Journal of the Arkansas Academy of Science

Volume 24 Article 1

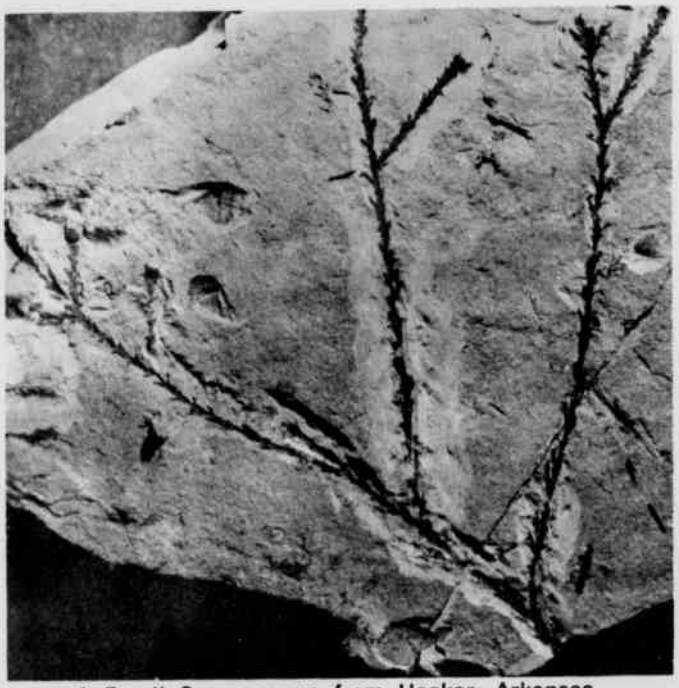
1970

Proceedings of the Arkansas Academy of Science - Volume 24 1970

Academy Editors

Proceedings of the

ARKANSAS ACADEMY OF SCIENCE



A Fossil Gymnosperm from Hooker, Arkansas

Volume XXIV
1970

EDITOR: Lester C. Howick
Department of Chemistry, 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. Manuscripts are to be presented to the section chairmen at the time of the reading of the paper. The Editorial Board reserves the right to edit, shorten, or reject any papers submitted to it. In general, submitted papers will be reviewed by persons competent in the area of study.

Manuscripts should be typewritten, double spaced throughout, with the format followed being that of a commonly used journal in the area of study. Illustrations may be used but special care should be exercised to insure that drawings and photographs are of the highest quality. Such illustrations should be properly proportioned to fit the **Proceedings** page and lettering should be large enough to be legible upon size reduction.

Manuscripts will normally be limited to three **(Proceedings)** pages with pages in excess of this being charged to the author at cost. Authors may be expected to bear charges arising from exceptional typesetting or illustration.

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

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 1971 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

Arkansas Academy of Science, Box 1709, University of Arkansas
Fayetteville, Arkansas

ARKANSAS ACADEMY OF SCIENCE

Volume XXIV **Proceedings** 1970

Secretary's Report

The 54th Annual Meeting of the Arkansas Academy of Science was held at Arkansas Polytechnic College, Russellville, April 17 and 18, 1970, with Professor Maurice L. Lawson, Harding College, President of the Academy, presiding.

At the business meeting, Dr. J. P. Jones, Treasurer circulated the Financial Statement which is summarized below:

Summary of Financial Statement
April 1, 1970

Cash Balance on Hand, April 1, 1969	$1863.91
Reserve Fund	1358.35
Total Assets, April 1, 1969	3222.26
Receipts — April 1, 1969 - March 31, 1970	
Membership Dues	$1251.25
Institutional Memberships	440.00
Sales of Proceedings	151.80
Reimbursement from AAAS for Junior Academy Research Grants	178.68
Banquet Tickets	162.50
Miscellaneous	81.60
Total Receipts —	2265.83
Disbursements — April 1, 1969 - March 31, 1970	
1969 Proceedings - Southwest Printing Co.	2140.24
Junior Academy Expenses	200.00
Junior Academy Research Grants	103.20
Banquet Expenses	325.00
Subscriptions — Science Talent Search	15.00
Mailing and Postage	87.62
Office Supplies	46.02
Executive Committee Expenses	73.41
Miscellaneous	55.79
Total Disbursements —	3046.28

Summary

Original Balance, April 1, 1969	$1863.91
Receipts — April 1, 1969 - March 31, 1969	2265.83
Total	4129.74
Disbursements	3046.28
Cash Balance, March 31, 1970	1083.46
Reserve Fund, April 1, 1969	1358.35
Interest on Reserve Fund	65.29
Total Assets — April 1, 1970	2507.10

The Editor, Dr. L. C. Howick, reported that page costs are continuing to increase and this accounts for the major expenditure in the financial statement. The Editor indicated that the 1970 Proceedings would be published in a two column 8½x11 format which should reduce publication costs considerably.

Representatives of the following Academy sponsored activities presented reports which are summarized in the Minutes of the meeting:

Junior Science and Humanities Symposium — Dr. Eugene Wittlake

Collegiate Academy of Science — Dr. Joe Nix

Junior Academy of Science — Mr. E. E. Hudson

Arkansas Biology Curriculum Development Conference — Dr. Neal Buffaloe

Science Talent Search — Dr. Leo Paulissen

State Science Fair — Dr. Lowell Bailey

Secretary's Report

The President reviewed the discussion which had been held regarding the advisability of the Academy working with state agencies in an advisory capacity. Members of the Executive Committee had met with the State Science and Technology Council and the Council had asked the Academy to prepare some recommendations regarding possible activities of the state group. A statement on the position of the Arkansas Academy of Science on possible future activities of the Arkansas Science and Technology Council was circulated to the membership and approved. The President agreed to transmit the statement to the Chairman of the Science and Technology Council.

President Lawson asked for an expression from the membership of their willingness to see the Academy become involved in the formulation of science policy and in serving in an advisory role. The following resolution addressed to the Governor of the State was adopted:

> WHEREAS we believe that the Chief Executive of the State of Arkansas and the Boards and Commissions appointed by him wish to utilize all resources available to them in the formulation and establishment of a sound science policy for making decisions affecting the health and welfare of the citizens of Arkansas, therefore be it
>
> RESOLVED that we, the members of the Arkansas Academy of Science, do offer our separate and collective services to assist in the establishment of such science policy for the State of Arkansas.

The Nominating Committee appointed by President Lawson nominated Dr. George Templeton, Professor of Plant Pathology, University of Arkansas, for the position of President-Elect, and Dr. Templeton was elected unanimously. It was announced that the meeting for 1971 would be held at Harding College, Searcy, the meeting in 1972 would be at the University of Arkansas, Fayetteville, and the meeting in 1973 would be at State College of Arkansas, Conway. The nominating committee for AAAS Fellows, with Dr. Paul Sharrah chairman, recommended that Dr. Arthur Johnson, Hendrix College, and Dr. Walter Meyer, University of Arkansas, be nominated to be Fellows in the American Association for the Advancement of Science.

The Constitution and By-Laws were amended by a favorable vote of three-fourths of the members present so that Article 10 of the By-Laws now reads: "Dues for members of the Academy shall be $8.00 per year for Regular Members and $10.00 or more per year for Sustaining Members and will entitle the member to receive a copy of the Proceedings." The change increases the Regular Member dues from $5.00 per year to $8.00 per year.

The Minutes of the 54th Annual Business Meeting, April 17-18, 1970, have been circulated to the membership by mail.

Respectfully Submitted,

William C. Guest, Secretary

PROGRAM
Arkansas Academy of Science

Fifty-Fourth Annual Meeting
ARKANSAS POLYTECHNIC COLLEGE
Russellville, Arkansas

Friday, April 17, 1970

SENIOR, JUNIOR, COLLEGIATE ACADEMY—Registration

SCIENCE FAIR — Registration

SENIOR ACADEMY — Executive Committee

COLLEGIATE ACADEMY — Executive Committee

SCIENCE TALENT SEARCH

SENIOR ACADEMY — Business Meeting

Talk by RICHARD B. HOOVER, NASA

JUNIOR ACADEMY — Business Meeting

COLLEGIATE ACADEMY — Business Meeting

SENIOR ACADEMY — Archeology and Anthropology Section

JUNIOR ACADEMY — Papers

COLLEGIATE ACADEMY — Papers

SENIOR ACADEMY — Science Education Section

SCIENCE FAIR — Open to public

JUNIOR ACADEMY, COLLEGIATE ACADEMY, SCIENCE FAIR PARTICIPANTS — Supper

SENIOR ACADEMY — BANQUET
ADDRESS: RICHARD B. HOOVER of NASA: "X-Ray Astronomy"

SCIENCE FAIR, JUNIOR ACADEMY, OUTSTANDING BIOLOGY TEACHER — Awards

Saturday, April 18, 1970

ARKANSAS SCIENCE TEACHERS ASSOCIATION — Breakfast

SCIENCE FAIR — Open to public

SENIOR, JUNIOR ACADEMY — Registration

ADDRESS: HARLAN T. HOLMES of A.P. & L.: "Arkansas Nuclear One"

SENIOR ACADEMY SECTION MEETINGS

SENIOR ACADEMY — Business Meeting

SENIOR ACADEMY SECTION MEETINGS CONTINUED —

SECTION PROGRAMS

SCIENCE EDUCATION SECTION

Business Meeting

WILLIAM W. TRIGG: The Use of the Programable Electronic Calculator in the Undergraduate Laboratory

COLLEGIATE ACADEMY, PHYSICAL SCIENCES SECTION

JIM PFEIFER: A Method for Determining Molecular Photoionization Cross Sections for Gaseous Vapors

GENE BANGS: Gas-Liquid Chromatography of Amino Acid and Carbohydrate Derivatives

JOHN B. CONE: A Linear Device for Measuring Pressures from Atmospheric to Ion-Guage Range

BOB WELLES: Synthesis and Infra-Red Study of P-OH-3-Phenylindolizidine

DAVID ROLL: Synthesis and Infra-Red Study of O-OH-3-Phenylindolizidine

STEVEN C. MOSS: An Improvement on the Born Approximation

JOHN HOLSTON: Laboratory Simulation of Stratified Reservoir Conditions

LEE KUYPER: Factors Affecting the Distribution of Oxygen in Lake Hamilton, Arkansas

COLLEGIATE ACADEMY, BIOLOGICAL SCIENCES SECTION

RICHARD BROWN: Toads and Frogs as Predators in Southeast Arkansas Cropland

M. F. McFARLAND III: A Comparative Study of the Helminth Parasites Found in Grackles, Starlings, Cowbirds, and Red Wing Blackbirds in Faulkner County

FRANCES DUKE: A Comparison of the Algae Population of a Clean Water Supply

ROBERT J. MANIS: A Preliminary Study of the Trematode Fauna of Selected Arkansas Amphibians

PATRICK OSAM: Acid Phosphatase Activity of Lysosomes as an Index to Freeze-Thaw Induced Latent Injury in Hepatic Cells

JOHN RANSOM: Production and Growth of Channel Catfish Fingerlings. **Ictalurus punctatus (Rafinesque)**

RONALD HUBBARD and GEORGE HARP: The Limnology of Lakes Formed in Areas of Bauxite Strip-Mining Operations

ARCHEOLOGY AND ANTHROPOLOGY

Chairman: Kenneth W. Cole

MARTHA ROLINGSON: Archeological Investigation of Bayou Bartholomew, 1969

STEVE ADAMS: Profiling Techniques in Archeology

CHARLES JOHNSON: Art and Culture Among the Ashanti of Ghana

JOHN HUNER: A Classification of Some European Trade Beads from Louisiana and Mississippi

GLORIA YOUNG: Reconstruction of an Arkansas Hopewellian Panpipe

MICHAEL P. HOFFMAN: Crockett Curvilinear Incised — The Evolution of a Design Style in the Little River Region, Southwest Arkansas

Business Meeting

BIOLOGICAL SCIENCES

Chairman: Gary E. Tucker

MARGARET B. DAVIS and EDWARD E. DALE, JR: The Ecology of Bangle Grass **(Chasmanthium latifolium)** (Michx.) (Yates) in Northwest Arkansas

RICHARD L. MEYER, JAMES H. WHEELER and J. R. BREWER: The Freshwater Algae of Arkansas. II. New Additions

DANIEL L. MARSH: Observations of flowering in **Arundinaria gigantea** in Arkansas

EDWIN B. SMITH: Additions to the Arkansas Flora

GARY TUCKER and BILL GRABILL: Floristic Elements of the Pope County, Arkansas, Area

EDWARD E. DALE, JR. and THOMAS L. FOTI: Relationships of Vegetation Cover to Forage Weights in Deer Enclosures

RUSSELL McNALTY and E. LEON RICHARDS: The Vascular Plants of Lawrence County, Arkansas

JOE YATES: Land Use in Northwestern Arkansas: A Case Study

E. B.: WITTLAKE: **Glyptostrobus europaeus** in Arkansas

J. T. DANIEL and GEORGE TEMPLETON: Enzymatic Evidence that Leucine from Tentoxin is Levorotatory

H. B. BETTON, L. ROLFE, P. S. REED, and S. V. BRADLEY: The Effect of **Rhizobium phaseoli** on the Amount of Nodulation and Mineral Uptake of Snapbean var. Contender. I. Trifolid vs. Seed Inoculation Stage.

H. B. BETTON and L. ROLFE: The Effect of **Rhizobium phaseoli** on the Amount of Nodulation and Mineral Uptake of Snapbean var. Contender. II. Cotyledon vs. Trifolid Stage

DAN TIMMERMANN, JR., HOWARD G. APPLEGATE, and E. MARK ENGLEMAN: Macroscopic and Microscopic Response of **Gossypium hirsutum** L. to Hydrogen Fluoride Fumigation

H. B. BETTON: Taxonomy of the Genus **Bacillus.** I. Cultural and Biochemical Studies

H. B. BETTON and M. KELLEY: Taxonomy of the Genus Bacillus. II. Growth and Cytological Studies

H. B. BETTON and J. D. ALEXANDER: Physiology of Tomato Plants var. Bradley Inoculated with **Bacillus stearothermophilus**

REX L. ELEY: Community Metabolism and Oxygen Budget of Keystone Reservoir, Oklahoma

PEGGY RAE DORRIS: Observations on the Impact of Certain Insecticides on Spider Populations in a Cotton Field

TOM PALKO: A Preliminary Study of Zooplankton Over a Six Months Period on Lake Dardanelle

D. LEROY GRAY and RICHARD A. COLLINS: The Age and Growth of the Blue Catfish, **Ictalurus furcatus,** in the Arkansas River

ROLLIN REIMER: Notes on the Crawfishes of Arkansas

CHARLES LINCOLN and JACOB R. PHILLIPS: The Impact of Resistance to Insecticides on Cotton Insect Problems in Arkansas

J. W. E. WORTHAM and EARL L. HANEBRINK: A Road-Kill Census of Mammals in Northeastern Arkansas

JAMES HOUSTON: Notes on the Habitat and Distribution of the Odonata of Franklin County, Arkansas

JOHN K. BEADLES: Effects of Domestic Effluents on the Distribution of the Fish Fauna of Lost Creek, Craighead County, Arkansas, from 1966-1970

E. PHIL ROUSE: The Nymphalidae of Arkansas

CHEMISTRY

Chairman: W. W. Trigg

JAMES O. WEAR: Apparatus for Dielectric Constant Measurements

EDGAR D. SMITH and KLUGH E. SORRELLS: A Quantitative Comparison of Gas Chromatography Septum Bleed

T. D. ROBERTS and TOM FANNING: Thiodiazocarboxylates

W. L. MEYER and R. J. HOFF: An A-B-C Approach to the Synthesis of Diterpenoid Alkaloids. Total Formal Synthesis of dl-Atisine

A. B. GOSNELL and J. T. EDMONDSON: Anionic Copolymerization of Dimethyl Sulfoxide and Divinyl Sulfone

C. T. BOUNDS and A. F. GREMILLION: The Gas Chromatographic Separation of the Open Chain C_6 Monoolefins

SAMUEL SIEGEL: Alkenes as Possible Intermediates in the Catalytic Exchange of Alkanes with Deuterium

WALTER L. MEYER: Computation of Non-Chair Conformations of Cyclohexanones

MATHEMATICS

Chairman: C. E. Padgett, Jr.

DON STOKES: Simple Algebraic Extensions and Characteristic Polynomials

JOHN M. HOPPER: Current Trends in the Mathematics Curriculum

PHYSICS

Chairman: H. E. McCloud

J. G. WEBB: Application of the Kohn Variational Principle to the Theory of Three Particle Inelastic Scattering

J. R. SINGER: Excess Ultra-sonic Attenuation and Volume Viscosity in Simple Liquids

C. J. BRONCO: Molecular Photo Dissociation

C. H. ROGERS: The Liquid Structure of Sulfur Dioxide

P. C. SHARRAH: The Solar Eclipse as Viewed from Southern Mexico

BUSINESS MEETING

D. C. WOLD: A Microscopic Description of the Zirconium (alpha, alpha prime, gamma) Reaction

L. COLEMAN: Atomic Effects in Nuclear Resonances

D. A. AVERY: The Thermagnetic Torque Effect in Ortho —and Para-Hydrogen

J. E. MACKEY: Some Combinations of Third Order Elastic Constants of Strontium Titinate

J. HENDREN: The Structure of Glass by X-Ray Diffraction

GEOLOGY

Chairman: R. R. Cohoon

JOHN A. ROTH: The Ammonoid Quinnoceras from the Morrowan Series of Arkansas

JAMES D. MORRISON: The Eddy Shelter of Beaver Reservoir

Arkansas Collegiate Academy Of Science

ABSTRACTS

JIM PFEIFER: A Method For Determining Molecular Photoionization Cross Sections For Gaseous Vapors.

This paper presents a mathematical procedure for computing molecular photoionization cross sections from experimental data taken by using a set of far ultraviolet filters. The basic advantages of this filter method will be pointed out.

GENE BANGS: Gas-Liquid Chromatography of Amino Acid and Carbohydrate Derivatives.

A brief discussion of the practical application of GLC to amino acid and carbohydrate analysis. The discussion is based on research performed during the summer of 1969 at Oak Ridge National Laboratories in Oak Ridge, Tennessee.

JOHN CONE: A Linear Device For Measuring Pressures From Atmospheric to Ion-Gauge Range.

An investigation of a pressure gauge based on the scattering of ultraviolet light. This type of vacuum pressure gauge should have a linear calibration curve over the region from atmospheric pressure down to the one micron range. This type of gauge should be able to replace the two or three gauges now needed to cover this range. Such a gauge would have the added advantage of introducing no contaminants into the system.

BOB WELLS: Synthesis and Infra-Red Study of **Para**-Hydroxy-3-Phenylindolizidine.

2-Pyridine carboxaldehyde was reacted with **para**-hydroxyacetophenone by a crossed aldol condensation. The product was reductively cyclized with PtO_2 catalyst to give **para**-hydroxy-3-phenylindolizidine. An infra-red spectrum was taken of the condensation product and the indolozidine. An infra-red dilution series was also carried out with the **para**-hydroxy-3-phenylindolozodine.

DAVID ROLL: Synthesis and Infra-Red Study of **ortho**-Hydroxy-3-Phenylindolizidine.

2-Pyridine carboxaldehyde was reached with **ortho**-hydroxyacetophenone to give the crossed aldol condensation product, 2-pyridal-**ortho**-hydroxyacetophenone. This was then reductively cyclized to give the desired **ortho**-hydroxy-3-phenylindolizidine. Infra-red studies on the identification of the predominant epimer are discussed.

STEVEN MOSS: An Improvement On The Born Approximation.

An improvement on the Born Approximation is developed with calculations using the Kohn variation method.

JOHN HOLSTON: Laboratory Simulation of Stratified Reservoir Conditions.

Water conditions similar to those found in stratified reservoirs during the summer and early fall months have been simulated in a 50 gallon polyethylene tank. Mud taken from the bottom of Lake Hamilton was placed in the bottom of the tank. Water was introduced bringing

the level near the top of the container. The lower one-third of the tank was cooled to maintain the thermal stratification.

The distribution of dissolved oxygen, pH, iron, and manganese was observed to be very similar to distributions observed in Lake Hamilton. The tank has been used to supply "in lab" samples for the study of the migration of trace metals from bottom muds.

LEE KUYPER: Factors Affecting The Distribution of Oxygen in Lake Hamilton, Arkansas.

The distribution of dissolved oxygen in Lake Hamilton has been studied for a period of two years. The principle factors which affect the oxygen distribution have been found to be 1) a cold density current originating from an upstream cold water release reservoir, 2) interflow density currents observed during heavy spring rains, 3) oxygen consumption by bottom muds and dissolved organic matter during periods of low flow through the reservoir.

RICHARD BROWN: Toads and Frogs as Predators in Southeast Arkansas Cropland.

One thousand fifty Anurans were trapped over a twelve week period in the delta crops of cotton, soybeans, corn, and grassland. The majority of frogs were trapped in the crops at White River Wildlife Refuge as compared to the area trapped at Pickens, Arkansas which is under heavy insecticide application. Ninety per cent of the frogs trapped in both areas were **Bufo woodhousei fowleri, Gastrophryne carolinensis,** and **Hyla cineres.** Dissection of the 1050 Anurans revealed diets totaling almost 34,000 insects and other invertebrates. Ants comprised over 70% of the total number of insects eaten. Almost 10% of the insects eaten were ground beetles (Carabidae). The number of destructive insects eaten was relatively small.

M. F. McFARLAND III: A Comparative Study of the Helminth Parasites Found in Grackles, Starlings, Cowbirds, and Red Wing Blackbirds in Faulkner County.

Parasites have been collected from ten hosts of each species and have been stained and mounted. These parasites will then be identified.

ROBERT J. MANIS: A Preliminary Study of the Trematode Fauna of Selected Arkansas Amphibians.

The present project is a study of the trematodes from selected Arkansas amphibians. This study has included the collection, identification, and dissection of amphibian hosts, the preparation of trematode whole mounts, and the systematic classification of all trematodes recovered. Five families, six subfamilies, seven genus, and thirteen species are recorded for the first time in their respective hosts.

PATRICK OSAM: Acid Phosphatase Activity of Sysosomes As An Index to Freeze-Thaw Induced and Freeze-Thaw-Induced Latent Injury in Hepatic Cells.

A study has been made evaluating the effects of freezing and thawing at a subcellular level for determination on a biochemical basis of cryobiological factors of injury and protection. Liver tissue from mice has been employed to analyze the initial and long term (latent injury) effects of freezing and thawing on the functional integrity of the cell, the organelles of the cell, and the enzymes or enzyme systems associated with these organelles. Particular attention has been paid to the lysosome which contains an array of hydrolytic enzymes within its interior. One enzyme, acid phosphatase, is used as a characteristic marker for the lysosome. A biochemical assay procedure has been utilized which serves as an indicator of alteration of the lysosomal membrane due to freezing and thawing by measuring the resultant release of acid phosphatase as reflected by its activity of forming measurable, fluorescent alpha naphthol as a product of a biochemical reaction.

JOHN RANSOM: Production and Growth of Channel Catfish Fingerlings, **Ictalurus punctatus** (Rafinesque).

Four ponds were stocked with ½ oz. channel catfish fingerlings. Ponds number one and two were each 0.65 acre in size and were stocked with 1,000 fish. Ponds number three and four were 1.31 acre and were stocked with 3,000 fish.

Supplementary feeding was begun on May 16, 1969. Fish were fed floating fish pellets at the rate of 3% of their body weight per day. After 22 weeks of feeding, the fish averaged weighing 12 ozs. each with an average daily gain of .0746 ozs.

RONALD HUBBARD, GEORGE HARP: The Limnology of Lakes Formed in Areas of Bauxite Strip-Mining Operations.

Strip-mining for coal commonly leaves pits which subsequently fill with water. Initially, such lakes contain water contaminated with sulfuric acid formed by the oxidation of sulfur compounds associated with the coal. No investigation has been conducted to date concerning the physico-chemical or biological characteristics of strip-mine lakes resulting from bauxite mining, which also results in acid water formation. This study is a preliminary survey to qualitatively and quantitatively describe the physicochemical characteristics and the aquatic biota of four strip-mine lakes in Saline County, Arkansas, resulting from bauxite mining. This information will be compared with that known concerning coal strip-mine lakes.

GARY CASE, GEORGE HARP: The Benthic Macroinvertebrate Fauna of an Ozark and a Deltaic Stream.

The physicochemical and benthic macronivertebrate parameters were studied to determine longitudinal and vertical zonation within each stream. J a n e s Creek

(ozark) was clear, spring-fed and alkaline with a steep gradient. Big Creek (deltaic) was turbid, low in alkalinity, with slight gradient and low stream velocity. Mean standing crop for Janes Creek was 265 organisms/M². One hundred taxa were identified, snails dominating. Big Creek supported a mean standing crop of 726 organisms/M². Only 55 taxa were identified, oligochaetes and chironomids dominating. These streams exhibited two distinct habitats due to differences in substrate, watershed and land use.

Optical Phenomena in Diatoms

by Richard B. Hoover, Applied Physics Branch, Technology Division
Geo. C. Marshall Space Flight Center, Marshall Space Flight Center, Alabama
and
Miriam J. Hoover, Lockheed Missiles and Space Company,
Huntsville Research and Engineering Center, Huntsville Research Park,
Huntsville, Alabama

ABSTRACT

Diatoms are unicellular algae which fabricate siliceous shells that are frequently marked with intricate ornamentations and patterns. The nature and characteristics of the siliceous shells provide a basis for diatom taxonomy and give rise to a number of interesting and colorful optical phenomena. This paper presents the results of investigations of diffraction phenomena, complementary color behavior, Rayleigh scattering and optical activity in diatoms.

1. INTRODUCTION

Diatoms are a distinct group of unicellular algae belonging to the phylum Chrysophyta and the family Bacillariophyceae. All diatoms characteristically encase themselves in cell walls (frustules) composed of extremely pure hydrated amorphous silica (i.e., silicic acid as a polymer). Chemical analysis of the frustules of marine planktonic diatoms indicated 96.5% SiO_2 and approximately 1.5% of Al_2O_3 and 1.5% Fe_2O_3.[1] Diatom shells have a refractive index of 1.43.

The diatom shell is constructed of two overlapping valves (resembling a hat box). As the diatom grows, these two valves can slide apart, thereby permitting some expansion of this otherwise rigid quartz structure. The two diatom valves are frequently connected by a girdle-like band (intercalary band). When viewed from the top (valve view), the shape of the diatom varies widely; when viewed from the side (girdle view), diatoms are generally rectangular. Diatoms are usually divided into two orders; the Centrales comprising the radially symmetric diatoms and the Pennales comprising bilaterally symmetric and asymmetric diatoms, as seen in valve view. Many of the Pennate diatoms possess a V-shaped groove (raphe) in the valve wall. By exuding cytoplasm along this raphe, and collecting it again at a central or polar nodule, the diatom can propel itself through the water[2,3]. Only diatoms with a true raphe have the power of locomotion; all others are either free floating or attached to aquatic plants or other underwater objects.

The surfaces of diatom shells or frustules often exhibit complex and intricate ornamentations. These usually consist of thickened ribs arranged in a fairly definite pattern, hyaline areas, spikes, alveoli, costae and fine

(1) "Silicification" by Joyce C. Lewin in **Physiology and Biochemistry of Algae,** Academic Press, New York, New York (1962), p. 448.

(2) Cornelius Onderdonk, **The Microscope,** August, 1890.

(3) Ruth Patrick and Charles W. Reimer, **The Diatoms of The United States,** Vol. 1., Academy of Natural Sciences of Philadelphia, 1966, pp. 22-23.

lines or striae. The nature and characteristics of these ornamentations and the structure of the siliceous shell provide a basis for diatom taxonomy. They also give rise to a number of interesting and colorful optical phenomena.[4] Many of these effects are well understood, while others await explanation.

II. DIFFRACTION PHENOMENA IN DIATOMS

Beautiful diffraction colors may be observed by illuminating a spray of diatoms which possess straight parallel striae (e.g., Navicula, Nitzschia, Pinnularia, etc.) with an intense unidirectional white light source. The diatoms oriented such that these striae are perpendicular to the direction of the light will behave as small diffraction gratings and produce brilliant colors.[5] The entire range of the spectrum is obtainable and the hue will change markedly with small variations in the angle of illumination. These colors disappear in uniform light and are not visible with a large aperture objective or with a wide illuminating cone.

Diffraction colors are only observable if the illuminating beam is in the proper azimuth and are best seen against a dark background. The colors will disappear if the system is rendered optically homogeneous by using a mounting medium of the same refractive index as the diatoms.

III. RAYLEIGH SCATTERING

Many diatoms contain pores, poroids or fissures in the cell wall which are so small that they may not be seen directly with the visible light microscope. However, their presence may be detected by observing the diatom in dark field illumination. If the transparent particles or pores of the diatom are larger than 1 micron diameter, the diatom will appear white under dark field illumination. Diatoms belonging to the Genus Triceratium, Coscinodiscus, Synedra, Pinnularia, Melosira, Stictodiscus, Hyalodiscus, Fragillaria and many others behave in this way.

If the diatom contains transparent pores which are approximately 0.3 microns in diameter, the scattered light will be a brilliant Tyndall blue and the transmitted light is turbid orange or yellow.[6] This occurs because the pores are large enough to scatter the short wavelengths but too small to deviate the longer waves which are consequently transmitted. Due to Rayleigh scattering, Heliopelta appear bright blue with a bronze maltese cross in the center surrounded by a crown of golden spikes.[7]

This technique has been used to detect the presence of subwavelength diameter pores in Navicula, Nitzschia, Pleurosigma, Gyrosigma, Stauroneis, Pleurostauron, Actionoptychus, and Actinocyclus, etc. It is a valuable tool because it provides useful information about the microstructure of the cell wall.

IV. OPTICAL ACTIVITY IN DIATOMS

Since the diatom cell wall is hydrated amorphous silica, it is generally assumed that diatoms would have no effect on the state of polarization of visible light. During this work, over a thousand species of diatoms were examined and only a few were found to have any effect on the state of polarization of visible light.

These include:

1. A specimen Aulacodiscus Oregonus from Santa Maria, California which glows a brilliant yellow when viewed through crossed polarizers.[8]

2. Pleurosigma Angulatum from the United States as well as from Hawksbury, Australia, has been found to exhibit bright blue colors under crossed polarizers. Where two specimens overlap, a color shift may occur and shades of red and pink have been observed and photographed. This may be caused by organic material remaining in the specimen.[9]

---

(4) During this research, several thousand color photomicrographs were produced, which clearly illustrate these phenomena. Many of these photographs have already appeared in full color in a wide variety of publications. These will be referenced to permit the reader to observe these interesting color phenomena.

(5) Diffraction colors are illustrated in the spray of diatoms from Pensacola, Fla., which will appear in the color plate "Diatoms," to be published in the McGraw-Hill Encyclopedia of Science and Technology, 1971 Edition. The diagonally oriented Navicula lyra and Nitzschia sp. are a brilliant yellow whereas those oriented horizontally are a deep reddish orange (Photograph b).

(6) The photograph of Actinoptychus heliopelta published in **Physics Today,** p. 24, December 1970, shows the brilliant Tyndall blue arising from Rayleigh scattering at small pores in the diatom frustule. The unscattered radiation forms a gold maltese cross in the center of the diatom and a golden periphery.

(7) The Tyndall blue can also be seen in the spray of Heliopelta, McGraw-Hill Encyclopedia of Science and Technology, 1971 Edition, (Photograph g). (The subtle colorations of the central cross and spikes cannot be seen in this reproduction.) The actual pores forming the striae can be seen in the oil immersion photomicrograph of Actinocyclus Ellipticus (McGraw-Hill Encyclopedia of Science and Technology - Photograph i).

(8) Photomicrographs showing optical activity in this diatom have been published in color by the Dicalite Division of Grefco, Inc. Some of the publications in which this photograph may be found include: **Chemical Week,** May 6, 1970, p. 20; **Chemical and Engineering News,** May 11, 1970; **Filtration Engineering,** May 1970; **Chemical Engineering Deskbook,** April 27, 1970.

(9) A photomicrograph of a spray of Pleurosigma (produced by another researcher) appears on the cover of the September issue of **Saturday Review.**

3. Melosira Numuloides and Grammataphora have also been observed to rotate the plane of polarization of visible light.

4. Some specimens of Triceratium favus, Nitzschia sp. and Coscinodiscus sp. from Pensacola, Florida, and St. Andrews Bay, Florida, have also exhibited optical activity.[10] The reasons why these diatoms affect the plane of polarization of visible light is not yet thoroughly understood.

V. COMPLEMENTARY COLOR PHENOMENA IN ACTINOCYCLUS

An interesting effect has also been observed in diatoms of the Genus Actinocyclus. An unusual diatom, which appeared green in bright field illumination, was first observed in a spray of diatoms from Apalachicola, Florida. This diatom, Actinocyclus Ehrenbergii, changed to brilliant red as the microscope condenser was moved from dark field illumination. Several other diatoms of this species from Pensacola, Florida, also exhibited the same property. The diatom, Actinocyclus ellipticus, from Richmond, Virginia, was found to have the same ability to switch from one color distribution to the complementary one as the mode of illumination was changed from bright field to dark field. A beautiful spray of multicolored diatoms (of the Genus Actinocyclus) which exhibit this interesting property has also been found on a slide from Walvis Bay, South Africa.

The reason for this interesting behavior, which seems to be restricted to the Genus Actinocyclus, is not fully understood. These diatoms do not affect the state of polarization of visible light.

(10) McGraw-Hill "Encyclopedia of Science and Technology," 1971 Edition (photograph j).

ACKNOWLEDGEMENTS

This work was primarily conducted on diatoms of the rare and extensive collection compiled by Cornelius Onderdonk. The authors are deeply indebted to the fine work of this diatom pioneer of the last century. Other diatoms of the world used in this work were provided by Professor G. Dallas Hanna, California Academy of Sciences, and Kent Cochran, Dicalite Division, Grefco, Inc. The authors are grateful to Professor G. Dallas Hanna, Professor Charles Reimer, and Dr. Joyce Lewin for their many helpful comments and encouragement. The kind offer of Mr. Kent Cochran, Dicalite Division, Grefco, Inc., to supply interested readers with framing reprints of diatoms in color is gratefully acknowledged. Requests for these reprints may be submitted to the authors.

An Undergraduate Research Program In Chemistry At Philander Smith College

James O. Wear, Ph.D., Philander Smith College and

Veterans Administration Hospital, Little Rock, Arkansas 72206

Introduction

Philander Smith College is a predominantly Negro institution located in the heart of Little Rock, Arkansas. It is supported by the United Methodist Church. The school has an enrollment of approximately 750 students and is accredited by the North Central Association of Colleges and Secondary Schools. Baccalaureate degrees are granted in arts and sciences and teacher education.

Philander Smith College maintains an integrated faculty and strives to serve the undereducated and the underprivileged student. The college offers special opportunities and support for students who:

(1) Need assistance in the development of college level skills in reading, writing, listening, organizing, and interpreting information and mathematics;

(2) Show evidence of ability to achieve academically in a small, individually oriented college curriculum.

The Chemistry Department is part of the Division of Natural Sciences. The chemistry faculty consists of a full-time Ph.D., two part-time M.S. level instructors and a part-time Ph.D. At times, other part time people are used to teach special topics. There are 3-6 junior and senior chemistry majors at any time with 10-20 junior and senior minors.

The chemistry program has been developed in the

past three years with a stable part time and full time faculty. In this period the course work has approached the American Chemical Society requirements, and undergraduate research has been instituted.

Facilities

Undergraduate research in chemistry at Philander Smith College appears to be impossible when one considers the laboratory and library facilities on campus. The library on campus is excellent for a liberal arts college, but it does not have the collection of scientific books and journals that are required for research. The laboratories are not adequately equipped for current teaching purposes.

Fortunately, in Little Rock there are two good scientific libraries. These are at the University of Arkansas Medical Center (UAMC) and at the Graduate Institute of Technology (GIT), University of Arkansas. Most current journals in chemistry are received by these libraries, and all major journals are on hand for several years back. The various standard reference handbooks are available as well as several hundred volumes on chemistry topics. Both institutions have complete sets of Chemical Abstracts.

There are also some very good research laboratories in Little Rock at the branches of the University of Arkansas and the Veterans Administration Hospital.

Since the author is an employee at the Veterans Administration Hospital and has appointments at UAMC and GIT, it was decided that an undergraduate research program in chemistry could be established at Philander Smith College.

In the physical chemistry laboratory at the VA hospital, the following major equipment is available: light scattering photometer, differential refractometer, UV-Vis spectrophotometer, and electron spin resonance spectrometer. Many other types of minor equipment are also available. The VA hospital administration was more than willing to cooperate on an education project of this type as long as the students were supervised by VA personnel.

Program

In the fall of 1966, this undergraduate research was started with one student. This was not a formal program, and the student could not obtain credit for the work because it was not listed in the catalog. However, the student did spend ten or more hours working in the laboratory each week on a research project.

Initially, the student worked with an M.S. chemist to learn techniques. A project was chosen by the student from several suggested by the author, and the student began reading while she was learning lab procedures. After approximately one month, the student started performing work on her own project.

During the course of the year, she read and discussed the project with the author. She developed a better understanding of chemistry and a greater interest in school as a whole. Because of this work and interaction, she decided to go on to graduate school. It was the success with this student that initiated the expansion of the program.

In the past two years, arrangements have been made to allow students to obtain up to four hours credit for research. The course has been made more formal and serves as a real supplement to the program for chemistry majors.

The current program includes lectures and reading about research techniques in addition to working on a research project. The book, "Introduction to Scientific Research", by E. Bright Wilson, Jr., is used as a text. The material in the book as well as laboratory techniques are discussed in lectures. These lectures are really seminars that are held at least every two weeks. At the end of the year, the students present their work in these seminars.

The research work is done in two 3-4 hour sessions per week. Generally two students are working in the laboratory at a time, and the author will spend some time in each session with them individually. In these individual discussions, the students learn how to interpret data and project further experiments.

The projects are chosen in such a manner that they can be finished in an academic year. The student then writes his work up in a format for publication and presentation. This phase is an important teaching part of the program and is an aspect that is not available in any other part of their college work.

Goals

The chemical research program at Philander Smith College has several goals which are especially worthwhile for the students at an institution of this type. The principle goals are to create interest in chemistry on the part of the students, to fill in some of their weaknesses and to better prepare the students for industry or graduate school. All of these goals are met with an increased interaction between student and teacher in a research training situation. A research problem becomes a teaching tool in much the same way it is in graduate school.

The student develops a greater interest in chemistry as a career while doing a research problem because this is a real situation with a purpose and not just another laboratory experiment. The feel of doing something that has not been done adds enthusiasm. Of course some students discover that chemistry is really not what they wanted, which is also worthwhile.

The laboratory work develops a better understanding concerning why careful measurements are important. The students learn to be careful with expensive equipment,

because their work depends on the use of the equipment. The measurements are made more carefully when they see how carelessness can cause scatter in data so that it cannot be interpreted. The research project is different from a laboratory experiment because the answers are not known. Again, the challenge of doing something new is important.

The student also learns to keep good records and to make them permanent so someone else can follow them. This is developed as they try to repeat other work while checking techniques and also as they need to look up something they did in the past. This aspect is discussed initially and monitored periodically. The best teaching tool here is when the student makes mistakes and has to work to find some information he has previously taken.

Throughout the program, the student is encouraged to ask questions about the work and make decisions on what to do next. This process means that a lot of mistakes are made and time is wasted, but the students learn by their mistakes. The project is the student's responsibility as much as possible; but of course, they receive a lot of guidance.

A major goal of this research course is to teach the student to present his results both orally and in writing. The student tabulates and graphs his data and discusses it with the author before he starts writing. After this data interpretation session and some general guides on writing the work up, the student writes up the research work. The format is generally according to American Chemical Society journals.

The paper is then criticized by the author before the student presents his work in a seminar The student then presents his work to the other students and chemistry faculty in a seminar. Here he answers questions and defends his results.

After the seminar, the student writes a final paper and receives a grade for the course. If the project is sufficient in scope, it is submitted for publication. Frequently, two or three projects are put together for a journal article.

Results

Six students have worked on research projects during a three year period. Five of these students are currently working on projects, and three of these will work in the program next year. These projects and the students are discussed in this section.

The first student in 1966-67 worked on a determination of hydrolytic species of UO_2^{++} using the coagulation of silver halides as a tool. The coagulation was followed with a light scattering photometer. Precise solution preparation and pH measurements were required. This student finished the project and prepared it for presentation. The work was presented at a regional meeting of the American Chemical Society (ACS) and has been submitted for publication. The student went on to graduate school at Wayne State University in Detroit.

In 1967-68 a second student (a junior) started working on a light scattering project. This project was to see if the technique used to study hydrolysis could be extended to general complex studies. This project developed many problems and has been finished this academic year. The work is very good and will be presented at an ACS meeting and submitted for publication. The student has developed into an excellent laboratory worker and plans to work for the Defense Department as a chemist and attend graduate school part time.

In the fall of 1968 three additional students, one senior and two juniors, entered the program. This was when discussions and more formal sessions were developed. At semester, another junior student started a project. These projects are as follows:

(1) **Mn^{2+} -Cl^- complex formation in dimethyl formamide.** This is a spectrophotometric study using the mole-ratio method to confirm some ESR studies. This project was completed at semester and is being written up. It will be incorporated into the ESR paper or published as a note.

(2) **Solvent effects of $Mn(ClO_4)_2$ in dimethyl formamide - methanol.** This is an ESR study that appears to be a promising piece of work. It will be carried over to next year.

(3) **Effect of solvent on the coagulation of AgI in n-propyl alcohol-water mixtures.** Th^{4+} is used as a tool to measure this effect by light scattering techniques. This work is almost complete and will be written up this semester. This student is a senior and is going on to graduate school.

(4) **Complexes of Mn^{2+} with portions of an ATP molecule.** Two projects have been started in this area. Ribose and PO_4^{3-} are being used in these two studies. ESR is the tool that is used for studying possible complexes.

In general the program is creating interest among students. At the same time it is developing students who have potential by giving them self-confidence as well as additional training. A cooperative arrangement of this type would be useful for many small colleges that do not have equipment for good research projects.

Archeological Investigation of Bayou Bartholomew, 1969

Martha Ann Rolingson

Arkansas Archeological Survey, Arkansas A&M College, Monticello, Arkansas 71655

ABSTRACT

Archeological investigation along Bayou Bartholomew in Ashley County was initiated with the primary objective of establishing a chronological sequence of prehistoric cultures. This paper reports the first season of fieldwork. Emphasis was placed on locating sites and obtaining adequate surface collections while only two sites were tested. The different types of sites and their relationship to the Bayou Bartholomew channels are discussed. Prehistoric occupations from four general periods are outlined, including late Archaic, early to middle Woodland, late Woodland and Mississippi.

At the beginning of the nineteenth century that portion of Arkansas lying south of the Arkansas, east of the Ouachita and west of the Mississippi rivers was known as an extensive, gloomy, uninhabitable wilderness of mosquito-infested swamps dominated by cypress, tupelo gum and cane. It was thought to be used by Indians only as a hunting territory and it remained relatively unexplored through out the early period of archeological investigation in the Mississippi valley. Cyrus Thomas located sites south of the Arkansas River in 1894 and C. B. Moore investigated sites on the Arkansas, Mississippi, Ouachita, Saline and Bartholomew rivers between 1908 and 1913. These men located neither large, spectacular sites nor cemeteries with large numbers of pots and other desirable museum items. The region was largely ignored in the succeeding 50 years. The survey of the Mississippi Alluvial Valley by Phillips, Ford, and Griffin in the early 1940's and the work of Ford and Redfield in 1962 barely touch upon the area. None of the prehistoric sites have been excavated and reported on by a professional archeologist.

Our knowledge of the archeology of this region is therefore minimal. Perhaps the lack of archeology is a reflection of the prehistoric situation, that is, it has not attracted attention because it was always marginal to centers of development in other areas. Even if there was no cultural climax here, it should be a zone of contact between climax regions. It lies between northeastern Arkansas, the southern portions of the lower Mississippi valley and the Red River area of Texas, Louisiana and Arkansas. These regions each have centers of distinctive local development where extensive archeological work has been done. The nature of contact between the Mississippi Valley and the Red River valley and between the lower and central Mississippi valley regions has been the subject of much debate. Questions cannot be resolved without information on the developments in the intervening region.

The Bayou Bartholomew area was chosen for the initial investigation in southeastern Arkansas for a number of reasons, some theoretical and some practical. First, the bayou is on the western edge of the delta and the physiography is much the same as in other portions of the Mississippi Alluvial Valley. Despite this physiographic link with the Mississippi River area, the stream is in the Ouachita River drainage system and was once the main channel of the Arkansas River. Second, it has been used as a boundary for the definition of archaeological regions although little is known about the area itself. Third, almost the entire area is under cultivation and sites are thus easy to locate. These sites are also rapidly being destroyed by the increasing mechanization of agriculture and need to be investigated before they are gone. Fourth, some Arkansas Archeological Society members have made the work easier by accurately reporting site locations, donating surface collections from the sites, and generally being helpful in every way possible.

Two distinct physiographic units are included in southeast Arkansas, locally termed the "delta" and the "hills". The division between them is an abrupt escarpment. The delta portion is flat and is almost entirely converted to large-scale mechanized agriculture of cotton and soybeans. The hills were cleared for small subsistence farms in the early nineteenth century but the soils are too poor in quality for good crop production and are now covered with tree farms of southern pine.

Geologically, the "hill" portion is called the Prairie Terrace and is Pleistocene in age. The "delta" portion is Recent in age and is the Arkansas River alluvial fan. This portion of the alluvial fan has two units, Macon Ridge and the Boeuf Basin. The Boeuf Basin encompasses most of the delta in southern Arkansas and Macon Ridge separates this Basin from the Mississippi River floodplain. The Boeuf Basin has never been part of the Mississippi River system, rather it has always been Arkansas River drainage, paralleling the Mississippi and draining into the Ouachita River.

The major features of the Boeuf Basin are the Ar-

kansas River meander belts that are now occupied by smaller streams. H. N. Fick's study of the Mississippi valley placed the Arkansas River channels in a sequence: Stage B3 was along the edge of the Prairie Terrace, Stage C in Crooked Bayou and Boeuf River, Stage H in Bayou Macon, Stage 4 in the series of small bayous 2 to 6 miles east of Bayou Bartholomew, Stage 11 in Bayou Bartholomew and Stage 12 in the present channel. Roger Saucier, geologist with the U. S. Corps of Engineers Waterways Experiment Station, Vicksburg, has recently undertaken a geological study of the Boeuf Basin. He estimates that the deposits in the Bayou Bartholomew area are less than 5000 years old.

Bayou Bartholomew flows in an entrenched meander belt from Pine Bluff, Arkansas, to Monroe, Louisiana. The Bayou is bordered by sandy natural levees built up to an elevation of 125 feet mean sea level. The land between the Bayou and the Terrace is less than two miles wide and is a backswamp deposit with a drainage system distinct from that of the Bayou. As is typical of a meander belt, the present channel of the bayou is lined with abandoned channels and oxbow lakes, some of which are characterized by open water while others are almost completely filled in. Today the bayou is a slow-moving stream throughout most of the year. The area escaped the great floods of 1874 and 1882, but was flooded in 1927.

The initial investigation of the Bayou Bartholomew area concentrated in Ashley County in the vicinity of Portland. The project started with a core of forty-two sites located and reported by members of the Arkansas Archeological Society. These sites are primarily along the east bank of Bayou Bartholomew and on Dry and Big Bayous in Chicot County. The tributaries of Big Bayou drain the backslope of the Bayou Bartholomew levee and Big Bayou flows south, paralleling the Bartholomew, six miles to the east. These streams carry little water most of the year. This is the location of the Stage 4 channel of the Arkansas River. One month of site survey in June, 1969, added 22 sites to the list. Most of these are located on the west side of the Bartholomew. The area of intensive archeological work extends along both banks of Bayou Bartholomew from Parkdale to Boydell, a distance of 18 miles north-south on a straight line. Within this area, especially between Montrose and Boydell, there are still portions to be investigated. Two sites tested are the Wilson Brake site, 3AS85, and the Ellis Pugh Site, 3CH20 in July, 1969; Burney McClurkan tested the Grampus Site, 3AS84, in June 1968. All are multiple component with little indication of stratigraphic separation of these components.

The most common type of site is termed "diffuse" and is characterized by a scattered distribution of artifacts including both projectile points and grinding stones but without much pottery. There is no darkening of soil color to distinguish site area and the artifacts are often apparently eroding out of the red clay subsoil.

A second type is termed a hamlet and has a heavy concentration of artifacts easily distinguished by the sterile surrounding soil. These are usually small, less than 100 feet in diameter, and often characterized by a darker soil color. Potsherds are abundant. Sometimes they also have bone and shell debris, while stone is scarce.

The third type of site is termed a village because the midden accumulation covers a more extensive area. These sites are usually oblong, up to 1000 feet in length, and contain relatively large amounts of pottery and lesser amounts of stone. There are seven village sites and three of these also have small mounds.

The fourth type of site is a mound site. These are differentiated because they are prominent mounds but a village area has not yet been located. Two of the mounds may be flat-topped pyramidal mounds while the other six are so altered that the original outline is no longer evident.

In general, the different types of sites have different location in relation to the bayou and its abandoned channels. Most of the diffuse sites are situated on the banks of the abandoned channels. All of the abandoned channels so far checked for sites are lined with a scattering of artifacts but with one or more relatively concentrated areas. These concentrations are more sparse and scattered than the hamlet and village site concentrations.

Most of the village and hamlet type sites are located on the present bayou channel. Seven of the eight mounds are also located on the banks of the present bayou channel. The situation along the oxbow lakes is in marked contrast to that on the abandoned channels as only six sites are on the banks of these lakes.

There is, of course, no reason to think that all abandoned channels are the same age or that all oxbow lakes are the same age, although most of the oxbow lakes are probably younger than most of the partially filled abandoned channels. Also, the lakes or sloughs in the oxbows and abandoned channels may have been considered desirable site locations and chosen in preference to the bank of the river so that there will not be a direct, one-to-one correlation of site age to channel age.

Only two sites have so far been located in the backswamp area between the bayou and the hill escarpment. This may be due to the fact that sites have been buried by flood-deposited alluvium. More likely is the fact that we have not yet looked here for sites. The two that have been located were reported by local residents. One is apparently a single component late prehistoric village and the other is a diffuse late Archaic site.

The situation along Big and Dry Bayous is somewhat different. Three of the sites are villages, one is a hamlet, and there were three mounds, two of which have been leveled. The other sites are small, sparse concentrations scattered along the banks of the bayous. These are characterized by a predominance of pottery with some stone debris but no heavy concentration or change in soil color.

A phase sequence of the area will not be defined until after the second season of work is completed, however, some trends are already clearly evident. For general comparative purposes, I am using the periods and cultures of the Lower Mississippi Valley as defined by Philip Phillips. The major problem in analysis and interpretation is the fact that this region is marginal to areas where extensive work has already been done but in which separate lines of analysis have developed. The Bartholomew ceramic analysis is based strictly on sherds and yet decorative techniques overlap regions while pottery types are actually distinguished by paste, design style and vessel form. For example, a shell-tempered potsherd decorated with trailed-incised lines might be classified as Wallace Incised, Foster Trailed, Keno Trailed or Leland Incised. Clay-tempered pottery decorated with narrow incised lines in multiple parallel line designs might be Manchac Incised, Alligator Incised, Dunkin Incised or even Pease Brushed. Further complications are added when allowance is made for characteristics that may be distinctive for this region alone.

Some general conclusions about the ceramics of the area can be made, however. Common vessel forms are straight sided vessels with rounded bases. Some flat bases, both round and square, are present but are a distinct minority. Bowls are also common. A minor variation of these has a slightly flared rim. Rims are predominantly unmodified or tapered although nicking of the exterior edge of the lip is a minor variation. Absent are appendages, handles, and effigy forms. Shell tempering, when present, is always a minor percentage of any site sample and the shell is always finely crushed. Bone tempering is also present at many sites. The sherds with bone do not differ from the Baytown Plain except for the addition of finely crushed bone and it is always a minor inclusion in the paste. The amount of sherds with bone ranges from 0.5 to 11.0 percent of the Baytown Plain sample at the site and is usually 5 to 7 percent. Bone tempering is also present in some decorated types, all of which are considered part of a late occupation of the area.

The earliest occupation is in the late Archaic period. The distinction between late Archaic and early Woodland is not yet established as only three sites in the area do not have any potsherds. Sites with early diagnostic artifacts are the diffuse sites on the abandoned channels of Bayou Bartholomew. Gary Stemmed points are common artifacts and these are usually made of novaculite. Worked and unworked flakes are common on these sites and 43 percent of the worked flakes are of novaculite. Relatively large, trianguloid, bifacially flaked tools are also common. Minor yet distinctive artifacts include both chipped and ground celts and adzes, spearthrower weights, magnetite plummets and crude biconical clay balls. Three sherds from the Grampus site are identified as Tchefuncte Stamped and Lake Borgne Incised.

An early to middle Woodland occupation is indicated by the presence of Withers Fabric-impressed, Marksville Stamped, Marksville Incised and Churupa Punctated pottery types at five sites. One of these sites is on an abandoned channel, two are on oxbow lakes and two are on Dry Bayou. The Wilson Brake site has both an early Woodland-Marksville and Plaquemine - like occupations. A conical mound was located off one end of the midden area. Since this mound has been leveled, we will never know much about it. Reports indicate, however, that no bone and little pottery was uncovered during the leveling. When the flat-based vessel form occurs, it is usually on one of these sites. These sites also have Gary Stemmed projectile points but the specimens are usually smaller and less crudely shaped than on the Archaic sites.

The succeeding Baytown and Coles Creek periods are more of a problem. Most of the diagnostic pottery types for these periods have not yet been found. Minor amounts of Mulberry Creek Cord-marked, Larto Red Filmed and Woodville Zoned Red types are present only at the Ellis Pugh site, 3CH20, and French Fork Incised is present at the Hackett site, 3CH32. Both of these sites are in the Dry-Big Bayou area east of Bayou Bartholomew and both are multiple component. A few sherds of Mulberry Creek Cord-marked are also found on some Bayou Bartholomew sites. Diagnostic Coles Creek culture ceramic types such as Coles Creek, Greenhouse, Mazique and Beldeau Incised and Chevalier Stamped are completely absent in the entire survey area. Twelve of the 50 sites on Bayou Bartholomew, however, have only Baytown Plain pottery. These sites are all rather nondescript but, since not all have been visited in the past year, the surface collections are not as complete as at some of the other sites. Two of these sites have small, badly damaged mounds. Perhaps the relationships of the Bayou Bartholomew region during the Marksville, Baytown, and Coles Creek periods are strongest with the Lower Arkansas River region to the north. An alternative is that the sites of the Baytown and Coles Creek periods are not in the delta but are on the Terrace where we have not yet looked for sites. It is also within the realm of possibility that the Arkansas River shifted to its present channel about this time. If so, the environmental conditions of the Bartholomew area might not have been very stable or desirable.

The late prehistoric occupation is clearly related to developments in the south. For the moment I am using the term "Plaquemine-Caddoan" because the material seems to be related to, but separate from, both of these. Most of the hamlet type of sites as well as components of the village sites were occupied at this time. Sites are located on the present channel of Bayou Bartholomew and on Dry and Big Bayous. Single component hamlet sites do not have much stone debris present. Projectile points are tiny, barbed and bulbous stemmed and are probably related to the Alba Barbed type. Pottery types include Plaquemine Brushed, Harrison Bayou Incised, Manchac Incised and Evansville Punctated. All of these have parallel Caddoan types. In the Bayou area these types have a minor percentage of sherds with bone tempering. I assume that the Baytown Plain bone tempered sherds are also part of this phase. Minor amounts

of shell-tempered sherds are present on some, but not all, of these sites. I would not interpret this as an intrusion of Mississippian culture. As at Plaquemine and Caddo sites, shell tempering appears to be an addition to an already well-established pattern rather than part of a drastic change. Pottery decorative techniques and styles are within the range of Leland Incised and Keno Trailed. The distinctive Caddo engraved pottery has not yet been found.

Valuable information has come from this initial fieldwork, especially in regard to settlement patterns and conditions of sites. Questions of chronology and interpretation can now be stated and will provide the guidelines for a second phase of research emphasizing site excavation. It should then be possible to establish a chronological sequence of phases and reach some conclusions about cultural-environmental interaction and interregional relationships.

Profiling Techniques In Archaeology

Stephen E. Adams, Department of Anthropology
University of Arkansas, Fayetteville, Arkansas 72701

Introduction

The purpose of this paper is to describe various techniques used in archaeology to record graphically soil strata, features, and in-place artifacts of trench or pit walls. The advantages and disadvantages of these techniques will also be described. Presently, however, I would like to discuss some of the basic tools of the profiler.

Tools

The most important tools of the profiler are, of course pencil and paper. I myself have found a number two pencil best for the job, since its heavy, black marks are easily seen even in the bright sunlight encountered, more often than not, in the field. Profiling often entails recording minute details, therefore distinct markings and drawing are essential to accuracy. Standard rule graph paper seems to be best for recording graphic details. it is available in large rolls and can easily be cut to size to fit the profiler's needs. An excellent drawing board can be made simply by taping a piece of graph paper to a plywood board of a size which can be conveniently handled. In trench profiling the board can be suspended from two sticks of wood placed across the trench. Large gum erasers are handy not only for erasing mistakes but also for removing dust and dirt that constantly and consistently get on the graph paper. A twelve-inch ruler with the English and metric scales is a tool which also should be included in the profiler's basic kit. Another important tool is a metal tape measure which is used to measure the dimensions of whatever is being recorded and its distance from a reference point. A trowel is used to plane the trench or pit wall for easier profiling. Freshly cut walls show features and strata more clearly than walls which have dried out in the sun or have been mottled by rain. For heavier cutting, a small profiling shovel with a straight, flat blade is best. Ice picks or small, pointed sticks can be used to mark artifacts, features, or strata to which the profiler wishes to pay particular attention. An Army surplus field pack is a convenient carry-all for the smaller profiling tools and small luxury items such as insect repellent, suntan lotion, and a transistor radio.

There are larger tools which are important to the profiler. A long handled shovel and a mattock are needed when the profiler needs to move large amounts of dirt rapidly. A round-point shovel is best for breaking ground and a flat-nose shovel is best for levelling a trench or pit floor. Water sprayed from a large, refillable, pump spray can often help distinguish different strata and features temporarily for the profiler, especially in strong sunlight. However, I have found it easier and more convenient to shade the area to be profiled. Shading seems as effective as spraying in making distinct those features to be drawn. Also, operating the spray can becomes quite awkward and time consuming.

A grid screen and a horizontal-vertical string system are used as large measuring tools in profiling. The grid screen is constructed in the shape of a rectangle with the use of small and light, but strong, boards. Eyelets are screwed into the inside surfaces of the boards at regular intervals based on the metric scale. Ten centimeters is a common interval used. String is then tied to the eyelets to form a grid screen within the structure. The length and width of the grid screen should be chosen in a size best suited for the intended job.

Once the grid screen is properly set up, it provides a very accurate measuring device; however, the grid screen is difficult to set up properly. The screen is hung from sawhorses placed across the trench or pit. In the case of the trench, the trench surface is usually rough and uneven. The grid screen and the sawhorses have to be moved each time a grid profile is finished. Time-consuming adjustments have to be made again and again

in order to set the screen properly. Because the whole screen is shifted, it is difficult to place the screen at the same level as the previous one so that the next grid profile will connect accurately with the last. Further, two persons are required to move the grid screen. This causes the periodic interruption of someone's work in order to have his assistance. Another disadvantage of the grid screen is that its size and construction make it clumsy. Also, if the grid screen is not properly constructed, it will not allow accurate measurements. In very deep trenches or pits, however, where the horizontal-vertical string system is too crude to be adequate, the grid screen is a handy item (Fig. 1).

Figure 1. Setting up to profile a trench. Note grid screen on ground beyond sawhorse.

When using the second measuring tool, the horizontal-vertical string system, the horizontal string is set up by fixing one end of the string in the trench or pit wall, usually with an ice pick, and fixing the other end on the same plane, with the use of a line level, at a point farther along the wall. The length of the string can be varied according to need, but it is best to keep it at a length which will not allow it to sag in the middle and thus impair accuracy. The vertical string is attached by an ice pick to the wall at a measured distance above the horizontal string. The lower end of the vertical string is attached to a plumb bob which will indicate where the lower end of the string should be affixed to the wall.

The horizontal-vertical string system is a simple but accurate tool of measure if used properly. It is easy to set up and can be set up quickly. It is shifted simply by removing one end of the string, rotating it to the opposite side of the stationary end, and fixing it again in the wall on the same horizontal plane by use of the line level. The vertical string is then removed and reset in its new place in relation to the new position of the horizontal string. In shallow pits or trenches or in confined spaces, this system is much more convenient than the large, clumsy grid screen. The horizontal-vertical string system is also faster to set up and can be varied in length and depth to fit the needs of the profiler. The fixed construction of the grid screen is less flexible in operation.

In view of the advantages and disadvantages of the grid screen and the horizontal-vertical string system, the logical and obvious answer is to use both methods, applying each to the situations in which it is more convenient. If, however, one wished to use only one, I would recommend the horizontal-vertical string system. It is simpler and quicker to set up. I found it was just as accurate, in some cases even more so, as the grid screen. Of course, every profiler has his own likes and dislikes and should try, if time permits, several profiling methods before settling on any particular one.

Profiling Techniques

Now, let's take a look at profiling techniques. There are three general parts to profiling: pre-profiling, the profiling itself, and post-profiling. In pre-profiling, the profiler, of course, gathers the equipment he needs. It is helpful to go through the trench or pit and inspect the wall that is to be profiled. This gives a view of what will be encountered during profiling. This procedure also indicates what equipment will be needed during the profiling. Considering soil color and texture differences beforehand will help form more accurate profiling descriptions.

After an inspection of the area to be profiled, the profiler should pick out a point along the profile wall which will serve as a reference point. This point should be selected to fit the needs and desires of the profiler. Ideally, it should be located somewhere near the trench datum stake so that datum level can be included on the profile sheet as a further reference line. Planting the datum stake by transit survey should be a pre-profiling procedure.

The reference point the profiler chooses will be the point of reference for the grid screen, horizontal-vertical string system, or whatever profiling measuring device is being used. As a right-handed person, I have found it easier to begin profiling from left to right across the trench or pit wall.

Before the profiling device is set up, the portion of the wall to be profiled should be freshly cut to provide an even, smooth, and moist wall. Soil colors and textures are harder to distinguish in a dried-out or mottled wall. For this reason, it is important not to prepare too much of the wall at one time. Sunlight will dry out a wall quickly and rain will instantly mottle and deface the wall surface.

After the wall is prepared and profiling device is set up, profiling itself consists simply of measuring strata and features and recording them graphically on paper. Because trench profiling is concerned mainly with recording strata and features, the recording of in-place

artifacts is optional. Recording every artifact is unrealistic if the artifactual content of the wall is dense.

After strata and features have been recorded, the profiler should describe the soils as to color and texture and also should record, on the profile, his interpretation of each feature. Description of soils and interpretation of features will allow for further interpretations of the wall from which soil, radiocarbon, and paleo-magnetic samples can be taken.

When profiling is completed, the profiler should again inspect the trench or pit wall to make sure he has left nothing out of the profile. He should then record on the profile any further comments or thoughts he might have. He should always initial each profile sheet so that those who are studying the profiles later will know whom to consult should a problem in interpretation arise. The profile should be dated and should include the site designation and the trench or pit designation. A scale on the profile is always included along with an arrow indicating north.

When two or more profilers are to work in different pits or trenches on the same site at the same time, they should go together to a freshly cut wall and try to reach agreement in their descriptions of the same types and colors of soil and interpretation of features. If possible, their nomenclature should be coordinated so that different profile sheets can be accurately compared. Color and texture charts for soils can be used but are often inconvenient because they are time-consuming to use. Ideally, the profilers should have some background in geology or earth science.

Using two persons working together as a profile team has its advantages. One person records while the other measures strata and features. Two persons together usually see more than one person alone; therefore, it is less likely that something will be left out of the profile. However, in confined spaces two persons get in each other's way. Also, there may be some disagreement in description and interpretation. One person can profile just as accurately and quickly as two persons if his efforts are concentrated!

Conclusion

This paper is intended to be a general description of profiling techniques. The profiling techniques described in this paper are but a few of many. It is not intended to lay down hard and fast rules for profiling procedures; each individual profiler should choose methods best suited to his own needs and likes. It is my personal belief that various techniques should be tried before a profiler chooses any particular ones. Such action will improve profiling accuracy and so lend more accuracy to the interpretation of the data. This, in turn, will make the profiling meaningful.

Art And Culture Among The Ashanti of Ghana

By Charles E. Johnson

Area of Anthropology, A. M. & N. College

Pine Bluff, Arkansas 71601

FOREWORD

This case study in cultural anthropology was designed to test an hypothesis presented by Morton Levine (New York University, and a fellow classmate at Harvard) relative to the interpretation of art forms among pre-literate people as an expression of cultural orientations, values, and how a people see themselves relating to lifeways. Levine was involved at the time with a similiar study of the plastic arts and mythological expressions among the aborigines of Australia.

In this approach to cultural understanding we utilized some of the concepts and models presented by Sigmund Freud (Psychopathology of Everyday Life and Moses and Monotheism) and Franz Boas (Primitive Art), as well as Western European traditional and contemporary art forms Realism (Millet), Naturalism (Daumier), Impressionism (Manet), Expressionism (Raoult), Abstraction (Klee), Fantasy (Miro), Surrealism (Dali) and especially Analytic Abstraction dealing with Cubism influenced by African sculpture and art objects.

We operate on the premise that when an understanding of ways of life very different from one's own is gained through an analysis of all phases of expression by a people, abstractions and generalizations about social behavior, social structure, cultural values, subsistence techniques, and other universal categories of human social behavior become meaningful.

A difficult problem confronting us in 1965 was how and when to indicate signs of change in traditional Ashanti cultural expressions. For the most part we are describing the Ashanti from 1953-1964 (W. R. Bascom and Paul Gebauer, Handbook of West African Art,

University of Wisconsin 1964).

The project was financed by the Wenner-Gren Foundation, Harvard Peabody Museum, and the Agency for International Development.

Introduction

"Ashanti," refers both to the territory and to the people that inhabit the central portion of the modern political state of Ghana in West Africa. History records the Ashanti, members of the Akan-speaking groups, as having migrated to this region from an area around the Niger River bend near Timbuctoo in the eleventh or twelfth centures (Meyrowitz 1958: 17-19). These Akan-speaking people, after having defeated, driven out, or enslaved the people they found there, banded themselves together in a confederacy. When Europeans visited Ashanti in the nineteenth century, "they found a nation that had a well developed government of imperial cast and of remarkable political complexity for the non-literate world, being bureaucratic and hierarchic in its structure but using a principle of decentralization of authority which permitted the member states to manage all affairs which did not affect the confederacy" (Lystad 1958: 27).

The Ashanti are a predominantly rural people, living in small towns, villages and hamlets, and farming extensively the land surrounding these habitats. The area of Ashanti is approximately 24,000 square miles, and the population numbers about 850,000 persons (Lystad 1958: 28). Kumasi, the ancient capitol of the kingdom is the seat of government, center of commercial activities and sacred shrine to the Ashanti. In Kumasi is to be found the palace of the Asantehente (king) as well as the provincial council for the new state of Ghana, the weighing stations and storage houses for the cocoa beans (the Ashanti produce the great bulk of the Ghana crop), stores, shops and markets of all descriptions, and the Ashanti Golden Stool (which contains the soul of the Ashanti nation).

Like its history and political organization, Ashanti art, religion, and culture are elaborate, complete, and highly developed. This we hope to bring out more forcefully in an analysis of Ashanti art which is an expression of the cultural ontology of the people.

Ashanti Social Organizations

Genetically, the Ashanti are members of the large family of Negroes inhabiting the African Guinea Coast. They are of moderate stature, slight build, dark skin, and long headed cephalic index. Culturally the Ashanti are characterized by elaborate political and military organizations, highly developed legal systems based on a hierarchy of local and regional councils acting both as administrative and judicial bodies culminating in the king's court, and a subsistence economy based upon extensive farming and domestication. A somewhat shadowy conception of a high god is associated with the worship of numerous lesser gods and quasi-mythological deified heroes, often connected with natural phenomena of social significance (e.g., rivers, lakes, thunderstorms). Throughout Ashanti land craftsmanship in wood, textiles, gold, bronze, and pottery is highly developed, being carried on by guilds in specialized villages giving hereditary craft services to the courts (Rattray 1924: 8-9). Trade is highly developed among them and was directed by the king. Commerce with the coastal tribes played a very important part in their history. Gold and slaves were exchanged at coastal ports for firearms, textiles, and other European products.

The basis of Ashanti social organization is the rule of matrilineal descent. Every Ashanti belongs to one of eight exogamous matrilineal clans, each associated with a totemic animal connected with the emergence of the first clan ancestress on earth (Rattray 1924: 13). Some secrecy surrounds these totems, but each Ashanti child is taught to respect them.

While inheritance of property and succession to chiefship and other offices and ranks are determined by matrilineal descent, paternity is especially important in Ashanti social organization. Through his father every man is a member of a ritual group (ntoro) or patrilineally connected people. There are about twelve such groups dispersed throughout the country. Each ntoro has one or more mythical animal ancestors, and should one of these animals (python or leopard) be found dead, members of the appropriate ntoro are obliged to bury it and put on mourning signs. Marriage is prohibited between near ntoro kin (Rattray 1924: 23).

"Neither clans nor ntoro groups ever act as units on a tribal basis. Such action occurs only in the local divisions of the clan" (Gotti 1960: 128). These groups in Ashanti, as previously mentioned, consist of matrilineal lineages of acknowledged common descent, whose members lived close together, have a common "stool house" in which are kept the consecrated stools of their ancestors, bury their dead in their private cemetery and in particular have a male head who, with the assistance of the elders and a female head, exercises oversight over the affairs of the lineage. All political offices, from the kingship down, are hereditary in particular lineages of the community in which the office is exercised. Thus the kingship is vested in the lineage of the clan domiciled in the Kumasi area, the royal city and territory. Land and other property rights are generally vested in segments of these local lineages. (Land cannot be sold in Ashanti because it belongs to no one earthly being, but to the spirits that inhabit it.) Sexual relationships between members of the same lineage are incestuous and violaters are punished by execution.

The brief foregoing statements relative to the general character of the Ashanti point out the elaborateness of Ashanti belief and imagination, and the fact that these beliefs are deeply rooted in the traditional mythology of the people. To the Ashanti these mythological characters are not only real but their spirits exist among the Ashanti

in everyday life experiences, along with the spirits of the deceased ancestors.

The Ashanti are an agricultural people, depending entirely upon the yield of the land for subsistence. Ashanti farms are worked intensively from early dawn until late in the afternoon. Basic food crops are yams, corn, casava, bananas, and palm oil. Goats and chickens are the principal domestic animals; hunting and fishing contribute only slightly to the Ashanti diet. One poor crop year and the Ashanti will be in danger of starvation. Hence, a person feels completely dependent upon the land upon which he must rely for his very livelihood.

Today, however, in addition to the aforementioned crops, the Ashanti grow and harvest most of the cocoa exported from Ghana, which produces more cocoa than any other nation in the world. Ashanti land is also rich in mahogany and gold, the latter from whence the old colonial territorial name Gold Coast was derived several centuries ago. One of the richest gold mines in the world is located near Kumasi, capital of the kingdom. Hence, even though the Ashanti subsistence farmer might supplement his food crops with cash, his cash-producing wealth is still due to the generosity of the land. This generosity of the good earth is never taken for granted by the Ashanti, for he gives thanks to the earth spirit whenever anything is extracted by offering ritualistic libations and beseeching the spirits to continue blessing the Ashanti people with bountiful crops. Celebrations are held before the harvesting of each crop. (I was fortunate to be in Ashanti during such celebrations in October of 1966.)

One such celebration is that of "Odwira", the great festival of the dead, often referred to as the "Yam Custom" (Bascom and Gebauer 1953: 12). This is the most important of all ceremonial rites. The ceremony is the occasion of the sacrifice to the ghost of the kings with these words:

> The edges of the years have met, I take sheep and new yams and give you that you may eat.
>
> Life to me.
>
> Life to this my Ashanti people.
>
> Women who cultivate the farms, when they do so grant the food comes forth in abundance.
>
> Do not allow the penis of the Ashanti men die.
>
> Grant fertility and many offspring to the women.
>
> (Apter 1955: 30)

Only after the spirits had partaken of the new crops might the king and nation eat of them. The ceremony is also occasion for cleansing and purification of the Ashanti nation. Shrines, stools, and places of abode for lesser non-human spirits are thoroughly cleaned. During the ceremony, rules of society are relaxed and wine drinking, feasting, and sexual intimacies are indulged in with license.

Another ceremony observed with less ceremonial participation is that of "Adae," which is observed locally throughout Ashanti twice in every successive forty-three days (Rattray 1924, Preface). The spirits of the appropriate clan chiefs are propitiated and their favors solicited. In this ceremony the chief sacrifices a goat in the stool-house, the blood is smeared on the stools, and a piece of meat placed on each with a prayer for long life and prosperity, while the drums call out the names of the departed and the people chant the attributes of each chief.

Out of these experiences the Ashanti have developed a wealth of music, dancing, folktales, proverbs, riddles and a form of artistic expression equal to that found among non-literate people anywhere in the world (Rattray 1924: 5). In the graphic and plastic arts, also, the Ashanti are not easily matched elsewhere in the world. Examples of Ashanti art are to be found in pottery, appliqued work in cloth, sculpture and filigree work in gold, bronze, iron, and wood, and in weaving and dyeing which is done in cotton, wild and imported silk, raffia, and banana fibers. It is probably in wood-carvings, brass castings, and weaving that the Ashanti craftsmen reached their highest degree of perfection in technique and style.

Even though there is no written record of the remote achievements of the Ashanti, much can be learned from the folklore and mythology of the people, which is in use by the Ashanti in ritually acting out through song and dance their past history, glory, and sorrows. Apter (1955: 30) gives an account of this in the following statement:

> Tribal history is a mixture of the factual and the supernatural. In the beginning there is a man having supernatural powers, or acted upon by the supernatural. After a series of tests, or escapades this person sires a people. From the blood affiliation, mythologically reckoned, the relationships between other groups and other tribes is defined. The history of battles, famous victories, exploits and glories are all incorporated in the tribal mythology. Out of the histories, some of which, like the Dagoma drum history, are highly ritualized symbolic expressions, the traditions of the past are related to the people of today. Membership in a tribe or ethnic group is participation in a corporate body, the limits of which go beyond the immediate living environment, reaching backwards into the past. In the dance and the beat of the drums this past can be participated in, a process whereby strength

is renewed, the ancestors greeted, the gods propitiated, and the devils exorcised.

Ashanti Wood-Carving

The Ashanti Stools

Legend and mythology records the royal stool of Ashanti as having come into being during the reign of Osai Tutu (1700-1730), the fourth king of the Ashanti dynasty and founder of the empire. In the early days of his reign a man named Anotchi arrived in the country and announced that he had a mission from the Sky God to make Ashanti a great and powerful nation. A great gathering was summoned in Kumasi, and while the air was thick with dust and the heavens terrible with thunder, Anotchi drew from the sky a wooden stool, partly covered with gold. This stool did not fall to earth, but descended slowly upon the knees of Osai Tutu, to whom and to whose people Anotchi proclaimed that the stool contained the soul of the Ashanti nation, that their power, their health, and their bravery and welfare were in this stool, and that if it were destroyed then the Ashanti nation would sicken and lose its vitality. The stool is said never to have touched the ground, nor did any mortal sit upon it, and when it was taken to Batama once a year for the Odwira ceremony, it was conveyed under its umbrella (the umbrella is a symbol of aristocracy and authority in Ashanti), and surrounded by resplendent attendants (Rattray 1927: 5-24).

In addition to the "Golden Stool" which possesses the soul and spirit of the nation, the king has a stool, each chief has a stool, and each Ashanti has a stool which is the repository of each owner's soul; also there are a tribal stool, clan stool, family stool and village stool. Members participate in ritual ceremonies around their own stools, and also around the state, tribe, clan, and village stools. As the stool contains the soul of the individual, so it contains the soul of the clan, tribe, village, family, and state and serves as a symbol of unity for the Ashanti people in addition to its specific use.

Further these stools embody the spirits of the ancestors and are the living symbols of their presence, thereby giving the Ashanti access to constant relationships with the ancestors. To the Ashanti, not only does man possess a soul spirit, but so do plants and animals. In fact the tree from which a carving is to be made is recognized to have a soul, so that when the craftsman is about to cut such a tree he will make a libation to the soul of the tree. assuring the tree-spirit that the stool or drum to be carved will contain its soul in repository also (Rattray 1927: 5-24). The Ashanti stool is a beautiful art piece carved from a single block of wood with a seat shaped in the form of a slight crescent, and with no back, showing the skill, individuality, and craftsmanship of the carver.

Tools used by the Ashanti carver are often themselves elaborately decorated. Such tools consist of small chipping hoes, a hoe for splitting, a carpenter's plane, a small knife, a spokeshave, chisels, an awl, and a cutting tool. Before the tools are used, the craftsman makes a libation of propitiation and grace, asking that the tools not harm the carver, and that no harm or sickness befall his family nor let his penis become sick or die as a result of work. Wine is poured over the tools and a sacrifice of blood from a fowl. Every stool in use has its own particular significance and its own special name, which denotes the sex, social status, and clan of the owner. One village Afwia, is the center of the stool-carving craftsmanship, and the art is passed down through heredity of sons and sisters' sons from father or uncle respectively.

Many of the stools are the copyright of the king of Ashanti and might not under any circumstances be sold on the open market; these are first given to the king, who will then present them to chiefs whom he wishes to honor. A woman might not carve a stool, because of the taboo against menstruals. She cannot even visit the workshop of the carvers; to do so is to invite severe pain upon herself and a fine to be used in purchasing the necessary libations to make propitiations to the spirits that have been offended.

The final product of the carver is christened through ceremonial ritual appropriate to the particular clan or tribe that it denotes. These stools are then taken out to the stool houses where they are deposited alongside the other ancestral stools. Upon initiation each Ashanti receives a stool which then contains his soul; until this moment his soul has been in a state of wandering with no special place to settle down. An individual is called by the name of his stool, which is his mark of identification. In the past this design might even be tattooed on his person (Rattray 1927: 5-24).

Ceremonial Drums

In the case of ceremonial drums carved from the same tree as the stools, the artist will engage in the same ritual for the tree spirit as exhibited previously. The aim is to provide a pleasant atmosphere for the spirit of the tree while at the same time creating a utilitarian object. Hence, the Ashanti will keep the drum or stool free from those taboos that he recognizes to be abhorred by the spirits, since all spirits are deemed to have taboos against certain things just as do human beings.

In the case of ceremonial drums two spirits must be reckoned with, those of the tree, and those of the elephant whose ears have been used for the head-covering of the drum. Each Ashanti drum has a special name, dress, and taboo.

In all of these actions by the Ashanti, there is a recognition of the important part played by all of the forces of nature in his survival. This is vividly portrayed in the acts of propitiation made to the spirits of all the tools in carving. It is further elaborated in his unwillingness to cease the ritual with the finished product, but in

the permanence of the art piece which is constantly consecrated and heaped with ritual libations.

This analysis of one aspect of Ashanti carvings shows clearly the incorporation of myth, everyday experiences of life, and the supernatural by the Ashanti craftsman in executing a work of art. Furthermore, while the artist is free to execute and perform a work of art according to his own style and technique, this is governed somewhat by the individuals doing the buying. A stool might vary somewhat if the important family, tribal, or clan designs are not adhered to rigidly. Unless these details are rigidly held to, the stool is useless and in fact is considered ugly to the Ashanti no matter how intricate the designs. Throughout the work of art by the Ashanti craftsman, ritual and ceremony is of utmost importance lest not only the final product be a failure, but also so that the spirits might look with good favor on the craftsman and shield him from harm and danger, and bless his household with fertility and increase.

The Ashanti are unique amongst Guinea coast Africans in making art work for ritual, in that they never made masks for ceremonial purposes; however, small figures and figurines are carved representing characters from mythological folklore. Ashanti folklore is filled with stories about the fairies (mmoatia), forest monsters (Sasabonsam), ghosts of hunters (saman bufuo), and witches (abayifo). These carved figures are used as sumans of fetishes, which are deemed to have exceptional powers and are worn by men to ward off impotency and by women to help strengthen fertility. In fact these objects are said to be made by the fairies themselves that inhabit the forest area. "Suman (fetish) come from the mmoatia, by whom they were first made and from whom they are now obtained. You place ten cowrie shells (used for money) on a rock, go away; on your return you find your cowries gone, having been replaced by a suman" (Rattray 1927: 5-24). In Ashanti, as cowrie shells were traditionally means of economic exchange and women were mostly involved in trading, the women carried their wealth with them.

Proof that these wood "creatures" actually exist in the mind of the Ashanti is expressed through these wood carvings. An example would be in the physical characteristics of the fairies as described by Ashanti who have "seen" them. Folklore has it that these "forest fairies" or spirits are no more than a foot in stature (the same height as the carving?), with feet that point backwards instead of the characteristic human forward position. (Some Europeans seeing this attributed it to the stupidity of the African artist in not being able to detect that the feet of his figure are pointed in the wrong direction. In fact, the carver is not aware of this abnormal position of the feet because to him the carving is not only correct in detail, but is in fact very real.) These fairies are to be recognized in black, red, and white colors. Thus in these carvings the Ashanti craftsman creates not only the image of these "powerful forest sumans," but in fact his carving actually brings into existence such characters in accordance with the descriptions.

So far, an analysis of Ashanti wood-carvings tends to express latent anxiety by these people for maintaining an adequate food supply for a society entirely dependent upon the good fortunes of earth and environment for survival. This anxiety is expressed through the Ashanti desire for potency, fertility, and increase of the natural species, man, plants, and animals, to insure continuity of the existing supply. In the Ashanti attempt to overcome this complete reliance upon the spirits of natural phenomena by recognizing the existence of a "soul" or spirit for all segments of the tropic scheme, man, plants, animals and the earth itself, he strives to placate all these spirits by offering libations when some part is to be altered or destroyed for his own use by restoring some parts of the destruction, or by offering a sacrifice and by creating a pleasant abode for the spirits to reside in, providing them with food and drink. This tropic recognition is extended even to the tools used by the carver.

Ashanti Weaving

Besides carvings, Ashanti artistic activity includes weaving of cloths. In this craft, the Ashanti is a master at his trade unrivaled anywhere. Of all the crafts in Ashanti land, weaving is the one that has not only survived in its original form and technique, but has seen an increasing demand as a result of the emergence of the state of Ghana into the modern political arena. The theme and ritual of the Ashanti weaver corresponds to that of the carver. The patterns of the cloth follow that of the social position of the individual, his clan, tribe, and trade. As in carving, weaving as an art is confined to the male sex; however, the cotton may be picked and spun into thread by women who have reached their menopause (Meyrowitz 1958: 23). Silk used by the Ashanti weaver is either collected growing wild in the forest or imported.

These cloths are woven into long slender bolts of geometric designs and patterns; afterwards they are sewn together in order to obtain the desired width. Each Ashanti weaver is known by the pattern of his materials, such patterns, as well as the art itself, being passed on hereditarily through apprenticeship in the same lineage manner as in the carving trade. Children begin apprentice training at a very early age. The boy selected to carry on the art is given a toy loom on which to practice while being near the adult weaver. The cloth designs are woven in colors of red, blue, greens, gray, yellow, brown, white, black, and orange.

Stamp-Cloth

Another technique used in designing of Ashanti cloth is stamping of the design upon the fabric. Fabrics done in this manner are referred to as "Adinkira" cloth. Legend records Adinkira as being a king of the adjacent Ivory Coast kingdom of Jaman, who angered the Ashanti

king by making a replica of the "Golden Stool"; for this he was killed by the king of Ashanti. Thus the term Adinkira in Akan is synonomous with imitation, which this method of cloth designing is considered to be. These cloths are worn mostly by common people who cannot afford to wear the more expensively woven designs.

Tools used in weaving consist of spools, bobbins, bobbin carriers, an iron skewer with wooden hammer-shaped head, a weaving reed, pulleys, loom, and a bowl used for dying threads. All these tools are consecrated before use.

Pottery

Pottery as a medium of Ashanti art is unique in many respects. First, there is rarely any design engraved or figurine modeled. Second, the craft is almost entirely in the hands of women, which accounts for the fact that there are no engravings or modeled figurines. Since there is a taboo against women modeling figures or figurines depicting ritualistic symbolism, these are always absent on pottery made by the women. This aspect of Ashanti art tends to point out more emphatically the place of ceremonial ritual in carving and weaving. In these two media, the beauty of a particular piece is not the ultimate goal of the craftsman but is incidental to ritualistic dictation. Since pottery has no such ritualistic symbolism, it can be carried on by women and there is no attempt to adhere to prescribed pattern or designs.

This art, however, is practiced with skilled craftsmanship. The art is passed on hereditarily from mother to daughter. Certain Ashanti villages are known as "pottress villages" in which whole families of women and girls engage in craft, selling their products all over Ghana and in many adjacent areas (Rattray 1927: 103).

Certain pottery objects used in ritual ceremonies and in burial rites are modeled by men and have ritual designs engraved on them.

Clays used in pottery making are of white, red, yellow, grey, and brown colors. The implements or tools used in making pottery consist of corn cobs, rags, small blocks of wood, a ring made from a strip of palm stem and used as a scraper, and a small smooth pebble used for polishing. A hoe is also used in digging the clay.

Ashanti Metal-Casting

As in other ancient kingdoms of the Guinea coast, the Ashanti reached a high degree of perfection in metal work. This craft has almost vanished in Ashanti due to the influence of more accessible metals from Europe: however, there are some older craftsmen to be found around Kumasi still plying this ancient trade. The metalsmiths cast objects from brass, iron and gold through use of the cire-perdue (lost wax) process.

Material used in this craft are clay and charcoal used as a foundation upon which the wax is laid, a forge made of clay for heating the metal, both double and single bellows, small scales for weighing, tongs for holding the hot metal, block of wood with a hole in the middle upon which the wax is rolled, a wooden knife or spatula for working wax on the block, a small iron anvil, and a thin iron skewer. All these tools are consecrated before use by the craftsman (Rattray 1927: 314). The principal objects made from metal are small brass and iron figures used in weighing gold-dust. Such figures represent mythological characters or experiences from everyday life. Other objects include bells of various sizes and descriptions and little figures called Aqua Ba. These little figures are worn by women to insure fertility and healthy offspring.

These (carvings from wood, weaving, pottery, metal-casting) are the basic media in which the Ashanti make art. On rare occasions, the Ashanti paint upon the pottery or carvings. When this is done a stick is chewed at the end to make a brush (Rattray 1927: 314). The painting is done with ritual ceremony being performed before such paintings take place, and the objects painted on take on ritualistic significance with all of the taboos surrounding the other forms of art.

Modifications of ritual designs are to be seen in Ashanti house architecture and utensils of technology. These have no specific meaning to the Ashanti and are done purely for esthetic beauty. Rattray (1927: 217) points out that these must have had some significance in times past, but lost their meaning as they were replaced with more powerful spirits. Similiarly gourds for carrying things are often so decorated. This would, it seems, aside from ritual and ceremonial objects, show the emphasis placed upon esthetic beauty by the Ashanti people as a result of their rich background in art expression and art making.

BIBLIOGRAPHY

Apter, David E.
1955 **The Gold Coast in Transition.** Princeton University Press, Princeton.

Bascom, W. R. and Paul Gebauer
1953 **Handbook of West African Art.** University of Wisconsin Press, Madison.

Gotti, Ellen and Atillo Gotti
1960 **The New Africa: A World Background View.** Houghton, Mifflin Company, New York.

Lystad, Robert A.
1958 **The Ashanti: A Proud People.** Rutgers University Press, Rutgers.

Mayrowitz, E. L. R.
1958 **The Akan of Ghana.** Faber and Faber Ltd., London.

Rattray, Robert S.
1924 **Ashanti.** Oxford University Press, London.
1927 **Religion and Art in Ashanti.** Oxford University Press, London.
1930 **Akan-Ashanti Folktales:** Oxford University Press, London.

A Classification of Some European Trade Beads From Louisiana and Mississippi

by John B. Huner

Arkansas Archeological Survey, Conway, Arkansas 72032

Abstract

The sources of trade beads found in archeological sites in North American may be discovered through a system of bead classification. Typology should be based on shape, size, materials, color and translucency, decoration, and method of manufacture. A chronology can then be established. Ethnological data may reveal European contact and intertribal trade.

Glass beads have a long history; in fact, they were manufactured in Egypt as early as the 4th millennium B.C. (Turner 1936). The production and dispersal of glass and glass beads progressed up until the fall of the Roman Empire. The art of glass manufacture, lost during the Dark Ages, was revived in the 12th and 13th centuries, and Venice became the center of this industry. It is said that the bead industry became prominent after 1295, when Marco Polo returned from the Orient with tales of the insatiable desire of nobles of that part of the world for gems (Diamond 1953). The manufacture of imitation gems and beads of glass quickly established itself as the mainstay of the Venetian export trade. During the Age of Exploration trade beads were so important to trade with primitive peoples that their production continued to support the Venetian industry as long as Italy controlled their manufacture. In Venice, guilds were formed and other European governments sought then to establish industries in England, France, Spain and other countries.

Beads were used as an item of barter with primitive peoples at very early times. This practice may date back to the Romans (Diamond 1953). The earliest known date for the introduction of trade beads into the New World is October 12, 1492, by Columbus. His Log is quoted as follows:

> Soon after a large crowd of natives congregated there . . . In order to win the friendship and affection of that people, and because I was convicted that their conversion to our Holy Faith would be better promoted through l o v e than through force, I presented some of them with red caps and some strings of glass beads which they placed around their necks, and other trifles with which we have got a wonderful hold on their affections.
>
> Oct. 15. A man from Conception Island was presented with a red cap and a string of small glass beads. (Orchard 1929: 14)

Many other similar accounts exist in old journals and some exist almost with a folk tale aura, such as the Manhattan Purchase.

It is not too clear where trade beads were manufactured. Venice, of course, is the most logical and preferred answer, but Diamond (1953) implies that, although the British and French were buying the majority of the trade beads that they used from Venice, they still manufactured some of their own. The Spanish had a glass factory at Barcelona whose product was comparable to that of Venice (Bushnell 1937), and as early as 1611 there was a glass factory at Jamestown which manufactured glass beads for trade with the Indians (Bushnell1937; Rogers and Beard 1948). It is the author's opinion that common sources of supply were used or that craftsmen with similar backgrounds and training were to be found in glass factories all over Europe. In the factory established at Jamestown, as stated in the **Records of the Virginia Company,** ". . . 6 strangers

Italians [Rogers and Beard 1948: 48] Skillful in making of Glasse and Beads to go over to Virginia to be employed in the aside work. . ." (Bushnell 1937: 28). It can be seen how men could manufacture similar types of beads in different factories; however, it is felt that certain types of beads will be associated with a given European group and given period of time.

To establish any types of European trade beads there must be a system of classification and as the basis of any system of classification there must be criteria which by their definitions limit groups and allow an individual artifact to be associated with a given group and located in time and place. The typology of trade beads, however, is unique. Because they are manufactured, trade beads may appear to be of different groups, when in reality they are of the same type. For this reason a classification of beads cannot be too exact. Beck states, "To describe a bead fully it is necessary to state its form, perforation, color, material, and decoration" (1928 p.B.). None of the other works researched proposed any criteria except shape, size, and color. It is the author's opinion that the following criteria for trade beads should be used: shape, size, materials, color and translucency, decoration, and method of manufacture. It is believed that describing the perforation can be omitted, for the method of manufacture determines the perforation.

The three most important characteristics of trade beads are shape, color, and translucency, and decoration. The color and translucency of a bead are most difficult to determine. The abundance or lack of materials and moisture in the soil affect the rate of decomposition so that a bead which was originally clear may appear to be white and opaque after a hundred years in the ground. The decoration of a bead is easily determined and described but the shape of a bead is most difficult to describe accurately.

Quimby (1939) and Orchard (1929) used the terms elongate-spheroid and oblate-spheroid in the definition of bead shape while Beck (1928) uses more conclusive terms. The latter will be followed in this paper.

The following classification and definitions of shape have been set forth by Beck (1928: 2-11) and his work is used with some modification by the author.

Beads have been made in a variety of shapes and forms but for the most part trade beads can be considered as regular beads. A regular bead is one whose shape is a simple geometric form that can be determined by its longitudinal and transverse sections. The transverse section is divided into two classes: round (one having a circular perimeter of its cross section) and faceted (one having a series of straight lines composing the perimeter of its cross section.) A round bead's transverse section is circular whereas a faceted bead's transverse section is described by the geometric figure that its perimeter forms. A bead in which the distance through the longitudinal axis is greater than one-third (1/3) but less than nine-tenths (9/10) its diameter is referred to as short. A bead whose length is greater than nine-tenths (9/10) but less than one and one-fourth (1¼) its diameter is termed standard. In the standard bead, the length-diameter ratio is approximately 1:1. A bead whose length is greater than one and one-fourth (1¼) its diameter is termed long.

To establish the longitudinal section of a trade bead, it must first be determined if the profile of the longitudinal section is convex or straight. If both the profiles of the longitudinal and transverse sections are round then a bead may be oblate, spherical, or elipsoid if the length is short, standard, or long, respectively. A bead with flat ends and a convex profile is termed a barrel. The cylinder is a bead whose longitudinal section has a straight profile and flat ends. The above mentioned characteristics occur in round beads. Faceted beads are described by their length and the solid geometric figure formed by the faces.

TRADE BEADS-BASIC SHAPES

(after Beck,1928)

LENGTH	TRANS-VERSE	LONGITUDINAL SECTION		
		CONVEX PROFILE		STRAIGHT PROFILE
		CIRCULAR	BARREL	CYLINDER
SHORT	CIRCULAR	Oblate	Short Barrel	Short Tube
STANDARD	CIRCULAR	Round (Spherical)	Standard Barrel	Standard Tube
LONG	CIRCULAR	Elipsoid	Long Barrel	Long Tube

The color of trade beads in this classification of them is simply based on the outward appearance. Orchard (1929) and Quimby (1939) classify the color of beads with the terms "monochrome" and "polychrome" and offer no further discussion of color or design. Beck (1928) recognizes the importance of color but fails to discuss it. These three authors are considered inadequate. As mentioned before, care should be used in color determination. In cases where there is a range of shades, the most commonly occurring one was typed and the others mentioned. It is believed that in some instances two types differing only in color were the same but it was felt that with such a small collection an assumption could not be made. Both monochrome and

polychrome beads occur and a clear or translucent bead is considered to be monochrome. When a bead is polychrome, it is identified by its basic or background color, and the color of ornamentation is considered as part of the decoration. In some cases, a bead may be composed of two colors such as the "Cornaline d'Allepo" or where an overglaze may have been employed. These types were treated as monochrome with explanatory notes. It is often difficult to determine if an overglaze was used or if a patina has been formed. The formation of a patina also interferes with the determination of translucency.

Translucency is closely associated with color but is considered separately. Trade beads are generally not as clear as modern transparent glass but they still possess the property of transmitting rays of light so that bodies may be seen through them. Translucent beads allow light to pass through them but objects cannot be distinguished through them, while an opaque bead is impervious to light rays.

Decoration in combination with shape is the most definitive description of trade beads. Decoration is any embellishment on the surface or within a bead with stripes being the dominant form of decoration in trade beads. A stripe is defined as a band of decoration in trade beads. A stripe in a single color is referred to as monochrome and a stripe composed of two or more colors is polychrome. In some cases a stripe may consist of a group of parallel monochrome lines. A stripe of this type is termed bilinear or trilinear, depending upon the number of lines involved. A stripe may be raised, impressed, or embedded, that is projecting above, flush with, or underneath the surface of a bead. Stripes appear in three main forms of line direction: straight, that is, parallel to the longitudinal axis; transverse, or at right angles to the longitudinal axis; and spiral or diagonal to the longitudinal axis. The only transverse striped type known is the crossed triple weave in which three strips intertwine transversely to the longitudinal axis.

Another form of decoration in trade beads is molding. Beads were blown into molds while still hot, creating various designs. Some examples of designs that were molded are the leaf-scroll the gadrooned and the knobby. The leaf-scroll is a scroll of leaves encircling the bead transversely to its longitudinal axis; a glaze was added to the raised design to bring it out. A description of the design is necessary to complete the classification of molded beads. Gadrooned beads are those which have raised convex curved ridges as the decoration. The ridges appear to rise from a base surface and are opposed to fluting which is a series of concave grooves. A knobby bead is one whose surface is covered by a series of circular knobs which gives an impression of a raspberry. Orchard claims that the raspberry bead was manufactured as an imitation of the fruit (1929), while Beck (1928) implies that the gadrooned bead was originally an imitation of a melon. It is the author's opinion that the knobby bead is an evolved form of the eye, spot, or horned bead. Both gadrooned and knobby beads are found among the earlier beads of the Old World.

The material used in the manufacture of trade beads was as a general rule, some form of glass but a small percent of ceramic beads occur. It should be noted that the one ceramic type defined appears to consist of broken pipe stems, and these were probably not traded by Europeans as beads. Glass is a hard brittle substance with a conchoidal fracture made of fused mixtures of silicate, potash or lime and sometimes metal oxides. Ceramics are anything made of pottery, earthenware, or porcelain. There has been some work in the chemical analysis of glass to determine its age. This provides a worthwhile topic for research but would be too involved to be discussed in this paper.

The history of the manufacture of ceramic trade beads was not discussed in any of the works researched but the methods used in the manufacture of glass trade beads are well known and quite interesting. Orchard describes these in three paragraphs. His second describes the manufacture of what is known as the cane or drawn bead, while the third describes the wire-wound bead. The descriptions are:

> The starting point in the manufacture of beads is a rod or cane of glass and depending on whether this cane is hollow or solid the manufacture is carried on by radically distinct methods.
>
> In the case of the cane or tube we start from a gathering at the end of the blowing iron and this gathering is slightly inflated to form a hollow pear-shaped vehicle and a rod of iron is attached to the further extremity. This rod is seized by a boy who runs with it at full speed so as to elongate the glass as much as possible before it has time to cool. The thin tube thus formed may, it is said, be as much as 150 feet in length. This tube is broken into sections of convenient length, which are now sorted as to size by women and then are cut into shorter lengths forming bugles or tubular beads.
>
> Spherical and barrel shaped beads are made from a solid rod of glass. The extremity of the rod is melted in a blow flame and a thread of the viscid glass is laid over a revolving iron bar. The motion of the bar draws the glass before it is made into tubes or rods. (1929: 83).

These two types are easily distinguished because, in the case of the wire-wound spiral, flaws appear in the bead. This method is usually found in the larger trade beads. Colored rods are fused on the surface of the main cane. It should be noted that the method used in the manufacture of can or drawn beads would rule out Quimby's (1939) type referred to as a "jointed"

bead. It is the author's opinion that the "jointed" bead is no more than an incomplete severing of the cane during manufacture.

The trade beads which were typed came from the archaeological collection at Louisiana State University. The European associations are assumptions based on ethnographic data; i.e., the Angola Farm and the Bayou Goula sites were known to be under French domination while the Chickasaw Old Fields were associated with the English. In fact, it has been said that the Chickasaw were more loyal to the English than were the Iroquois (Josephy 1961). In some cases beads associated with European groups have been found among Indians loyal to another group. This is believed to have been caused by trade among the Indians themselves or by one European group trying to win the tribe away from the other group. An example of this is the type known as the Cornaline d'Allepo. It is known as the "Hudson's Bay Beads", that is, from the Hudson's Bay Company. It is Venetian in origin and found widely throughout North American where it was distributed by the Hudson's Bay Company, yet one example is found in this collection. Since there is only one occurrence it should be noted that the collection is not complete. There is also no association as to site for this bead.

The date of introduction of beads also causes some difficulties. De Soto was the first European in the area and is dated here from 1539 through 1541. It is presumed that he did not trade with the Chickasaws, Houma, or Bayou Goula; however, his journals do mention trading beads. LaSalle in 1682 also had contact with three groups. La Page Du Pratz states:

> "When they have bead **(rassade)** they make necklaces composed of one or many rows. They make them long enough for the head to pass through. The rassade is a bead of the size of the end of the finger of a small infant. Its length is greater than its diameter. Its substance is similar to porcelain. There is a smaller one, ordinarily round and white. They value it more than the other. There is a blue and one of another style which is banded **(bardales)** with blue and white. The medium sized and smallest are strung to ornament skins, garters, etc." (Swanton 1911: 56).

We can assume that Du Pratz was in the Lower Mississippi Valley from 1718 to 1730 and that the beads which he speaks of were European. The knowledge of beads probably originated around 1700 with Iberville's introduction of trade beads, but there is some evidence that the beads may be older than the above mentioned date, especially among the Chickasaw Old Fields beads. Jennings (1941) states that many of the types found at the Chickasaw Old Fields site were the same as those found by Bushnell in Virginia. Bushnell believes that the beads which he found are of Spanish origin (1937), but it is the author's opinion that the beads are English, for there is no record of post-DeSoto Spanish contact with the Chickasaws. It is possible, however, that the beads in Virginia are Spanish and that the English and the Spanish had a common source of manufacture.

If a common source of manufacture did exist it would mean that no one type of bead can be located as to origin. Then the approach must differ, that is, not concern itself with a source but with "complex" — many types of differing percentages. This complex would then be placeable in time and space and as to source. The difference between French and English beads is readily apparent. The French beads are generally bright and gaily decorated and were manufactured by the drawn method while the English beads tend to be drab and were manufactured by the wire-wound method. Unfortunately there are not enough data to determine any complex or any chronological order, for two of the sites in the collection under discussion span most of the 18th century. It is believed that with the analysis of several more sites and more ethnological data a fairly strong chronology and European source groups can be established.

BIBLIOGRAPHY

Beck, Horace C.
1928 Classification and Nomenclature of Beads and Pendants. **Archaeological Society of Antiquaries of London,** Vol. 77. London.

Bushnel, David I.
1937 Indian Sites Below the Falls of the Rappahannock, Virginia. **Smithsonian Miscellaneous Collections,** Vol. 96, No. 4 Washington.

Diamond, Freda
1953 **The Story of Glass.** Harcourt, Brace and Co., New York.

Ford, James A.
1936 Analysis of Indian Village Site Collections from Louisiana and Mississippi. **Department of Conservation, Louisiana Geological Survey, Anthropological Study** No. 2. New Orleans.

Haldemans, S. S.
1878 On a Polychrome Bead from Florida. **Smithsonian Report 1877,** p. 302. Washington.

Jennings, Jesse D.
1941 Chickasaw and Earlier Indian Cultures of Mississippi. **Journals of Mississippi History,** Vol. 3, No. 3. Jackson.

Josephy, Alvin M., editor
1961 **The American Heritage Book of Indians.**

American Heritage Publishing Co. Inc., New York.

Northend, Mary H.
1926 **American Glass.** Tudor Publishing Co., New York.

Orchard, William C.
1929 Beads and Beadwork of the American Indians. **Contributions from the Museum of the American Indian, Heye Foundation,** Vol. XI. New York.

Quimby, George L.
1939 European Trade Articles as Chronological Indicators for the Archaeology of the Historic Period. **Papers of the Michigan Academy of Science, Arts, and Letters,** Vol. 24. Ann Arbor.

1943 European Trade Objects in Michigan and Louisiana. **Papers of the Michigan Academy of Science, Arts, and Leters,** Vol. 27. Ann Arbor.

1957 The Bayou Goula Site, Iberville Parish, Louisiana. **Fieldiana: Anthropology,** Vol. 47, No. 2. Chicago.

Rogers, Frances and Alice Beard
1948 **500 Years of Glass.** J. P. Lippincott Co., New York.

Swanton, John R.
1911 Indian Tribes of the Lower Mississippi and Adjacent Coast of the Gulf of Mexico. **Smithsonian Institution, Bureau of American Ethnology, Bulletin** No. 43. Washington.

Turner, Wiliam E. S.
1936 Glass. **The Encyclopedia Britannica,** Vol. 10. London.

Reconstruction of An Arkansas Hopewellian Panpipe

by Gloria A. Young

Department of Anthropology, University of Arkansas, Fayetteville 72701

Abstract

Panpipes have been found in North America only on Hopewell sites. A particularly well preserved specimen from the Helena Crossing Site was described by James A. Ford. From this description a reconstruction which produced a true octave was made from native cane. Since the panpipe is a more primitive instrument than the flutes in use during Hopewell florescence, it is postulated that this instrument was used by shamans in the cult of ancestor worship.

Hopewellian burial mounds have yielded, since the first exploration in the mid-nineteeth century, artifacts made of a square or rectangular sheet of hammered metal, usually copper, folded over with the edges meeting and overlapping in the center of the back. The front of the sheet of metal is found to be corrugated to form two to five smooth, rounded ridges. At first these objects were considered ornaments; later when tubes of bone or reed were discovered intact inside, they were thought to be either joined whistles or torches. Recently they have come to be considered true panpipes, a musical instrument which seems to be unique in North America to the Hopewell culture. So exclusive is the panpipe to this culture, in fact, that it is considered a diagnostic trait.

The latest and best description of a Hopewellian panpipe is found in James A. Ford's 1963 report of the burial mounds at the Helena Crossing site at Helena, Arkansas. The reeds and plugs of two of the tubes of this artifact were found intact. Even with Ford's exact description there is still some question as to whether or not these objects are actually panpipes. Several other questions concerning these artifacts also arise: If they are panpipes why do they occur isolated in space and time from all other examples of panpipes? What purpose did they serve in the Hopewell cult which made them unique to this culture? Perhaps these questions can be answered somewhat by an examination of the artifact itself.

The first artifact of this kind found by archeologists was probably the one from the Marietta, Ohio, mounds. It was a typical in that it was covered with a sheet of silver. The specimen was described and figured by Atwater in the **Transactions and Collections of the American Antiquarian Society** in 1820 and was said to have five tubular sections (Mills 1926: 265). It may have

been the same artifact as the one found by Dr. Hildreth in a mound at Marietta and mistaken for part of a European sword scabbard (Willoughby 1922: 50). In the 1890's two copper artifacts were found by Clarence B. Moore during his survey of the St. Johns River area of the northwest coast of Florida. One artifact was described as "an ornament of Sheet copper bent over and repousse . . . length about 7 inches, width, about 2 inches" (Moore 1894: 507). This is definitely the kind of artifact later called a panpipe, but the second find was one somewhat flared on the ends with a hole bored through the center for suspension. It is impossible to tell from the drawing whether or not it is a panpipe, but it is corrugated as if to hold three tubes.

Moore found still another fluted example at the "mound near the Shell heap, Crystal River, Citrus County". He described it as "an ornament of fluted sheet copper, badly broken," and he added, "This pattern was a popular one among the aborigines" (Moore 1903: 412).

J. F. Snyder who was exploring the Baehr Mound Group in Brown County, Illinois, at the time when Moore was in Florida reported his own finds in the **American Anthropologist** of 1891. In Mound G he found a copper casing which he described as smooth and accurately corrugated as though pressed by machinery (Griffin 1941: 182). The next discovery seems to have been made by Warren K. Moorehead in 1922 when in the Hopewell mound group of Ohio he found several copper cylinders. He was able to determine that they once covered bone tubes, although these were badly decayed and all but one were in fragments (1922: 128).

Finally, Charles C. Willoughby recognized that the strange objects were some kind of musical instrument. Finding an example made from meteoric iron in the Turner group of earthworks in Hamilton County, Ohio, he compared it to similar artifacts in museums in Tennessee and Grand Rapids, Michigan. The Tennessee specimen had surrounded three tubes of cane or reed, fragments of which had been preserved by the copper salts. Willoughby speculated that all of the artifacts of this kind had once cased similar tubes. He concluded, "Perhaps the tubes may have been whistles of different notes joined together in a single instrument" (Willoughby 1922: 51).

W. C. Mills apparently did not agree with Willoughby, however, including a panpipe casing of the Hopewell, Ohio, artifacts under the heading "Problematical Copper Object" in his 1926 publication. He discusses the object, compares it with several others and concludes that "Their form suggests a flute-like musical instrument and the presence in some specimens of fibers, cane or reeds. is taken by some to indicate their use as torches, neither suggestion, however, appears to account satisfactorily for the purpose of the objects" (Mills 1926: 265).

In 1931, W. C. McKern gave a detailed description of a find in Mound 12 of the Schwert Group in the Trempealeau Focus of southwestern Wisconsin, and in 1945, Robert Ritzenthaler found one in an "Old Copper" site near Potosi in the same state.

Marvin Fowler may have been the first archeologist to call the conjoined tubes panpipes. In his 1957 report of the Rutherford Mound in Hardin County, Illinois, he said that "Burial 31 had on its chest a panpipe . . . 3¾ inches (95 mm.) long and 1⅞ inches (48 mm.) wide . . . made of sheet copper wrapped around three reeds, fragments of which were preserved" (Fowler 1957: 17).

Ford's excellent description must be quoted here as it served as the instructions from which I constructed my panpipe.

> A set of copper-jacketed panpipes lay on the sternum of Burial 61. The copper jacket was badly corroded and quite fragile. It is 20.7 cm. long and 5.5 cm. wide and was made to hold three cane tubes approximately 1.3 cm. in diameter, side by side. On the side that may be referred to as the front of the instrument, the copper was bent into flutings to conform to the curves of three cane tubes. The jacket is flat on the reverse where the edges of the copper sheet were brought together and held by two cord ties that passed through holes in the sheet.
>
> At the mouthpiece end only, on the front side of the instrument, the copper has been coated with a thin sheet of silver for a distance of 3.2 cm. from the end . . . The cane tubes have been preserved by copper oxide. They run the full length of the copper jacket and apparently did not extend beyond . . . The left-hand cane tube was wrapped for part of its length near the center with twisted bast-fiber string. Two layers of vegetable material, possibly the inner bark of some tree, had been wound over this in strips 3 mm. wide. This wrapping perhaps helped to secure the cane tube in the copper covering.
>
> Usually in the making of panpipes of cane or bamboo the septum that closes the tube at each joint is utilized to control the length of the tube, but such is not the case with this instrument. The three cane tubes run the full length of the copper jacket, and no joints are visible. The right-hand tube has been plugged with a small stick for 11.5 cm. of its length, leaving an open tube 9.2 cm. long. The plug is a small twig of a variety of wood that has a pith center. It is about 3 mm. in diameter, wrapped with a two-ply yarn which,

in turn, is covered with a wrapping of ribbon-like strips about 3 mm. wide, probably the inner bark of some tree . . . The string is made of a bast fiber that cannot be identified with certainty.

No plug is visible in the central tube. A wooden plug in the left-hand tube extends to within 4.5 cm. of the end of the tube. Evidently this was the high note side of the panpipe.

Adhering to the upper side of the instrument as it lay on the chest of Burial 61, are fragments of bast-fiber-twined cloth preserved by the copper salts (Ford 1963: 16-17).

This detailed description aroused my interest in attempting a reconstruction. With all of the dimensions listed, I felt that I might construct an adequate duplicate of the cane tube part of the instrument. Accordingly, I set to work using a pocket knife with a serrated blade and a metric system ruler. I cut a stalk of wild cane from the bank of the White River and let it dry for two weeks. The cane was still green enough to work without splitting. Cutting several sections from the stalk, I was pleased to find that all of the sections near the center of the stalk were 1.3 cm. in diameter, giving me latitude to choose three tubes which produced pleasant tones before the septum was removed. I trimmed three smooth and fairly straight tubes which produced clear notes into 20.7 cm. lengths which did not contain a septum. This made the tubes completely hollow and open at both ends.

For a plug I used a shoot from a wild redbud tree. I had hoped to make some cedar bark string for wrapping the plugs, but, since it seemed like too ambitious an undertaking, I decided on carded cotton and two-ply jute twine. I felt that these two materials would adequately stop the air flow around the plug. Having wrapped the two plugs, 11.5 cm. and 16.2 cm. long respectively, with strips of cotton secured by the jute twine, I forced them into the hollows of two of the cane tubes. An extra wad of cotton was fixed at exactly 9.2 cm. in the right tube and 4.5 cm. in the left tube.

Although the tone quality was not as good as when the tubes were naturally stopped by the septum, the two artificially stopped tubes immediately produced tones when blown. The tube with the longer air column produced the lower note, an A flat one and one half octaves above middle C; the tube with the shorter air column produced an A flat one octave higher than the low note.

Since I was interested only in the musical aspect of the instrument, I did not try to cover the panpipe with metal, but bound the stopped tubes together with an unstopped middle tube in a ligature of split cane and twine. The resulting instrument is only a crude model of the original Hopewellian panpipe, but I believe it has the same dimensions and produces the same notes as

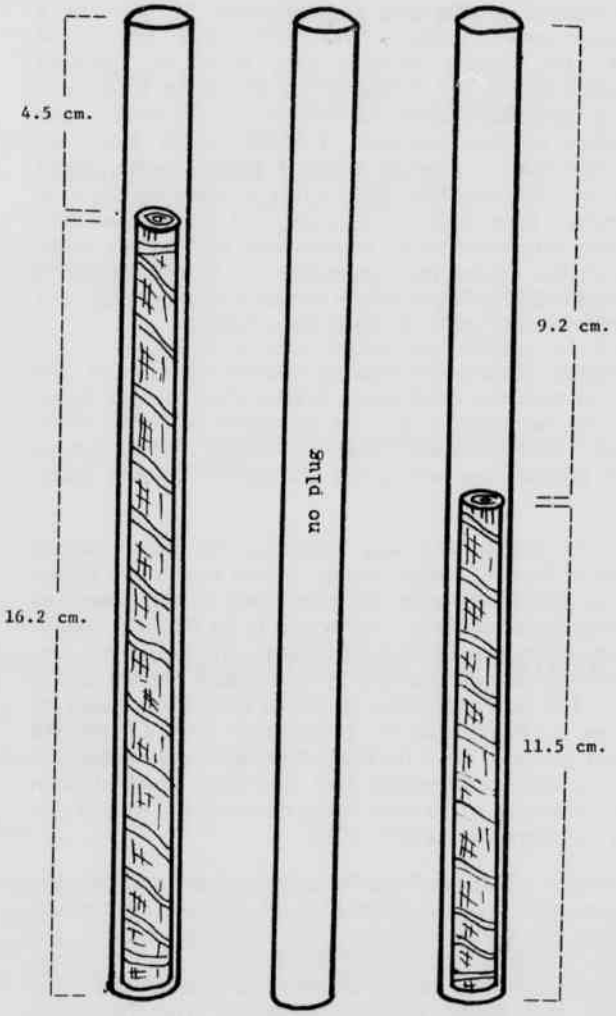


Figure 1. Diagram of a reconstruction of the panpipe found at the Helena Crossing site.

the resplendent original. Because a perfect octave was produced by the two stopped pipes, the artifact is, in my opinion, a panpipe even though it may have been used as an ornament in the burial.

If these are panpipes, then, why are they found in burials of the Hopewell culture, approximately between 500 B. C. and 1 A. D., and not in any other North American culture either before or after? The question is, in some measure, a part of the larger question of why Hopewell culture flourished at all. Willey and Phillips characterize the Hopewell phase as one in which "The technological skill and artistic sensitivity . . . were unapproached anywhere else in North America at that

time and hardly surpassed in Middle and South America" (Willey and Phillips 1958: 158).

Because of the high level of attainment of the Hopewell, some writers have argued for outside influence — a new race of people practicing cranial deformation, agriculture, and elaborate mortuary ceremonials moving into the Ohio and Illinois valleys, either from the Caribbean through Florida and the Southeast, or from Central America via the Mississippi River with Poverty Point, Louisiana, as an early manifestation of the culture. The fact that panpipes do occur from the San Blas Islands off Panama southward today and are found occasionally made of ceramic material in prehistoric sites on the west coast of Mexico could lend some weight to this theory. While there is no evidence to rule out such a theory entirely, no early site has been found in the south which shows more incipient Hopewellian traits than the burial mound cultures like the Adena which were already present in the Illinois and Ohio regions before the Hopewell florescence.

The most likely theory seems to be the one most widely accepted today: that there was no intrusion of foreign peoples, but rather that the Hopewell phase grew out of the Early Woodland Burial Mound cultures of the Ohio and Illinois valleys. Maize agriculture, Woodland pottery techniques, a growing circle of trade networks, and a religion which emphasized the elaborate burial of certain individuals were synthesized to make up the Hopewell complex. Hopewell culture could not be called a civilization but, more probably, a cult presided over by shamans, superimposed on the existing band or tribal organization. William Sears sees the Hopewell social systems as based on kin rather than class because of the settlement pattern of small equalitarian villages. His statement that "dominant individuals in Hopewell burial mounds were probably shamans" (Sears 1954: 344) is backed by evidence of cremation and unadorned burial for most of the population. If we surmise that this cermonial Cult of the Dead grew out of the worship of ancestors and that, as Sears believes, the grave goods such as panpipes, smoking or platform pipes, and ear spools were sacred or magical objects either traded widely or disseminated by "missionaries" of the cult, then the presence of the panpipes in the cult regalia can be explained.

The panpipe is the most simple tone-producing instrument. Excepting drums and rattles, it was one of the earliest instruments made by man. It is probably the instrument "referred to in Genesis called in Hebrew 'Ugab' and translated into the English version as 'organ' " (Miller 1932: 73). It is unthinkable that a people who lived along the banks of rivers where cane grows wild would not have known the principle of the panpipe without having to rely on recent diffusion for the idea. It is not unusual that no evidence of panpipes has been found in earlier cultures of the region. If the panpipes were not bound together in a set in the archaic cultures but used with a single pipe per individual musician as in some West African societies, the single section of cane would not be recognized by archeologists as a musical instrument should one be preserved for thousands of years. Knowledge of the principle of the stopped pipe leads naturally to the more advanced concept of the whistle and fingered flute, instruments found in abundance in prehistoric American contexts. It would not be unlikely that an advanced, flute-playing society would think of the panpipe as an ancient, crude instrument used in bygone days by their first ancestors. A panpipe would, then, be a fitting object to accompany the spirit of a shaman to the realm of the ancestors, an object with which the ancestors would be familiar. The importance of grave goods in Hopewell culture seems to have placed a high premium on excellent craftsmanship. and the copper objects must have been once smooth and beautifully burnished. It was probably for the sake of beauty that the Hopewell artisans removed the bulky septa from the cane, leaving straight, uniform tubes to be covered with the thin sheet metal. The lack of tone quality was probably not important, as the panpipes were made expressly for the occasion and may never have been played. The middle tube of the Helena panpipe may never have had a plug in it, being purposely made incomplete like later ritual pottery fired after holes were cut out. If it had a plug, it may have been ritually "killed" at the time of the burial so the spirit of the panpipe might accompany the spirit of the dead.

As the Hopewell cult declined, the function of the panpipes disappeared, as did the objects themselves from burials. Although platform pipes and other sacred objects were assimilated into the encroaching Southern Cult, there was no place for an instrument of the ancestors in the Mesoamerican-patterned religion of Quetzalcoatl and the pantheon of high gods.

REFERENCES CITED

Ford, James A.
1963 Hopewell Culture Burial Mounds near Helena, Arkansas. **Anthropological Papers of the American Museum of Natural History,** Vol. 50, Pt. 1. New York.

Fowler, Marvin L.
1957 Rutherford Mound, Hardin County, Illinois. **Scientific Papers, Illinois State Museum,** Vol. III, No. 1. Springfield.

Griffin, James B.
1941 Additional Hopewell Material from Illinois. **Indiana Historical Society,** Vol. II, No. 3. Indianapolis.

McKern, W. C.
1931 A Wisconsin Variant of the Hopewell Culture. **Bulletin of the Public Museum of the City of Milwaukee,** Vol. 10, No. 2, pp. 185-238. Milwaukee.

Miller, Dayton C.
1932 The Pipes of Pan, Old and New. **Scientific Monthly,** Vol. XXXIV, pp. 73-75. New York.

Mills, William C.
1926 Certain Mounds and Village Sites in Ohio. **Ohio Archaeological and Historical Society Publications,** Vol. 4, Pt. 4. Columbus.

Moore, Clarence B.
1948 Certain Sand Mounds at the St. Johns River, Florida. **Journal of the Academy of Natural Sciences of Philadelphia,** Vol. X, Pt. 2. Philadelphia.

1903 Certain Aboriginal Mounds, Central Florida, West Coast. **Journal of the Academy of Natural Sciences of Philadelphia,** Vol. XII, Pt. 3. Philadelphia.

Moorehead, Warren K.
1922 The Hopewell Mound Group of Ohio. **Field Museum of Natural History, Publication** 211. Chicago.

Ritzenthaler, Robert
1946 The Osceola Site, an "Old Copper" Site near Potosi, Wisconsin. **The Wisconsin Archeologist,** new series Vol. 27, No. 3, pp. 53-70. Milwaukee.

Sears, William H.
1954 The Sociopolitical Organization of Pre-Columbian Cultures on the Gulf Coast Plain. **American Anthropologist,** Vol. 56, pp. 339-346. Menasha.

Willey, Gordon and Philip Phillips
1958 **Method and Theory in American Archaeology.** University of Chicago Press, Chicago.

Willoughby, Charles C.
1922 The Turner Group of Earthworks, Hamilton County, Ohio. **Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University,** Vol. VIII, No. 3. Cambridge.

The Freshwater Algae of Arkansas

II. New Additions

Richard L. Meyer, James H. Wheeler and J. R. Brewer

Department of Botany and Bacteriology, University of Arkansas

Fayetteville, Arkansas 72701

INTRODUCTION

This paper is the second in a series reporting the algal flora of Arkansas. A previous paper (Meyer, 1969) reviewed the published literature and recent additions to this little known flora. Thirty-two genera and 82 species or varieties are presented in this inventory. These include 24 Chlorophyceae, 4 Conjugatophyceae, 9 Xanthophyceae, 14 Chrysophyceae, 1 Bacillariophyceae, 5 Pyrrhophyceae, 25 Euglenophyceae, 4 Cryptophyceae, 4 Cyanophyceae and 1 Rhodophyceae. Except for **Porphyrosiphon notarisii** (Menegh.) Kutz. et Gom.; each of these taxa have not previously been reported from the State of Arkansas. Daily (1958) noted that an Arkansas collection of this species is on deposit in the Chicago Natural History Museum.

Annotations accompanying each species gives a brief description of the habitat and subcommunity in which the organism was collected. The aquatic subcommunities described by Round (1965) are indicated in the text by leters. The subcommunities recognized include the euplankton (P), neuston (N), epipelic (EP), epilithic (EL), epiphytic (ET) and epizoid (EZ). Metaphyton (M) is used in the sense of Behre (1956) and refers to those algae, especially desmids and flagellates, which occur in close assocation with epiphytes but are not attached to them.

ACKNOWLEDGEMENTS

Two of the authors (RLM and JHW) were supported by the Water Resources Research Center, University of Arkansas, Grant No. A-011-ARK.

Division Chlorophyta

Class Chlorophyceae

Order Volvocales
The nomenclature used within this order is that of Huber-Pestalozzi (1961).

Gonium sociale (Duj.) Warm.
Eutrophic lakes and ponds. (P)

Phacotus angulosa Lemm.
Organically rich ponds. (P)

Volvox globator L.
Organically rich pond. (P)

Order Tetrasporales

Chlorophysema inertis (Korsch.) Pasch.
Eutrophic ponds. (ET)

Elaktothrix viridis (Printz) Snow
Organically rich pond. (P)

Order Chlorococcales

Actinastrum hantzschi Lagerh.
Eutrophic pond. (P)

Ankistrodesmis falcatus **var.** acicularis (Braun) G. West
Eutrophic pond. (P)

Coelastrum microporum Naeg.
Eutrophic lakes (P)

C. sphaericum Naeg.
Eutrophic lakes

Crucigenia quadrata Morren
Eutrophic and organically rich pools. (P)

C. rectangularis (Braun) Gray
Organically rich pools. (P)

Francia droescheri (Lemm.) G. M. Smith
Organically rich pond. (P)

Gloeocystis gigas (Kuetz.) Lagerh.
Euthrophic pond. (P)

G. vesiculose Naeg.
Eutrophic lake. (P)

Kirchneriella obesa **var.** major (Bern.) G. M. Smith
Eutrophic ponds. (P)

Oocystis solitarea Whittr.
Eutrophic lake. (P)

Pediastrum simplex **var.** duodenarium (Bailey) Rabenh.
Euthrophic lake. (P)

Quadrigula lacustris (Bohlin) Printz
Organically rich ponds. (P)

Tetraedron caudatum (Corda) Hansg.
Organically rich ponds. (P)

T. multicum (Braun) Hansg.
Eutrophic lake. (P)

T. reglulare Kuetz.
Organically rich ponds. (P)

Order Ulotrichales

Microspora elegans Hansg.
Eutrophic pond. (ET)

Order Chaetophorales

Draparnaldia plumosa (Vauch.) C. Agordh.
Slowly running water. (EL)

Order Cladophorales

Basicladia chelonum (Collins) Hoff. **et** Tilden
On **Chrysemys picta.** (EZ)

Class Conjugatophyceae

Order Zygnematales

Hyalotheca mucosa (Dillw.) Ehrbg.
Quiet pools in river and pasture pools. (M)

Spirogyra farlowii Trans.
Eutrophic pond. (EL)

Staurastrum chaetoceros (Shrod.) G. M. Smith
Euthrophic lake. (P)

Staurodesmus dickei (W. **et** W.) Teil.
Euthrophic pond. (P)

Division Chysophyta

Class Xanthophyceae

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

Order Heterococcales

Characiopsis elegans Ettl
Eutrophic Pd. (ET)

C. longipes (Rabenh.) Borzi
Organically rich pool. (ET)

C. turgida W. **et** W.
Organically rich pool. (ET)

Goniochloris trigona Pasch.
Organically rich pond. (P)

Mischococcus confervoides Naeg.
Eutrophic lakes and ponds. (ET)

Ophiocytium arbuscula Rabenh.
Eutrophic pond. (ET)

Tetraplektron acuminutum (Pasch.) Fott
Organically rich pond. (P)

Order Heterotrichales

Tribonema subtillisima Pasch.
Organically rich pond. (ET)

Order Heterosiphonales

Vaucheria hamata (Vauch.) DeCand.
Eutrophic Lake. (EL)

Class Chrysophyceae

Order Chrysomonadales

Chrysococcus diaphanus skuja
Organically rich pond. (P)

Chrysosphaerella longispina Laut.
Organically rich pond. (P)

Dinobryon bavaricum Imh.
Eutrophic lake. (P)

D. cylindricum Imh.
Eutrophic lake. (P)

D. cylindricum var. alpinum (Imh.) Bachm.
Eutrophic lake. (P)

D. cylindricum var. palustre Lemm.
Eutrophic lake. (P)

Mallomonas akromonas var. parvula Conrad
Eutrophic lake. (P)

M. fagtigata Zach.
Eutrophic pond. (P)

M. pseudo-coronata Press.
Eutrophic lake. (P)

Ochromonas crenulata Klebs
Mesotrophic lake. (P)

Uroglena sonica Conrad
Mesotrophic lakes. (P)

U. volvox
Mesotrophic lake. (P)

Order Rhizochrysidales

Stylochrysallis parasitica (Stein) em. Meyer et Brook
Mesotrophic lake. (ET)

Order Chrysocapsales

Chrysocapsa paludosa (Korsch.) Bour.
Mesotrophic lake. (P)

Class Bacillariophyceae

Order Centrales

Cyclotella meneghiana (Kuetz.)
Eutrophic lake. (P)

Division Pyrrhophyta

Class Dinophyceae

The nomenclature followed within this class is that of Schiller (1933-35).

Order Gymnodiniales

Gymnodinium lacustre Schil.
Eutrophic lake. (P)

Order Peridiniales

Hemidinium bernardinense (Chod.) H-P.
Organically rich pond. (P)

H. nasutum var. tatricum Wol.
Mesotrophic lake. (P)

Peridinium cunningtonia (Lemm.) Lemm.
Eutrophic lake. (P)

Order Dinococcales

Phytodinedria coconiforme Baum.
Mesotrophic lake. (ET)

Division Euglenophyta

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

Clas Euglenophyceae

Order Euglenales

Astasia klebsii Lemm.
Eutrophic lake. (P)

Entosiphon sulcatum (Duj.) Stein
Organically rich pond. (P)

Euglena ehrenbergii var. torta Ped.-Stscheg.
Eutrophic lake. (P)

E. oxyuris Schmarda
Eutrophic lake. (P)

E. torta Stokes
Eutrophic lake. (P)

E. tripteris (Duj.) Klebs
Eutrophic lake. (P)

Lepocinclis acicularis France
Organically rich pond. (P)

L. ovum var. dimidio-minor Defl.
Organically rich pond. (P)

L. radiata Chad.
Eutrophic lake. (P)

L. texta (Duj.) Lemm. em. Con.
Eutrophic pond. (P)

Phacus granum Drez.
Organically rich pond. (P)

P. longicaudata (Ehrbg.) Duj.
Eutrophic lake. (P)

P. platalea var. tiszae Hortb.
Mesotrophic pond. (P)

P. suecica Lemm.
Eutrophic lake. (P)

Trachelomonas benardinensis Visch. em. Defl.
Eutrophic lake. (P)

T. cervicula Stokes
Organically rich pond. (P)

T. curta DaCunha
Organically rich pond. (P)

T. curta **var.** castrensis (Palmer) Defl.
Organically rich pond. (P)

T. granulosa **var.** oblonga Ulayf.
Eutrophic lake. (P)

T. horrida Palmer
Organically rich pond. (P)

T. oblonga Lemm.
Organically rich pond. (P)

T. raciborskii Wol.
Eutrophic lake. (P)

T. raciborskii **var.** roggiea Skv.
Eutrophic lake. (P)

T. umbilicoforme **var.** deflandrei Conrad
Organically rich pond. (P)

T. volvocina **var.** papilopunctate Skv.
Organically rich pond. (P)

Class Cryptophyceae

Order Crytomonadales

Chroomonas nordstedtii Hansg.
Rivers and eutrophic lake. (P)

Cryptomonas ozolini Skuja
Organicalluy rich pond. (P)

C. tetrapyrenoidosa Skuja
Eutrophic lake. (P)

Order Chloromonadales

Gonyostomun semen (Ehrbg.) Diesing
Mesotrophic lake. (P)

Division Cyanophyta

Class Cyanophyceae

The nomenclature used in this class is that of Geitler (1931-32).

Order Chroococcales

Coleosphaerium kuetzingianum Naeg.
Eutrophic lakes. (P)

C. naeglianum (Lemm). Ung.
Eutrophic lakes. (P)

Order Oscillatoriales

Porphyrosiphon notarisii (Menegh.) Kutz. **et.** Gam.
On soil. (EL)

Raphidiopsis curvata Fritsch
Organically rich vernal pool. (P)

Spirulina okensis (C. Meyer) Geit.
Eutrophic lake. (P)

Division Rhodophyta

Class Rhodophyceae

Order Nemalionales

Lemanea australis Atk.
Rapidly flowing river. (EL)

LITERATURE CITED

Behre, L., 1956
Die Algen besiedlund einiger Seen um Bremen und Bremerhaven. Ver. Inst. Meersk. Bremmerhaven 4:221-283.

Daily, W. A., 1948
Notes on Algae III. Butler Univ. Bot. Stud. 8:121-122.

Geitler, L., 1931-32
Cyanophyceae. In L. Rabenhorst, Kryptogamen-Flora von Deutschlands, Osterreich und der Schweiz. Bd. 14., 1056 pp.

Huber-Pestalozzi, G. 1955
Das Phytoplankton des Susswasser. Bd. 16, T. 4 Euglenophyceae. E. Schweizerbart'sche Verlag. Stuttgart. 606 pp.

_____, 1961
Das Phytoplankton des Susswasser. Bd. 16, T. 6 Volvocales. E. Schweizerbart'sche Verlag. Stuttgart, 644 pp.

Meyer, R. L., 1969
The Freshwater Algae of Arkansas. I. Introduction and Recent Additions. Ark. Acad. Sci. Proc. 23:145-156.

Pascher, A., 1939
Heterokonten. In L. Rabenhorst, Kryptogamen-Flora von Deutschlands, Osterreich und der Schweiz. Bd. 11. 1092 pp.

Round, F., 1965
The Biology of Algae. E. Arnold, Ltd. London, 269 pp.

Schiller, J., 1933-35
Dinoflagellates. In L. Rabenhorst, Kryptogamen-Flora von Deutschland, Osterreich und der Schweiz. Bd. 10. T. 3(1-2).

Daniel L. Marsh

Observations of Flowering in Arundinaria gigantea (Walt.) Chapm. in Arkansas

Daniel L. Marsh, Division of Biology

Henderson State College, Arkadelphia, Arkansas 71923

It is widely stated in the literature that flowering in **Arundinaria gigantea**, as in many other bamboos, occurs infrequently. Hitchcock (1935) stated that flowering generally occurs simultaneously over a wide area.

My first observation of **Arundinaria** in flower, was on April 2, 1967 along a sandy bank of the Buffalo River at Rush in Marion County (Marsh 2124). An unsuccessful search was made for other flowering sites (during several successive weeks).

In 1969, nine flowering sites in six counties of Arkansas were observed. These were located in the southwestern and north central parts of the State. Other occurrences in northwestern Arkansas were observed by Dr. Edwin B. Smith (personal communication).

My observations in 1969 were made from late March to late May in a variety of ecological situations. The sites were as follow:

1. Clark County, 1½ mi. SW of Vaden, March 31 (Marsh 2237). One patch covering about 30 m^2 was found in a grazed area near a large spring above a bald cypress swamp. The area was an abandoned farmstead cleared in a **Pinus - Quercus Liquidambar** woodland. The plants were mostly cut or grazed to less than four feet high.

2. Little River County, near White Cliffs on the flood plain of Little River, April 26 (Marsh 2421). The flowering plants were abundant over an extensive area. The area had been recently flooded, leaving a film of mud on all of the plants. Both new shoots, often nearly leafless, and old leafy shoots up to nine feet high were found profusely flowering. Some of the new shoots were connected by rhizomes to old shoots.

3. Hempstead County, Beard Lake Recreational Area below Millwood Dam, April 26 (Marsh 2431). The plants were mostly small, from one to four feet high, scattered abundantly over the picnic area which is in a moist, level, sedgy area.

4. Marion County, mouth of Water Creek on Buffalo River, May 3 (Marsh 2471). This sandy-soiled river and creek bank area was divided by a fence and partly grazed. The plants were mostly three to six feet high and profuse flowering was seen throughout the canebrake. Immature grains were found.

5. Searcy County, bank of Big Creek, east of Harriet, and upstream from Highway 14, May 4 (Marsh 2498). This small brake was situated in the splash area of a spring-fed fall from a bluff above. The steep, calcareous, rocky bank was very wet and well protected from grazing. The plants were growing among and from under the rocks.

6. Clark County, on the Caddo River flood plain, north of Amity and just west of Ark-182, May 5 (Marsh 2499) and May 31 (Marsh 2532). The large, dense canebrake, mixed with **Ulmus** and **Acer negundo** borders a small field and extends along the banks of several small creeks. Flowering occured in scattered patches, mostly on old plants from four to sixteen feet high.

7. Clark County, Caddo River at Parker Falls north of Arkadelphia (area now inundated by DeGray Reservoir), May 24 (Marsh 2529). A large patch, (heavily in flower), was located along the sandy river bank. No flowering was found in the brake higher up the hillside. Both new and old shoots were flowering, and new shoots were very abundant. Many inflorescences throughout the colony were bent or curved, and insect larvae were noticed attached to some of the curves.

8. Hot Spring County, west of Malvern on the local service road along I-30, May 25 (Marsh 2530). This small patch was located on the roadside on the bank of a small stream. Flowering was not heavy. No flowering was found in large canebrakes nearby.

9. Hot Spring County, east of Malvern in bottom land along Nine Mile Creek, May 25 (Marsh 2531). Among the extensive canebrakes examined, flowering was found in only one patch. This was in a swampy area with saturated soil.

It may be seen that flowering has occurred in a variety of ecological situations during the same season, and from the widespread locations of the observations it may be inferred that flowering occurred over much if not all of the state.

Although I observed pollen formation in all the sites, fruit formation was found only in the site at Water Creek in Marion County. Hughes (1951) found at Plymouth, North Carolina, that immature fruit was destroyed by insects. Observation of insect larvae on

the inflorescences in the canebrake at Parker Falls and the lack of fruit formation in the other sites may indicate a similar situation in Arkansas.

Apparently the flowering in other genera of the Bambuseae has been remarkable in recent years. Newspapers in 1969 carried accounts of flowering in imported bamboos in Arkansas and elsewhere in this country, and there have been numerous reports by the popular press of dramatic flowering in the orient. Harney (1970) reported that in Japan flowering in timber bamboos followed by large scale death has become marked since 1959.

According to McClure (1966) two important items of information often neglected in reports on bamboos is the quantity of mature fruits produced and the survival of plants after flowering. Thus far I have found no mature fruit in **Arundinaria gigantea.** On April 16, 1970 I revisited the large canebrake north of Amity. Many plants which had flowered the previous spring were dead, but a few flowering plants were found among them. In another part of the brake abundant flowering was observed (Marsh 3523).

In this study no attempt has been made to distinguish **A. tecta** (Walt.) Muhl. from **A. gigantea,** although McClure (1963) has reported anatomical differences in the rhizomes which may distinguish the two taxa. Certainly the two taxa cannot readily be distinguished on the basis of whether the inflorescences are borne on leafless new shoots or leafy branches of old canes, as indicated by earlier manuals such as Small's (1933).

Further study of the current flowering cycle is projected.

ACKNOWLEDGEMENTS

The author thanks Dr. Delzie Demaree for his company in the field and for his suggestions during this study. Gratitude is also expressed to Dale Wilson for location of the Vaden site.

LITERATURE CITED

Harney, Tom, 1970. Japanese bamboo dying. **Biomedical News,** p. 15. January.

Hitchcock, A. S., 1935. **Manual of the Grasses of the United States.** United States Dept. of Agri. Misc. Pub. No. 200. Washington, D. C.

Hughes, R. H., 1951. Observations of cane **(Arundinaria)** flowers, seed, and seedlings in the North Carolina Coastal Plain. **Bull. Torrey Botan. Club** 78:113-121.

McClure, F. A., 1963. A new feature in bamboo rhizome anatomy. **Rhodora** 65:63-65.

_____, 1966. **The Bamboos, a fresh perspective.** Harvard University Press, Cambridge, Mass.

Small, John Kunkel, 1933. **Manual of the Southeastern Flora.** New York.

Additions To The Arkansas Flora

Edwin B. Smith, Department of Botany and Bacteriology

University of Arkansas, Fayetteville, Arkansas 72701

I have noticed in the last two years several collections in the state of Arkansas which apparently represent new records for the Arkansas flora, and it seems worthwhile to call these to the attention of other botanists in the state. The following species were not included in Branner & Coville's list (1891), Buchholz & Palmer's supplement (1926), any of the various papers on the Arkansas flora since that time (see Dale, 1963, etc.), nor were they specifically indicated to occur in Arkansas in any of the manuals available for Arkansas or adjacent states (e. g. Small (1913), Steyermark (1963) etc.).

GRAMINEAE (Tribe Chlorideae)

Chloris virgata Swartz

Arkansas County: Common near Airport, even in cracks in the runway, outside of Stuttgart, Aug. 22, 1969, Sophia McCoy 3. This species was not included by Moore (1961) in his list of grasses of Arkansas. It differs from the similar **C. verticillata** Nutt. in the long whitish tufts of hair near the apex of the lemmas.

CONVOLVULACEAE

Ipomoea cairica (L.) House

Hempstead County: South of Hope, Sept. 7, 1940, D. M. Moore 400420. Prairie County: 2 mi. W. & ½ mi. S. of highway 11 at turn off from Slovak, Aug., 1969, Sophia McCoy 11. This is the only **Ipomoea** in the state with palmately compound leaves, and is apparently well established in

Prairie County. It is apparently an escape from cultivation.

COMPOSITAE

(Tribe Astereae)

Haplopappus ciliatus (Nutt.) DC.

Arkansas River Valley region of the state, as: Pulaski County: Camp Robinson, Sept. 6, 1938, G. M. Merrill 1003. Franklin County: Small colony on dry roadside bank by U.S. 64, 2.2 mi. E. of jct. of highways 186 and 64 in Altus; Aug. 22, 1968, E. B. Smith 1236. This species differs from **H. divaricatus** (Nutt.) Gray, common in southern Arkansas, and **H. validus** (Rydb.) Cory subsp. **validus** (reported below) by its much larger heads (ca. 2-3 cm wide), ovate-orbicular to oblong leaves which are spinous-ciliate, and glabrous condition. It might be mistaken for a **Helianthus** or **Silphium,** to which it bears superficial resemblance, but differs from both in its turbinate achenes with a pappus of capillary bristles.

Haplopappus validus (Rydb.) Cory subsp. **validus**

Conway County: Entomology Dept. Composite survey, July 14, 1965; Abundant on a sandy knoll near highway 9, ca. 0.4 mi. S. of the old Arkansas River bridge S. of Morrilton, Aug. 22, 1968, E. B. Smith 1235. Shinner's (1951) combination, **Croptilon divaricatum** (Nutt.) Raf. var. **hookerianum** (T. & G.) Shinners, which he applies to both this subspecies and to subspecies **torrey**i Smith, is in part a synonym of this subspecies. This taxon is similar to **H. divaricatus,** differing in several characters, among which are its shorter stature (ca. 40-50 cm tall) and its larger heads with more numerous flowers (ca. 15-25 ray flowers per head; ca. 45-75 disc flowers per head). This subspecies has apparently advanced from its usual range (Kansas to northern Texas) along the Arkansas River.

Solidago tortifolia Ell.

Jefferson County: Entomology Dept. Composite survey, exact locality not recorded, Sept. 17, 1965. Determined by Maxine Clark and confirmed by myself. This species resembles **S. odora** Ait., but differs in its leaves usually being few-serrulate at the apex and short-hairy on the lower surface (vs. the entire leaves of **S. odora** which are glabrous on the lower surface).

(Tribe Heliantheae)

Helianthus maximiliani Schrad.

Jefferson County: vicinity of W. 7th Avenue in Pine Bluff, Oct. 19, 1969, Marie P. Locke 67. Based on the distribution shown by Steyermark (1963) in Missouri, this species should also occur in northern Arkansas. This species is a narrow-leaved one with a yellow disk, most closely resembling **H. grosseserratus** Martens, but distinguished from that species by its short appressed hairiness of the upper stem (vs. glabrous in **H. grosseserratus)** and smaller leaves.

Polymnia laevigata Beadle

Franklin County: Entomology Dept. Composite survey, exact locality not recorded, June 18, 1965. This rare species has been recorded from only 7 counties in 5 states (Wells, 1969): Alabama, Florida, Georgia, Missouri, and Tennessee. This station is the western-most collection site for the species by well over 100 miles. It is unfortunate that the exact collection site was not recorded. This species can be distinguished from the other two species in the state **(P. canadensis** L. and **P. uvedalia** L.) by its glabrous lower leaf surfaces (vs. hairy, at least on the veins, in the other species).

(Tribe Cichorieae)

Tragopogon dubius Scop.

Northwestern Arkansas, as: Boone County: scattered in roadside gravel 1 mi. W. of the jct. of highways 62 and 65, May 29, 1968, E. B. Smith 1175. Washington County: Scattered along the ditch by highway 45 on the E. side of Fayetteville, May 19, 1968, E. B. Smith 1156. The **T. porrifolius** L. reported by Buchholz & Palmer (1926) was probably this species. **Tragopogon porrifolius** has pale to deep violet-purple ligules, while this species has pale lemon yellow ligules. The huge dandelion-like fruits of this species (achene ca. 3-4 cm long, not counting the pappus) immediately distinguish it from other Compositae in the state.

ACKNOWLEDGEMENTS

I thank the Entomology Department, University of Arkansas, for their donation of the salvageable material from their 1965 collection of Arkansas Compositae, and Maxine Clark for being instrumental in the acquisition of that collection. Thanks to Sophia McCay and Marie P. Locke for their interest in collecting specimens in southeastern Arkansas.

LITERATURE CITED

Branner, J. C. and F. V. Coville 1891. A list of the plants of Arkansas. Annual Report for 1888. Ark. Geol. Survey 4:155-242.

Buchholz, J. T. and E. J. Palmer 1926. Supplement to the catalogue of Arkansas Plants. Trans. Acad. Sci. of St. Louis 25:91-155.

Dale, E. E. 1963. Literature on the vegetation of Arkansas. Proc. Ark. Acad. Sci. 17:40-49.

Moore, D. M. 1961. Revised and annotated catalogue of the grasses of Arkansas. Proc. Ark. Acad. Sci. 15:9-25.

Shinners, L. H. 1951. Notes on Texas Compositae VIII. Field & Lab. 19:134.

Small, J. K. 1913. Flora of the Southeastern United States. 2nd ed. New York.

Steyermark, J. A. 1963. Flora of Missouri. The Iowa State U. Press, Ames.

Wells, J. R. 1969. Specific relationships between **Polymnia canadensis** and **P. laevigata** (Compositae). Castanea 34:179-184.

Floristic Elements of the Pope County, Arkansas, Area

Gary Tucker and Bill Grabill

Arkansas Polytechnic College, Russellville, Arkansas 72801

Pope County, Arkansas, a primarily mountainous county of the Arkansas River valley in west-central Arkansas, is a unique area floristically. The area has a rich flora representing a number of different habitats and vegetation types: rock outcrop (sandstone, shale, and limestone); unconsolidated sand dunes; several deciduous climax forest types, principally dominated by oaks of several species, often accompanied by one or more species of hickory, but with mesophytic species prevailing on moister, cooler sites; cypress-tupelo swamp forest; several forest types of successional nature, including shortleaf pine; various aquatic and semiaquatic vegetation types; and disturbed habitats in several stages of succession. Extensive agricultural land utilization and building construction activity allows for an abundance of weedy species.

Extensive vascular plant collections have been made within Pope County, and surrounding counties, within the past three years. Preliminary examination of these and other herbarium specimens has revealed several important phytogeographical elements within the flora of the area.

Any area, regardless of geographic location, will harbor species having many different geographic ranges. Any area, therefore, will have certain "rare" species which are either local endemics, disjuncts, or at least marginal in range. Many workers, therefore, think it idle to mention "northern" or "southeastern" or "western" species of an area. Such species, to be sure, are usually not of consequence if considered individually. It is less than easy, however, to discount large assemblages of such species groups on the basis of present distribution patterns alone. An assemblage of "rare" or "marginal" species is often instructional in interpreting past geological history, former distributional patterns, and, in many cases, present ecological conditions of an area.

The following lists of taxa broadly categorize the phytogeographical affinities of important elements of the flora of Pope County and surrounding area. Sources of distribution data include Gleason and Cronquist (1963), Harrington (1966), Radford et al (1968), and Steyermark (1963). The lists are not exhaustive and are not intended to represent major contributions toward a check list of the area. They are offered as evidence of a diverse flora which offers much potential for serious study.

Specimens cited are on deposit in the Herbarium of the Biology Department, Arkansas Polytechnic College, unless otherwise noted.

TAXA HAVING PRIMARY DISTRIBUTION IN SOUTHEASTERN STATES

Trichomanes petersii Gray — Pope County (Redfearn, University of Arkansas Herbarium)

Aira elegans Willd. ex Gaud. — Pope County (Tucker 4191)

Dichromena colorata (L.) Hitchc. — Pope County (Tucker 4776)

Rhynchospora macrostachya Torr. — Pope County (Tucker 3624)

Tradescantia hirsuticaulis Small — Pope County (Wilson s.n.)

Aneilema keisak Hassk. — Conway County (Tucker 7760)

Ulmus crassifolia Nutt. — Conway County (Tucker 8357)

Planera aquatica Walt. ex Gmel. — Pope County (Tucker 3610)

Brunnichia cirrhosa Gaertn. — Pope County (Stringfellow s.n.)

Podostemum ceratophyllum Michx. — Pope County (Tucker 8029)

Neviusia alabamensis A. Gray — Conway County (Tucker 6897)

Cladrastis lutea (Michx. f.) Koch — Pope County (Tucker 3543)

Glottidium vesicarium (Jacq.) Mohr. — Johnson County (Tucker 8241)

Aeschynomene indica L. — Pope County (Moore s.n.)

Sesbania exaltata (Raf.) Rydb. ex Hill — Pope County (Tucker 7622)

Zanthoxylum clava-herculis L. — Pope County (Tucker 7131)

Berchemia scandens (Hill) Koch — Pope County (Tucker 7702)

Eryngium prostratum Nutt. — Pope County (Tucker 7210)

Trepocarpus aethusae Nutt. — Pope County (Tucker 7995)

Apium leptophyllum (Pers.) Muell. — Pope County (Tucker 7998)

Nyssa aquatica L. — Pope County (Tucker 3607)

Lyonia ligustrina (L.) Britt. — Pope County (Tucker 7215)

Lyonia mariana (L.) D. Don — Pope County (Tucker 7214)

Fraxinus caroliniana Mill. — Pope County (Tucker 8038)

Forestiera acuminata (Michx.) Poir — Pope County (Tucker 7107)

Verbena brasiliensis Vell. — Pope County (Tucker 7132)

Spermacoce glabra Michx. — Pope County (Tucker 7548)

Sherardia arvensis L. — Pope County (Tucker 7993)

Sphenoclea zeylandica Gaertn. — Yell County (Tucker 6801)

Senecio tomentosus Michx. — Pope County (Reddell s.n.)

Liatris elegans (Walt.) Michx. — Pope County (Tucker 3498)

Mikania scandens (L.) Willd. — Pope County (Tucker 3613)

Facelis retusa (Lam.) Sch.-Bip. — Pope County (Tucker 7030)

Baccharis halimifolia L. — Pope County (Grabill s.n.)

Soliva pterosperma (Juss.) Lessing — Pope County (Tucker 7930)

TAXA HAVING PRIMARY DISTRIBUTION IN NORTHERN AND EASTERN STATES

Carex albursina Sheldon — Pope County (Tucker 7873A)

Cypripedium calceolus var. **pubescens** (Willd.) Correll — Pope County (Wright s.n.)

Orchis spectabilis L. — Pope County (Tucker 7918)

Goodyera pubescens (Willd.) R. Br. — Pope County (Tucker & Hodges s.n.)

Actaea pachypoda Ell. — Pope County (Tucker 7650)

Magnolia acuminata L. — Pope County (Tucker)

Magnolia tripetala L. — Pope County (Tucker 7666)

Physocarpus opulifolius (L.) Maxim — Pope County (Tucker 7652)

Cornus alternifolia L. f. — Pope County (Tucker 7663A)

Panax quinquefolius L. — Pope County (Tucker 7672)

Halesia carolina L. — Pope County (Tucker 3553)

Fraxinus quadrangulata Michx. — Pope County (Tucker 3539)

Viburnum molle Michx. — Pope County (Tucker 6867)

TAXA HAVING PRIMARY DISTRIBUTION IN WESTERN STATES

Festuca dertonensis (All.) Aschers. & Graebn. — Pope County (Tucker 5003)

Eragrostis oxylepis (Torr.) Torr. — Pope County (Tucker 7235)

Cycloloma atriplicifolium (Spreng.) Coult. — Pope County (Tucker 7205A)

Froelichia gracilis (Hook.) Moq. — Pope County (Snodgrass s.n.)

Dalea lanata — Pope County (Tucker 7173)

Cotinus obovatus Raf. — Pope County (Tucker 5804)

Sapindus drummondii Hook. & Arn. — Pope County (Tucker 7043)

Callirhoe involucrata (T. & G.) Gray — Pope County (Tucker 8041)

Spermolepis echinata (Nutt.) Heller — Pope County (Tucker 7106)

TAXA HAVING PRIMARY DISTRIBUTION IN MISSISSIPPI RIVER VALLEY

Cynosciadium digitatum DC. — Pope County (Tucker 8039)

Hydrolea uniflora Raf. — Pope County (3621)

TAXA HAVING PRIMARY DISTRIBUTION IN OZARK HIGHLANDS REGION

Carya texana Buckl. — Pope County (Flanagin s.n.)

Castanea ozarkensis Ashe — Pope County (Tucker 4182)

Phlox pilosa var. **ozarkana** Wherry — Pope County (Moore 54-100)

Penstemon arkansanus Pennell — Pope County (Wlison s.n.)

Ruellia pedunculata Torr. — Pope County (Tucker 7996)

Galium arkansanum Gray — Pope County (Williamson s.n.)

REFERENCES

Gleason, H. A. and S. Cronquist. 1963. Manual of vascular plants of northeastern United States and adjacent Canada, Princeton, N. J.

Harrington, H. D. 1966. Manual of the plants of Colorado. Denver.

Radford, A. E. et al. 1968. Manual of the vascular flora of the Carolinas. Chapel Hill.

Steyermark, J. A. 1963. Flora of Missouri. Ames, Iowa.

Waterfall, U. T. 1969. Keys to the flora of Oklahoma. Stillwater.

Land Use In Northwestern Arkansas: A Case Study

Joe E. Yates, State College of Arkansas

Conway, Arkansas 72032

The area of study is a civil township in Benton County in northwestern Arkansas. The topographical features range from a flat prairie surface in the southern portion of the township to a rugged, stream dissected surface in the northern portion. The total acreage of the area is 7,851.6 acres. The physical elements of the region will allow the growing of most mid-latitude crops but only a few are found in the area. Therefore, the author turned to the cultural factors to determine the use of land, while keeping in mind that physical controls would exert some influence. In an attempt to get an insight into the cultural involvement, the population was divided into groups based on whether they were full-time farmers, part-time farmers, non-farming families, or absentee owners of farms. A questionnaire was used and all affected people were interviewed.

The major categories used are cropland, pasture land, abandoned agricultural land, farmsteads, forest land, and public and semi-public land.[1]

A total of 536 acres, 6.8 per cent of the township, is used for crops. There are four commercially grown crops in the area. Green beans utilize 276 acres, wheat 143 acres, soybeans 67 acres, and corn 50 acres.

Green beans are raised as a cash crop, and all are sold to Allen's Canning Company in Siloam Springs, Arkansas. One farmer who resides in the township raises 80 acres of green beans in addition to producing beef cattle and poultry. The remaining 196 acres are grown by two absentee owners who reside close to the township. Both of these farmers engage in beef production as well as green beans. They raise no other crops. All beans are grown in the southern portion of the township where the soil has developed under prairie vegetation. This soil is productive farming land when properly drained and limed.

All three farmers who grow green beans moved into the area from another state and brought capital with them. This cultural influx has had an impact on cash crop production in these prairie areas. Several years ago much of the prairie area was in apple orchards but because of disease, insects, and the ease of pasturing cattle, the orchards were allowed to die and were never replanted. The native people regarded the land as too

(1) Data was collected during the week of March 24, 1969.

wet for crops other than orchards, and the land was devoted to pasture until people moved in and placed a portion of it into the production of green beans.

Wheat is grown on five farms and comprises a total of 143 acres. The prairie area accounts for 121 acres of wheat while 22 acres are grown on a flat ridge top in the northern portion of the township. Wheat production represents a minor use of land within the area, and this may result from government interference as well as a shortage of good wheat land. The majority of those farmers who raise wheat moved into the area from western Oklahoma or Kansas, and some of the production may be a holdover from earlier farming types. Acreages are about evenly divided between part-time and full-time farmers.

Soybeans take up 67 acres. One part-time farmer grows 25 acres to supplement off-farm income. One full-time farmer raises the other 42 acres. This is also produced as a cash crop.

Corn is grown by two full-time farmers. A total of 50 acres is produced. Thirty acres will be used for feeding cattle and the remaining 20 acres will be sold as a cash crop. The small amount of corn raised appears to be the result of a normally low yield and the time necessary to cultivate and harvest the crop. A number of years ago there was a considerable amount of corn produced in the area, but the farmers quit raising it when other types of land use became more profitable and less time consuming.

Pasture for grazing animals is the major land use within the township. Many areas that were formerly in orchards or were forested have been placed into this category. Most people, when interviewed, stated that beef cattle production offered the highest return on their investment when they considered the amount of work and the size of the farm.

There are 3,880.5 acres of both wooded and open pasture land. Tame grasses, mainly fescue, are found on 3,023 acres while native grasses are found on 857.5 acres. Full-time farmers and part-time farmers have about the same amount of pasture land. Several of the full-time farmers engage in poultry raising and have neither the time nor the desire to enlarge their pasture acreage while others who do desire to expand are restricted by the refusal of people to sell their land.

The only factors that limit a greater use of land for pasture are the degree of slope and the need for other uses. Pasture land is found throughout the township and does not appear to be selected on the basis of soils. The soils have an influence on the quality of pasture but not on the extent.

There have been 225 acres cleared in the past five years. All of the cleared land has been placed in pasture land.

Cattle represent one of the major farm activities of the township. There is a total of 1,941 head of cattle. Of this number, 1,721 are beef cattle and 220 are dairy cattle. Part-time farmers have a greater number of beef cattle than do full-time farmers, but the difference in the number of cattle is made up by dairy herds of the full-time farmers. There are over twice as many dairy cattle used for Grade C production as there are for Grade A.

There are a total of 48 head of horses in the area. All are kept for recreational purposes and do not adhere to any physical or cultural pattern.

There are 62 goats kept by two persons. Both people are non-natives, one from Mexico and the other from Arizona. One is a part-time farmer and has 60 head which are used solely as brush goats. The other two are kept by a full-time farmer for milking purposes. All goats are found in the rugged terrain of the northern portion of the township.

There is one part-time farmer in the township who has 108 sheep. They are found in the rugged area of the northern portion. This farmer has just recently moved into the area and brought the sheep with him.

Poultry is one of the major farm activities of the region. Poultry utilizes a small amount of land but represents a large portion of the economy. The area has poultry houses with a total capacity of 430,000. Broilers number 390,500, layers number 25,500, and turkeys number 10,000. Approximately 38 per cent of the poultry is produced by the part-time farmers, the rest by the full-time farmers. Only five of the seventeen people who produce poultry are natives of Arkansas. Native farmers are reluctant or unable to invest a large amount of capital into what they consider a speculative venture. Those non-native farmers who engage in poultry raising either had capital when they entered the area or were not afraid to borrow it.

Abandoned agricultural land constitutes 5.5 per cent of the total area or 431 acres. For land to be placed in this category it could not have been cropped or pastured within the past five years. There was no land abandoned by part-time or full-time farmers. Absentee owners accounted for most of the land and have two reasons for abandonment:

1. They were raised in the area, and when they left, they did not want to rent or sell their land, mainly for sentimental reasons; or
2. They were from another state and had bought the land as an investment or to hold for future use.

The non-farming owners abandoned 74 acres of land. Their reason was that they were retired and did not want to rent or sell their land. Some of this land is on productive soils, so abandonment appears to be caused by cultural factors rather than physical factors.

Farmsteads occupy 195.5 acres of land. Their average size varies from 3.8 acres to 1.1 acres for full-time farmers and non-farmers, respectively. The size of the

farmstead depends on the use of the farm and is not affected by physical factors. The selection of farmstead locations at one time was influenced by physical factors such as springs, creeks, or proximity to firewood, but modern technology has altered this pattern. The present location of farmsteads tend to be along well travelled roads and highways as a general rule, but some are found on the creeks where people have located for aesthetic reasons or privacy.

There are 2,629 acres or 33.4 per cent of the total land area in forest. Most of this is located in the northern portion of the township where the terrain is rugged. There are no mature, pure stands of timber in the area. Most of it is in early successional stages held there by periodic forest fires. Some farmers cut firewood and two full-time farmers cut lumber for personal use. Generally speaking there is little lumbering activity carried on. Large parts of this area belong to absentee owners. In most instances they are native to the area but have sought employment elsewhere and simply refuse to sell the land.

TABLE 1

LAND USE BY MAJOR CATEGORIES

	Acres	Percentage of Total Land
Government Programs	41.0	0.5
Crops	536.0	6.8
Forest	2,629.0	33.4
Farmsteads	195.5	2.5
Pasture	3,880.5	49.5
Abandoned Agricultural Land	431.0	5.5
Highways and Roads	132.1	1.7
Church	.5	0.01
Cemetery	6.0	0.09
Total	7,851.6	100.00

There are some small areas of forest located in the flatter region on productive soils, but they are usually found alongside natural drainage ditches. The clearing of this land could cause greater erosion, and most farmers are reluctant to change the current condition.

Public and semi-public owned land use is relatively insignificant. This land use totals 138.6 acres or 1.8 per cent of the total land area. There are three subtypes found in the area: highways and roads, a cemetery, and a church. Highways and roads use up the larger portion of this land.

In summary one should note that approximately one-third of the area is in forest that is virtually waste land. Public and semi-public uses constitute another 1.8 per cent. Together they total slightly over thirty-five per cent. This leaves 5,084 acres of land open to uses for economic activity although all of it is not utilized.

The land use of the township is what one would expect to find in any area of similar topography in northwestern Arkansas. The prominence of the poultry industry coupled with the absence of a large local market and shortage of farm labor have helped to determine land use. A few years ago one would have found most families engaged in small field farming of cash crops. The advent of the poultry industry attracted processing plants which provided off-farm employment and many persons who at one time made a living on the farm became wage earners. This occurrence along with other plants moving into the area has permitted a change in land use. The result is a less intensive type of use and a general improvement of land through an increase in land care. Many part-time farmers use their farm income on fertilizers, fences, and farmstead buildings. The author believes that the current uses of land in the township represent the most practical and economic uses at this time.

REFERENCES

J. E. Yates, **Land Utilization in Cherokee Township, Benton County, Arkansas** (unpublished Master's Thesis, University of Arkansas, 1970).

Glyptostrobus europaeus (Brongn.) Heer in Arkansas

Eugene B. Wittlake

Arkansas State University, State University, Arkansas 72467

ABSTRACT

Glyptostrobus europaeus (Brongn.) Heer, a fossil gymnosperm is found at a few locations in central North America, in deposits of the Eocene. This work cites previously reported localities and reports a new site at Hooker, Arkansas. This deposit appears to be the most abundant for specimens of **G. europaeus** in the Eocene of North America. History of the Hooker site, characteristics of the living species **G. pensilis** (Abel) Koch and **G. europaeus** is presented. World-wide distribution of both species through time, is discussed. Specimens of many parts of the life cycle of **G. europaeus** are recorded and illustrated.

Glyptostrobus europaeus is a fossil gymnosperm belonging to the Coniferales, the Taxodiaceae and is closely related to the genera **Taxodium** and **Cryptomeria.**

There are one hundred and twenty papers published in which the fossil species of **Glyptostrobus** is described, according to this author's review. The greater percentage of these is on worldwide distribution and paleoecology. About two percent of the publications deal with the taxonomy and morphology of the species.

Florin (1963) in his monograph on the distribution of Conifer and Taxad genera of both past and present species, states that numerous finds have been made in the Tertiary of continental Europe from the Eocene to the Pliocene. He also states that in western North America, **Glyptostrobus** ranged from Montana to southern Alaska in the Paleocene; from Idaho and Montana through Oregon it was widespread, even to Nevada and northern California in the Ciocene and Oligocene. He does not take note of any of the recorded finds that were made in the past as far as the Wilcox group of central and eastern North America are concerned. Berry (1916) records twig impressions from the Holly Springs sand formation at Oxford, Mississippi. Berry (1930) also records twig impressions from the same formation at LaGrange, Fayette County, Tennessee and from the same formation in Chester County, Tennessee.

Another site, the Brandon Lignite of Vermont, was interpreted by Berry (1919) as early Tertiary and probably Eocene from megafossil evidence. Later authors however questioned his interpretation. Traverse and Barghoorn (1953), through a pollen analysis of the Brandon lignites, did obtain **Glyptostrobus** pollen and found their pollen samples contained tropical, subtropical and warm temperate species; this is typical of other Eocene deposits during Wilcox times.

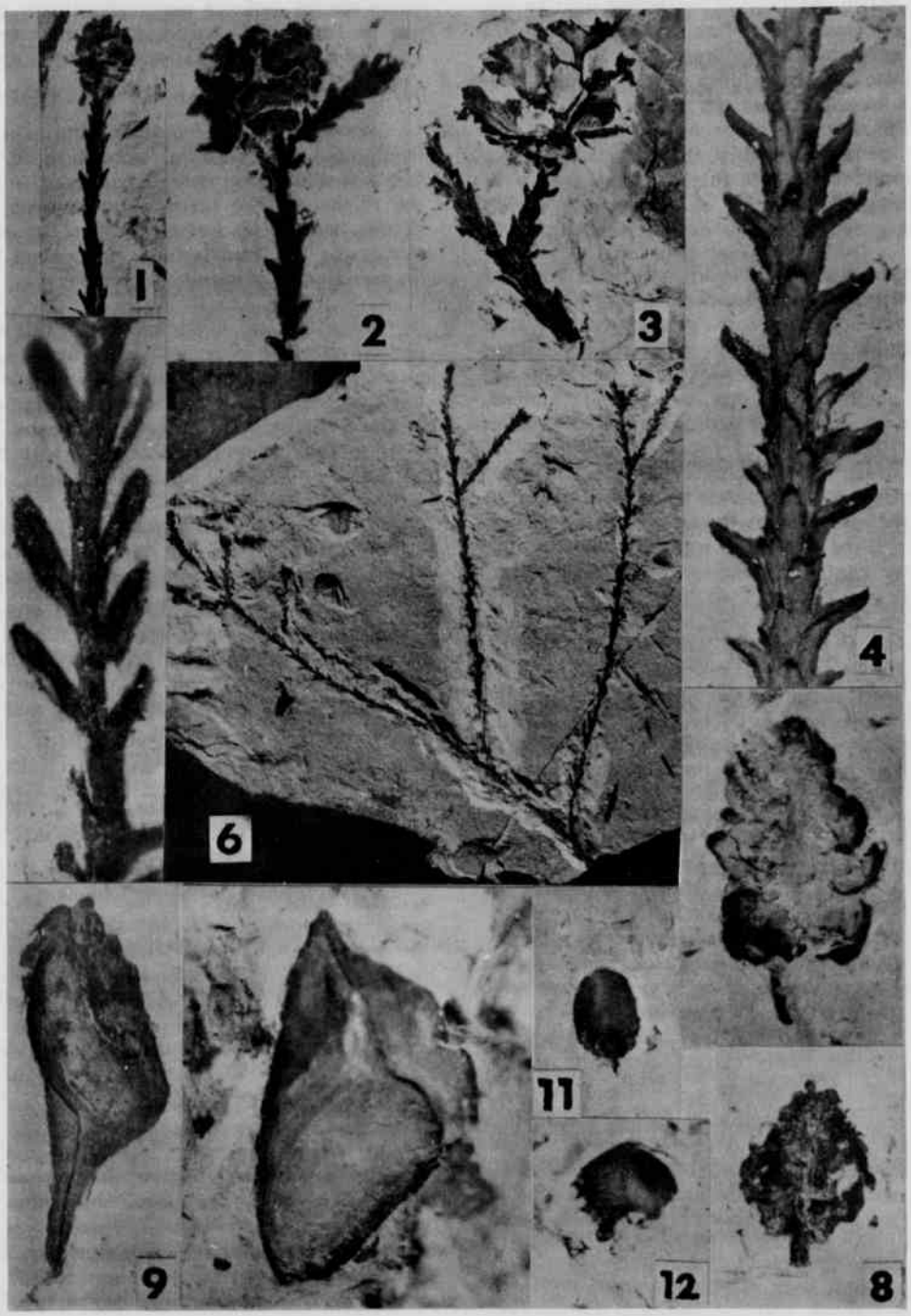
The Hooker, Arkansas deposit is an outcropping of the lower Eocene, namely Wilcox formation. All known Wilcox sites in Arkansas are of the upper part of this formation and are usually referred to as the Grenada formation. Indications are that during this period, an already warming trend was taking place toward Claiborne and Jacksonian times, or the Middle and Late Eocene.

The Hooker deposit on which this work was done, was visited and observed by Professor R. E. Call in 1889; the account appears in the 1889 Report of the Arkansas Geologic Survey in 1891. He describes the site as composed of "Tertiary blue clay and imbedded in this clay near the summit of a hill, is a large stump of silicified wood in place as it grew, with all its roots still embedded and ramifying in every direction." He further states that "fifty feet away at a lower level, occurs another stump similarly disposed and near at hand are two or three silicified logs." Professor Call sent specimens of silicified wood to Dr. F. H. Knowlton, assistant Paleontologist of the U.S. Geological Survey, who named the wood **Cupressinoxylon calli** n. sp. in honor of the collector. This wood on microscopic examination had all the characteristics of **Glyptostroboxylon** sp. No. 1 described by Greguss (1967) in his work on the fossil woods of Hungary.

In the fall of 1948, Dr. Delzie Demaree and Dr. Dwight Moore accompanied the author to the site. The stump at the lower elevation to the east and the fossil logs had disappeared although there were numerous fragments of the silicified wood scattered about. The first stump, viewed by Professor Call was still standing. It was one meter and a half in diameter and approximately a meter high. The blue clay, described by Professor Call, was actually a shale, very hard and very fine-grained. In fact, it is the only deposit on Crowley's Ridge known to the author, that has the appearance of clay, is the same color as most Wilcox clays, and yet is a shale.

Pieces of loose shale were scattered over the site; partial impressions of angiosperm leaves and twig impressions that reminded one of cedar twigs, were evident. The so-called "cedar twigs" were **Glyptostrobus** twigs and led the author to study the deposit further. Since 1959, it has been excavated periodically. The farmer and owner of the land broke up the last re-

*This study was supported by a grant from the Faculty Research Committee of Arkansas State University.



Figures 1 - 12. 1. Young gynostrobilus., X 2.32; 2. Mature unexpanded gynostrobilus, X 2.32; 3. Mature expanded gynostrobilus, X 2.32; 4. Cupressoid twig, X 5.25; 5. Young taxodioid twig, X 5.25; 6. Cupressoid twig with young androstrobili at apices, X .825; 7 - 8. Mature and young unexpanded androstrobili respectively, X 6.58; 9 - 10. Mature seeds, X 5.25; 11 - 12. Microsporophylls, X 6.58.

maining stump into several pieces, and moved the reassembled stump on to the lawn of his home next to the road. Most of our excavation has been at the exact spot where this last remaining stump stood. On closer inspection, the base of the stump described by Professor Call at the elevation was discovered and a third stump base smaller than the other two. Perhaps in the early part of the nineteenth century, three massive trunks stood on the summit of the hill; in situ, they grew with their roots in the geologic mud of a brackish marsh which now is the gray-blue shale of the deposit.

During this investigation, recovery has been made of over nine hundred catalogued specimens of twigs, both young and old; many seeds, both young and old that show great detail in all their characteristics; eighteen gynostrobili attached to their twigs and fourteen androstrobili. The shale matrix has hundreds of microsporophylls scattered through it and casts of their pollen sacs. Solid and hollow casts of young and old female gametophytes situated on ovuliferous scales and bracts, were found. When one gynostrobilus was being prepared for cataloguing, a hollow gametophyte cast was accidentally ruptured. A fossil embryo was detected through the rupture in the cast-epidermis of the gametophyte. Investigation of three others yielded three more embryos cast in silica. Also a few samples of shale have been subjected to pollen analysis and **Glyptostrobus** pollen has been found to have been present. Most of the specimens are third-dimensional impressions either stained by brown ferric iron oxide or a blackish ferrous iron oxide. A white substance, sometimes amorphic in nature, or rather fibrous to crystalline in character, is found occupying these impressions. The female gametophte casts from which the fossil embryos were obtained, were composed of this material. Until further chemical analysis can be made, the author tentatively suspects it to be a hydrous aluminum silicate.

Comparisons with the fossil specimens are now being made with the living monotypic species, **Glytostrobus pensilis** (Abel) Koch. Today it has a very restricted distribution in the southeastern Chinese provinces of Fukien and Kwangtung. This species has had a stormy taxonomic past. It has been classified in the genus **Thuja** and in the genus **Taxodium**. Wodehouse (1935) called it a small shrub eight to ten feet high. Florin referred to it as a small tree. Metcalf (1937) states that it grows to a height of thirty-five feet, in the area around Foochow, China. The general appearance and habit of **Glyptostrobus** is very similar to that of **Taxodium.** The gynostrobili are pear-shaped and the foliage is polymorphic. Many genera in this family are dimorphic in foliage. Looking over specimens from both the Missouri Botanical Garden and the National Herbarium, cupressiod, taxodioid and cryptomeroid foliage was quite obvious. The cupressiod foliage is the most permanent; the other two types are deciduous.

The typical habitat of **Glyptostrobus** is on the borders of brackish swamps that are affected by the fall and rise of tide. According to Metcalf, knees are evident in some places and are never prolifically produced as they are in **Taxodium.** Buttressess are also evident in this species but are more elevated and bulbous in character than in **Taxodium.**

Since the North American continent has been rising throughout the Tertiary, according to Chaney (1940), **Glyptostrobus** disappeared from our area at the end of the Pliocene. The distribution-patterns of not only **Glyptostrobus** but also several other gymnosperms and angiosperms has been greatly contracted by this influence on continental climates.

In conclusion, it appears, that the Hooker site is an exceedingly rich deposit for the fossil species of **Glyptostrobus.** It contains a predominance of plant fossils indicating the deposit was part of a non-alluvial, brackish swamp, essentially a settling basin with very little stream-type influent. Associated with the gymnosperm material, are several species of ferns; many species of angiosperm leaves and their fruits; two new Lower Eocene species of fossil mosses Wittlake (1968); nine species of insects and a few young marine oysters and clams in addition to one excellent specimen of a marine annelid.

REFERENCES

Berry E. W. 1916. Lower Eocene Floras of Southeastern North America. U.S. Geol. Survey Prof. Paper 91.

_____ 1919 The age of the Brandon lignite and flora. Amer. Journ. Sc. 47: 211-216.

_____ 1930 Revision of the Lower Eocene Wilcox Flora of the Southeastern States. U.S. Geol. Survey Prof. Paper 156.

Branner, J. C. 1891 Annual Report of the Geological Survey of Arkansas; The Geology of Crowley's Ridge-R. Ellsworth Call. 2: 102-103 and 254-255.

Chaney, R. W. 1940. Tertiary forests and continental history. Geol. Soc. Am. Bull. 51.

Florin, R. 1963. The distribution of Conifer and Taxad genera in time and space. Acta Horti Bergiani Band 20, No. 4, pp. 211-212.

Greguss, P. 1967 Fossil Gymnosperm woods in Hungary, Akademiai Kiado, Budapest. pp. 66-67.

Metcalf, F. P. 1937. Water Pine. Lingnan Agricultural Journal 5:397-406.

Traverse, A. and Barghoorn, E. E. 1953. Micropaleontology of the Brandon Lignite, an early Tertiary Coal in Central Vermont. Journ. Paleontology. 27:289-295.

Wittlake, E. B. 1968. Fossil Mosses from the Upper Wilcox (Lower Eocene) of Arkansas. Am. Mid. Nat. Vol. 80, No. 2. pp. 543-547.

Wodehouse, R. P. 1935. Pollen Grains. Hafner Pub. Co. pp. 270-271.

Enzymatic Evidence That Leucine From Tentoxin Is Levorotatory

J. T. Daniel and G. E. Templeton[1]

Department of Plant Pathology, University of Arkansas, Fayetteville, Arkansas 72701

Introduction

Tentoxin is a highly specific, biologically active peptide from **Alternaria tenuis** Auct., a common seed and soil inhabiting fungus. Grossly, its biological activity consists solely of irreversibly blocking the development of chlorophyll in cotyledons of certain plants when applied to seeds during imbibition or to young seedlings prior to their emergence from the soil. Most dicots tested, with the exception of tomato and members of the cruciferae, have been found to be sensitive while most monocots tested were resistant with the exceptions of sorghum and crabgrass (1, 2, 6, 7).

Halloin and associates (4) have shown that tentoxin disrupts chloroplast development in sensitive species without noticeably affecting the ultrastructure of other organelles. They also demonstrated that it does not block the conversion of protochlorophyll to chlorophyll in either sensitive or insensitive species. In fact, they showed a slight but consistent increase in chlorophyll in resistant species.

The peptide was purified by Grable (3) from culture filtrates or mycelial mats of **Alternaria tenuis** grown on Richards solution supplemented with V-8 juice. Structural determinations (7) have revealed it to be a cyclic tetrapeptide consisting of leucine, N-methylalanine, glycine and N-methyldehydrophenylalanine. The sequence of these amino acids and the stereoisomerism of all but glycine must be established to complete the determination of the primary structure of this peptide.

This study was undertaken to determine which optical antipode of leucine is present in tentoxin.

(1) Undergraduate Research Participant and Professor of Plant Pathology, respectively.

Materials and Methods

Hydrolysis of the peptide

The crystalline toxin was hydrolyzed in 6 normal HC1 at 110°C for 24 hours according to the procedure of Spackman (5). After removal of the HC1 in vacuo the hydrolyzate was taken up in 10% 2-propanol for immediate spotting of preparative thin layer plates.

Separation of Leucine from the Hydrolyzate.

Leucine was separated from the hydrolyzate by preparative thin layer chromatography on 2mm thick plates of Silica gel PF (Merck) with a propanol: water (80:36) solvent in one dimension. Leucine was located on the developed chromatogram by reacting one edge of the plate with ninhydrin. The surface of the plate containing leucine (unreacted) was scraped into a Millipore filter and the leucine was leached from it with distilled water. The concentration of leucine recovered was determined on an aliquot from this solution using a standard colorimetric procedure.

Enzymatic Oxidation of Leucine

Snake venom L amino acid oxidase was used in a Warburg manometric procedure as outlined by Wellner and Meister (9) to determine the susceptibility of tentoxin-leucine to this enzyme. The concentration of tentoxin-leucine was 12 millimoles per ml. The enzyme was obtained from Nutritional Biochemicals Corporation, Cleveland, Ohio and was used at a concentration of 100 mg/ml. At this enzyme level oxygen uptake with L leucine was 3.6 microliters per minute. Commercially prepared D and L leucine were used as controls. Three replications were employed.

Results

L amino acid oxidase oxidized leucine from tentoxin

at a rate comparable to that of known L leucine (Figure 1). The D leucine control was not oxidized.

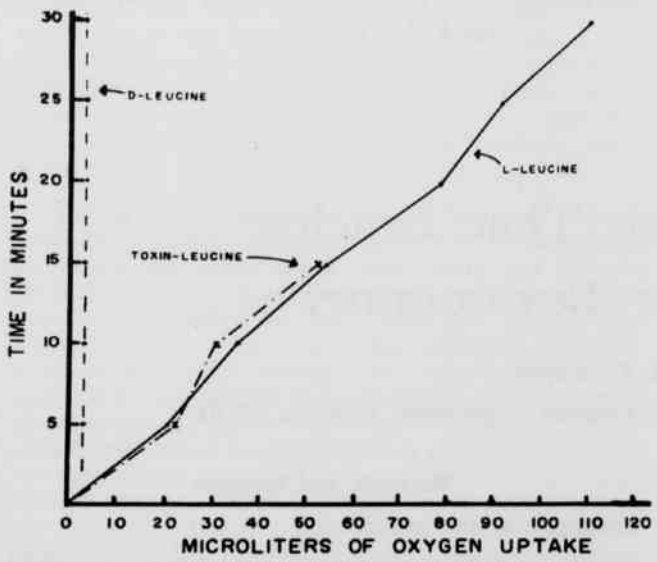


Figure 1. Enzymatic Oxidation of Leucine from Tentoxin.

Summary and Conclusion

These data indicate that the leucine in tentoxin is levorotatory. Supporting data with higher concentration of this antipode subjected to D amino acid oxidase would be highly desirable but is currently considered too extravagant with the limited supply of peptide available.

These data further suggest that the optical isomerism of leucine is not the basis for tentoxins inhibition of chlorophyll or plastid formation in sensitive plant species.

Literature Cited

1. Fulton, N. D., Katharina Bollenbacher and B. J. Moore. 1960. A chlorosis of cotton seedlings caused by **Alternaria** sp. Phytopathology 50:. 575. (Abst.).

2. Fulton, N. D., Katharina Bollenbacher, and G. E. Templeton. 1965. A metabolite from **Alternaria tenuis** that inhibits chlorophyll production. Phytopathology 55:49-51.

3. Grable, C. I. 1967. Purification and characterization of a chlorosis toxin from **Alternaria tenuis.** M. S. Thesis Univ. of Arkansas.

4. Halloin, J. M., G. A. deZoeten, G. Gaard and J. C. Walker. 1970. The effects of tentoxin on chlorophyll synthesis and plastid structure in cucumber and cabbage. Plant Physiology. 45: 310-314.

5. Spackman, D. H. 1962. Instruction manual AIM 2, Model 120B Amino Acid Analyzer. Spinco Division, Beckman Instruments Inc., Stanford Industrial Park, Palo Alto, Calif.

6. Templeton, G. E., C. I. Grable, N. D. Fulton and Katharina Bollenbacher. 1967. Factors affecting the amount and pattern of chlorosis caused by an **Alternaria tenuis** metabolite. Phytopathology 57:516-518.

7. Templeton, G. E., W. L. Meyer, C. I. Grable and C. W. Sigel. 1967. The chlorosis toxin from **Alternaria tenuis** is a cyclic tetrapeptide. Phytopathology 57:873 (Abst.).

8. Templeton, G. E., C. I. Grable, N. D. Fulton and W. L. Meyer. 1967. Tentoxin from **Alternaria tenuis**: its isolation and characterization. Proc. 1967 Mycotoxin Res. Seminar held at Washington, D. C., June 8-9, 1967. USDA. pp. 27-29.

9. Wellner, D. and A. Meister. 1960. Crystalline L-Amino Acid Oxidase of Crotalus adamanteus. The Jour. of Biological Chem. 235:2013-2018.

Macroscopic and Microscopic Response of Gossypium hirsutum L. to Hydrogen Fluoride Fumigation[1]

Dan Timmermann, Jr.,[2] Howard G. Applegate[3] and E. Mark Engleman[4]

INTRODUCTION

Hydrogen fluoride is one of the more important gaseous air pollutants and its phytotoxic effects have been well established. The principal sources of atmospheric fluorides are producers of phosphate fertilizers, ceramics, and certain metals. Stomatal penetration and subsequent accumulation of fluorides may variously affect the growth rate, yield, and macroscopic appearance of exposed plants (DAINES **et al.** 1952). Wide interspecific and intraspecific differences in susceptibility to macroscopic injury by hydrogen fluoride have been reported (Thomas and Hendricks, 1956).

Microscopic study of fluoride injury in plants has been limited. Investigations by SOLBERG **et al.** (1955) and THRESHOW (1956) revealed microscopic damage only when macroscopic injury was evident and then only in tissues immediately adjacent to macroscopically damaged areas. Other fluoride fumigation studies (SOLBERG and ADAMS 1956) showed microscopic injury to appear first in abaxial mesophyll and lower epidermis. Little apparent damage was found in vascular tissue of exposed leaves. THRESHOW (1956) found epidermal cells less sensitive to damage than underlying mesophyll cells. Investigations by MOHAMED (1968) and MOHAMED **et al.** (1966) have shown that fluorides may also inflict chromosomal injury.

The present study was prompted by the sparsity of available information on microscopic effects of gaseous fluorides in plants, particularly in fluoride resistant plants such as **Gossypium hirsutum** L. Research objectives were to: (1) determine the macroscopic response of **G. hirsutum** to fluorides in a range of exposure levels, (2) compare fluoride injury symptoms to those reported for more sensitive species, and (3) assess microscopic damage in mesophyll of treated plants.

MATERIALS AND METHODS

Plants (**Gossypium hirsutum** L. Acala glandless var.) were grown and exposed to fluoride in environmental chambers under the following conditions: (1) Light — 1800 foot candles from fluorescent tubes and 200 foot candles from incandescent bulbs, as measured at a level 60 cm above the chamber floor; (2) Photoperiod — 14 hours light and 10 hours darkness; (3) Temperature — 30 ± 2 C during light periods and 24 ± 2 C during dark periods; (4) Air exchange — flow of 12 m^3 per minute in each of the 3 m^3 chambers, using fresh carbon-filtered air; (5) Relative humidity — 50 ± 5%; (6) Available moisture and nutrients — all plants were grown in a half-peat, half-perlite medium in 6-inch standard plastic pots and watered daily using a water-soluble 15-15-15 fertilizer at the rate of 1.2 grams per liter of distilled water; (7) Fumigation — fumigant was injected continuously into the treatment chamber at a constant rate of 2100 cm^3/minute, according to the method of HILL **et al.** (1959), modified to maintain the hydrogen fluoride generator at 22 ± 2C. Aqueous HF concentrations of 10%, 5%, and 2.5% were used in the generator during this study and these will subsequently be referred to as "high," "medium," and "low" fumigant levels. Most experiments reported here used high fumigant levels which resulted in HF concentrations of 2.3 to 3.2 $\mu g/m^3$ of air in the treatment chamber.

Initial studies utilized 12-day old plants (post-emergence) which were exposed continuously for the next 14 days to high fumigant levels. Subsequent experiments using low and medium fumigant levels were conducted on plants ranging in age from 0 to 56 days after emergence. All fumigations were repeated five times, using 12 plants per chamber. To minimize variations in stomatal penetration of the fumigant, all exposures were initiated during the early parts of photoperiods.

Leaf samples from treated and control plants were collected repeatedly during each fumigation run and fresh hand sections examined by the phase microscope. Representative samples were also fixed in FAA and later processed into permanent slides. Samples were taken from treated plants exhibiting all types and degrees of macroscopic foliar damage. Hand sections were mounted in isotonic or slightly hypotonic sucrose. The plasmolytic response of cells was studied by varying the sucrose concentration in the mounting medium.

Chloroplast frequencies in functional palisade cells of 26-day old plants were determined after one 14-day fumigation run with high fumigant levels. For this purpose, five treated and five control plants were randomly selected at the end of fumigation. The number of chloroplasts was then microscopically determined in each of 30

(1) Supported in part by an Institutional Research Grant from Arkansas State University to the senior author and in part by U. S. Public Health Service Grant No. AP 28-02.

(2) Assistant Professor of Botany, Department of Biology, Arkansas State University, State University, Arkansas 72467.

(3) Associate Professor of Plant Physiology and Pathology, Texas A & M University.

(4) Assistant Professor of Biology, Texas A & M University.

palisade cells from three randomly selected sections obtained from the first leaves above the cotyledons on each plant.

The fresh and dry weights of all plant parts above and including cotyledons were determined after five separate fumigations. Each of these fumigations exposed 12-day old plants for the next 14 days to high fumigant levels and utilized 12 control and 12 treated plants. Dry weights were recorded after dehydration for 24 hours at 105 C.

RESULTS AND DISCUSSION

When the concentration and duration of fluoride fumigation is sufficient to induce injury, the macroscopic response of **G. hirsutum** is similar to that reported for more sensitive species. Table I summarizes the chief macroscopic effects produced by fumigating 12-day old plants for the following 14 days with high fumigant levels. Response of plants treated with lower fumigant levels was found to be similar except that injury symptoms appeared later and were less pronounced. Figures 5 - 8 show the injury symptoms most frequently observed in fumigated plants. Typical macroscopic damage to foliage consisted of varying degrees of marginal and intercostal chlorosis or necrosis. Wrinkling and distortion of the lamina was also common in younger leaves. Injury was most extensive in emerging or partially expanded cotyledons and leaves. Treated plants, especially during early stages of growth, increased more slowly in height, fresh weight, and dry weight, than corresponding controls. As shown in Figure 1, the effect of fluoride on fresh and dry weight production was pronounced. Although some variation in response to fluoride was common, many treated plants were observed to increase slightly in height but very little in foliar development over that present at the initiation of fumigation.

Light microscopy revealed a close correlation between the macroscopic and microscopic appearance of leaves. The photomicrograph in Figure 9 shows a transverse hand section of a normal expanded leaf, while Figures 10 and 11 show microscopic injury in leaves of fumigated plants. Except for the observation of fewer chloroplasts in treated mesophyll, microscopic damage was restricted to foliar tissue within 1 mm of areas exhibiting macroscopic effects. Within 0.5 mm of necrotic areas, all cells were typically in varying states of plasmolysis when placed in a medium considered isotonic or slightly hypotonic for control cells. Mesophyll cells from other macroscopically damaged tissues were also found to plasmolyze and undergo cell wall collapse more readily than control cells.

The number of chloroplasts in palisade cells of expanded leaves was determined by randomly selecting tissue samples and then focusing through individual cells with the light microscope. As shown in Figure 2, the mean cellular chloroplast frequency was significantly lower in treated plants than in controls. Whether this lower frequency in treated cells resulted from the degradation of chloroplasts during the fumigation period could not be determined by light microscopy. However, chloroplasts in moderately to severely chlorotic tissues apeared in the light microscope to have decreased pigmentation and frequently exhibited a surface granularity as seen in face view.

Spongy mesophyll cells generally responded to fumigation before palisade cells. This difference in response may be attributable to an increased exposure to the fumigant brought about by comparatively more extensive intercellular air spaces and less intercellular support in the spongy layer. However, in leaves which were nearly fully expanded before fumigation, damage frequently developed in localized intercostal spots, with the collapse of palisade cells and upper epidermis preceding the collapse of abaxial leaf tissue (Figure 10). In advanced stages of injury (Figure 11) a complete collapse of leaf tissue occurred. After dehydration, such tissue would appear as necrotic areas on the leaf (Figure 8).

Cells of the vascular tissue were generally more resistant to cell-wall collapse and appeared less sensitive to plasmolysis than surrounding mesophyll cells. However, these differences in plasmolytic behavior were not so pronounced when all cells, adjacent to cut surfaces, received approximately equal exposure to the fumigating atmosphere.

SUMMARY

The macroscopic and microscopic effects of chronic exposure of **G. hirsutum** to hydrogen fluoride were studied. Macroscopic foliar injury included wilting, marginal and intercostal chlorosis and necrosis, and distorted expansion of leaves. The rapidity with which damage became evident and its extent were inversely correlated with plant age and directly correlated with fumigant concentrations and durations. Visible growth retardation in exposed plants was further evidenced by lower fresh and dry weight production. Light microscope study revealed altered plasmolytic behavior and fewer chloroplasts in mesophyll cells of fumigated plants.

LITERATURE CITED

DAINES, R. H., I. A. LEONE, and E. G. BRENNAN. 1952. The effect of fluorine on plants as determined by soil nutrition and fumigation studies. McCabe, L. C., Ed. Air Pollution. McGraw Hill, New York.

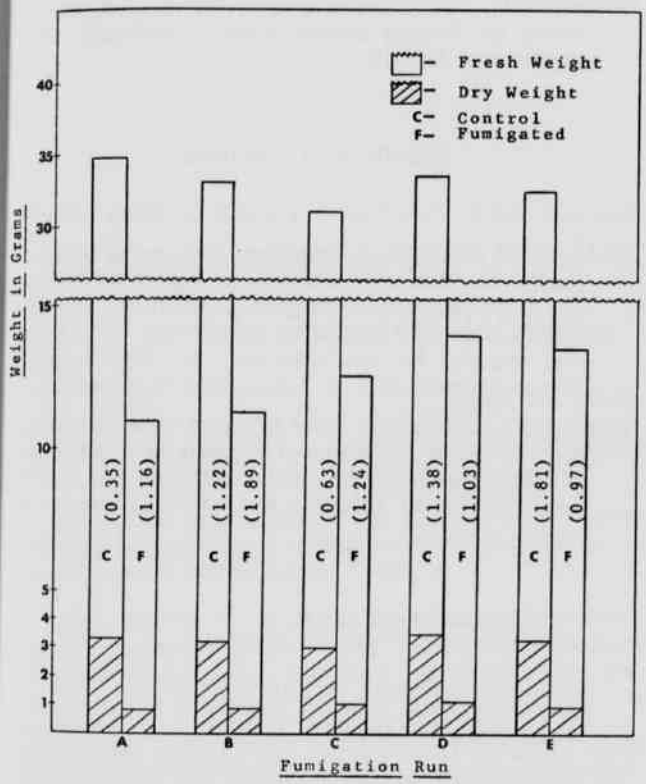
HILL, A. C., L. G. TRANSTRUM, M. R. PACK, and A. HOLLOMAN JR. 1959. Facilities and techniques for maintaining a controlled fluoride environment in vegetation studies. J. Air Poll. Control Assoc. 9:22-27.

MOHAMED, A. H. 1968. Cytogenetic effects of hydrogen fluoride treatment in tomato plants. J. Air Poll. Control Assoc. 18:395-398.

Macroscopic and Microscopic Response of Gossypium hirsutum L. to Hydrogen Fluoride Fumigation

FIGURE 1

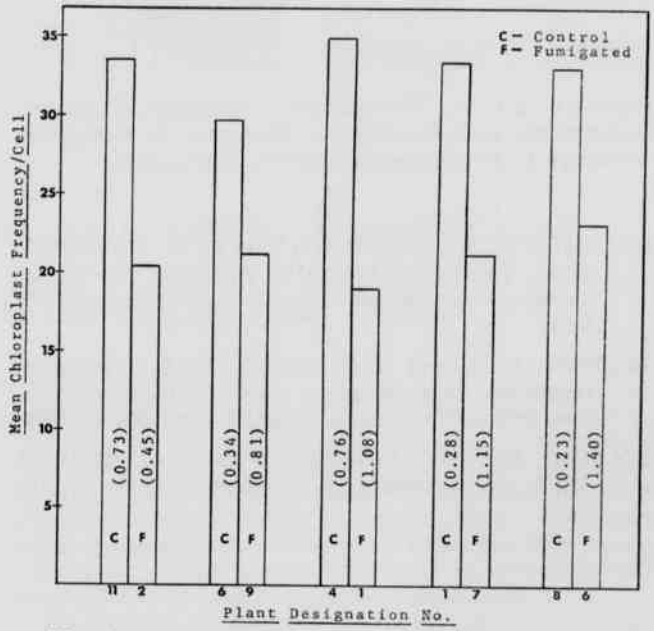
Mean* Fresh and Dry Weights of 26-Day Gossypium hirsutum L. Exposed For Preceding 14 Days to High Fumigant Concentrations - Versus Control Plants



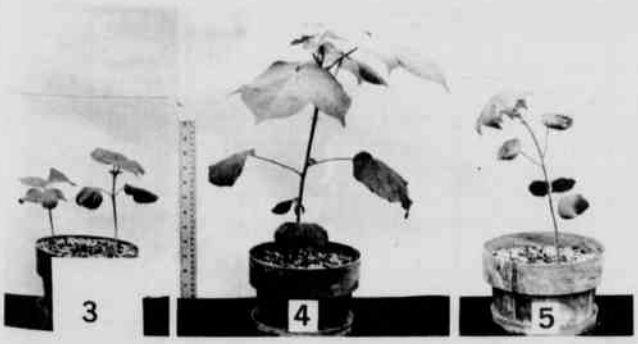
*Mean fresh and dry weights based on 12 treated and 12 control plants for each fumigation run. Standard error of the mean for fresh weights shown in parentheses.

FIGURE 2

Mean* Chloroplast Frequency in Functional Palisade Cells of 26-Day Gossypium hirsutum L. Exposed For Preceding 14 Days to High Concentrations of Fumigant - Versus Controls

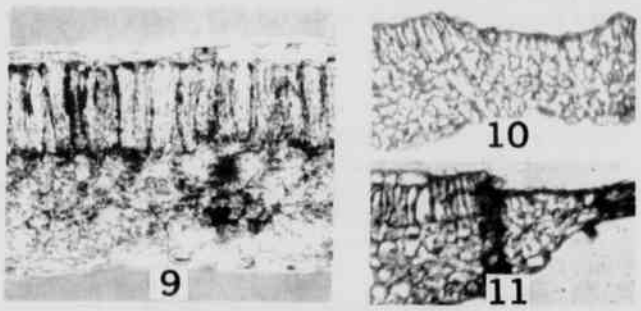


*Mean based on number of chloroplasts in 30 cells from three randomly selected sections per plant. Sections collected from first leaves above cotyledons on five fumigated and five control plants randomly selected and paired at end of fumigation run. Standard errors shown in parentheses.



Figures 3, 4, 5. (Timmermann, Applegate, Engleman.) Macroscopic and Microscopic Response of **Gossypium hirsutum** L. to Hydrogen Fluoride Fumigation.

Figures 6, 7, 8. (Timmermann, Applegate, Engleman.) Macroscopic and Microscopic Response of **Gossypium hirsutum** L. to Hydrogen Fluoride Fumigation.



Figures 9, 10, 11. Timmermann, Applegate, Engleman. Macroscopic and Microscopic Response of **Gossypium hirsutum** L. to Hydrogen Fluoride Fumigation.

MOHAMED, A. H., J. D. SMITH, and H. G. APPLEGATE. 1966. Cytological effects of hydrogen fluoride on tomato chromosomes. Can. J. Genet. Cytol. 8:575-583.

SOLBERG, R. A. and D. F. ADAMS. 1956. Histological responses of some plant leaves to hydrogen fluoride and sulfur dioxide. Amer. J. Bot. 43:755-760.

SOLBERG, R. A., D. F. ADAMS, and H. A. FERCHAU. 1955. Some effects of hydrogen fluoride on the internal structure of **Pinus ponderosa** needles. Proc. 3rd Natl. Air Poll. Symp. p. 164-176. Stanford Research Institute, Los Angeles, California.

THOMAS, M. D. and R. H. HENDRICKS. 1956. Effect of air pollution on plants. Magill, P. L., F. R. Holden, and C. Ackley, Eds. Air Pollution Handbook, Chapt. 9. McGraw Hill, New York.

TRESHOW, M. 1956. The effects of fluorine on the anatomy of Chinese apricot leaves. (Abstract). Phytopathology 46:640.

LEGENDS FOR FIGURES

Figures 1 and 2. See Figures 1 and 2 for these legends.

Figures 3-5. **Gossypium hirsutum.** Figure 3. Control plants, 12 days after emergence. Figure 4. Control plant, 26 days after emergence. Figure 5. Fluoride treated plant, 26 days after emergence. This plant was exposed for the preceding 14 days to high fumigant levels (2.3 to 3.2µg fluoride/m³ of air).

Figures 6-8. Macroscopic foliar injury in fluoride treated plants. Figure 6. Marginal necrosis in a cotyledon (X0.41). Figure 7. Intercostal chlorosis and wrinkling in a young trifoliate leaf (X 0.31). Figure 8.

TABLE I

Macroscopic Effects Produced by Fumigating 12-Day Old Gossypium hirsutum L. for the Succeeding 14 Days With Atmospheres Containing High Concentrations of Fumigant

Macroscopic Effect	Description and/or Location of Effect	Percentage of Plants Exhibiting Effect After Indicated Days of Exposure*															
		½	½	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Water-logged or wilted appearance (Rapidly becoming Necrotic)	Cotyledonary Margins	7	8	23	32	37	52	58	67	72	72	80	83	87	87	87	88
Marginal Chlorosis	First leaves above cotyledons	-	-	-	-	-	-	-	2	5	8	17	22	22	23	30	32
	Other expanding leaves	-	-	-	-	3	7	15	15	42	67	80	87	92	92	95	95
Generalized Intercostal Chlorosis	First leaves above cotyledons	-	-	-	-	-	-	-	-	-	-	2	7	17	17	23	28
	Other expanding leaves	-	-	-	-	-	8	13	37	45	63	75	82	88	90	90	92
Pin-Point Chlorosis	First leaves above cotyledons	-	-	-	-	-	-	-	5	13	18	32	35	42	43	48	55
	Other expanding leaves	-	-	-	-	-	-	-	-	-	-	-	-	-	3	7	7
Marginal Necrosis	First leaves above cotyledons	-	-	-	-	-	-	-	-	-	-	7	13	15	20	23	23
	Other expanding leaves	-	-	-	-	-	-	-	-	10	18	27	43	57	65	72	77
Generalized Intercostal Necrosis	First leaves above cotyledons	-	-	-	-	-	-	-	-	-	-	-	-	8	10	10	15
	Other expanding leaves	-	-	-	-	-	-	-	-	-	-	-	-	-	7	12	13
Pin-Point Necrosis	First leaves above cotyledons	-	-	-	-	-	-	-	-	-	7	17	23	30	33	42	42
	Other expanding leaves	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Wrinkling or Curling of Leaves	First leaves above cotyledons	-	-	-	-	-	-	-	-	-	-	3	8	15	18	27	32
	Other expanding leaves	-	-	-	-	5	17	27	42	53	68	80	87	93	97	97	97
Retardation of Growth	Retarded plant height or decreased foliar development as compared to controls	-	-	-	-	-	22	37	53	73	92	100	100	100	100	100	100

* - Mean Whole Percentages Based on 5 Fumigations With 12 Plants per Fumigation

Macroscopic and Microscopic Response of Gossypium hirsutum L. to Hydrogen Fluoride Fumigation

Severe chlorosis and necrosis in the first leaf above the cotyledons (X 0.31).

Figures 9-11. Photomicrographs of transverse sections of leaves. Figure 9. Fresh hand section of a normal expanded leaf, mounted in isotonic sucrose (X140). Figure 10. Paraffin embedded section showing an initial stage of leaf damage in a fluoride treated plant. Collapse of the upper epidermis and underlying palisade cells is evident (X100). Figure 11. Paraffin embedded section showing an advanced stage of fluoride damage. Progressively increasing degrees of injury can be seen from left to right with complete collapse of leaf tissue evident on the right (X100).

Observations on the Impact of Certain Insecticides On Spider Populations in a Cotton Field

Peggy Rae Dorris, Department of Biology

Henderson State College, Ardkadelphia, Arkansas 71923

Insecticide application is the greatest single factor affecting populations of predators which act as biological control agents within cotton fields.

According to a Louisiana Agriculture Experiment Station Bulletin (1967), many bollworm moths are caught in spider webs. The most important spider species effective in control of cotton field insects is the star-bellied orb weaver **Acanthepeira stellata** (Walckenaer), but other large orb weavers **Neoscona sacra** (Walckenaer), and various species of **Araneus** also captured many moths. Certain spiders capture bollworm moths directly, without using webs. **Lycosa rabida** (Walckenaer), **Lycosa helluo** (Walckenaer), **Lycosa carolinensis** (Walckenaer), **Lycosa annexa** (Chamberlin and Ivie), **Schizocosa avida** (Walckenaer) and other hunting wolf spiders attack bollworm moths, especially when they light on the ground.

A few spiders attack large bollworms on the plant. The female green lynx, **Peucetia viridans** (Walckenaer), bites the larva medially and shifts her hold to the head when the larva expresses backward body contortions in response to the initial bite. Large jumping spiders such as **Phidippus audax** (Hentz) will attack even the largest bollworm larva.

Observations of spiders feeding on bollworm eggs showed that jumping spiders accounted for 1.5 per cent destruction of eggs in a local cotton field.

At least 22 species of spiders have been collected from cotton fields and many more from areas adjacent to cotton fields. Spiders appear to be more abundant than any other predators in cotton fields. They also seem to persist better than other predators after applications of certain insecticides such as either 3-5-40 (BHC-DDT-sulfur) or calcium arsenate.

It is a well-known fact that the level of insecticide resistance of boll weevils and bollworms increases as the season progresses and that insecticide application is the greatest single factor affecting populations of predators within cotton fields; therefore, to spray heavily with insecticides drastically reduces predator control by spiders.

In an effort to elucidate the effects of spiders as biological control agents, the writer collected species of spiders from a Clark County, Arkansas cotton field and subjected them to common insecticides to show the reduction in numbers of spiders as insecticides are applied.

Families of spiders such as Salticidae, Oxyopidae, Araneidae, Thomisidae, Lycosidae, and Dictynidae were widely distributed over the fields, and surrounding grasses and wooded areas. Live specimens were taken from the cotton plants, ground, and surrounding vegetation by hand picking and by use of a heavy insect net.

In Clark County, Toxaphene-DDT, Methyl Parathion, and Sevin are the most widely used insecticides for control of insect pests in cotton fields. Standard solutions which are commonly applied to fields were used to determine effects on spiders kept in captivity. The table below shows the results obtained after one day and one application:

Insecticides	Total No. Individuals Tested	No. Surviving One Day After Application	No. In Control Tanks	No. Surviving In Control Tanks
Sevin	85	20	85	80
Toxaphene-DDT	65	3	65	58
Methyl parathion	73	3	73	70

Laboratory conditions did not exactly simulate the ecological conditions of a cotton field but potency of certain insecticides was shown. No attempt was made to determine which species was least or most resistant to the three types of insecticides used.

This writer believes that entomological evaluations are important steps which should determine whether insecticides are more important than natural biological controls when factors such as resistance, destruction of wildlife, and the breakdown of the food chain are considered. Too little foresight has been used in the past with the unwise random use of insecticides. Without a background of information obtained through research, the decision for artificial control may have far reaching detrimental effects upon human populations in the future.

Chemical pesticides that hang heavy in the air and mix with the rich soil during the cotton growing season are later washed into the bayous, lakes and drainage ditches by fall rains. Here and there in the sluggish water lie bodies of fish, victims of the chemicals that make cotton prosper.

Side effects of the chemicals used in cotton fields are beginning to concern biologists. They have found not only ecological disturbance but also genetic changes in vertebrate animals.

Some fish have developed so much resistance to agricultural pesticides that they have become "living bombs", lethal bait for any animal higher in the food chain.

There is no illusion that the pesticide pollution problem will be solved by the recent federal limitation on DDT. Some of the pesticides which will still be used will be just as dangerous and perhaps more dangerous.

A cotton farm is now just another factory injecting fumes into the air like any other industry. From March through November, the air is filled with chemicals to keep weeds from sprouting, and others to kill them if they do. Chemicals to kill boll weevils, bollworms, thrips and many other insects are applied and finally at harvest time a foul-smelling chemical defoliant is applied to remove leaves.

The defoliant, unlike the pesticides was made necessary by man's inventiveness and not by nature's perverseness. This allows the cotton to be picked by machine.

Various chemicals are spread on the soil and water of cotton fields and in Delta areas these chemicals are applied 10 to 20 times a season.

Farmers, many members of the Agriculture Department, and chemical companies generally d e f e n d the chemicals, stating that they are not only necessary to maintain the production of food demands, but are harmless if used properly. However, the advantages of chemicals are beginning to be questioned even by some farmers. Some of the lighter Delta soils have been damaged by chemical residues and insecticides are diminishing in their effectiveness. Farmers who sprayed for insects three times in 1968 sprayed as many as nine time in 1969.

Several years ago the boll weevil was a problem and the bollworm was not, but the chemicals that killed and controlled the weevil also killed the beneficial spiders and insects that preyed upon the bollworm, thereby permitting the bollworm to flourish.

Not only improved chemicals but also sterilization of insects and other biological control agents such as spiders and insects should be used to replace the pollutants which are now being employed.

The present study deals only with some adverse effects of insecticides on spider populations but the overall effect on all animals in the area, especially predators, points up the fact that a great percentage of nature's biological control mechanism is being wiped out. The food chain, the web of life, and the very balance of nature has been thrown out of control by use of biocides (destroyers of all living things).

As populations increase, efficiency of food production will become more and more important and the methods of pest control will have to be seriously considered. It is important that in the next few years scientists be given the opportunity to devise a variety of methods for control without serious effects on the animal population. Some of these methods will surely be less detrimental and more effective as related to the interrelations of organisms to their environments.

Literature Cited

1967 The bollworm-tobacco budworm problem in Arkansas and Louisiana. Louisiana Agri. Expt. Sta. Bull. 720:37-39.

A Preliminary Study of Zooplankton Over a Six Month Period on Lake Dardanelle

Tom N. Palko, Arkansas Polytechnic College
Russellville, Arkansas 72801

INTRODUCTION

This limnological investigation was undertaken to establish preliminary base lines or normals of zooplankton for use of comparison for future studies on Lake Dardanelle. Lake Dardanelle is a large, artificial lake created by the damming of the Arkansas River as a part of the Arkansas River Navigation Project. It is located in North Central Arkansas near Russellville. The study covers only macrozooplankton and mesozooplankton (Welch, 1963). Samples were taken at two stations (Fig. 7). These stations were chosen because of their positions to incoming streams which have constant flow. The sampling stations were approximately 0.5 miles apart and varied in depth from 6.5 ft. at station I to a depth of 12.0 ft. at Station II. The temperature of the water was generally higher by 0.5°C to 1°C at Station I (Table 2). Only samples from surface to approximately 18 inches were collected. Samples were taken on a weekly basis. This paper is concerned with collections over a 24 week period.

A total of 40 genera were identified during the study. Similar organisms were observed at both stations (table I). The total number of zooplankton organisms per liter reached their peak at both sampling stations on July 30, 1969.

ACKNOWLEDGEMENTS

This study was supported by a grant from the Faculty Research Committee of Arkansas Polytechnic College, Russellville, Arkansas.

Materials and Methods

The first sample was collected on May 29, 1969, and sampling was continued on a weekly basis through November 5, 1969, except for the week of June 8. There were a total of 23 collections made over a period of 24 weeks.

The method used in collecting was the vertical drag method, and not the standard method set forth by Welch (1948). With the use of the standard formula for the volume of a cylinder, $V = \pi r^2 h$ (C.R.C. Standard Mathematical Tables, 1964), it was determined that a 14.38 ft. drag would represent a 200 liter sample. This sample was taken from a boat. Only surface to approximately 18 inch samples were collected at both of the collecting stations. The water temperature was also recorded each time along with other information such as wind and sky conditions.

A plankton net equipped with No. 25 silk bolting cloth was used. The sample was concentrated in a 30cc collecting bottle attached to the plankton net by use of an adapter. Approximately 3 ml. of formaldehyde solution N.F. was used to fix and preserve the organisms. The sample was diluted to 100 ml. and with the use of a Sedgewick-Rafter Counting Chamber the average number of organisms in 10 fields was determined.

The taxonomic scheme of Pennak (1953) was used in this paper in the placement of those flagellated organisms which possess both plant and animal characteristics. Identification below the level of genera was not attempted in this study. The classification of nauplii was not undertaken. They are listed under Copepoda. The works of Hyman (1951), Needham and Needham (1966), Pennak (1953), Samuel Eddy and A. C. Hodson (1967), and Ward and Whipple (1966) were used for the identification of the zooplankton.

Acknowledgement is given to Dr. Carl E. Hoffman, Professor of Zoology, University of Arkansas, for his Identification of **Codenella** and **Difflugia.**

RESULTS

Because of the limiting time factor concerning this research (approximately 6 months during one year) no definite conclusions can be reached. Some of the more notable results of the study are:

1. In the 23 different times when samples were taken, Station I had the highest total number of organisms per liter a total of 7 times. Station II had the highest total number of organisms per liter a total of 16 times (Table 2). Station I has a depth of 6.5 ft. while Station II has a depth of 12.0 ft. (Fig. 7). The surface temperature of the water at Station I was warmer than Station II, 22 times out of the 23 times sampled. The temperature difference ranged from 0.0°C to 4.0°C.
2. **Asplanchna, Hexarthra, Filinia,** (Fig. 2 & 5) and **Brachionus, Keratella, Polyarthra,** (Fig. 1 & 4) were common rotifers to both stations. The follow-

ing is a list of times in 23 samplings that each of the six organisms were observed at the two sampling stations.

	Station I	Station II
Asplanchna	20	21
Brachionus	22	22
Filinia	19	14
Hexarthra	15	18
Keratella	22	23
Polyarthra	22	22

Although **Keratella** was observed in more samples, probably the most representative genus was **Polyarthra,** which ranked highest in number of specific organisms per liter in most samples. **Polyarthra** reached its highest count in Sample No. 11 at Station I when a total of 7600 organisms per liter was recorded (Fig. 1). The number of total organisms per liter reached their peak on July 30 Sample No. 18, station II and then showed an irregular decrease during the duration of the research (Table 2).

3. Although the six (6) rotifers listed above were present in most of the samples counted, they did not remain the predominant organisms through the entire study. **Difflugia, Codenella, Ceratium, Peridinium** and other protozoa became predominant in the latter part of the study. This shift in types of predominant organisms was first noted in Sample No. 33 on September 24, temperature 28°C at Station I and Sample No. 34 on September 24 temperature 27.5°C at Station II.

4. The increase and decrease in total number organisms per liter showed a positive correlation to the temperature change (Table 2).

5. Brachionus mictic females (Donner, 1966) were observed on September 24, sample No. 34 (Station II) when a temperature of 27.5°C was recorded.

6. All organisms identified were common to both sampling stations. Neither station ranked consistent with the highest number of organisms present.

A radical change in the type of predominant organisms occurred only once during the course of the study. Sample No. 7 station I June 25, contained 3600 **Eudorina** per liter. The water was very turbid when this sample was collected due to a very severe rain storm (approximately 5 inches) which had occurred two days prior to this date.

Number of organisms/liter for three consecutive weeks in samples from Station I and Station II were as follows: (the middle sample represents the sample collected two days after the rain)*

Station I	Station II
Eudorina — 150/liter	**Eudorina** — 0/liter
Polyarthra — 350/liter	**Polyarthra** — 250/liter
Brachionus — 200/liter	**Brachionus** — 300/liter
Total Number of Organisms in the sample 1750 /liter	Total Number of Organisms in the sample 1800 /liter
***Eudorina** — 3600/liter	**Eudorina** — 50/liter
Polyarthra — 100/liter	**Polyarthra** — 0/liter
Brachionus — 0/liter	**Brachionus** — 150/liter
Total Number of Organisms in the sample 6100/ liter	Total Number of Organisms in the sample 950/ liter
Eudorina — 0/liter	**Eudorina** — 0/liter
Polyarthra — 700/liter	**Polyarthra** — 400/liter
Brachionus — 150/liter	**Brachionus** — 600/liter
Total Number of Organisms in the sample 3050 /liter	Total Number of Organisms in the sample 3200 /liter

Many small developing colonies of **Eudorina** were observed in the sample collected two days after the 5 inch rain. This would indicate either the establishment of probable nutrient features beneficial to the organism or the introduction of organisms already in existence in stagnant areas of the lake at the mouth of Baker's Creek, these being washed in as a result of the heavy precipitation. Due to the autotrophic characteristics of **Eudorina,** and the adverse effects which increased turbidity would establish, and because of the lack of any notable increase in **Eudorina** at Station II, it is the belief of the author that the introduction of the organisms from stagnated areas is the most likely.

This was the only hard rain which occurred during the testing period and this was the only time that a **Volvocidea** representative was present in an abundant amount in a sample.

Hoffman (1952) in his study of the effects of heavy precipitation on the plankton in Lake Fort Smith reported a marked reduction in the number of phytoplankton. In his study **Eudorina** was classified under phytoplankton.

The decrease in number of rotifers after the heavy rain may have been due to increased turbidity or it may be indicative of a periodic cycle. It is of interest to note that in the sample preceding the period of heavy rain, many rotifer eggs were observed. Pennak (1953) states that "the cycles of abundance for plankton species are highly variable within each species, variable from year to year within a single lake, and especially variable from one small lake to another."

Evidence of periodic plankton cycles is present in McGaha's data from his sampling of Sardis Reservoir in Northern Mississippi. McGaha (1966) states that in his sampling of Sardis Reservoir, he has observed shifts in plankter from predominant, to virtually absent, to predominant in types of organisms present in a period as short as one week. This type of periodic cycle may be interpreted from the data present when one considers the number of **Polyarthra** present in the first and third samples in the three (3) samples listed.

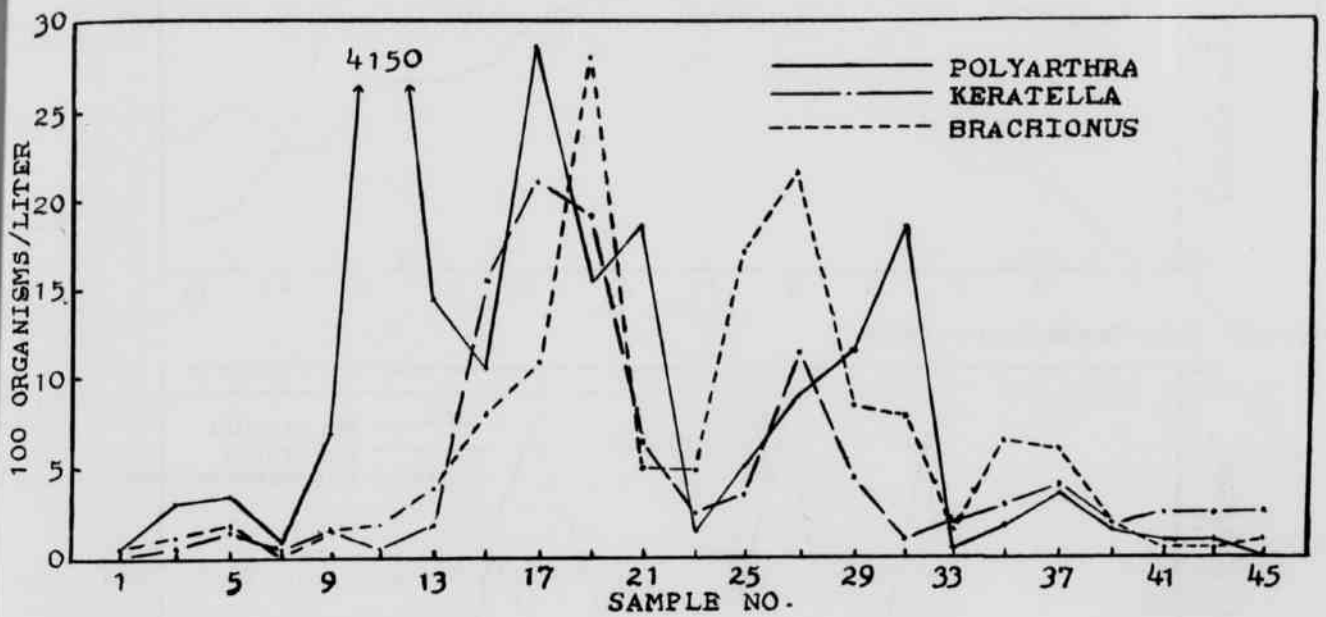


Figure 1. Polyarthra, Keratella, and Brachionus at Station I.

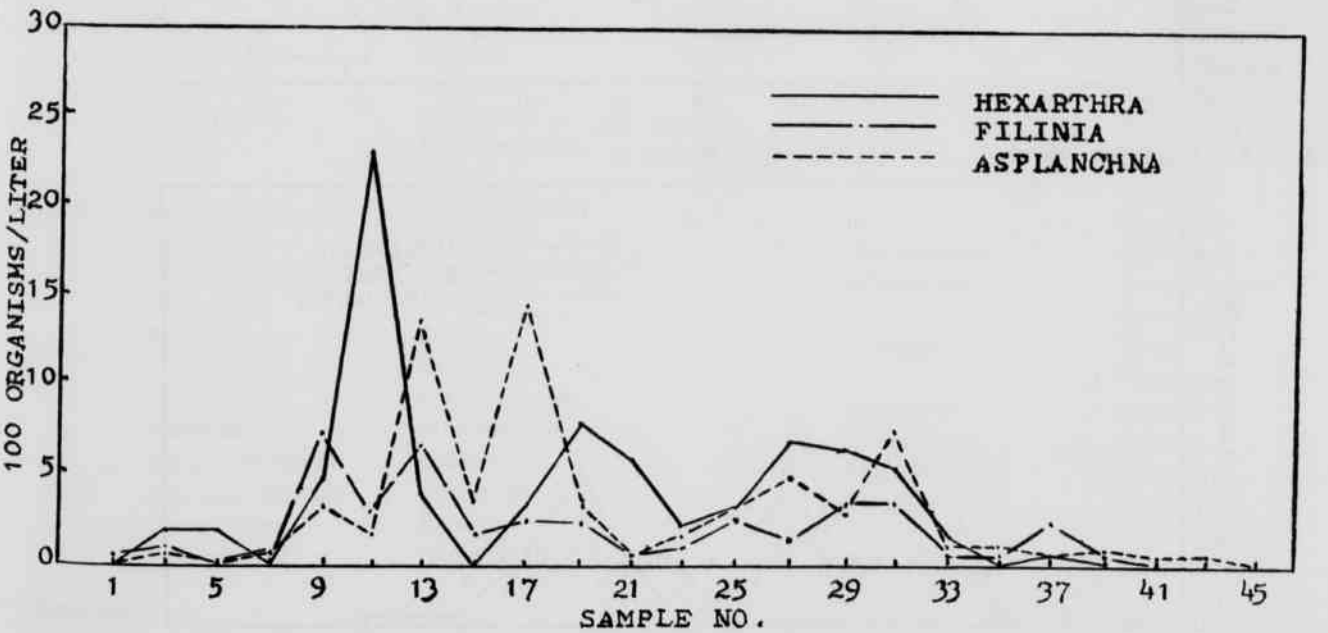


Figure 2. Hexarthra, Filinia, and Asplanchna at Station I.

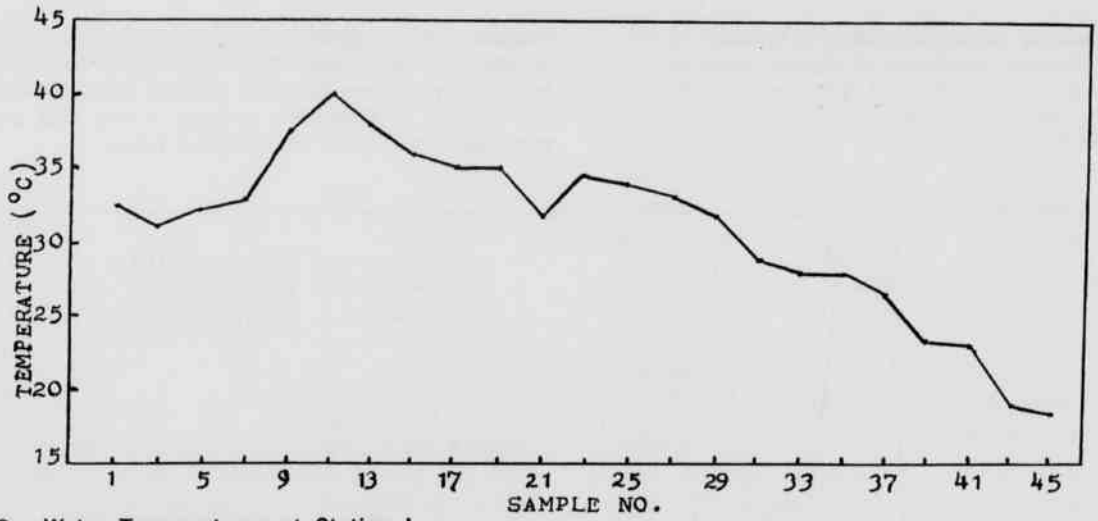


Figure 3. Water Temperatures at Station I.

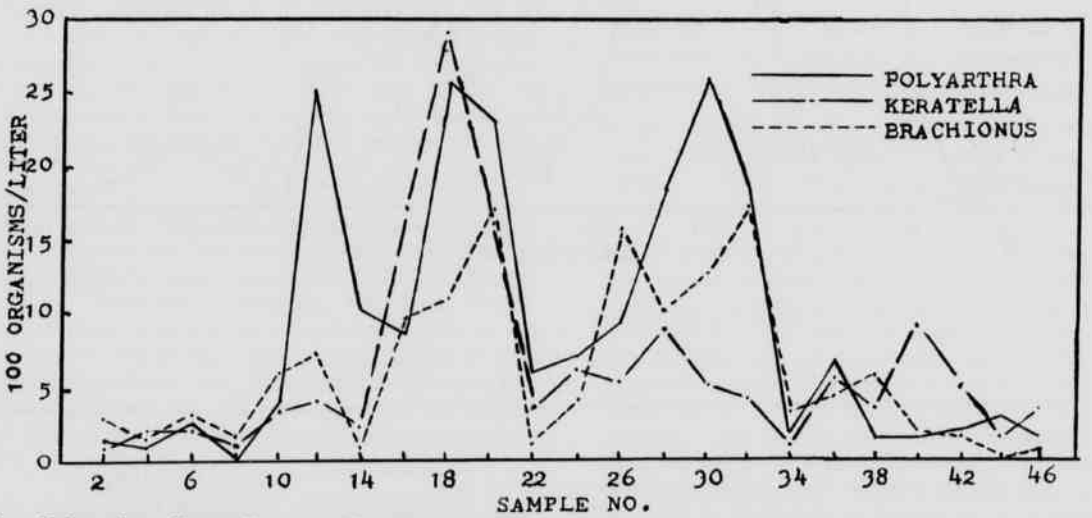


Figure 4. Polyarthra, Keratella, and Brachionus at Station II.

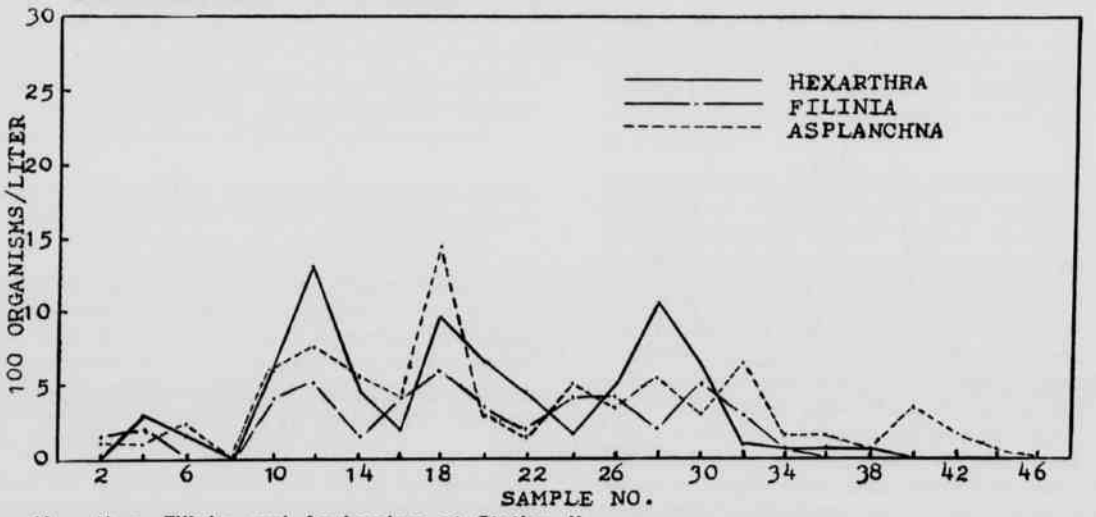


Figure 5. Hexarthra, Filinia, and Asplanchna at Station II.

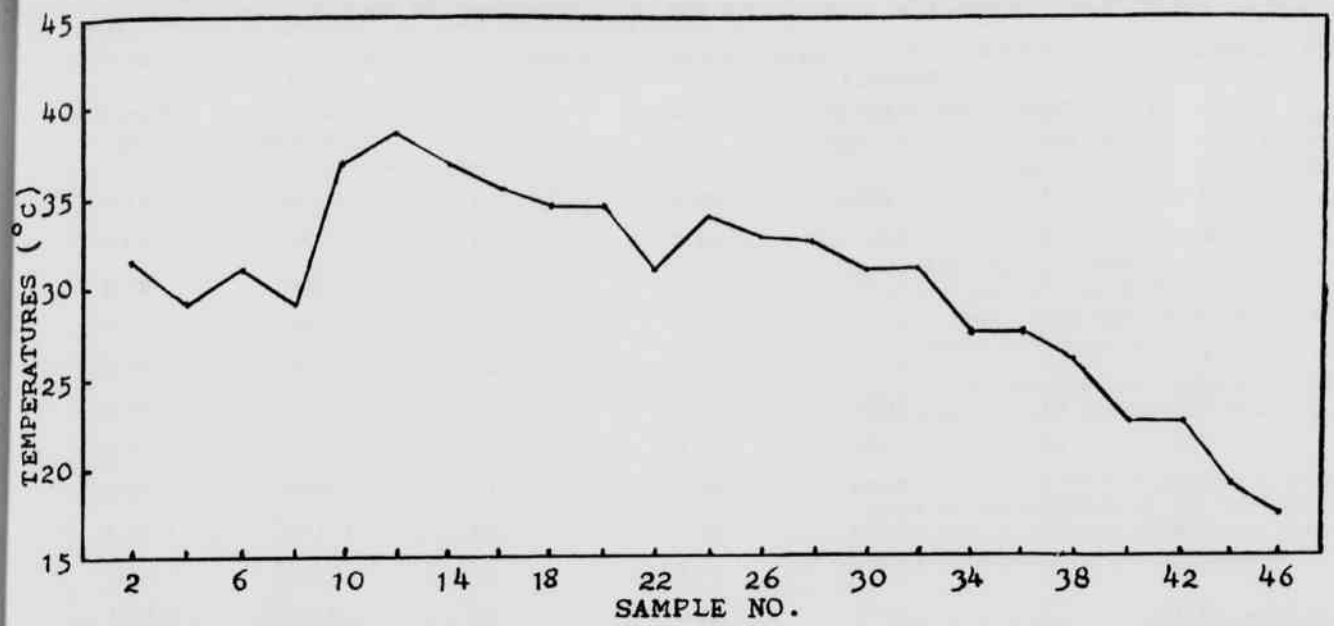


Figure 6. Water temperature at Station II.

Table 1. Phylum, family, and genera of the zooplankton according to Pennak (1953)

Phylum	Family	Genera
Crustaceae*	Bosminidae	Bosmina
	Cyclopidae	Cyclops
	Daphnidae	Daphnia
	Diaptomidae	Diaptomas
	Sididae	Diaphanosoma
Protozoa	Actinophryidae	Actionshaerium
	Ceratioceae	Ceratium
	Chlamydomonadaceae	Chlamydomonas
	Difflugiidae	Difflugia
	Euglenuaceae	Euglena
		Phacus
		Trachelomonas
	Halteriidae	Strombidium
	Mallomonadaceae	Mallomonas
	Ochromonadaceae	Dinobryon
	Oxytrichidae	Urostyla
	Paramecidae	Paramecium
	Peridinaceae	Peridinium
	Tintinnidae	Codonella
	Volvocidae	Eudorina
		Pandorina
		Volvox
Rotatoria	Asplanchnidae	Asplanchna
		Asplanchnopus
	Brachionidae	Anuraeopsis
		Brachionus
		Epiphanes
		Keratella
		Lepadella
	Collothecidae	Collotheca
	Conochilidae	Conochiloides
		Conochilus
	Filiniidae	Filinia
		Hexarthra
	Lecanidae	Lecane
	Philodinidae	Rotaria
	Ploesomatidae	Plaesoma
	Synchaetidae	Polyarthra
		Synchaeta
	Trichocercidae	Trichocerca

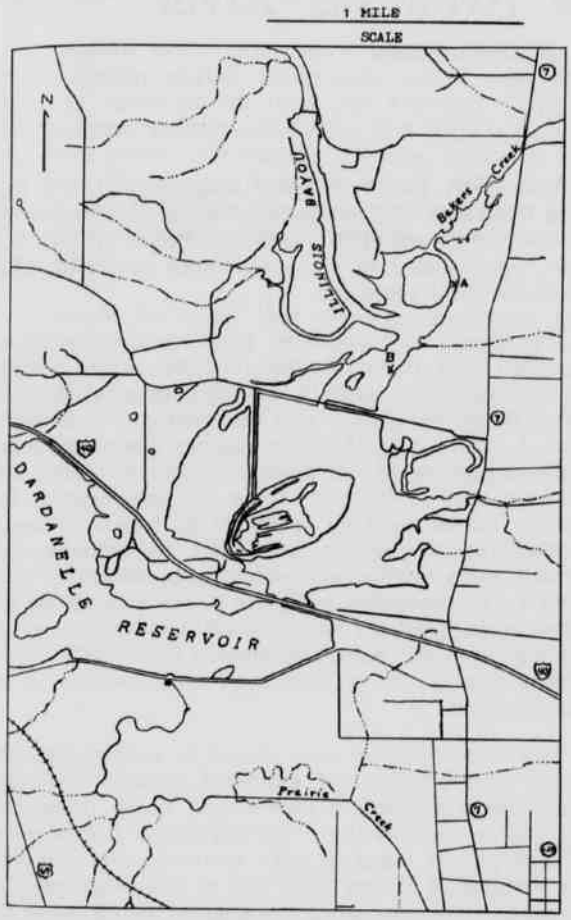
* Nauplii included.

Other organisms present stone fly larva and nematodes.

Table 2. The dates of collection, total organisms per liter, and temperatures for stations 1 and 2.

Date Month/day 1969	Station I Sample No.	Station I Total organisms Per liter	Station I Temperature °C	Station II Sample No.	Station II Total organism per liter	Station II Temperature °C
5/29	1	250	32.5	2	950	31.5
6/ 3	3	1300	31.0	4	1150	29.0
6/18	5	1750	32.0	6	1800	31.0
6/25	7	6100	33.0	8	950	29.0
7/ 2	9	3050	37.5	10	3200	37.0
7/10	11	7600	40.0	12	6850	38.5
7/17	13	4500	38.0	14	2600	37.0
7/25	15	4100	36.0	16	5250	35.5
7/30	17	9200	35.0	18	10150	34.5
8/ 7	19	8050	35.0	20	7350	34.5
8/15	21	5050	31.8	22	3750	31.1
8/21	23	1600	34.5	24	3850	34.0
8/28	25	4250	34.0	26	5250	33.0
9/ 4	27	6100	33.0	28	6350	32.5
9/12	29	4700	31.5	30	6600	31.0
9/17	31	5650	29.0	32	6300	28.5
9/24	33	1550	28.0	34	2950	27.5
10/ 1	35	2600	28.0	36	2950	27.5
10/ 8	37	2650	26.5	38	2450	26.0
10/15	39	2600	23.5	40	2650	22.5
10/22	41	1150	23.0	42	1950	22.5
10/29	43	1050	19.0	44	1400	19.0
11/ 5	45	800	18.0	46	1250	17.5

Figure 7. Dardanelle Reservoir northwest of Russellville with sample station 1 at point "A" and station 2 at point "B";



Literature Cited

Donner, Josef, 1966. **Rotifers** Frederick Warne & Co. Ltd, London, England.

Eddy, Samuel, and A. C. Hodson, 1967. **Taxonomic Keys to the Common Animals of the North Central States,** 3rd ed. Burgess Publ. Co. Minneapolis, Minnesota.

Hoffman, Carl E., 1952. Limnological Studies in Arkansas No. II. The effect of intense rainfall on the abundance and vertical distribution of plankton in Lake Fort Smith, Arkansas. **Proceedings of Arkansas Academy of Science** 5: 83-89.

Hyman, L. H., 1951. **The Invertebrates: Acanthecephala and Entoprocta,** Vol. IIII. McGraw-Hill Book Co., Inc., New York.

McGaha, Y. J., and Luther A. Knight Jr., 1966. A qualitative study of net plankton of the four flood control reservoirs in northern Mississippi. **Journal of the Mississippi Academy of Science 12:** 384-404.

Needham, J. G., and P. R. Needham, 1962. **A Guide to the Study of Fresh-Water Biology,** 5th ed. Holden-Day, Inc., San Francisco.

Pennak, R. W., 1953. **Fresh-Water Invertebrates of the United States.** The Ronald Press Company, New York.

Ward, H. B., and G. C. Whipple, 1959. **Fresh-Water Biology,** 2nd ed. John Wiley and Sons, Inc., New York.

Welch, P. S., 1948. **Limnological Methods.** The Blakiston Company, Philadelphia.

Welch, P. S., 1952. **Limnology.** McGraw-Hill Book Company, Inc. New York.

Age and Growth of the Blue Catfish, Ictalurus furcatus, in the Arkansas River[1]

D. Leroy Gray[2]
Richard A. Collins[3]

The Arkansas River has in the past been a fast-flowing, muddy river which fluctuated markedly in depth, but it is now in the process of being stabilized and cleared by jetties and navigation dams. The blue catfish has been one of the dominant species in the river for many years, to the extent that it has supported commercial fishing. The dominance of the species in this environment was demonstrated several years ago when personnel of the Arkansas Game and Fish Commission sampled the population by the use of rotenone and recovered over 900 pounds of blue catfish and not more than 100 pounds of all other species combined. Since the Arkansas River was well suited for the blue catfish, knowledge of the distribution and growth of this species in this passing natural environment is of significance.

The Arkansas Game and Fish Commission biologist, interested in the blue catfish as a commercial species, provided material, equipment, and personnel necessary to obtain samples of this fish population for study. Four samples of blue catfish were taken by the use of rotenone from the Arkansas River during the perlod September 15 to October 22, 1964. An average of 275 pounds of 5 percent powdered rotenone was used for each sampling. The rotenone was mixed with water in tubs and spread across the river at points where the channel was narrow and the water somewhat turbulent. The turbulence resulted in further distribution of the rotenone before it flowed into deeper and wider parts of the river.

As the rotenone moved with the current, it was followed by men in 6 boats and the fish were dipnetted as they came to the surface. Fish continued surfacing and were captured for a period of 5 to 6 hours after application of rotenone and this time represented approximately 4 miles of river for each sampling.

Minnows, shad, and suckers were affected almost immediately after the rotenone was applied but about 15 minutes was required before catfish began to surface. Blue catfish and channel catfish were readily affected but flathead catfish did not come to the surface and none were collected, although they were known to be relatively abundant in the river.

After each fish had been weighed and the total length measured, the left pectoral spine was removed as described by Sneed (1951) and Schoffman (1954). The spines were placed in scale envelopes and later dried and stored until sectioned.

The spines were sectioned by a modification of the equipment and methods described by Sneed (1951), Leonard and Sneed (1951), and Schoffman (1954). A Dremel Moto-Tool No. 2[4] was mounted as illustrated in Figure 1. By the use of practice spines, the stop pin was set to determine the thickness of the sections. The lever was used to hold the spine in position while sectioning. Spines could be sectioned by free-hand use of the Moto-Tool, but it was found that the sections could be made more rapidly and uniformly by mounting as in Figure 1. As illustrated in Figure 2, the articulating end of the spine (part A) was cut off and three sections were cut from the adjoining portion (part B-C). These sections were stored in numbered vials for use in age determinations.

The spine sections were placed in a petri dish containing ethyl alcohol and examined through a variable magnification dissecting microscope using transmitted light. Spine sections from hatchery-reared fish of known age, age groups I and II, were examined and compared with sections of spines from fish of the Arkansas River population. Narrow, more transparent bands were distinct and were interpreted as winter growth rings.

Among most spines from fish of age group IV and older, the first annulus was not present as a result of the enlarged lumen. At best, only the tip of the first winter growth ring was present. Since sections from spines of 1 or 2-year-old fish always contained the first annulus and had practically no lumen, these were compared with the spine sections from older fish to verify the presence or absence of the first annulus.

In Tables I and II and Figure 3, the length and weight of the fish collected is given by age groups. The absence of fish in age group V and the presence of only one in age group IV may indicate years of poor conditions for spawning or survival, since 16 fish were taken in the subsequent age groups VI, VII, and VIII. The overlap of total lengths between age groups 0 and I was carefully

(1) In partial fulfillment for master's degree.

(2) Extension Fish and Wildlife Biologist, Agricultural Extension Service, Little Rock.

(3) Associate Professor of Biology, State College of Arkansas, Conway, Arkansas 72032.

(4) Dremel Manufacturing Company, 2429 18th Street, Racine, Wisconsin.

checked and found to be correct. This overlap was probably a result of the fact that blue catfish may spawn over a period of three months and thereby produce a wide variation in size during the first year.

The results of this study were compared with the results of similar studies using blue catfish from lakes (Table 3). Blue catfish from the Arkansas River exhibited a more rapid growth for the first 5 years than did those from either Lake Texoma (Jenkins, 1956) or Kentucky Lake (Conder and Hoffarth, 1962). After the 5th year, the fish from Lake Texoma showed a greater growth rate than those from either Kentucky Lake or the Arkansas River.

It should be noted that the sampling from Lake Texoma covered a period of 9 months. Sampling from Kentucky Lake covered a period of 4 months and was conducted at a different time of the year than the present study. The difference in length of the sampling period and time of year during which samples were taken would influence the size of the fish representing a given age group.

TABLE I

Number, weight and length of blue catfish from the Arkansas River, by age group and year class

Age group	Year class	Number of fish	Weight (pounds)[1/]	Length (inches)[1/]
0	1964	28	.1	7.2
I	1963	55	.5	11.5
II	1962	19	1.4	16.7
III	1961	6	2.1	19.0
IV	1960	1	3.5	20.0
V	1959	0	—	—
VI	1958	2	6.3	24.4
VII	1957	6	9.2	27.9
VIII	1956	8	10.1	29.1
IX	1955	0	—	—
X	1954	0	—	—
XI	1953	1	25.0	37.2

[1/] Weighted means.

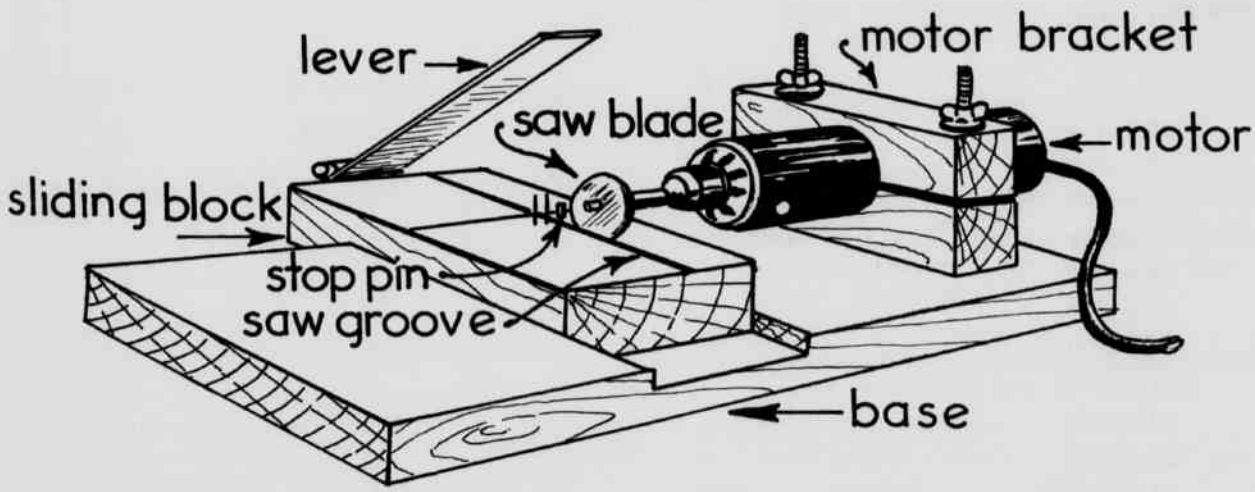


Figure 1. Apparatus designed to section catfish spines rapidly and uniformly.

TABLE 2

Range of length frequencies by age group of blue catfish from the Arkansas River

interval Length	Age group											
	0	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
3.0- 3.9	1	-	-	-	-	-	-	-	-	-	-	-
4.0- 4.9	4	-	-	-	-	-	-	-	-	-	-	-
5.0- 5.9	6	-	-	-	-	-	-	-	-	-	-	-
6.0- 6.9	6	-	-	-	-	-	-	-	-	-	-	-
7.0- 7.9	2	1	-	-	-	-	-	-	-	-	-	-
8.0- 8.9	-	1	-	-	-	-	-	-	-	-	-	-
9.0- 9.9	1	5	-	-	-	-	-	-	-	-	-	-
10.0-10.9	5	8	-	-	-	-	-	-	-	-	-	-
11.0-11.9	3	21	-	-	-	-	-	-	-	-	-	-
12.0-12.0	-	12	-	-	-	-	-	-	-	-	-	-
13.0-13.9	-	3	-	-	-	-	-	-	-	-	-	-
14.0-14.9	-	4	3	-	-	-	-	-	-	-	-	-
15.0-15.9	-	-	1	-	-	-	-	-	-	-	-	-
16.0-16.9	-	-	6	-	-	-	-	-	-	-	-	-
17.0-17.9	-	-	4	1	-	-	-	-	-	-	-	-
18.0-18.9	-	-	4	-	-	-	-	-	-	-	-	-
19.0-19.9	-	-	1	5	-	-	-	-	-	-	-	-
20.0-20.9	-	-	-	-	1	-	-	-	-	-	-	-
21.0-21.9	-	-	-	-	-	-	-	-	-	-	-	-
22.0-22.9	-	-	-	-	-	-	-	-	-	-	-	-
23.0-23.9	-	-	-	-	-	-	1	-	-	-	-	-
24.0-24.9	-	-	-	-	-	-	-	-	-	-	-	-
25.0-25.9	-	-	-	-	-	-	1	-	-	-	-	-
26.0-26.9	-	-	-	-	-	-	-	2	1	-	-	-
27.0-27.9	-	-	-	-	-	-	-	2	2	-	-	-
28.0-28.9	-	-	1	-	-	-	-	-	1	-	-	-
29.0-29.9	-	-	-	-	-	-	-	1	1	-	-	-
30.0-30.9	-	-	-	-	-	-	-	1	2	-	-	-
31.0-31.9	-	-	-	-	-	-	-	-	-	-	-	-
32.0-32.9	-	-	-	-	-	-	-	-	-	-	-	-
33.0-33.9	-	-	-	-	-	-	-	-	-	-	-	-
34.0-34.9	-	-	-	-	-	-	-	-	1	-	-	-
35.0-35.9	-	-	-	-	-	-	-	-	-	-	-	-
36.0-36.9	-	-	-	-	-	-	-	-	-	-	-	-
37.0-37.9	-	-	-	-	-	-	-	-	-	-	-	1

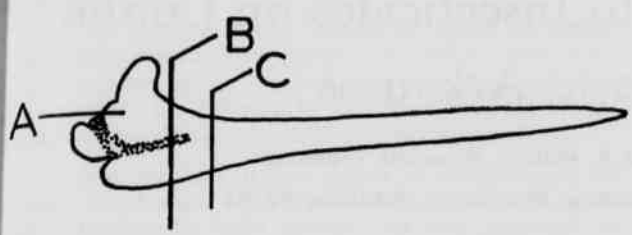


Figure 2. Catfish spine showing area of sectioning (B-C).

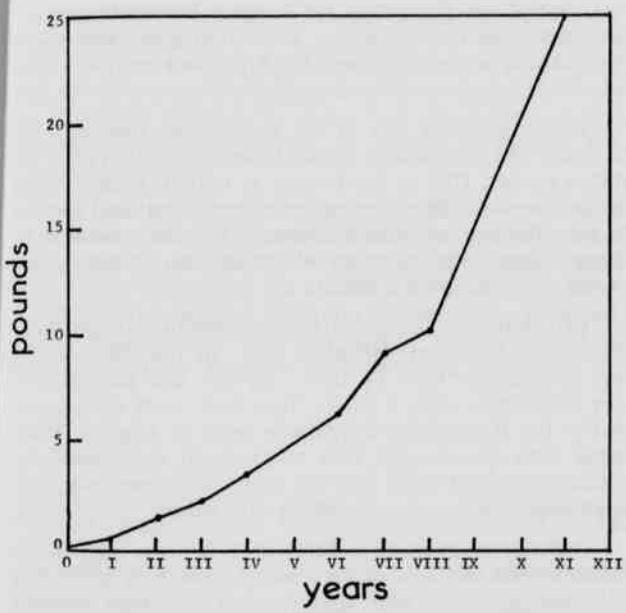


Figure 3. Growth curve of blue catfish from the Arkansas River.

TABLE 3

Comparison of the average total lengths by age groups of blue catfish from Lake Texoma, Kentucky Lake and the Arkansas River

Age group	Lake Texoma[1]/	Kentucky Lake[2]/	Arkansas River[2]/
0	—	—	7.2
I	5.7	—	11.5
II	10.0	9.0	16.7
III	13.8	10.6	19.0
IV	17.4	12.2	20.0
V	21.0	14.4	—
VI	25.8	17.1	24.4
VII	30.3	19.6	27.9
VIII	34.3	24.3	29.1
IX	40.4	27.5	—
X	42.1	33.9	—
XI	44.0	—	37.2

[1]/ Average length.

[2]/ Weighted average length.

Literature Cited

Conder, Jr. R., and R. Hoffarth. 1962. Growth or channel catfish, **Ictalurus punctatus,** and blue catfish, **Ictalurus furcatus,** in the Kentucky Lake portion of the Tennessee River in Tennessee. Proc. 16th Annual Conference S. E. Association Game and Fish Commission 348-353.

Jenkins, R. M. 1956. Growth of blue catfish, **Ictalurus furcatus,** in Lake Texoma. S. W. Nat. 1(4) :166-173.

Leonard, E. M., and K. E. Sneed. 1951. Instrument to cut catfish spines. Prog. Fish Cult. 13(4) :232.

Schoffman; R. J. 1954. Age and growth of channel catfish in Reelfoot Lake, Tennessee Jour. Tenn. Acad. Sci. 29(1) :2-8.

Sneed, K. E. 1951. A method for calculating the growth of channel catfish, **Ictalurus lacustrus punctatus.** Trans. Amer. Fish. Soc. 80: 174-183.

The Impact of Resistance to Insecticides on Cotton Insect Problems in Arkansas

Charles Lincoln, Professor and Jacob R. Phillips, Associate Professor

Dept. of Entomology, University of Arkansas, Fayetteville, Arkansas 72701

Insecticides have been used for cotton insect control in Arkansas for 100 years. For the 1st half of this period usage was very light, only occasional applications for cotton leafworm control. Then the boll weevil entered the picture. Calcium arsenate was developed for control of this pest but usage was relatively light. 1942 was a year of heavy infestation by boll weevil and cotton leafworm, and yet only 2 million pounds of insecticides were used in Arkansas according to our best estimates. This is no more than ¼ of an application per acre.

In 1945 DDT became available for commercial use, an event awaited with great anticipation. In 1946 a bollworm outbreak in southwestern Arkansas called for the first large scale usage of this miracle insecticide on cotton in the state.

DDT was not effective on boll weevil but other chlorinated hydrocarbons came along soon. A very heavy boll weevil outbreak extending from late 1948 through 1950 put these new insecticides to a severe test. Results were spectacular. Partly due to these new insecticides and partly to changing economic and social conditions, use of insecticides as needed became a standard production item. Over the past 20 years an average of 5 to 8 applications of insecticides has been made to about 2/3 of the cotton crop. Insect hazards are rather low in northeastern Arkansas. This results in little insecticide usage on about 1/3 of the Arkansas cotton crop.

Insect resistance to insecticides has been recognized for half a century. Mosquitoes and houseflies promptly developed resistance to DDT. Even so, it was fondly hoped that field resistance of our major cotton pests would not develop for many years, if ever.

In 1953 and 1954 cotton aphid populations appeared to be resistant to BHC in some locations. We were shortly too busy on other problems of resistance to pursue this and it has never been properly documented.

Weather conditions in 1955 were unusually favorable for boll weevil development and unfavorable for effective use of insecticides. By early August this pest was out of control throughout its normal range in the Mississippi Delta. Persistence and a break in the weather enabled farmers to bring the boll weevil under control, a truly spectacular save. In adjacent areas in Louisiana and in the South Delta of Mississippi farmers were not so fortunate. Runaway infestations persisted.

After some hasty lab tests, LSU Entomologists announced in early September, 1955 that some boll weevil populations were resistant to BHC and certain other chlorinated hydrocarbon insecticides.

Toxaphene was one of the chlorinated hydrocarbons to which the boll weevil showed resistance in 1955. As stated earlier, DDT is ineffective at normal field dosages on boll weevil. Mixtures of toxaphene and DDT proved to be effective on toxaphene-resistant boll weevils, although they were no more effective than straight toxaphene on susceptible weevils.

DDT afforded the 1st effective insecticidal control of the cotton bollworm, **Heliothis zea.** In the 40's control was spectacular with ½ lb/A. By the late 50's control was acceptable with 1 lb/A. This pest went out of control in the Russellville-Dardanelle area in August, 1961. Some time was bought with mixtures of chlorinated hydrocarbon insecticides and the resistance level was highly variable from one population to another.

Organophosphorous insecticides became popular in the late 50's because of their effectiveness in controlling boll weevil, aphid, and spider mites. At high dosages they came into common use for bollworm control.

Resistance to an organophosphorous insecticide, methyl parathion, interfered with bollworm control in Jackson county in 1969. This had been predicted from earlier lab work, from problems of control in Central America, and from problems with a related species, the tobacco budworm.

Carbaryl or Sevin is a carbamate insecticide, representing another chemical grouping. Like the organophosphorous insecticides it is a cholinesterase inhibitor. In a few years low-level resistance in bollworm has developed.

Several caterpillars that are sometimes pest of cotton appear to represent cases of non-target species being selected for resistance. These include tobacco budworm, cabbage looper, and beet armyworm. Spider mites are readily selected for resistance. In cotton fields in Arkansas resistance to organophosphorous insecticides has de-

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

veloped, apparently another case of a non-target organism being selected for resistance.

After 25 years of heavy insecticide usage on cotton in Arkansas, several pest insects and mites have developed resistance to the 3 principal groups of insecticides and miticides: the chlorinated hydrocarbons, the organophosphorous compounds, and the carbamates.

The first reaction of the farmer to resistance is to increase the dosage and frequency of insecticide application. During the brief period that this approach is partially effective, it exaggerates the problem of environmental contamination.

Cotton is in dire straits economically. Every effort is being made to reduced the cost of production. But the resistance problem adds to the cost of production.

Cotton insects are the subject of this presentation, but the situation is similar for many of our food and feed crops. Furthermore, a pest species may develop a high level of resistance from exposure to insecticides on cotton, making it difficult to control on other crops. Examples include cabbage looper on greens crops and bollworm on soybeans.

It is neither cheap nor easy to discover new chemical groupings that will control insects and meet acceptable standards of safety and economics. Several years and millions of dollars are required to carry out the research to serve as the basis for registration. Prospects are so discouraging that at least 4 major companies have closed their primary synthesis and screening laboratories in the past 3 years.

It appears unlikely that new insecticides can be synthesized and developed rapidly enough to offset the present rate of obsolescence of insecticides through resistance. More realistic requirements on registration of new insecticides would help, but would not solve the problem. Biological insecticides (bacteria, viruses, etc.) are under more stringent registration restrictions than are chemical insecticides.

There are many exciting possibilities of insect control that do not depend upon conventional insecticides. There are only a few proven successes to date. To adequately implement these new approaches in terms of practical insect control will require many years, tremendous investments in research, and a high level of cooperation by many disciplines of the biological and physical sciences.

SUMMARY

In 25 years of heavy insecticide usage on cotton in Arkansas, resistance has become a problem with several pest insects and mites to the 3 principal groups of insecticides and miticides: the chlornated hydrocarbons, the organophosphorns compounds, and the carbamates.

Development of control measures, chemical or otherwise, is not proceeding at a sufficiently rapid pace to stay ahead of the problem posed by insect resistance to insecticides.

A Road-Kill Census of Mammals in Northeastern Arkansas

J. W. Ed Wortham[1] and Earl L. Hanebrink

Box 67, Arkansas State University, State University, Arkansas 72767

INTRODUCTION

It is the purpose of this study to investigate species composition and numbers of mammals killed on selected highways in northeastern Arkansas. Roadside counts have been used by wildlife personnel to determine population indices for areas under study for a wide variety of game species. Hendrickson (1939) was the first to describe the roadside census as an inventory method for rabbits. Wight (1959) used roadside counts to estimate statewide rabbit population trends in Missouri. Regular predetermined highway routes were driven in an automobile at a prescribed time of day and rabbits were counted per mile. Lord (1955, 1961) used the roadside census method to count rabbits in Illinois and made comparisons of censuses taken during early morning and night. Newman (1959) reported on weather factors influencing the roadside counts of cottontail rabbits.

Ornithologists have used the roadside census technique for many years. Nice and Nice (1921) used this method to study Oklahoma bird populations as early as 1920. Since their pioneer studies, this technique has been used by a number of research workers. Kendeigh (1944) evaluated the roadside census in relation to other types of censuses used in studying birds. Dice (1938, 1952) thoroughly discussed and compared numerous census methods. Howell (1951) made detailed studies using relative conspicuousness in determining bird numbers along roadsides in Tennessee. The roadside census is used as a method of determining relative abundance and not absolute abundance. Variability of roadside cen-

(1) Present address: Dept. of Zoology, Southern Illinois Univ., Carbondale, Ill.

suses have been reported on by Peterle and Eherhardt (1958).

An Annual Progress Report, W - 29 - R - 14 (1966-67), conducted in Louisiana contains many roadside censuses taken in that state of both living and dead wildlife species including the cottontail rabbit. This technique has been used for determining relative abundance for a number of game species in many areas of the United States by wildlife biologists.

ACKNOWLEDGEMENTS

Some of the censuses taken for this study were completed by Bob R. Singleton and James R. Grissom, graduate students at Arkansas State University. Dr. Max Nickerson critically read the manuscript. The writers are grateful for their assistance.

METHODS

A total count of species of wildlife mammals was taken by automobile census during early morning and late afternoon on highways in northeastern Arkansas. Counties where censuses were conducted included Clay, Greene, Craighead, Poinsett, and Jackson. Secondary blacktop delta roads transversing slash-cleared agricultural areas were mainly utilized for this study. The census period extended from September 1969 through March 1970 .

DESCRIPTION OF AREA

All of northeastern Arkansas is extensive delta with the exception of Crowley's Ridge. The flat land reaches to the base of the Ouachita hills at the edge of North Little Rock. It then continues north into southeastern Missouri and south into Louisiana without any natural break. Crowley's Ridge runs for a distance of 200 miles from southeastern Missouri down to the Mississippi River at Helena, Arkansas. Accounts of the geology of Crowley's Ridge are given by Call (1889). Magill (1958) summarized the various theories concerning the origin of the ridge.

DISCUSSION AND RESULTS

Lowland deciduous woods in northeastern Arkansas are being destroyed at a rapid rate by slash clearance. These once swampy areas are being drained and cleared for fields to be planted in cotton, soybeans, and rice. Destruction of swampy woods has decreased wildlife habitats over this vast area of the state for most species of mammals so that many are forced into poor cover along the edge of the roadside where one of their greatest dangers is the automobile.

Mortality of wildlife species, caused by the automobile, is not an entire loss to the area in terms of energy loss within the biotic community. These dead mammals are eaten by species of hawks and the Common Crow. There is a large population of Red-tailed Hawks in northeastern Arkansas during the fall and winter months. Many of these can be observed from the roadside perched on a tree or telephone pole. During early morning hours on several occasions, the Common Crow was observed feeding on dead rabbits killed by automobiles. It is apparent that one of the greatest enemies of the cottontail rabbit, opossum, and skunk is the automobile.

During this census 10,025 miles were driven and a total of 438 dead mammals were counted. The average mammal kill per 100 miles was 4.37 (Table 1). Twelve species of mammals were recorded as roadside kill. These included 263 rabbits **(Sylvilagus floridanus** and **Sylvilagus aquaticus)**, 108 opossums **(Didelphis marsupialis)** 42 skunks **(Mephitis mephitis)**, eight gray squirrels **(Sciurus carolinensus)**, six raccoons **(Procyon lotor)**, four muskrats **(Ondatra zibethicus)**, two fox squirrels **(Sciurus niger)**, two Norway rats **(Rattus norvegicus)**, one cotton rat **(Sigmodon hispidus)**, one red fox **(Vulpes fulva)**, and one coyote **(Canis latrans)**.

TABLE 1. ROADSIDE CENSUS OF TOTAL MAMMAL KILL FROM SEPTEMBER 1969 TO MARCH 1970

MONTH	NO. MI. TRAVELED	TOTAL KILL PER 100 MI.	Rabbit	Opossum	Skunk	Raccoon	Muskrat	Fox Squirrel	Gray Squirrel	Red Fox	Coyote	Norway Rat	Cotton Rat
September	686	3.79	5	15	4	-	-	2	-	-	-	-	-
October	987	5.27	23	23	3	2	-	-	-	-	-	1	-
November	1458	5.76	50	21	9	3	-	-	-	-	-	-	1
December	1809	5.31	83	4	4	1	-	-	3	1	-	-	-
January	1750	1.71	23	7	-	-	-	-	1	-	1	1	-
February	2041	3.43	38	20	12	-	-	-	-	-	-	-	-
March	1294	6.18	41	21	10	-	4	-	4	-	-	-	-
Total	10025	4.37	263	108	42	6	4	2	8	1	1	2	1

Total mammal kill per 100 miles was highest during March with an average of 6.18 per 100 miles, and the lowest counts were in January with an average of 1.71 per 100 miles. The January low count possibly reflects less movement of opossums and skunks as they are not as active during the colder weather. The rabbit count of 23 for January was also lower than other census months. Early low counts of rabbit mortality during September and October may be accounted for in part because of large acreage of crops and cover remaining in most fields. As these areas are harvested, much of the cover is destroyed forcing the rabbits to move about in search of better cover.

SUMMARY

A roadside census of mammal kill was conducted in northeastern Arkansas from September 1969 through March 1970. Some 10,025 miles were driven, and a total of 438 dead mammals were censused. An average of 4.37 mammals were killed per 100 miles. Twelve species of mammals were recorded as roadside kills with rabbits having the greatest mortality.

CITED LITERATURE

Annual Progress Report, W-29-R-14. 1966-67. A Pittman-Robertson Project. Louisiana Statewide Wildlife Investigations. Louisiana Wildlife and Fisheries Commission, Baton Rouge, La. 155p.

Call, Richard Ellsworth. 1891. Crowley's Ridge. Ark. Geol. Surv. Ann. Report 2:22.

Dice, Lee R. 1938. Some census methods for mammals. J. Wildl. Mgmt. 2: 119-130.

Dice, Lee R. 1952. Natural communities. Univ. of Michigan Press, Ann Arbor. 547p.

Hendrickson, George O. 1939. Inventory methods for Mearns cottontail. N. Amer. Wildl. Conf. Trans. 4: 209-215.

Howell, Joseph C. 1951. The roadside census as a method of measuring bird populations. Auk. 68: 334-357.

Kendeigh, S. Charles. 1944. Measurements of bird populations. Ecol. Monogr. 14: 69-106.

Lord, Rexford D. Jr. 1959. Comparison of early morning and spotlight roadside censuses for cottontails. J. Wildl. Mgmt. 23 (4): 458-60.

Lord, Rexford D. Jr. 1961. Seasonal changes in roadside activity of cottontails. J. Wildl. Mgmt. 25(2): 206-209.

Magill, Arthur C. 1958. Geography and geology of the southeast Missouri lowlands. Ramfre Press, Cape Girardeau, Mo. 62p.

Newman, D. E. 1959. Factors influencing the winter roadside count of cottontail. J. Wildl. Mgmt. 23(3): 290-294.

Nice, Margaret M., and L. B. Nice. 1921. The roadside census. Wilson Bull. 33: 113-123.

Peterle, T. J. and L. Eherhardt. 1959. Is the Lincoln index reliable for cottontail census. Trans. 24th. N. Amer. Wildl. Conf. 261-271.

Wight, H. M. 1959. Eleven years of rabbit population data in Missouri. J. Wildl. Mgmt. 23(1): 34-39.

Notes on the Habitat and Distribution of the Odonata of Franklin County, Arkansas

by Jim Houston

Westark Junior College, Fort Smith, Arkansas 72901

INTRODUCTION

There is no publication dealing with the Odonata of Arkansas on a state-wide basis. Information on odonates in this state is scattered in the literature, and it is usually found only in broad regional works with only incidental mention of Arkansas.

The ranges of a few species are listed as extending to Arkansas by Hagen (1861), and by Muttkowski (1910). Needham and Heywood (1929) list six species of Odonata for the State, and Needham and Westfall (1955) list eleven species of the Anisoptera.

The most significant contributions on Arkansas Odonata are a list included in "Predaceous insects, spiders, and mites of Arkansas cotton fields", by Whitcomb and Bell (1964), which includes twenty-six species of the

Anisoptera and nine species of the Zygoptera, and the Odonata collection at the University of Arkansas, contributed mainly by Mr. E. P. Rouse. The species in this collection have not been reported. Another list for the State was furnished to me by Dr. Minter J. Westfall, Jr., which included sixty-five species of the Anistoptera and twenty-four species of the Zygoptera.

ANNOTATED LIST OF SPECIES

Suborder — ANISOPTERA

Family — AESCHNIDAE

1. **Anax junius** Drury

Distribution—General distribution throughout the United States.

Arkansas Record—Whitcomb and Bell (1964); University of Arkansas Entomology Museum; Westfall list.

Remarks—This species can be seen flying over ponds and lakes and adjacent fields in the late afternoon. It is of common occurrence in this area from late August or September to October.

Family—CORDULEGASTERIDAE

2. **Cordulegaster obliquus** Say

Distribution—Eastern United States

Arkansas Record—Needham and Westfall (1955); Westfall list.

Remarks—This species can be seen flying over open fields adjacent to ponds or resting on vegetation at the edge of fields. One specimen was collected from the underside of a leaf on a red oak tree (6-20-68).

Family—GOMPHIDAE

3. **Gomphus graslinellus** Walsh

Distribution—Central United States from Oklahoma to Wisconsin.

Arkansas Record—Westfall list.

Remarks—This species can be found on ponds, creeks, rivers, and sometimes in open fields adjacent to water. A male was collected on the bank of a pond (6-5-66). Another male was collected on the bank of a small creek (6-8-66), and one specimen was taken on the bank of the Arkansas River (6-15-66).

4. **Gomphus (Gomphurus) vastus** Walsh

Distribution—Eastern United States, west to Kansas and Missouri.

Arkansas Record—None.

Remarks—This species frequently alights on sand bars along the Arkansas River. A female, feeding on a robber fly, was taken while flying in a field adjacent to the Arkansas River. This species has not been previously reported from the State.

5. **Gomphus oklahomensis** Pritchard

Distribution—Oklahoma and Texas.

Arkansas Record—Westfall list.

Remarks—Only one specimen was taken. It was flying just above the water surface of a small stock pond (4-20-68).

6. **Gomphus (Agrigomphus) lentulus** Needham

Distribution—Central United States.

Arkansas Record—Whitcomb and Bell (1964); Westfall list.

Remarks—One species was taken on the ground adjacent to a farm pond (6-5-66).

7. **Dromogomhus spinosus** Selys

Distribution—Eastern United States west to Texas.

Arkansas Record—Westfall list.

Remarks—Three males were taken on Mulberry River (6-23-66). This species is easy to collect because of its habit of alighting on rocks at the edge of the water.

8. **Dromogomphus spoliatus** Hagen

Distribution—Eastern United States.

Arkansas Record—University of Arkansas Entomology Museum; Westfall list.

Remarks—One male was taken on a persimmon bush in the middle of a large field, one-fourth mile from a stock pond (6-10-68).

Family—LIBELLULIDAE

Sub-family—Libellulinae

9. **Celithemis elisa** Hagen

Distribution—Eastern United States west to Kansas.

Arkansas Record—Whitcomb and Bell (1964); University of Arkansas Entomology Museum; Westfall list.

Remarks—This is a slow flying species and easy to collect. It alights frequently on vegetation near ponds and can frequently be seen hovering over the edge of a pond. Several specimens were taken.

10. **Celithemis eponina** Drury

Distribution—Eastern United States west to Kansas and Oklahoma.

Arkansas Record—Whitcomb and Bell (1964); University of Arkansas Entomology Museum; Westfall list.

Remarks—Only one specimen was collected. It had been struck by a car while flying along a roadside two miles west of Cecil (8-4-66). It is a pond species.

11. **Erythemis simplicicollis** Say

Distribution—General distribution throughout the United States.

Arkansas Record—Whitcomb and Bell (1964); University of Arkansas Entomology Museum; Westfall list.

Remarks—A male was collected while it was flying over a small pond in a hardwood forest (6-15-66). Several females were collected in bermuda grass beside a pond just after emergence (5-28-68).

12. **Libellula cyanea** Fabricius

Distribution—Eastern United States west to Kansas.

Arkansas Record—Westfall list.

Remarks—Two males were collected while flying very low over the surface of a farm pond (6-15-66). The species was very common at another farm pond (6-13-68).

13. **Libellula incesta** Hagen

Distribution—Eastern United States.

Arkansas Record—Whitcomb and Bell (1964); University of Arkansas Entomology Museum; Needham and Westfall (1955); Westfall list.

Remarks—A male was collected resting on a bush on the bank of a small creek (6-8-66). Other specimens were taken over a small stock pond (6-27-68).

14. **Libellula luctuosa** Burmeister

Distribution—Eastern United States extending as far west as New Mexico and Kansas.

Arkansas Record—Whitcomb and Bell (1964); University of Arkansas Entomology Museum; Westfall list.

Remarks—This is a common pond species of this area. Several specimens were collected flying near the edge of the water of small ponds.

15. **Libellula pulchella** Drury

Distribution—General distribution throughout the United States.

Arkansas Record—Whitcomb and Bell (1964); University of Arkansas Entomology Museum; Westfall list.

Remarks—This species has a rather diversified habitat. A specimen was taken along a small fast-flowing creek (5-30-66). However, it more commonly occurs around ponds.

16. **Pachydiplax longipennis** Burmeister

Distribution—General distribution throughout the United States.

Arkansas Record—Whitcomb and Bell (1964;) Needham and Westfall (1955); University of Arkansas Entomology Museum; Westfall list.

Remarks—This is a pond species and is very common in early summer. It is often found resting on vegetation adjacent to the water's edge.

17. **Perithemis tenera** Say

Distribution—Eastern United States extending as far west as Oklahoma.

Arkansas Record—Whitcomb and Bell (1964); University of Arkansas Entomology Museum; Westfall list.

Remarks—Found mainly on ponds but one specimen was taken on a small creek (6-8-66). The species is common from May throughout the summer. It flies low over the surface of the water, resting frequently on vegetation at the water's edge.

18. **Plathemis lydia** Drury

Distribution—General distribution throughout the United States.

Arkansas Record—Needham and Heywood (1929); Needham and Westfall (1955); Whitcomb and Bell (1964); University of Arkansas Entomology Museum; Westfall list.

Remarks—This is the most common species in the County. It has been collected or observed on all ponds where collections were made, and also along small creeks and Mulberry River. It is abundant around ponds from early April until October. They can be found through most daylight hours and are active even during adverse weather.

19. **Tramea lacerata** Hagen

Distribution—General distribution throughout the United States.

Arkansas Record—Whitcomb and Bell (1964); University of Arkansas Entomology Museum; Westfall list.

Remarks—This is one of the most abundant and con-

spicuous species in the County. It can be found flying a few feet over the surface of ponds or flying over open fields. Many times several mating pairs have been observed flying over a pond.

20. **Tramea onusta** Hagen

Distribution—General distribution throughout the United States.

Arkansas Record—University of Arkansas Entomology Museum; Westfall list.

Remarks—A common pond species. It occurred in abundance on ponds in June, 1968.

21. **Micrathyria hageni** Kirby

Distribution—Texas.

Arkansas Record—None.

Remarks—This is a pond species previously reported in the United States only from Texas. One specimen was taken flying about two feet above the surface of the water at the edge of a small stock pond (6-8-68).

22. **Orthemis ferruginea** Fabricius

Distribution—General distribution.

Arkansas Record—None.

Remarks—Several specimens were taken on a stock pond in June, 1968.

23. **Epicordula princeps** Hagen

Distribution—Eastern United States extending to Texas.

Arkansas Record—Westfall list.

Remarks—This species is often very common around dusk, flying over the low marshy areas of pastures and fields. One specimen was taken on a pond (6-9-66).

24. **Somatochlora linearis** Hagen

Distribution—Eastern United States extending west as far as Oklahoma.

Arkansas Record—Westfall list.

Remarks—One specimen was collected along a small fast moving creek.

25. **Somatochlora ozarkensis** Bird

Distribution—Central United States.

Arkansas Record—Westfall list.

Remarks—One specimen was taken on a stock pond in June, 1969.

26. **Tetrogoneuria cynosura** Say

Distribution—Eastern United States west to Texas.

Arkansas Record—Whitcomb and Bell (1964); University of Arkansas Entomology Museum; Westfall list.

Remarks—This species occurs along ponds, small creeks, and woodland openings. This was the earliest species of Anisoptera taken in the County (3-30-68), and they remain abundant until about the middle of May. Several specimens were collected on grass at the edge of a pond just after emergence (4-13-68).

27. **Neurocordulia xanthosoma** Williamson

Distribution—Central United States.

Arkansas Record—Westfall list.

Remarks—Two specimens were take in grass on the bank of Mulberry River (7-4-68).

Suborder—ZYGOPTERA

Family—LESTIDAE

28. **Lestes disjunctus australis** Walker

Distribution—Eastern United States.

Arkansas Record—Westfall list.

Remarks—A pond species and an early emergent. One specimen was taken from a pond site (3-27-67). It is a rather large species and alights frequently for short intervals.

Family—COENAGRIIDAE

29. **Enallagma aspersum** Hagen

Distribution—Eastern United States.

Arkansas Record—Westfall list.

Remarks—Specimens were collected in a road ditch that temporarily contained water (5-5-68). It flies very low over the water, alighting frequently on low over-hanging vegetation.

30. **Enallagma signatum** Hagen

Distribution—Eastern United States.

Arkansas Record—Whitcomb and Bell (1964); Westfall list.

Remarks—Specimens were collected on two dates along road ditches temporarily filled with water (5-5-68; 5-18-68).

31. **Enallagma exsulans** Hagen

Distribution—Eastern United States.

Arkansas Record—Westfall list.

Remarks—One specimen was taken on some Johnson grass at the edge of the Arkansas River (6-3-68). Another specimen was collected in flight over a small creek (6-5-68).

32. **Enallagma civile** Hagen

Distribution—General distribution throughout the United States.

Arkansas Record—Westfall list.

Remarks—All specimens were collected in the grass at the edge of stock ponds (4-20-68; 5-5-68; 6-18-68).

33. **Argia apicalis** Say

Distribution—Eastern United States.

Arkansas Record—Needham and Heywood (1929); Whitcomb and Bell (1964); Westfall list.

Remarks—These are long, slender damsalflies. They were collected in Johnson grass on the bank of the Arkansas River (6-3-68).

34. **Argia moesta** Hagen

Distribution—General distribution throughout the United States.

Arkansas Record—Whitcomb and Bell (1964); Westfall list.

Remarks—One specimen was taken on the bank of a small rocky creek (6-5-68).

35. **Argia violacea** Hagen

Distribution—General distribution throughout the United States.

Arkansas Record—Witcomb and Bell (1964); Westfall list.

Remarks—The males of this species are bright blue or purple. One specimen was collected on a small fast flowing stream (6-5-68). Two males were taken on a stock pond (6-12-68), and a male was taken on Mulberry River (7-4-68).

36. **Ischnura verticalis** Say

Distribution—Eastern United States.

Arkansas Record—Westfall list.

Remarks—Specimens were collected on grass and in low flight over the shallow edge of a stock pond (4-20-68).

Family—CALOPTERYGIDAE

37. **Calopteryx maculata** Beauvois

Distribution—Eastern United States.

Arkansas Record—Whicomb and Bell (1964); Westfall list.

Remarks—Several specimens were collected in black willow and sweet gum bushes on the bank of Mulberry River (7-4-68).

38. **Hetaerina americana** Fabricius

Distribution—General distribution throughout the United States.

Arkansas Record—Whitcomb and Bell (1964); University of Arkansas Entomology Museum; Westfall list.

Remarks—A male was collected on a rock jutting out of the water in a very shallow region of Mulberry River (7-4-68).

SUMMARY

Collection of odonates have been made from Franklin County for the past four years. Thirty-eight species of adults were collected, representing twenty-five genera, and seven families. **Gomphus (Gomphurus) vastus, Micrathyria hageni** and **Orthemis ferruginea** are recorded from Arkansas for the first time. Among the remaining thirty-five species, thirty-three are new reports for the County.

The Odonata of Franklin County may be classified as primarily Eastern since twenty of the thirty-eight species were Eastern, twelve were General and six were Central. None of the species was Western.

Collections were made on ponds, lakes, creeks, rivers and transient pools of water, marshes and seepage areas.

LITERATURE CITED

Hagen, Hermann 1861. Synopsis of the Neuroptera of North America, with a list of the South American species. Smithsonian Misc. Coll., 4:1-347.

Muttkowski, Richard A. 1910. Catalogue of the Odonata of North America. Bull. Pub. Mus. City Milwaukee, 1:1-207.

Needham, James G. and Hortense Butler Heywood 1929. A handbook of the Dragonflies of North America. Springfield, Ill.; C. C. Thomas. pp. vii + 378.

_____ and Minter J. Westfall, Jr. 1955. A Manual of the Dragonflies of North America. Berkeley: Univ. Calif. Press, pp. xii + 615.

Smith, R. F. and A. E. Pritchard 1963. Usinger's Aquatic Insects of California with keys to North American genera and California species. Univ. Calif. Press, ch. 4 pp. 106-153.

Walker, E. M. 1953. The Odonata of Canada and Alaska. Toronto: Univ. Toronto Press, pp. xi + 292.

Whitcomb, W. H. and K. Bell 1964. Predaceous insects, spiders and mites of Arkansas cotton fields. Univ. of Ark. Agr. Expt. Sta., Bul. 690: 15-16.

The Effect of Domestic Effluent on Two Spring Surveys Of Fishes in Lost Creek, Craighead County, Arkansas

by John K. Beadles
Division of Biological Sciences, Arkansas State University
State University, Arkansas 72467

ABSTRACT

Lost Creek is representative of deltonic streams of the St. Francis Basin possessing characteristics of being turbid. It has a low flow velocity except during the annual spring rains. Lost Creek meanders approximately 18 km. before receiving effluents and empties into Big Creek approximately 4 km. west of Jonesboro, Arkansas. Five collecting stations were studied in 1966 while six stations were sampled in 1970.

Some fishes have been found to tolerate moderate amounts of domestic effluents and it is probable that the two species **Lepomis cyanellus** and **Ictalurus melas,** collected within the effluents, were more resistant than the other species of fish collected from Lost Creek.

The fishes of Lost Creek, Craighead County, Arkansas, were studied from five collecting stations in 1966 (Jackson and Beadles, 1966) and from six collecting stations in this study. Many stations above the effluent outfalls were intermittant during certain times of the year; however, during these sampling periods, March 27 through April 10, there was moderate flow. During 1966, the daily discharge of sewage effluent was approximately 3,780,000 liters (Jackson and Beadles, 1966). The daily discharge during this investigation was approximately 4,762,800 liters.

Lost Creek is representative of deltonic streams of the St. Francis Basin possessing characteristics of being turbid, and it has a low flow velocity except during the annual spring rains when its flow increases markedly. Lost Creek meanders approximately 21 km. and empties into Big Creek approximately 4 km. west of Jonesboro, Arkansas. It is located on Crowley's Ridge within the Mississippi River alluvial valley. The continuity of the valley floor is broken by various ridges, the longest and northernmost being Crowley's Ridge. Crowley's Ridge, which rises about 62 m. above the valley floor, consists of a bedrock core with rocks of Eocene age plus a small amount of Cretaceous rocks. Pliocene gravels (Lafayette) and loess overlay the bedrock (Croneis, 1930; Thornbury, 1965).

The stream is turbid with a very small volume of flow except where moderate amounts of effluents from a

TABLE I. FISHES OF LOST CREEK RANKED IN DECREASING ORDER OF ABUNDANCE, INCLUDED IN THE COLLECTIONS OF JACKSON AND BEADLES, 1966 (J) BEADLES, 1970 (B).

	STATION I		STATION II		STATION III		STATION IV		STATION V	
	J	B	J	B	J	B	J	B	J	B
Lepomis cyanellus	-	10	-	1	-	3	16	51	6	1
Notropis umbratilis	-	-	-	-	-	-	43	48	-	-
Notemigonus crysoleucas	-	-	-	-	-	-	33	4	-	-
Fundulus olivaceus	-	2	-	-	-	-	-	20	-	-
Ictalurus melas	-	-	-	-	-	-	-	12	1	3
Semotilus atromaculatus	-	-	-	-	-	-	3	-	-	-
Erimyzon oblongus	-	-	-	-	-	1	1	-	-	-
Gambusia affinis	-	-	-	-	-	-	-	1	-	-

slaughterhouse and domestic effluent enter the stream. There has not been much detectable change in the stream between the two sampling periods. The average daily sewage load has increased approximately 982,800 liters over the 1966 sampling period. In 1966, Jackson and Beadles collected six species of fishes, and seven species were collected in 1970. A total of eight species was taken between the two sampling periods (Table 1).

The stream was divided into five sampling stations. A "common-sense" minnow seine was utilized in taking these samples.

Station I: Located at S35T15NR4E (Fig. I) was in the headwaters and had moderate flow with a large amount of sand, mud, and parent material.

Station II: Located at S3T15NR4E (Fig. 1) had moderate flow, and the stream bottom was clay and parent material.

Station III: Located at S22T14NRAE (Fig. 1) had moderate flow, and the stream bottom was sand, clay, and parent material.

Station IV: Located at S8T14NR4E (Fig. I) had moderate flow, and the stream bottom was clay, mud, and parent material.

Station V: Located at S13T14NR3E (Fig. I) and continued to the confluents of Big Creek. The stream bottom was sand, mud, clay, and parent material.

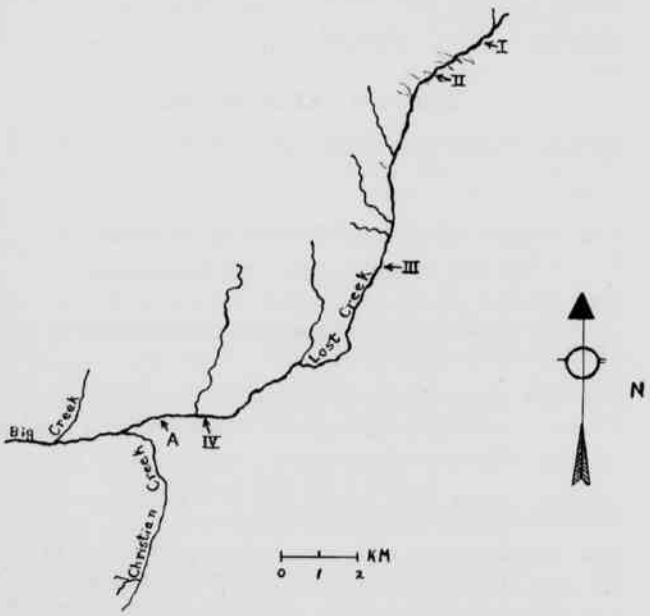


Fig. 1. Lost Creek, Craighead County, Arkansas. Stations I, II, III and IV are above the effluent outfalls. Station A represents the area of effluent outfalls. Station V is from Station A to the confluence of Lost and Big Creeks.

The two species of fishes collected in the headwaters of Lost Creek were **Lepomis cyanellus** and **Fundulus olivaceus.** Since **F. olivaceus** and **Gambusia affinis** can utilize surface oxygen, and **L. cyanellus** appears to be acclimated to harsh environmental conditions, these fishes were probably immigrating upstream utilizing more of the available habitats.

Notropis umbratilis and **Notemigonus crysoleucas** were abundant directly above the effluent outfalls at Station IV, and it would appear that they had less tolerance than **L. cyanellus** and **F. olicaceus** to the heavier silt load in the headwaters.

Ictalurus melas was found at Station IV directly above the effluent outfalls; however, like **L. cyanellus** they were the only species that were tolerating the sewage and slaughterhouse effluents.

Three specimens of **Semotilus atromaculatus** were collected by Jackson and Beadles (1966); however, this species was not found during the 1970 sampling period. A single specimen of **Erimyzom oblongus** was taken from Station III in 1970 and from Station IV in 1966.

Many of the fishes utilizing Lost Creek enter from Big Creek during heavy discharges of runoff water. This increased flow dilutes the effect of the effluents; however, some of the immigrating fishes become trapped as the water recedes following the heavy rains.

Since there were two small farm ponds within the water shed above the effluent outfalls, **L. cyanellus, N. crysoleucas** and **I. melas** could have escaped from the ponds and been trapped above the effluent outfalls. Some fishes have been found to tolerate moderate amounts of domestic effluents, and it is possible that the two species, **L. cyanellus** and **I. melas** collected within the effluents, were more resistant than the other species of fish collected within Lost Creek.

Acknowledgements

I would like to thank Mr. James T. Jenkins, Mr. Ronald E. Jackson, Mr. John M. Ransom and Mr. Daniel W. Doshier for their assistance in taking these samples.

Literature Cited

Croneis, C. 1930. Geology of the Arkansas Paleozoic Area. Arkansas Geological Survey. Bull. 3. Little Rock, Arkansas. 457 p.

Jackson, R. E. and J. K. Beadles. 1966. Spring Distribution Survey of Fishes in a Polluted Stream in Northeast Arkansas. Unpublished research paper. Arkansas State University Library. 10 p.

Thornbury, W. D. 1965. Regional Geomorphology of the United States. John Wiley and Sons, Inc., New York. 609 p.

The Butterflies of Arkansas Family Nymphalidae

E. Phil Rouse, Entomology Department

University of Arkansas, Fayetteville, Arkansas 72701

The members of the family Nymphalidae vary in color from orange marked with black to shades of blue and purple. They can usually be separated from other families by the greatly reduced front legs; the cubitus appearing three-branched; and the presence of scales on the definitely clubbed antennae.

Families likely to be confused with the Nymphalidae are Libytheidae, Danaidae, Pieridae, and Satyridae. These families can be distinguished by the following characters. The Libytheidae have extremely long palpi, longer than the thorax and extending forward. The Danaidae have scaleless antennae. The Pieridae have well developed front legs with bifid claws. The Satyridae have the base of the wing veins greatly swollen.

The larvae of the family Nymphalidae do not bear fleshy filaments although many have branching spines. The pupae have many projections and hang unsupported from the cremaster attached to hidden surfaces.

For clarity a phylogenetic list according to Dos Passos of the Nymphalidae in Arkansas follows.

SUBFAMILY CHARAXINAE

Anaea andria Scudder. Goat weed butterfly

SUBFAMILY APATURINAE

Asterocampa celtis (Boisduval & LeConte). Hackberry butterfly

Asterocampa clyton (Boisduval & LeConte). Tawny emperor

SUBFAMILY LIMENITIDINAE

Limenitis (Limenitis) **astyanax** (Fabricius). Redspotted purple

Limenitis (Limenitis) **archippus** (Cramer). Viceroy

SUBFAMILY VANESSINAE

Vanessa atalanta (Linnaeus). Red admiral
Vanessa virginiensis (Drury). American painted lady
Vanessa cardui (Linnaeus). Painted lady
Junonia coenia (Hubner). The buckeye

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

SUBFAMILY NYMPHALINAE

Nymphalis antiopa (Linnaeus). Mourning Cloak
Polygonia interrogationis (Fabricius). Question mark
Polygonia comma (Harirs). Hop merchant or comma
Polygonia progne (Cramer). Gray comma

SUBFAMILY MELITAEINAE

Phyciodes (Tritanassa) **texana** (Edwards). Texan crescent
Phyciodes (Phyciodes) **tharos** (Drury). Pearl crescent
Phyciodes (Phyciodes) **gorgone** (Hubner). Phaon crescent
Melitaea (Microtia) **nycteis** Doubleday. Silver checkerspot
Melitaea (Microtia) **ismeria** Boisduval & LeConte. Ismeria checkerspot
Euphydryas phaeton (Drury). The Baltimore

SUBFAMILY ARGYNNINAE

Speyeria (Semnopsyche) **cybele** (Fabricius). Great spangled fritillary
Euptoieta claudia (Cramer). Variegated fritillary

SUBFAMILY HELICONIINAE

Agraulis vinillae (Linnaeus). Gulf fritillary

KEY TO THE GENERA AND SPECIES OF THE NYMPHALIDAE OF ARKANSAS

1. a. Distal margin of the front wing straight or convex, wing tip rounded 2
   b. Distal margin of the front wing deeply concave or deeply emarginate usually with a ragged appearance 7
2. a. Large wing spread 3.3 to 3.7 inches. Yellow-brown background above with black marking. Six dark round spots in apical third of the front wing. No round spots near base .... **Speyeria cybele** (Fabricius)
   b. Small to medium wing spread, 1 to 2 inches 3
3. a. Background black above checkered with white and orange-brown spots. Bluntly pointed front

wing with distal margin straight. Wing spread 2 inches ..... **Euphydryas phaeton** (Drury)

b. Checkered with orange-bronw and brown above. Wing-spread 1 to 1½ inches 4

4. a. Darkly checkered with orange-brown and brown above with a narrow medial band of white extending from the leading edge to the posterior edge of the front wing .... **Phyciodes gorgone** (Edwards)

b. Medial light band in front wing above, never white, usually orange-brown 5

5. a. Orange-brown medial band in front wing less than ⅛ inch wide. Heavily mottled basically with orange-brown on a dark background .... **Phycoiodes tharos** (Drury)

b. Orange-brown medial band in front wing above over ⅛ inch wide. 6

6. a. Submarginal row of black dots in hind wing above has at least one with a white center ..... **Melitaea nycteis** Doubleday

b. Submarginal row of dots in hind wing without white centers .... **Melitaea ismeria** (Boisduval & LeConte)

7. a. Front wing more than twice as long as wide, wing tip bluntly rounded, orange-brown above marked with black, and with three dark spots with white centers near the anterior margin basically ..... **Agraulis vinillae** (Linnaeus)

b. Length of front wing less than twice its width 8

8. a. Front wing falcate, reddish-orange above margined with black distally; short tails on the hind wing ..... **Anaea andria** (Scudder)

b. Front wings not falcate; with or without tails 9

9. a. Wing margin deeply emarginate distally; wing tips may be rounded or ragged at the apex 10

b. Wing margin distally not or only shallowly emraginate; wing tip never ragged 15

10. a. Wings above purple, edged with gold distally. Wing spread 2½ to 3 inches .... **Nymphalis antiopa** (Linnaeus)

b. Color variable, but never purple edged with gold 11

11. a. Front wing about black with orange-red and white markings. An orange-red medial bar extending diagonally across the front wing. The hind wing above black with an orange-red tip with tiny black dots ..... **Vanessa atalanta** (Linnaeus)

b. Never black with an orange bar across the front wing. Background color variable 12

12. a. Very dark brown to black above with orange mottling basically. One deep emargination in front wing with the tip rounded. Wing spread 1½ inches ..... **Phyciodes texana** (Edwards)

b. Never very dark orange above overlaid with orange-brown markings; anterior wing margins ragged 13

13. a. Silver dot following a silver comma forming the question mark on the underside of the hind wing. Wing spread 2¼ to 2¾ inches .... **Polygonia interrogationis** (Fabricius)

b. Silver mark on underside of hind wing comma-shaped without a silver dot. Wing spread 1¾ to 2 inches 14

14. a. Underside of wings mottled with brown .... **Polygonia comma** (Harris)

b. Underside of wings mottled with gray .... **Polygonia progne** (Cramer)

15. a. Background color above dark blue anteriorly fading into pale blue on the posterior half of the hind wing. Red spots on the underside of the front wing show through, marking the wing above with faint red spots. Wing spread 2½ to 3 inches .... **Limenitis astyanax** (Fabricius)

b. Color variable, but never dark blue fading into pale blue on the hind wing 16

16. a. A black band medial across the veins of the hind wing. Background color orange-brown with the distal margins black with white spots ..... **Limenitis archippus** (Drury)

b. Without a narrow black band above on the hind wing. Color variable 17

17. a. Yellow-brown with black markings, and with five round black spots above in the apical 1/3 of the front wing .. **Euptoieta claudia** (Cramer)

b. Without five round black spots above in apical 1/3 of front wing. 18

18. a. Two eyespots above on front wing on a brown background, one of them large the other small, and with a bar of white diagonally between them ..... **Junonia coenia** (Hubner)

b. Less than two eyespots above on the front wing 19

19. a. One black eyespot above on the front wing on a light gray-brown background with white irregular medial spots .... **Asterocampa celtis** (Boisduval & LeConte)

b. Without eyespots above in front wing 20

20. a. Orange-brown above with dark markings. Never

with any white markings or eyespots in the front wing. Round dark spot in the hind wing. .... **Asterocampa clyton** (Boisduval & LeConte)

b. Front wing above mottled with orange, black, and white 21

21. a. At least 2 of the 4 submarginal eyespots in the hind wing above have blue centers. A broad medical band of orange-brown extends from the anterior margain 2/3 of the way across the hind wing above; two eyespots are blue in the hind wing. .... **Vanessa virginiensis** (Drury)

b. The 4 round black spots in the hind wing above are without blue centers. Never with a broad medial band of orange-brown above in the hind wing; 4 eyespots below on the hind wing. ..... **Vanessa cardui** (Linnaeus)

The members of the family Nymphalidae vary greatly in their appearance, habits, and environments. Thus, only a few generalizations can be made. The majority are fast, strong fliers, and visit flowers freely where they may be collected. Of the twenty-two species listed from Arkansas, eighteen are common, with only four uncommon or local in distribution. Strays into the state are rare, except along the borders, and are not included.

Anaea andria Scudder, the goat weed butterfly, is easily recognized by its falcate, reddish-orange wings edged in dark brown to black. The hind wing is tailed. Sexual dimorphism is present. The females are patterned with more dark medial markings above in both wings.

The grayish green larva, tapering posteriorly, is covered with fine raised points. It feeds on crotons or goatweed **(Croton sp.)** and has two broods yearly. The adults hibernate in winter, coming out in April.

Asterocampa celtis (Bois. & LeC.), the hackberry butterfly, is orange-brown with black and white spots. The hind wing is somewhat pointed.

Asterocampa clyton (Bois. & LeC.), the tawny emperor, is very similar to **A. celtis,** but lacks the white spots and the single black spot above on the front wing. Larvae of both species feed on hackberry where the adults linger after emergence. This genus overwinters as half-grown larvae. The adults emerge in June.

Limenitis astyanax (Fab). The red-spotted purple is easily recognized by its dark blue front wing with the red spots beneath showing through above. It is usually found in or near open wood feeding on carrion or other decaying organic matter. Food habits of the larva are varied, but willow and poplar are preferred.

There are three broods yearly, and the adults appear in May.

Limenitis archippus (Cramer) the viceroy, is often called the mimic because it resembles the monarch butterfly. It can be readily separated from **L. astyanax** by its orange-brown color and the presence of a black line across the middle of the hind wing. Its food preference and life habits are similar to **L. astyanax.**

Vanessa atalanta (Linnaeus), the red admiral, is easily recognized by the bright orange-red band across the front wing and the outer margin of the hind wing. The larvae are found singly in a folded leaf of its primary food plants which are the nettles or other members of the nettle family (Urticaceae). There are two broods yearly and the adults appear in late spring.

Vanessa virginensis (Drury), the American painted lady, is separated from **Vanessa cardui** (Linnaeus) by the coloring of the spots on the hind wing. At least one of the four spots of **V. virginensis** are larger than the other and have blue centers with only two of the eyespots repeated in the hind wing below.

Vanessa cardui (Linnaeus), the painted lady, is found in nearly all environments if open and brightly lighted. It can be separated from **V. virginensis** by the spots above and below on the hind wing. The four spots above are uniform in size and color, and are repeated below as four eyespots. The larvae are chiefly feeders on **Compositae** especially sunflowers **(Helianthus)** where they reach economic importance on sunflowers as a crop.

Junonia coenia (Hubner), the buckeye, is very common and widespread in the United States It is readily recognized by the two eyespots of different size on both front and hind wings. The larger of these eyespots in the front wing is partly circled by a white medial bar. Enough orange markings are present to give an orange tinge to the wing color. The olive-gray striped yellowish larvae feed on varied plants with no well-defined host. The adults live over winter and are somewhat migratory.

Nymphalis antiopa (Linnaeus), the mourning cloak, is a medium-large beautiful butterfly with purple wings edged in gold. It emerges from hibernation quarters very early in the spring. It is often seen on forest roads flying up as it is approached, and is probably the first butterfly to be seen each year. The black spiny larvae feed extensively on willow and will defoliate the tree when numerous, though they are not host-specific.

Polygonia interrogationis (Fabricius), is a medium sized orange-brown butterfly. This species is known as the question mark due to the silvery mark on the under side of the hind wing resembling this symbol. The edges of the wings are deeply emarginate and irregular giving the wing a ragged appearance.

The larval food includes both woody and non-woody plants. As many as five broods yearly are reported. Adults appear in April.

Polymonia comma (Harris), known as the comma, is separated from other members of this group by the brown underside of the wings and the silver comma without a silver dot.

The larva are not host-specific. It has two to three broods yearly.

Polygonia progne (Cramer), the gray comma, is very similar to **P. comma** (Harris), but differs in that the underside of the wings are gray, never brown. Larvae feed extensively on gooseberry. There are two broods yearly.

Phyciodes texana (Edwards), the Texan crescent, is easily separated from other members of this genus because of its deeply emarginated front wing with its dark brown, black, and white checkering. Wing spread is usually about 1¼ to 1½ inches.

Phyciodes tharos (Drury), the pearl crescent, has only slightly over 1 inch wing spread. The rounded front wing is greyish brown checkered with yellow. The medial yellow band across the front wing is less than ⅛ inch wide in the Arkansas species.

Phyciodes gorgone (Edwards), the phaon crescent, can be recognized by its small size of about 1 inch wing spread, and the narrow white medial band above on the front wing.

Militaea nycteis Doubleday, the silvery checkerspot, is larger than **P. tharos** and **P. gorgone** and has about 1½ inch wing spread. The medial orange-brown band on the front wing is over ⅛ inch wide. At least two of the submarginal black spots above on the hind wing have white centers. The larvae feed on sunflowers **(Helianthus)**, asters **(Aster)**, and **(Actinomeris)**. There are two broods in the south, and adults emerge in June.

Melitaea ismeria Boisduval & LeConte, the ismeria checkerspot, is separated from **M. nyceteis** Doubleday by having black submarginal spots without white centers.

Euphydryas phaeton (Drury), the Baltimore, is easily recognized by its larger size; about 2 inches in wing spread; and its dark black, brown, and white checkered front wing. It is wide-spread in the U.S., but very local. It occurs only in the vicinity of its preferred host, turtlehead **(Chelone glabra)**. The larvae feed in a communal web where they hibernate. The adults are found in May and June.

Speyeria cybele (Fabricius), the great spangled fritillary, is our largest Nymphalid butterfly. It has a wingspread of 3.3 to 3.7 inches. Its size and the six submarginal black spots with black medial zigzag markings on an orange-brown background separate it from **Euptoietea claudia (Cramer)**. **Euptoietea claudia** (Cramer), known as the variegated fritillary, is smaller than **S. cybele.** It has usually less than 3 inches of wing-spread and has only 5 medial black spots on a mottled yellowish background. It feeds on violets and pansies, sometimes becoming very destructive. There may be two or three broods yearly.

Agraulis cinillae, (Linnaeus), the gulf fritillary, is our only member of the subfamily Heliconiinae in the state. It is orange-brown with dark spots on a long pointed front wing. The length of the front wing is more than twice its width. The larvae feed on passion flowers **(Passiflora)** where three or more broods develop yearly. The adults appear as early as February or March in Florida, but the emergence date has not been established in Arkansas.

PARTIAL BIBLIOGRAPHY

Masters, John H. 1967. Observations on Arkansas Rhopalocera and a list of species occurring in Northeastern Arkansas. Journ. of Lepidopterist's Society, Vol. 21. No. 3, pp. 206-209.

Dos Passos. 1969. A synonymic list of the Nearctic Rhopalocera. The Lepidopterist's Society, Mem. No. 1, pp. 38-50.

Comstock, John Henry. 1962. Ninth edition revised. An introduction to Entomology. The Vail-Ballou Press Inc., Binghamton, New York, 1064 p.

Ehrlich, Paul R., and Anne H. Ehrlich, et al. 1961. How to know the butterflies. Wm. C. Brown Co. Publishers, Dubuque, Iowa, 262 p.

Klots, Alexander B. 1960. A field guide to the butterflies of North America, East of the Great Plains. Houghton Mifflin Co., Boston, 349 p.

McDunnough, J. 1938. Check list of the Lepidoptera of Canada and the United States of America. Vol. 1, part 1. pp. 7-11.

Holland, W. J. 1916. The butterfly book. Doubleday, Page & Co. Garden City, New York, 382 p.

Apparatus For Dielectric Constant Measurements and Measurements For Water-Methanol Mixtures

By James O. Wear
Central Research Instrument Program, Veterans Administration Hospital
Little Rock, Arkansas 72206

Abstract

A system for measuring dielectric constants has been constructed using a Sargent Oscillometer and an air bath for temperature control. The design and construction of the air bath as well as the temperature control achieved with it are described. The overall performance of the system including a computer program for forming the calculations is described. The system is one that requires calibration using two or more standard solvents and is good for both conducting and non-conducting liquids. Data are presented for water-methanol mixtures at 25 degrees with several points near pure methanol and also near pure water.

Introduction

Dielectric constants of pure and mixed solvents are frequently needed to treat kinetic data, electrolyte measurements, and other data in solutions. Values are tabulated for most pure solvents (1) at the more common temperatures, but this is not true for many mixed solvents except water-alcohols (2). With more and more work being done at high and low temperatures, even values for pure solvents frequently need to be measured.

Since the apparatus generally used for measurement of dielectric constants are large, delicate and relatively expensive (2-6), few laboratories are equipped to make these measurements. The major constraint is the space required and the fact that the apparatus cannot be set up and taken down conveniently.

Most systems that have been used are for direct measurement of dielectric constant, but there is a commercial device with which measurements can be made relative to two standards. This device is a Sargent Oscillometer. The Oscillometer is very compact but is not equipped for temperature controlled measurements.

This paper discusses the design of a temperature bath for the Sargent Oscillometer, a computer program for data analyses, and measurements of water-methanol mixtures with the system.

Temperature Bath

Dielectric constant depends on temperature according to the following relationship (7):

$$D = D_0 e^{-LT} \qquad (1)$$

where D is the dielectric constant, T is the absolute temperature, and D_0 and L are constants for a given solvent. Values of D_0 and L for typical standard solvents are presented in Table I.

TABLE I

Constants for the Equation $D = D^0 e^{-LT}$ for Standard Solvents (7)

Solvent	D_0	$Lx10^3$
Benzene	2.95	0.876
Methanol	157.6	5.39
Nitrobenzene	164.7	5.21
Water	311.17	4.63

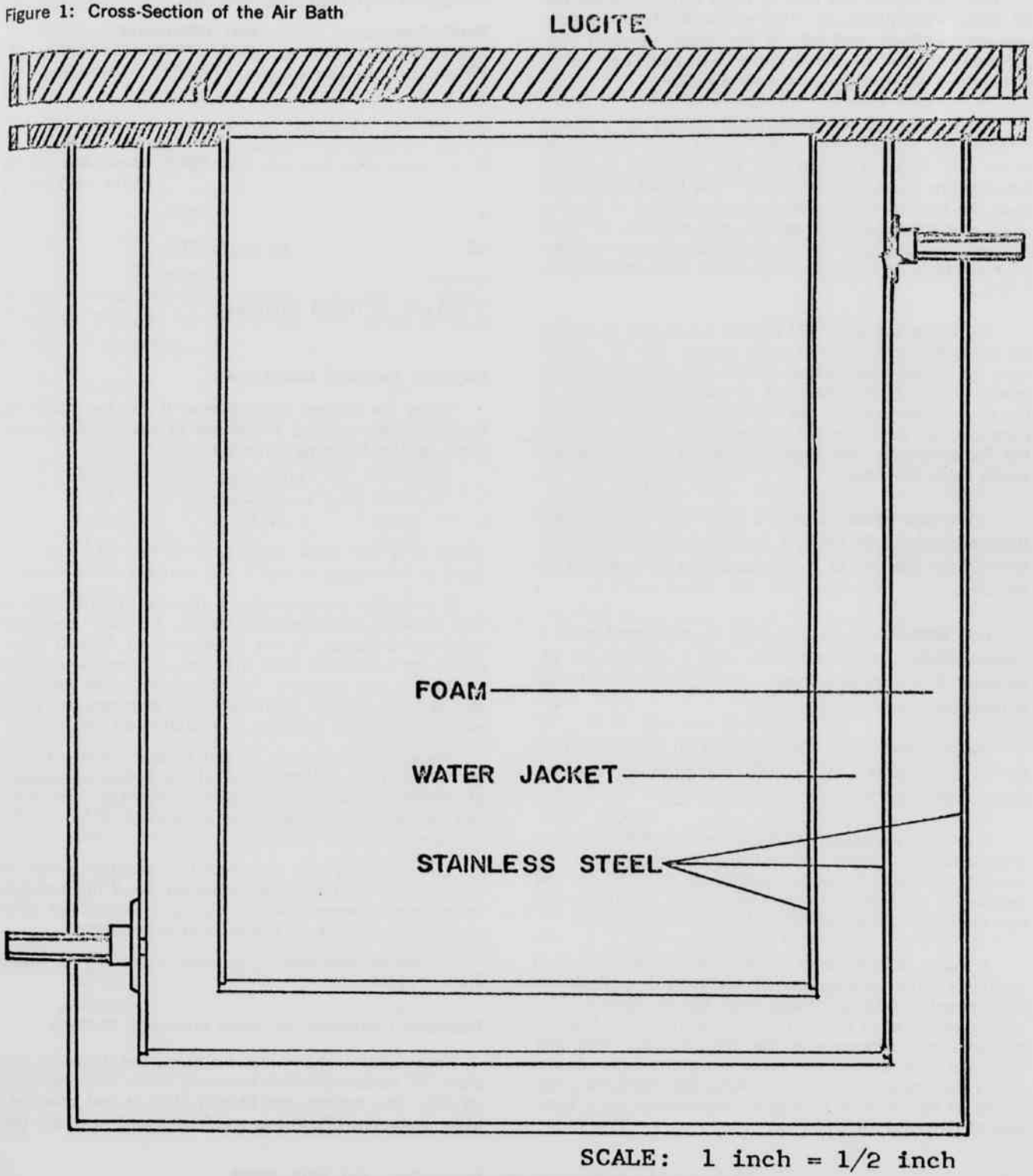
At any given temperature, close temperature regulation is only important for precise dielectric constant measurements. For nitrobenzene, D is only decreased 0.18 units for a temperature change from 298°C to 299°C. The same temperature change decreases D for water by 0.35 units. However, since many studies where dielectric constants are needed are over wide temperatures ranges, the dielectric constant must be measured over a wide range. For various mixed solvents, a range of at least -20 to 100°C is desirable since this is the most common range for kinetic and other studies in solutions.

Because of the design of the oscillometer and its cells, the bath media has to be air or some other gas. The cell electrodes are externally applied metal coated areas which will cause fringe electrical loss in conduct-

ing media such as water. This media requirement was the principal consideration for the bath design. A static system was chosen for easier temperature control since slow equilibration could be tolerated.

The design chosen for the bath is a large jacketed container where the cell could be placed in an air medium that would be maintained at a constant temperature. Figure 1 is a cross-sectional view of the bath.

Figure 1: Cross-Section of the Air Bath



The bath is constructed of stainless steel so that the problems of corrosion from the circulating liquid are minimized.

The first wall of the bath is filled with Lockfoam No. BX-105-B6 for insulation. This one inch of foam insulation reduces heat exchange to the room. A room temperature variation of two degrees centigrade has no effect on the temperature of the air medium.

The liquid used for temperature control is circulated through the second wall. This liquid is a mixture of water and ethylene glycol and can be used over the temperature range -30° to 150°C. The liquid is pumped in at the bottom of the wall and pumped out at the top at a rate of about two gallons per minute. A short fluctuation of 0.2°C in the circulating liquid has no measureable effect on the cell temperature at thermal equilibrium.

The lid to the bath is made of Lucite and is bolted on to the lip of the bath at eight points. An "O" ring is used for a tight seal so that air movement to the atmosphere is minimized. There is a hole in the center of the lid to allow entry of the thermocouple and the cable from the cell holder to the oscillometer. The cable and the thermocouple pass through a No. 3 rubber stopper which seals the hole.

The cell holder is placed in a resin stand of low thermal conductivity so that basically no heat is transferred from the cell to the walls of the bath except by the air.

The temperature in the bath is monitored with a copper-constantan thermocouple with a melting ice reference. A K-3 potentiometer with a D-C null detector is used for measuring the EMF.

The described bath was operated at 25.00°$\pm$0.05°C for several weeks. In general, the deviation was approximately 0.01°C.

A sample previously thermostated at 25°C and then transferred to the cell in the bath requires about thirty minutes to reach thermal equilibrium at 25°C. If the sample is at room temperature (22°C), approximately one hour is required to attain thermal equilibrium.

A major concern with a static air bath is thermal gradients. The temperature of the bath was measured at different depths and these data are in Table II. The maximum variation of the EMF in the region of the cell amounts to a difference of less than 0.02°C. This data indicates that at thermal equilibrium the bath design meets the requirements for measuring dielectric constants of liquids with a Sargent Oscillometer as a function of temperature.

TABLE II

Temperature as a Function of Depth in the Air Bath. Temperature Given as EMF with a 0.0° Reference Using a Copper-Constantan Thermocouple

Depth (inches)	EMF (Millivolts)*	
Top	0.9800	
2	0.9845	
4	0.9872	
6	0.9901	(Maximum Height of the cell)
8	0.9894	
10	0.9900	
Bottom	0.9900	

* (25.0°C = 0.990 millivolts)

Dielectric Constant Calculations

Using the Sargent Oscillometer, it can be shown (8) that the scale reading is related to the dielectric constant by the following equation:

$$S = \frac{A(D - 1)}{1 + BD} \qquad (2)$$

where S is the scale reading, D is the dielectric constant of the liquid, A and B are complex cell constants.

A computer program was written in FORTRAN IV so that several measurements taken for two standards could be averaged, A and B determined, and D determined for unknowns from averages of several measurements. In this manner, four place dielectric constants should be calculated statistically and standard deviations established. (This program is available on request.)

Equation 2 is limited in that organic standards cannot be used for determination of the dielectric constant of conducting solutions. However, methanol and water can be used as standards for conducting solutions if a precision of a few tenths of a percent is acceptable.

Using the system for dielectric constant measurements, the best results are obtained when the unknown values are between the two standard values. In other words, interpolation is better than extrapolation.

A similar procedure has been used for a water-ethanol system (9).

Dielectric Constants for Water-Methanol Mixtures

In order to test the entire system, the dielectric constant of water-methanol mixtures were determined at 25.0°C. This system was chosen since it had previously been measured (2) at ten weight percent intervals over

the entire range. There also was some interest in possible discontinuous changes in dielectric constant near pure methanol and pure water since some electrochemical measurements appeared to be discontinuous in these regions (10).

Triply, glass distilled water and redistilled spectrograde methanol were used as standards as well as solution preparation. The nitrobenzene was vacuum distilled (11).

Using methanol and water as standards, the dielectric constant for nitrobenzene was found to be 34.85 at 25°C which is in good agreement with the NBS value (1) of 34.82.

TABLE III

Measurements for the Dielectric Constant of Water-Methanol Mixtures at 25.0°C as a Function of Mole Fraction of Methanol

N_{MeOH}	D_{25}
.9773	33.4_5
.9548	34.1_2
.9346	34.7_6
.9141	35.3_9
.8935	35.9_5
.8736	36.5_4
.8547	37.0_8
.8354	37.7_3
.8176	38.3_0
.7994	38.8_3
.6400	43.7_5
.5092	48.5_2
.3999	53.5_5
.3076	58.2_3
.2283	62.6_8
.1600	66.9_9
.09988	71.3_3
.04715	74.8_0
.04185	75.1_3
.03716	75.8_3
.03262	76.1_1
.02773	76.3_4
.02291	76.7_0
.01836	77.1_4
.009131	77.8_6

All water-methanol mixtures were prepared in 100 ml volumes by weight. Mole fractions of methanol were calculated from these weights which were corrected for air buoyancy.

The data for water-methanol mixtures at 25°C are presented in Table III. These data are in good agreement with the data of Akerlof (2) below a mole fraction methanol of 0.4, but are higher at higher mole fractions. However, Akerlof's data has a dielectric constant of 31.5 for pure methanol which is below the 32.63 value in the NBS Circular No. 514. The data in Table III extrapolate to a value of 32.7 for pure methanol which is in good agreement with the NBS value.

The water-methanol data product a smooth curve with no discontinuities at either extreme which means that the electrochemical results must be explained by something other than bulk dielectric constant changes.

REFERENCES

1. A. A. Maryott and E. R. Smith
Table of Dielectric Constants of Pure Liquids
N.B.S. Circular No. 514

2. G. Akerlof
J. Amer. Chem. Soc. **54,** 4125 (1932)

3. A. Piekara
Acta Phys. Polon. **18,** 361 (1969)

4. E. A. S. Cavell, H. G. Jerrard, B. A. W. Simmonds and J. A. Speed
J. Phys. Chem. **69,** 3657 (1965)

5. W. Dannhauser and A. F. Flueckinger
J. Phys. Chem. **68,** 1814 (1964)

6. H. R. Davidson
J. Chem. Educ. **27**, 598 (1950)

7. E. A. Moelwyn-Hughes
Physical Chemistry, 2nd Ed., Pergamon Press (New York) (1964) p. 854

8. P. H. Sherrick, G. A. Dawe, R. Karr, and E. F. Ewen
Manual of Chemical Oscillometry
Published by E. H. Sargent & Co. (1954)

9. M. L. LeHueron and C. R. Guerillot
Comp. rendus **258,** 2549 (1964)

10. S. L. Melton and E. S. Amis
J. Chem. Eng. Data **13,** 429 (1968)

11. E. M. Morimoto and M. Kahn
J. Phys. Chem. **68,** 201 (1964)

Simple Algebraic Extensions and Characteristics Polynomials

Don Stokes, Junior Mathematics
Arkansas Polytechnic College, Russellville, Arkansas 72801

Suppose that F(k) is a simple algebraic extension of a field F, formed by adjoining to F the single element k which is a root of the irreducible polynomial g(x) over F, where $g(x) = g_n x^n + g_{n-1} x^{n-1} + \ldots + g_1 x + g_0$. We know that if u is any element of F(k) then there exists a nonzero polynomial f(x) over F such that $f(u) = 0$. One method for finding f(x) has been to consider u as an element of the n dimensional vector space F(k) over F. $\{1, u, u^2, \ldots, u^n\}$ is a linearly dependent set in F(k). Therefore there must exist $a_0, a_1, \ldots, a_n \in F$ not all zero, such that $a_0 + a_1 u + \ldots + a_{n-1} u^{n-1} + a_n u^n = 0$, and u is a root of the polynomial $f(x) = a_n x^n + a_{n-1} x^{n-1} + \ldots + a_1 x + a_0$ over F. In order to present an alternate procedure for finding f(x), consider the following theorem and corollary.

Theorem: If A is any nth order matrix with characteristic roots $k_1, k_2, \ldots, k_n$, then A is similar to an upper triangular matrix P, where $(P)_{ii} = k_i$.

Corollary: If $k_1, k_2, \ldots, k_n$ are the characteristic roots of A, and m(x) is any polynomial in x, the characteristic roots of m(A) are $m(k_1), m(k_2), \ldots, m(k_n)$.

Now to find f(x), find the companion matrix A of the nomic polynomial $g_n^{-1} g(x)$: $A = C(g_n^{-1} g(x))$. Since u can be expressed in the form

$$u = m_{n-1} k^{n-1} + m_{n-2} k^{n-2} + \ldots + m_1 k + m_0 ,$$

u will be a root of the polynomial det(xI-M) where

$$M = m_{n-1} A^{n-1} + m_{n-2} A^{n-2} + \ldots + m_1 A + m_0 I.$$

This method simply considers u as the image of k under a particular polynomial, and since k is a characteristic root of $C(g_n^{-1} g(x))$, the preceding corollary assures a correct result.

REFERENCES

Murdoch, D. C. **Linear Algebra for Undergraduates.** New York: John Wiley & Sons, Inc., 1966.

Cullen, Charles G. **Matrices and Linear Transformations.** Reading, Mass.: Addison-Wesley Publishing Co., 1967.

Keesee, John W. **Elementary Abstract Algebra.** Boston: D. C. Heath & Co., 1965.

The Eddy Bluff Shelter of Beaver Reservoir of Northwest Arkansas

JAMES D. MORRISON
Dept. of Geology, University of Arkansas
Fayetteville, Arkansas 72701

INTRODUCTION

A bluff shelter on White River within the impoundment area of Beaver Reservoir near Springdale, Arkansas, was initially investigated by Paul S. Eddy, a University of Arkansas student interested in archeology. Several days of sifting through the material in the shelter provided an abundance of artifacts and animal bones which appeared to merit further investigation and description.

Although there has been extensive investigation of shelter assemblages with respect to artifacts and human occupation, little attention has been paid to animal remains. Such an investigation was undertaken and reported by Cleland (1965) on materials from several shelters in northwest Arkansas.

The Eddy Shelter is located on White River eight miles east of Springdale, Arkansas, and is one of many shelters in the Beaver Reservoir area. The shelter faces north and overlooks the lake from a point on a hillside fifty feet above the normal lake level. The mouth of the shelter is forty-six feet wide and its depth is thirty-nine feet (Figure 1). The ceiling rises to a maximum of seven feet. The origin of the shelter is believed to have been due to solution of a space in the lower part of the St. Joe limestone member of the Boone Formation. The floor of the shelter below the debris layer is on the Chattanooga Shale of Mississippian age. The greatest depth of debris is twelve feet.

Figure 1. Mouth of the Eddy Shelter, showing St. Joe Limestone.

Excavation Procedures were adapted from **A Guide to Archaeological Field Methods,** by R. F. Heizer, and from the advice of James A. Scholtz, Assistant Director of the Museum, University of Arkansas. Local "pot hunters" had removed small amounts of material from the shelter before the initial excavations for this survey were undertaken. An effort was made to prevent further intrusion by means of a notice concerning the nature of the work being done. This effort met with partial success. The initial excavations were mostly in the nature of a salvage operation. Because the shelter debris provides close association of artifacts and animal remains, it was decided that an additional orderly investigation would be made, involving control of location and depths from which material came. One test pit was excavated, with layers removed at six inch intervals. This pit was four and one-half feet square at the top. The walls sloped inward to a three and one-half foot square at the bottom (Figure 2). The slope of the pit walls provided support as a safety procedure. The pit was dug with a conventional trowel, with light furnished by a Coleman lantern. All material in the pit, as well as the rest of the shelter, was sifted through screens of one-quarter inch mesh, except that dampness of the clayey material in the lower levels of the pit made sifting impossible. A close and thorough inspection of this material had to suffice as a method of searching for any cultural or funal remains. Since the floor of the shelter had been lowered three feet before the pit was initiated, the uppermost part of the section, which contained most of the cultural and faunal material, was missing. This factor, combined with the fact that very little cultural material was obtained from the pit, eliminated the possibility of assembly of a meaningful cultural sequence.

Fallen rock from the ceiling of the shelter is intermingled throughout the deposits. Excavation of the pit indicates that there were intervals when rock fell from the ceiling in greater or lesser abundance. The concentration of rock in layers may represent times when larger

(1) Referred to in official records of the Arkansas Archeological Survey as 3WA146.

Figure 2. Excavated area of the Eddy Shelter, showing location of test pit in the left portion of the excavated area.

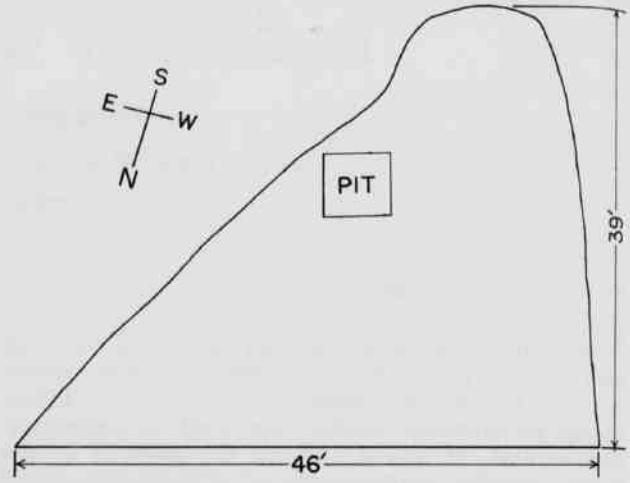


Figure 3. Floor plan of Eddy Shelter, showing location of pit.

amounts of water were seeping through the limestone, or when winter freezing was more intense, and thus may reflect variations in climate. (Figures 3 and 4).

Approximately 4,000 bones and bone fragments have been recovered from Eddy Shelter. These are principally the bones of animals hunted for food by the inhabitants. Among these are deer, woodchuck, raccoon, opossum, squirrel, turkey, and terrapin.

Some human remains were collected, but none seemed to be in what could be called a "burial", in that no artifacts were found in direct association with these remains. The bones occur in several places in the shelter and at different depths. Among them are fragments of foot, leg, and arm bones, and several pieces of skull, including two pieces of jaw with teeth.

Eight domestic pig teeth and three pieces of pig skull were recovered at levels from one to six feet. These pig remains have been investigated by Quinn (1970).

Quinn has pointed out that **Sus**, the Old-World pig, is believed to have been introduced into North America by Spaniards circa 1540 and that pig remains in pre-Columbian bluff shelter assemblages have systematically been attributed to intrusion of "recent" material into the older assemblages. In the Eddy Shelter, Quinn used the apparent association of pig remains with late Archaic to early Woodland projectile points, and with a Carbon 14 date of 2900 years before present to indicate presence of **Sus** in North America before 1492. Additional data may or may not substantiate this concept.

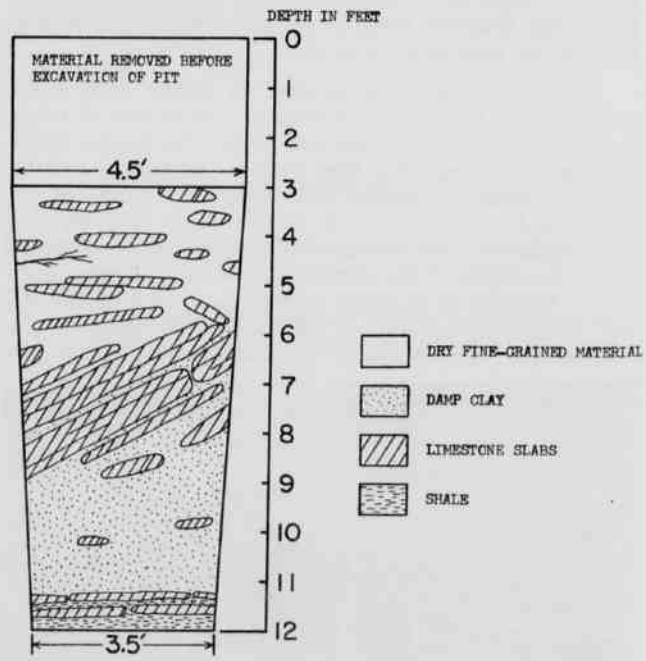


Figure 4. Profile of west wall of pit.

Journal of the Arkansas Academy of Science, Vol. 24 [1970], Art. 1

The bones from the shelter include remains of the following:

Class Mammalia	
Order Artiodactyla	
Family Cervidae	
Cervus canadensis	Elk
Odocoileus virgineanus	White-tailed deer
Family Suina	
Sus scrofa	Pig
Family Bovidae	
Ovis avies	Sheep (recent)
Order Carnivora	
Family Felidae	
Felis concolor	Cougar
Lynx rufus	Bobcat
Family Canidae	
Canis rufus	Red wolf
Canis latrans	Coyote
Vulpes fulva	Red fox
Urocyon cinereoargehteus	Gray fox
Canis familiaris	Indian dog
Family Procyonidae	
Procyon lotor	Raccoon
Family Mustelidae	
Mustela frenata	Weasel
Spilogale putorius	Stripped skunk
Order Marsupalalia	
Family Didephidae	
Didelphis marsupialis	Opossum
Order Insectivora	
Family Soricidae	
Sorex longirostris	Shrew
Family Tulpidae	
Scalopus aquaticus	Eastern mole
Order Lagomorpha	
Family Leporidae	
Sylvilagus floridanus	Eastern cottontail
Order Rodentis	
Family Sciuridae	
Sciurus carolininsis	Gray squirrel
Marmota monax monax	Woodchuck
Tamias striatus	Chipmunk
Family Castoridae	
Castor canadensis	Beaver
Family Cricetidae	
Neotoma floridana	Pack rat
Ondatra zebethicus	Muskrat
Peromyscus boylii	Mouse
Peromyscus leucopus	Mouse
Order Chiroptera	
Family Vespertilioindae	
Myotis lucifugus	Brown bat
Pipistrellus sublavus	Bat
Order Primates	
Family Hominidae	
Homo sapiens	Man
Class Aves	
Order Columbiformes	
Ectopistes migratorius	Passenger pigeon
Order Galliformes	
Meleagris gallopauo	Turkey
Class Reptilia	
Order Chelonia	
Terrapene carolina	Wood turtle
Class Pisces	
Aplodinotus grunnieus	Fresh water drum
Cyprinus carpio	Carp
Class Gastropoda	
Mesodon indianorum	Pulmonate snail
Class Pelecypoda	
Unio	Fresh water mussel

A very fine collection of artifacts was recovered from the Eddy shelter. A minimum of thirty-five projectile point styles have been recognized in the collection, as well as knives, scrapers, drill points, pottery fragments, and items of bone. The artifacts illustrated in plates one and two are but a small fraction of the total collection. Some of the point types not illustrated are Smith, Ellis, Marcos, Nodena, Johnson, and Williams.

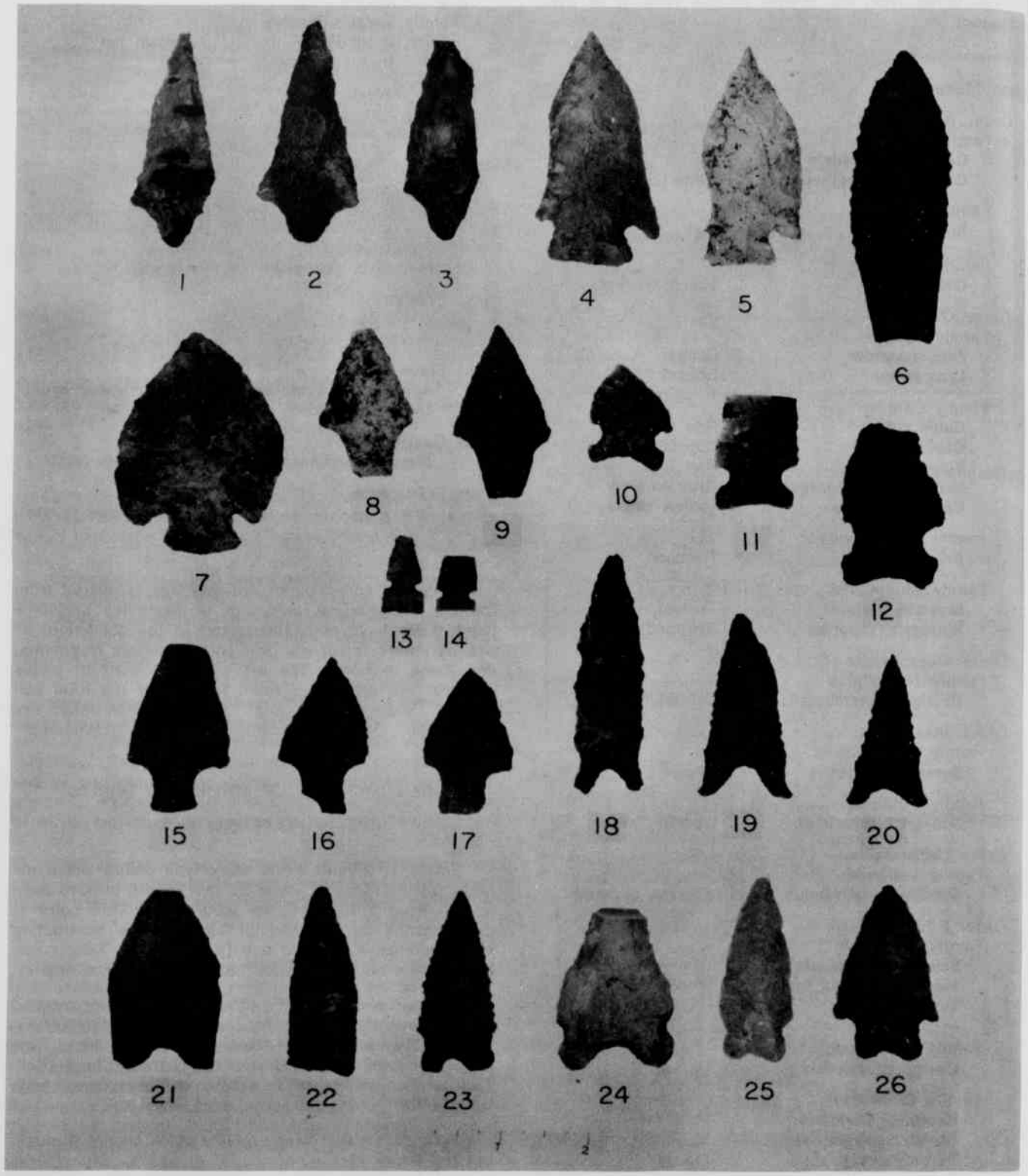
IDENTIFICATION OF PROJECTILE POINTS

PLATE ONE

Points 1, 2, and 3 are **Gary** type points which exhibits a wide range of variation and appear to have been in use from 2,000 B.C. to 1,000 A.D. This point is distinguished by a triangular blade and a contracting stem that has a rounded end (Bell, 1958). This is one of the most abundant types recovered from the shelter.

Points 4 and 5 are thin broad, deeply corner notched dart points with angularly recurved blade edges (Scholtz, 1967). They are named **Afton** points, and have a time range between 3,000 B.C. and the birth of Christ (Bell, 1958). Two points of this type were recovered from the shelter.

Point 6 is a fine **Searcy** point, which occurs throughout the Ozark area of northwest Arkansas. Characteristics of this point type are contracting stem, concave


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26


1
2
3
4
5
6
7
8
9
10
11
12
13

base, and convex bladge edges. Good workmanship is reflected in the delicate serrations of the blade, and the stem edges have been ground. The **Searcy** point was in use from 5,000 to 3,000 B.C. (Perino, 1968).

Point 7 has a broad ovate blade, a relatively small stem, and displays poor workmanship (Scholtz, 1967). The point compares with the CN4 Category of Scholtz, and has an estimated time range of 3-4,000 B.C. to 1,000 A.D.

Points 8 and 9 are **Langtry** points, which have an estimated age from an unknown time before Christ to around 1,000 A.D. This type point is one of the more abundant forms found in the Eddy Shelter assemblage. The point has a triangular blade and a long stem which terminates in a straight or concave base (Bell, 1958). Point 9 is a typical example of the **Langtry** point.

Points 10, 11, and 12 are varieties of the **Big Sandy** type point, which is distinguished by side notches and a slightly concave base. The blade is basically triangular in outline. The age range has been estimated from 5,000 B.C. to the time of Christ (Bell, 1960 . The three points shown are the only examples recovered from the shelter.

Points 13 and 14 exhibit thin profile, slightly concave base, and side notches. These points resemble the **Cahokia** and **Reed** points, which express considerable variation. They were in use about 900 A.D., thus they are one of the most recent types recovered from the shelter.

Points 15, 16, and 17 are of a widespread type known as **Table Rock** points. They are characterized by broad corner notches and an outline that has been compared to a "fir tree" by Scholtz. An estimated date for the point type is around 1,500 B.C. (Perino, 1968). Point 16 is a typical **Table Rock** point, including grinding and smoothing of all edges in the hafting area.

Points 18, 19, and 20 resemble the **Dalton** point which has a suggested range of 8,000 to 3,000 B.C. The three points shown are variations of the Dalton type point and are the only specimens recovered. The **Dalton** point is characterized by a triangular blade, which is beveled and serrated. The base is deeply concave and some display grinding or smoothing of the edges (Bell, 1958). Point 19 is the most typical example of this type point.

Points 21, and 22 have characteristics which compare to point styles of Late Paleo to Early Archaic age (around 8,000 B.C.). This factor, combined with the position of the points in the lower levels of the shelter, suggest that they are the oldest types recovered from the shelter.

Points 23 and 24 resemble the **Rice** point, which is abundant in the Ozark area of Arkansas, Missouri, and Oklahoma. The points are thick with triangular blades and slightly convex blade adges. Frequent resharpening causes the blade edges to become concave or recurved (Point 24). The corner notching and the concave base create a lobed effect. Other characteristics of the point are beveling and serrating of the blade and grinding in the hafting area. They were probably in use from 5,000 to 3,000 B.C. (Perino, 1968).

Points 25 and 26 are small to medium-sized dart points with slight shoulders, expanding stem, concave base, and well-rounded corner (Scholtz, 1967). These points are very similar to the **Uvalde** and **Frio** type points which were in use between 4,000 B.C. and 1,000 A.D.

ARTICLES OF STONE, BONE, AND POTTERY

PLATE TWO

Artifact 1 is the largest fragment of pottery recovered from the shelter. Many smaller pieces of pottery were collected but no pots could be reconstructed.

Artifact 2 is the shell of a land terrapin which has been smoothed on the inside and possibly used as a cup or dipper.

Artifact 3 is a "gorget" made of limestone which has been polished. It was worn around the neck for ornamentation or protection.

Artifacts 4 and 5 are fine awls or needles made from bone. They show much polishing from use.

Artifact 6 is the only complete fishhook recovered from the shelter. It is made from bone and illustrates good workmanship.

Artifacts 7 and 8 are parts of a necklace or bracelet which are made from teeth. Item 7 is made from a beaver tooth.

Artifacts 9 and 10 are blades fashioned from chert. Item 9 is thin suggesting use as a knife. Item 10 is thick, and was probably used as a scraper.

Artifacts 11, 12, and 13 are drill points displaying wide variation in style. Point 11 is probably a projectile point which has been reworked into a drill point.

ACKNOWLEDGEMENTS

Appreciation is due to Dr. James H. Quinn of the Department of Geology, University of Arkansas, and to James A. Scholtz, for their aid, interest, and advice. The permission of the landowner, Douglas Stone, for excavation is also appreciated, as well as the photography of James Edson.

REFERENCES

Bell, R. E. (1958), Guide to the Identification of Certain American Indian Projectile Points, Special Bulletin No. 1 of the Oklahoma Anthropological Society.

Bell, R. E. (1960), Guide to the Identification of Certain American Indian Projectile Points, Special Bulletin No. 2 of the Oklahoma Anthropological Society.

Cleland, C. E. (1965), Faunal Remains from Bluff Shelters in Northwest Arkansas, Bulletin of the Arkansas Archeological Society, Vol. 6, No. 2-3.

Heizer, R. F. (1958), A Guide to Archaeological Field Methods.

Perino, G. (1968), Guide to the Identification of Certain American Indian Projectile Points, Special Bulletin No. 3 of the Oklahoma Anthropological Society.

Quinn, J. H. (1970), Occurrence of **Sus** in North America, Geological Society of America, Vol. 2, No. 4.

Scholtz, J. A. (1967), Survey of Beaver Reservoir Area in Northwest Arkansas, M.A. thesis, University of Arkansas, Fayetteville.

Thomas, R. R. (1969), Breckenridge: A Stratified Shelter in Northwest Arkansas, M.A. thesis, University of Arkansas, Fayetteville.

Willard, Robert W. (1960), Bulletin of Arkansas Archeological Society, Vol. 1, No. 8, pp. 1-5.

INSTITUTIONAL MEMBERS

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

Arkansas College
Batesville

Arkansas Polytechnic College
Russellville

Arkansas State University
State University

College of the Ozarks
Clarksville

Harding College
Searcy

Hendrix College
Conway

Ouachita Baptist University
Arkadelphia

Southern State College
Magnolia

State College of Arkansas
Conway

University of Arkansas
Fayetteville

Westark Junior College
Fort Smith

INDUSTRIAL MEMBERS

The following organizations in the state of Arkansas contribute to and make possible the ongoing educational efforts of the Arkansas Academy of Science through their Industrial Memberships.

Murphy Oil Company
El Dorado

Journal of the Arkansas Academy of Science, Vol 24 [1970], Art. 1

ARKANSAS ACADEMY OF SCIENCE

Volume XXIV

Proceedings

1970

TABLE OF CONTENTS

	Page
Secretary's Report and Financial Statement	1
Program	3
Section Program	3
Abstracts of Collegiate Academy Papers	6
RICHARD B. HOOVER and MIRIAM J. HOOVER: Optical Phenomena in Diatoms	8
JAMES O. WEAR: An Undergraduate Research Program in Chemistry at Philander Smith College	10
MARTHA ANN ROLINGSON: Archeological Investigation of Bayou Bartholomew, 1969	13
STEPHEN E. ADAMS: Profiling Techniques in Archaeology	16
CHARLES E. JOHNSON: Art and Culture Among the Ashanti of Ghana	18
JOHN B. HUNER: A Classification of Some European Trade Beads from Louisiana and Mississippi	24
GLORIA A. YOUNG: Reconstruction of an Arkansas Hopewellian Panpipe	28
RICHARD L. MEYER, JAMES H. WHEELER and J. R. BREWER: Freshwater Algae of Arkansas II. New Additions	32
DANIEL L. MARSH: Observation of Flowering in **Arundinaria gigantia** (Walt.) Chapm. in Arkansas	36
EDWIN B. SMITH: Additions to the Arkansas Flora	37
GARY TUCKER and BILL GRABILL: Floristic Elements of the Pope County, Arkansas, Area	39
JOE E. YATES: Land Use in Northwestern Arkansas: A Case Study	41
EUGENE B. WITTLAKE: **Glyptostrobus europas** (Brongn.) Heer in Arkansas	44
J. T. DANIEL and G. E. TEMPLETON: Enzymatic Evidence that Leucine from Tentoxin is Levorotatory	47
DAN TIMMERMANN, JR., HOWARD G. APPLEGATE and MARK ENDLEMAN: Macroscopic and Microscopic Responses of **Gossypium hirsutum** to Hydrogen Fluoride Fumigation	49
PEGGY RAE DORRIS: Observation on the Impact of Certain Insecticides on Spider Population in a Cotton Field	53
TOM N. PALKO: A Preliminary Study of Zooplankton Over a Six Month Period on Lake Dardanell	55
D. LEROY GRAY and RICHARD A. COLLINS: Age and Growth of the Blue Catfish, **Ictalurus furcatus,** in the Arkansas River	62
CHARLES LINCOLN and JACOB R. PHILLIPS: The Impact of Resistance on Cotton Insect Problems in Arkansas	66
J. W. ED WORTHAM and EARL L. HANEBRINK: A Road-Kill Census of Mammals in Northeastern Arkansas	67
JIM HOUSTON: Notes on the Habitat and Distribution of the Ondonata of Franklin County, Arkansas	69
JOHN K. BEADLES: The Effect of Domestic Effluent on Two Spring Surveys of Fishes in Lost Creek, Craighead County, Arkansas	74
E. PHIL ROUSE: The Butterflies of Arkansas Family Nymphalidae	76
JAMES O. WEAR: Apparatus for Dielectric Constant Measurements and Measurements for Water-Methanol Mixtures	80
DON STOKES: Simple Algebraic Extensions and Characteristics Polynomials	84
JAMES D. MORRISON: The Eddy Bluff Shelter of Beaver Reservoir of Northwest Arkansas	85