway Co.; on cotton.
Glyptina cerina (Lec.). Washington Co.
Glyptina cyanipennis Crotch. Washington Co.
Glyptina spuria Lec. Washington Co., Conway Co., Faulkner Co.; on Compositae.
Longitarsus melanurus Melsh. Washington Co.
Longitarsus testaceus Melsh. Washington Co., Scott Co., Hempstead Co., Drew Co., Crawford Co.; on alfalfa and soybean.
Longitarsus turbatus Horn. Washington Co., Monroe Co.; on strawberry and oats.
Longitarsus varicornis Suffr. Washington Co., Hempstead Co., Arkansas Co.
Phyllotreta aeneicollis Crotch. Washington Co., Crawford Co.; on *Desmodium*.
Phyllotreta albionica (Lec.). Crawford Co.
Phyllotreta bipustulata (F.). Washington Co., Crawford Co., on turnips.
Phyllotreta liebecki Schffr. Perry Co.
Phyllotreta striolata (F.). Washington Co., Crawford Co., Jefferson Co.; on oats, also at Malaise trap.
Phyllotreta zimmermanni (Crotch). Washington Co., Crawford Co., Faulkner Co., Jefferson Co., Hempstead Co., Bradley Co., Mississippi Co.
Palaeothona picta (Say). Washington Co.
Dibolia borealis Chev. Benton Co., Washington Co., Crawford Co., Scott Co., Polk Co., Stone Co.
Psylliodes convexior Lec. Washington Co., Mississippi Co., Faulkner Co., Jefferson Co., Bradley Co., Crawford Co.; on mustard.

Subfamily Hespinae

Tribe Cephaloliini

Stenispa collaris Baly. Washington Co.
Anoplitis inaequalis (Weber). Washington Co., Mississippi Co.
Anoplitis ancoroides Schffr. Washington Co., Hempstead Co. (8); on soybean.
Anoplitis rosea (Weber). Washington Co., Mississippi Co.; on *Crataegus* and willow.
Baliosus ruber (Weber). Benton Co., Washington Co., Arkansas Co., Polk Co., Mississippi Co.
Chalepus bicolor (Oliv.). Franklin Co., Polk Co.; collected in Malaise trap.
Xenochalepus dorsalis (Thunb.). Washington Co., Franklin Co., Hempstead Co., Nevada Co., Crawford Co.; on soybean.
Xenochalepus horni (Smith). Washington Co., Crawford Co., Sebastian Co.
Xenochalepus mundulus (Sand.). Washington Co.
Xenochalepus scapularis (Oliv.). Conway Co.; on plum and cypress.

Tribe Uroplatini

Octotoma plicatual (F.). Washington Co., Hempstead Co., Conway Co.
Brachycoryna melsheimeri (Crotch). Montgomery Co.
Glyphuroplata porcata (Melsh.). Washington Co.
Microrhopala excavata (Oliv.). Washington Co.
Microrhipala rubrolineata vulnarata Horn. Johnson Co.

Subfamily Cassidinae

Tribe Stolaini

Chelymorpha cassidea (F.). Washington Co., Clay Co., Sebastian Co., Hempstead Co.

Tribe Cassidini

Johthonota nigripes (Oliv.). Washington Co., Hempstead Co., Mississippi Co.
Agroiconota bivittata (Say). Washington Co., Crawford Co., Randolph Co., Conway Co., Lonoke Co., St. Francis Co., Polk Co., Hempstead Co., Chicot Co.; on broom sedge, eggplant and *Erigeron*.
Nuzonia pallidula (Boh.). Benton Co., Washington Co., Clay Co., Conway Co., Sebastian Co., Scott Co., Montgomery Co., St. Francis Co., Lee Co., Lincoln Co., Hempstead Co., Desha Co.; on alfalfa, soybean, sweet potato, cotton, also at black light trap.
Deloyala guttata (Oliv.). Benton Co., Washington Co., Jackson Co., Crittenden Co., Desha Co., Crawford Co., Lawrence Co., Mississippi Co., Conway Co., Lonoke Co., Lincoln Co., Hempstead Co., Chicot Co., Arkansas Co., Perry Co.
Plagiometriona clavata (F.). Washington Co., Johnson Co., Miller Co., White Co.; on cotton, sweet potato.
Metriona bicolor (F.). Washington Co., Crawford Co., Madison Co., Lawrence Co., Conway Co., Lonoke Co., Lee Co., Arkansas Co., Lincoln Co., Hempstead Co., Chicot Co.
Metriona purpurata (Boh.). Washington Co.

DESCRIPTIONS OF NEW FORMS

Lema maculicollis ab. *inornata*, nov.

Differs from typical form in having prothroax unicolorously dark red, without black spots. Head black with vertex and occiput red.

Elytra very dark blue. Length of body 3.7 mm.

Arkansas: Montgomery Co., 1 specimen - holotype; Logan Co. 22.IV. 1967, 1 specimen - paratype.

Pachybrachis pinicola, sp. nov.

Male. Head flavous, labrum whitish, anterior margin of clypeus, spots at bases of antennae, longitudinal stripe on vertex and occiput dark brown, apical joints of antennae infuscated. Prothorax flavous with brown punctures, forming 5 poorly limited spots (2,3). Scutellum black with fulvous spot. Elytra flavous with brown punctures, partly arranged in indistinct spots, humeral spot and preapical transverse band more distinct. Underside black, pygidium and hind margin of fifth sternite fulvous. Legs fulvous with whitish apices of femora.

Ocular lines developed, rather fine. Eyes separated by about 1.4 the length of the basal antennal joint. Antennae about ¾ the length of the body, joints elongate, the third joint 1.5 times as long as the second.

Prothorax moderately narrowed in front, widest behind the middle, sides slightly convergent, surface alutaceous, thickly but somewhat unevenly punctured. Scutellum alutaceous, extremely finely punctured.

Elytra a little wider than the prothorax, rather deeply striate externally and on the posterior convexity, punctures confused in a scutellar area; eighth row more or less interrupted behind humerus, marginal interspace with one or two punctures; all surface alutaceous.

Anterior femora strongly thickened, claws of anterior tarsi distinctly enlarged (Fig. 1). Aedeagus, Figure 2. Length of body 2.5 mm, breadth 1.2 mm.

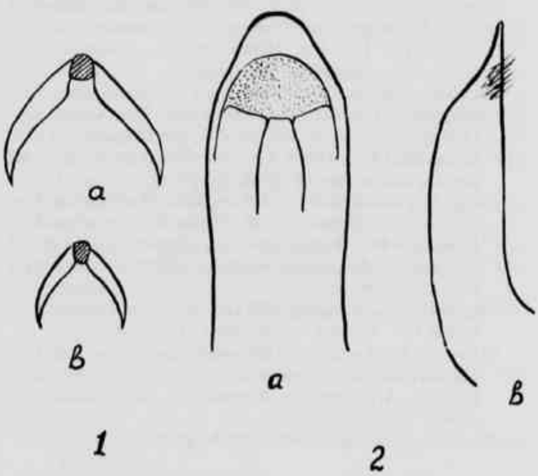

Figure 1. ***Pachybrachis pinicola*, sp. n., claws of male; (a) fore leg; (b) hind leg.**

Figure 2. ***Pachybrachis pinicola*, sp. n., aedeagus; (a) dorsal; (b) lateral view.**

Female. Pattern of elytra less distinct, sides of abdomen fulvous, body more robust. Eyes separated by about 1.6-1.7 the length of the basal antennal joint. Length 3.3 mm, breadth 1.6 mm.

This species is near *P. brevicollis* lec. from Texas, Colorado, and Montana, but differs in having frons more broad, prothorax less transverse (1.4 against 1.7), ocular lines present, etc.

Arkansas, Nevada Co., 6 VI. 1962, on pine. Holotype (male) and two paratypes.

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Checklist of Spiders Collected in Mississippi Compared With Preliminary Study of Arkansas Spiders

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ABSTRACT

This paper presents a comparative list of spiders collected in the 82 counties of Mississippi and in a random sampling of the spiders of Arkansas. The Mississippi list includes 26 families with 263 species, whereas the Arkansas collection includes 24 families with 206 species. Various methods of collecting were used in an effort to sample all populations and to contribute to knowledge of the taxonomy, ecology, and distribution of the spiders found in both Mississippi and Arkansas.

This paper presents a list of spiders collected in the 82 counties of Mississippi and in a random sampling of Arkansas counties. The Mississippi collection, housed at the University of Mississippi, includes 26 families and 263 species; the Arkansas collection includes 24 families and 206 species.

Collections were made at various times of day and in every month of the year. Every county of Mississippi was covered between summer 1960 and spring 1966. In Arkansas the collection was less concentrated, extending only from 1966 through 1970. The writer believes the Arkansas species will far outnumber the Mississippi species once extensive collections have been made throughout the state. The variety of habitats offered by Arkansas should yield a rich spider fauna.

The Mississippi checklist includes 263 species based on a total collection of approximately 20,000 specimens; the Arkansas list includes 206 species based on collections of nearly 10,000 specimens.

The names used are those employed by Comstock (1948), Kaston and Kaston (1953), and Gertsch (1949). The arrangement followed is that of Kaston and Kaston (1953). One asterisk indicates that individuals of the species also have been collected in Arkansas. Two asterisks indicate that the species have been collected in Arkansas but not in Mississippi.

Theraphosidae

* * *Dugesiella hentzi* Walckenaer

Oecobiidae

* * *Oecobius cellariorum* Duges

Filistatidae

* *Filistata hibernalis* (Hentz)

Scytodidae

* *Scytodes thoracica* (Latreille)
* *Loxosceles reclusa* Gertsch & Mulaik

Dysderidae

Dysdera crocata Koch
Ariadna bicolor (Hentz)

Lyssomanidae

* *Lyssomanes viridis* Hentz

Ctenizidae

* *Ummidia audouini* (Lucas)

Amaurobiidae

Amaurobius bennetti (Blackwall)
Titanoeca americana Emerton
Callioplus tibialis (Emerton)

Uloboridae

* *Uloborus americanus* Walckenaer
* *Hyptiotes cavatus* (Hentz)

Dictynidae

* *Dictyna sublata* (Hentz)
* *Dictyna volucripes* Keyserling
Dictyna cruciata Emerton
* *Dictyna annulipes* (Blackwall)
Dictyna foliacea (Hentz)
Dictyna florens Ivie & Barrows
Dictyna orbiculata Jones
Dictyna zaba Ivie & Barrows
Dictyna angulata Emerton
* *Dictyna segregata* Gertsch & Mulaik

Pholcidae

* *Pholcus phalangioides* (Fuesslin)
Spermophora meridionalis Hentz

Gnaphosidae

Gnaphosa sericata (Koch)
Gnaphosa muscorum (Koch)
Haplodrassus signifer (Koch)
* *Zelotes hentzi* Barrows
* *Callilepis imbecilla* (Keyserling)
Callilepis femoralis Banks
* *Cesonia bilineata* (Hentz)
* *Herpyllus vasifer* (Walckenaer)
* *Drassodes neglectus* (Keyserling)
* * *Rachodrassus echinus* Chamberlin
* *Drassylus depressus* (Emerton)
* * *Drassylus covensis* Exline
* * *Drassylus mephisto* Chambers
* * *Drassylus fallens* Chambers

* * *Drassylus creolus* Chambers & Gertsch
* * *Sergiolus capulatus* (Walckenaer)
* * *Cylphosa sericata* (L. Koch)
* * *Zelotes laccus* (Barrows)

Clubionidae

* *Clubiona excepta* Koch
* *Clubiona abbotii* Koch
Clubiona riparia Koch
* * *Clubiona moesta* Banks
Castianeira gertschi Kaston
Castianeira cingulata Koch
* *Castianeira descripta* (Hentz)
* *Castianeira longipalpus* (Hentz)
Castianeira amoena (Koch)
* * *Castianeira vulnerea* Gertsch
* *Agroeca pratensis* (Emerton)
* *Chiracanthium inclusum* (Hentz)
* *Marcellina piscatoria* (Hentz)
* *Trachelas tranquillus* (Hentz)
* * *Trachelas laticeps* Bryant
* *Clubiona obesa* Hentz
* *Micaria aurata* (Hentz)
* * *Meriola decepta* Banks
* * *Scotinella formica* (Banks)

Anyphaenidae

* *Anyphaenella saltabunda* (Hentz)
* * *Anyphaena maculata* Banks
* *Anyphaena celer* (Hentz)
* * *Anyphaena fragilis* Banks
* *Aysha gracilis* (Hentz)

Ctenidae

Anahita animosa (Walckenaer)
Zora pumila (Hentz)

Thomisidae

* *Misumena vatia* (Clerck)
* *Misumenoides formosipes* (Walckenaer)
* *Misumenops asperatus* (Hentz)
* *Misumenops celer* (Hentz)
* * *Misumenops oblongus* Keyserling
Coriarachne lenta (Walckenaer)
Coriarachne versicolor Keyserling
* *Xysticus ferox* (Hentz)
* *Xysticus tumefactus* (Walckenaer)
* *Xysticus texanus* (Banks)
* *Xysticus elegans* (Keyserling)
* *Xysticus triguttatus* Keyserling
Xysticus gulosus Keyserling
* * *Xysticus auctificus* Keyserling
Xysticus nervosus (Emerton)
* * *Xysticus funestus* Keyserling
* *Xysticus transversatus* (Walckenaer)
* *Synema parvula* (Hentz)
* *Philodromus pernix* Blackwall
* *Philodromus abbotii* Walckenaer
* *Philodromus rufus* Walckenaer
* *Philodromus imbecillus* Keyserling
* * *Philodromus keyserlingi* Marx
* * *Philodromus marxii* Keyserling
* * *Philodromus vulgaris* Keyserling
* * *Oxyptila conspurcata* Thorell
* *Thanatus formicinus* (Clerck)
* *Tibellus oblongus* (Walckenaer)
* *Tmarus angulatus* (Walckenaer)
* *Ebo latithorax* Keyserling

Salticidae

* *Phidippus audax* (Hentz)
* *Phidippus whitmanii* Peckham
* * *Phidippus insolens* Peckham
* *Phidippus purpuratus* Keyserling
* *Phidippus mystaceus* Emerton
* *Phidippus princeps* Peckham
* * *Phidippus incertus* Peckham
* *Phidippus putnamii* Peckham
* * *Phidippus insignarius* (C.L. Koch)
Phidippus otiosus Peckham
* *Phidippus clarus* Keyserling
* * *Phidippus carolinensis* Peckham & Peckham
* *Paraphidippus aurantius* (Kaston)
* *Paraphidippus marginatus* (Walckenaer)
* *Metaphidippus galathea* (Walckenaer)
* *Metaphidippus flavipedes* (Peckham)
* *Metaphidippus protervus* (Walckenaer)
* *Metaphidippus insignis* (Banks)
Metaphidippus canadensis (Banks)
Habrocestum pulex (Hentz)
* *Thiodina sylvana* (Hentz)
* *Zygoballis bettini* Peckham
* *Zygoballis sexpunctatus* (Hentz)
Zygoballis nervosus (Peckham)
* * *Eris pineus* (Kaston)
* *Agassa cyanea* Hentz
Sassacus papenhoei Peckham
Marpissa lineata (Koch)
Marpissa pikei Peckham
Marpissa bina (Hentz)
* *Marpissa undata* (DeGeer)
* *Metacyrba taeniola* (Hentz)
* *Myrmarachne hentzi* Banks
Phlegra fasciata (Hahn)
* *Ballus youngii* Peckham
* *Habronattus coronatus* (Hentz)
Habronattus viridipes (Hentz)
Habronattus agilis (Banks)
Habronattus borealis (Banks)
* *Habronattus decorus* (Blackwall)
* *Plexippus puerperus* Emerton
Icius hartii Emerton
* *Icius elegans* (Hentz)
* *Peckhamia picata* (Hentz)
* *Neon nelli* Peckham
* *Salticus scenicus* (Linnaeus)
* *Sitticus palustris* (Peckham)
* * *Sitticus floridanus* Gertsch & Mulaik
* *Maevia vittata* (Hentz)
Gertschia noxiosa (Hentz)
Evarcha hoyi (Peckham)
* *Hentzia mitrata* (Hentz)
* *Hentzia palmarum* (Hentz)

Agelenidae

* *Agelenopsis naevia* (Walckenaer)
* *Agelenopsis pennsylvanica* (Koch)

Agelenopsis texana (Gertsch)
Coras lamellosus Keyserling
* *Coras medicinalis* (Hentz)
Tegenaria domestica (Clerck)

Hahniidae

Hahnia cinerea Emerton

Pisauridae

Pelopatis undulata (Keyserling)
* *Dolomedes tenebrosus* Hentz
* *Dolomedes sexpunctatus* Hentz
Dolomedes scriptus Hentz
* *Pisaurina mira* (Walckenaer)
* *Tinus peregrinus* (Bishop)

Lycosidae

* *Lycosa helluo* Walckenaer
* * *Lycosa helluo annexa* Chambers & Ivie
* *Lycosa avida* Walckenaer
* *Lycosa rabida* Walckenaer
* *Lycosa aspersa* Hentz
* *Lycosa punctulata* Hentz
* *Lycosa baltimoriana* (Keyserling)
Lycosa riparia (Hentz)
* *Lycosa frondicola* Emerton
* *Lycosa gulosa* Walckenaer
Lycosa lenta Comstock
* * *Lycosa antelucana* Montgomery
* * *Lycosa carolinensis* Walckenaer
Lycosa avara (Keyserling)
Lycosa pratensis (Emerton)
* *Pardosa distincta* (Blackwall)
* *Pardosa milvina* (Hentz)
* *Pardosa saxatilis* (Hentz)
* * *Pardosa pauxilla* Montgomery
Pardosa lapidicina Emerton
* *Trochosa pratensis* (Emerton)
Trochosa acompa Chamberlin
* *Schizocosa bilineata* (Emerton)
Schizocosa saltatrix (Hentz)
Schizocosa crassipes (Walckenaer)
* * *Pirata sedentarius* Montgomery
* *Pirata insularis* Emerton
* * *Pirata minutus* Emerton
* * *Pirata sylvanus* Chambers & Ivie
Pirata montanus Emerton
* *Arctosa littoralis* (Hentz)
Arctosa floridana Banks
Arctosa rubicunda (Keyserling)
* *Arctosa funerea* (Hentz)
Tarentula aculeata (Clerck)
Sosippus floridanus Simon

Oxyopidae

* *Peucetia viridans* (Walckenaer)
Oxyopes aglossus Brady
* *Oxyopes salticus* Hentz
Oxyopes scalaris Hentz
* *Hamataliwa helia* Brady
Hamataliwa grisea Brady

Theridiidae

* *Theridion tepidariorum* (Koch)
Theridion rupicola Emerton
* *Theridion frondeum* Hentz
Theridion australe Banks
* *Theridion differens* Emerton
Theridion glauceseens Becker
* *Theridion flavonotatum* Keyserling
Theridion murarium Emerton
Spintharus flavidus Hentz
* *Teutana triangulosa* (Walckenaer)
Ctenium riparius (Keyserling)
Ulesanis americana Emerton
Crustulina altera Gertsch & Archer
Asagena americana Emerton
Henziectypus globosus (Hentz)
* *Euryopis limbata* (Walckenaer)
Conopistha rufa (Walckenaer)
* * *Conopistha trigona* (Hentz)
Dipoena nigra (Emerton)
* *Theridula emertoni* (Walckenaer)
Theridula quadripunctatus Keyserling
Anelosimus studiosus (Hentz)
* *Argyrodes nephilae* Taczanowski
Lithyphantes fulvus Keyserling
Enoplognatha marmorata (Hentz)
* *Latrodectus mactans* (Fabricius)
Episinus amoenus Banks

Mimetidae

* * *Mimetus interfector* Hentz
* *Mimetus puritanus* Chamberlin
* * *Ero furcata* (Villers)

Araneidae

* *Argiope aurantia* Lucas
Micrathena sagittata (Walckenaer)
* *Argiope trifasciata* (Forskal)
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* *Micrathena mitrata* (Walckenaer)
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* *Verrucosa arenata* (Walckenaer)
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Araneus miniatus (Walckenaer)
Araneus frondosa (Linnaeus)
* *Araneus thaddeus* (Linnaeus)
Araneus gemmoides (Linnaeus)
* *Araneus nordmanni* (Thorell)
Araneus corticaria (Emerton)
Araneus solitarius (Emerton)
* *Araneus marmoreus* (Clerck)
* *Neoscona domiciliorum* (Hentz)
* * *Neoscona sacra* (Walckenaer)
* *Neoscona arabesca* (Walckenaer)
* * *Neoscona pratensis* (Hentz)
* * *Mastophora bisaccatum* (Emerton)
* * *Conopeira ozarkensis* Archer
* * *Epeira cornuta* (Clerck)
* *Mangora gibberosa* (Hentz)
* *Mangora placida* (Hentz)
* *Mangora ornata* (Walckenaer)
Drexilia directa (Hentz)
* *Eustala anastera* (Walckenaer)

* *Gasteracantha elipsoides* (Walckenaer)
* *Nephila clavipes* (Linnaeus)
Scoloderus tuberculiferus (Cambridge)
* *Acanthepeira stellata* (Walckenaer)
* * *Acanthepeira moesta* Comstock
* *Acacesia hamata* (Hentz)
* *Araniella displicata* Chamberlin & Ivie
Cyclosa bifurca (Hentz)
* *Cyclosa conica* (Pallas)
Cyclosa turbinata (Walckenaer)
Metepeira labyrinthea (Hentz)
Allepeira lemniscata (Walckenaer)
* *Neosconella pegnia* (Walckenaer)
Kaira alba (Hentz)
Metazygia wittfeldae (McCook)
* *Singa pratensis* Emerton
Singa calix (Walckenaer)
Gea ergaster (Walckenaer)
* *Wixia ectypa* (Walckenaer)

Nesticidae

Nesticus pallidus Emerton

Tetragnathidae

* *Tetragnatha elongata* Walckenaer
Tetragnatha versicolor Walckenaer
* *Tetragnatha straminea* Emerton
* *Tetragnatha laboriosa* Hentz
* *Leucauge venusta* (Walckenaer)
* *Pachygnatha tristriata* C.L. Koch
* *Mimognatha foxi* (McCook)

Linyphiidae

Pityohyphantes costatus (Koch)
* *Linyphia marginata* (Koch)
* *Linyphia coccinea* (Hentz)
Linyphia pusilla Sundevall
Linyphia clathrata Sundevall
* *Frontinella pyramitela* (Walckenaer)
* *Meioneta micaria* (Emerton)
* *Meioneta fabra* (Keyserling)
Microneta viaria (Blackwall)
Estrandia nearctica (Banks)
Tapinopa bilineata Banks
Drapetisca alteranda Chamberlin
Tennesseellum formicum (Emerton)
Ceratinopsis interpres (Cambridge)
Ceratinopsis laticeps Emerton
Ceratinopsis anglicana (Hentz)

Micryphantidae

* * *Eperigone maculata* (Banks)
* * *Eperigone autumnalis* Emerton
* * *Erigone tridentata* (Emerton)
* * *Grammonata inornata* Emerton
* * *Grammonata maculata* Banks
* * *Walckenaera vigilax* (Blackwall)

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Conversion of Six Chemical Water Tests from Manual to Automated Methods

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ABSTRACT

Water quality assessments were made by a Technicon Basic Auto Analyzer system equipped with a Sampler II. This method replaced manual methods used during the first year of testing. Several problems were observed and corrected during the undertaking. It was necessary to modify manifolds, to increase sensitivity, to correct problems of turbidity, and to assure reagent stability.

INTRODUCTION

This paper concerns automation of procedures used in assessing water quality in Lake Dardanelle and some of its tributaries as it is affected by poultry effluents, and the effect of buildups of these pollutants on the zooplankton populations.

Samples came from eight stations on Lake Dardanelle and five stations on feeder tributaries. The stations ranged from points close to the lake itself to points approximately 20 miles from the lake. Testing started on 3 June 1970 and continued until 21 October 1970 for the first year. The second year of testing ran from 1 June 1971 to 16 November 1971. During both years, sampling was generally on a weekly basis for the first three months of testing and on a biweekly schedule for the remaining period.

The Chemistry Department at Arkansas Polytechnic College acquired a Technicon Basic Auto Analyzer with a Sampler II prior to the starting date of sampling for the second year of the project. This device made possible the automation of several water quality tests which had been performed by manual methods during the first period of testing. These tests had been performed on the Hach DR "Direct Reading" colorimeter and with Hach titration methods (Hach, Methods Manual, 5th Ed.).

Tests performed with the Hach kits included chloride (mercuric nitrate method), nitrate (nitrogen cadmium reduction method), phosphate (stannous reduction method), and total hardness (EDTA method). During the first year of the project ammonia levels were not determined and the determination of uric acid concentrations proved unsuccessful.

MATERIALS AND METHODS

The samples were labeled as they were collected. In the laboratory they were filtered through a Millipore filtering apparatus with a 0.45-micron pore size. The filtrates were stored in the refrigerator at a temperature of approximately 4C on the day they were collected. Several tests were performed on the samples before filtration and storage.

The chemical analyses of nitrate-nitrite, chloride, ortho-phosphate, ammonia, total hardness, and uric acid were performed on a Technicon Basic Auto Analyzer equipped with a Sampler II and a 15-mm flow cell.

During the second year of testing a colorimeter equipped with a 50-mm flow cell was used in some procedures. The modules of the basic system used included:

1. sampler
2. proportional pump (with specific manifold),
3. heat bath (used in NH_3 & nitrate-nitrite procedures),
4. colorimeter (with specific filters), and
5. recorder.

The principles of the reaction in the procedures for nitrate-nitrite, chloride, phosphate, ammonia, total hardness, and uric acid come from Technicon Auto Analyzer methodology (Technicon, Vol. II, III). All tests performed on the Auto Analyzer were color-producing reactions.

The platen manifolds for the ammonia, nitrate-nitrite, and total hardness tests were industrial manifolds and required only minor adjustments. The manifolds used in the chloride, phosphate, and uric acid tests were clinical manifolds and required modification.

In the chloride procedure, the color reagent consisted of the following chemical composition:

1. saturated aqueous mercuric thiocyanate (900 ml),
2. ferric nitrate solution (100 ml), and
3. mercuric nitrate solution, approximately 3.5 ml.

The mercuric nitrate solution was used to adjust the sensitivity of the color by reacting with the chloride ion first. The more $Hg(NO_3)_2$ that is added, the greater the reduction of chloride ions present in the sample. It therefore is recommended that the $Hg(NO_3)_2$ be omitted from the color reagent when samples of low chloride-ion content are being tested.

In the phosphate procedure the stannous chloride-hydrazine reduces the phosphomolybdic acid which is formed, producing a color reaction which is then measured colorimetrically. The stannous chloride-hydrazine sulfate working solutin had the following chemical composition:

1. stannous chloride (200 mg) and
2. 0.2% hydrazine sulfate in 1.0 N H_2SO_4 q.s. (1000 ml).

The stability of this reagent must be checked! The recommended duration for stability, at room temperature, is two weeks. The writer found that this reagent could be used for longer periods; however, as the reagent aged, a decrease in peak size was noted.

Both the sodium carbonate method and the cyanide-urea method for uric acid were tried and proved unsuccessful. The hydroxylamine method using 40% sodium tungstate as a stable alkalizing agent was found to be sensitive enough to produce good results at the low concentrations being tested. The reagents in this procedure included:

1. 0.2% hydroxylamine hydrochloride,
2. 40% sodium tungstate, and
3. phosphotungstate acid.

The use of this procedure with a 50-mm flow cell and 660-nm filters provided reproducible results.

The dialyzer module was not utilized in any of the procedures performed on the Auto Analyzer. Reagents were added directly to the prefiltered water samples.

RESULTS AND DISCUSSION

When the process of automation was started, four major problems became apparent:

1. The manifolds required modificaiton.
2. The sensitivity of the colorimeter was inadequate.
3. Turbidity had to be eliminated from the samples.
4. Reagent stability had to be assured.

Manifolds. Three of the manifolds purchased originally with the machine were designed for clinical analysis of body fluids, in which concentrations are very high in comparison with those generally found in water. This problem was corrected by determining the reagents-to-sample ratio giving the best results; when this ratio had been determined, the manifold was rebuilt to suit the need. In several procedures, an additional sample tube was used to introduce more sample into the system because of the small quantities of certain materials present in the water. This was accomplished easily by use of the proper fittings and tubing on the manifold.

If the amounts of sample and/or reagents being pumped across the manifolds are increased, it is essential that the inside diameter of the air tube be increased also to establish a better bubble pattern. A good bubble pattern is essential for acceptable results in this type of automated system.

Samples collected from streams and tributaries had very low chloride levels. Those taken in the lake proper had very high chloride levels. To retain the accuracy of the low readings the mercuric nitrate was omitted from the color-reagent solution. To accommodate the higher readings, a dilution factor was employed. A dilution factor of three was generally satisfactory. Distilled water was used as the diluent. The saline diluent tube was converted to a sample tube. The two sample tubes were joined by a DO fitting. Sample flow in the two tubes totaled 2.68 ml/min. This was read in a 15-mm flow cell with 480-nm filters. Sampling rate was 60 samples per hour with a 2:1 sample-to-wash ratio.

In the determination of phosphate an increase in sample size was required. This was accomplished by joining the saline diluent tube with the sample tube by a DO fitting. The total amount of sample aspirated across the manifold was 7.80 ml/min. The stream was read in a 15-mm flow cell with 660-nm filters during the first part of the project and then in a 50-mm flow cell with 830-nm filters. The test was run at the rate of 60 samples per hour with a 2:1 sample-to-wash ratio.

The clinical cyanide-urea manifold used in the determination of uric acid required modifications. The sample tube was changed from 0.10 to 0.60 ml/min (Fig. 1, a) and the saline diluent tube was changed from 1.0 to 0.42 ml/min (Fig. 1, b) and was converted to a sample tube by joining the two tubes with a D_1 fitting (Fig. 1,c). The inside diameter of the air tube was increased from 0.64 to 0.89 mm.

The single tube that was introduced into the stream was converted to a three-tube assembly by an HO fitting (Fig. 1, d). This made it possible to add the reagent $NH_2OH \cdot HCl$ to the stream of 40% Na_2WO_4 (Fig. 1,e) and the air tube (Fig. 1, f). It is important that the stream maintain a bubble pattern that will segment the solution at least once in each turn of the mixing coil to guarantee proper mixing. The double mixing coils were separated in the middle and equipped with a DO fitting to introduce the phosphotungstic reagent at this point (Fig. 1, g). An eleven-turn mixing coil was added to the stream (Fig. 1, h) to allow sufficient mixing. A 3-m delay coil (Fig. 1, i), with an inside diameter of 1.6 mm, was added to the system to allow a greater reaction time. The test was run at a rate of 40 samples per hour with a 2:1 sample-to-wash ratio. This modified system gave reproducible readings.

Colorimeter. The sensitivity of the colorimeter, which was equipped with a 15-mm flow cell, was inadequate to detect some of the very low concentrations of certain materials being tested. The problem was corrected when Technicon Instruments Corporation of Tarrytown, New York, made available a colorimeter equipped with a 50-mm flow cell.

Turbidity. The problem of turbidity in samples was eliminated by preliminary filtration with a Millipore filtration apparatus (Millipore Corp., 1969) equipped with 47-mm HA 0.45-micron pore size filter disk. Results similar to those reported by Kahn (1968) were observed. He found in his determinations of chloride in fresh and salt water that preliminary filtrations negated the need of the dialyzer or continuous filter, which had been employed by other investigators. In an automated procedure, the turbidity factor must be corrected before the samples are aspirated across the manifold. In some manual methods, the problem of slight turbidity of samples theoretically is corrected by the process of "self blanking."

Reagent stability. To assure accurate results the stability of reagents must be maintained and a preparation of reagent schedule followed. In projects concerned with the continuous monitoring of water quality in a given body of water, waste of reagents does not occur because of the large amounts of reagents which are consumed. Cananzaro et al. (1968) found in an automatic continuous multiple analysis of water in the Hudson River at Albany, New York, that it was practical to prepare quantities of reagents which would supply a two-week testing period. Quantities larger than this presented problems in storage space and stability, among others.

Some of the major advantages in the use of an instrument such as the Basic Auto Analyzer in water quality testing are the ease of running duplicate samples and standards to check

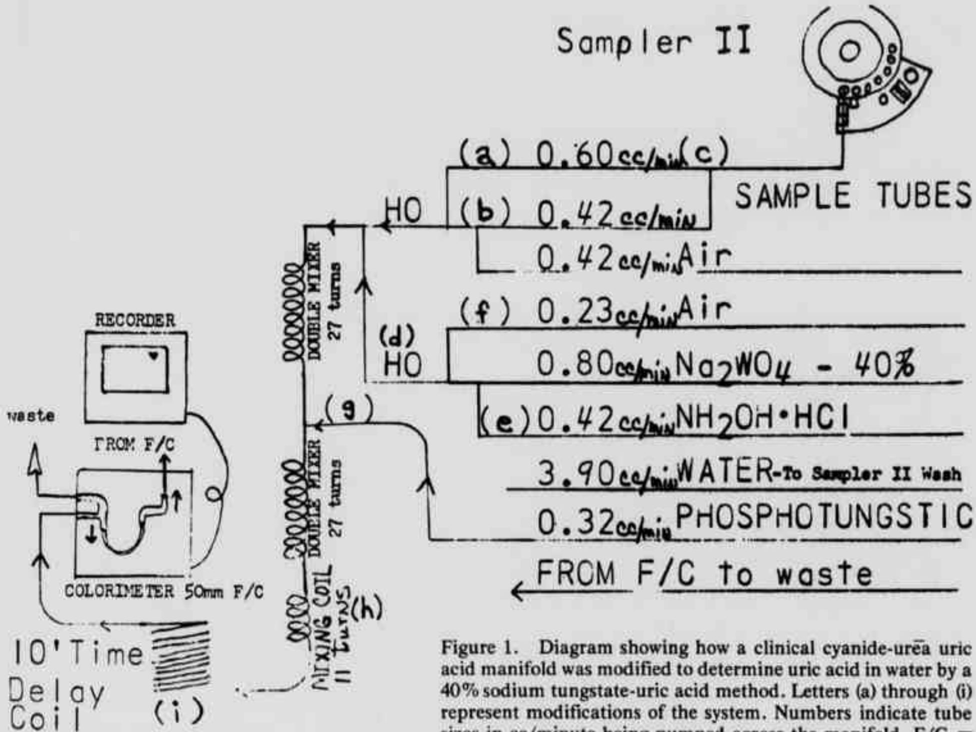

Figure 1. Diagram showing how a clinical cyanide-urea uric acid manifold was modified to determine uric acid in water by a 40% sodium tungstate-uric acid method. Letters (a) through (i) represent modifications of the system. Numbers indicate tube sizes in cc/minute being pumped across the manifold. F/C = flow cell.

reproductibility of the machine and the convenience in assessing reagent blank readings. The design and arrangement of the manifolds make it possible to adapt many types of modifications to the machine and give the device great versatility.

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