INSTITUTIONAL MEMBERS

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

Arkansas College Batesville
Arkansas Polytechnic College Russellville
Arkansas State University State University
College of the Ozarks Clarksville
Harding College Searcy
Henderson State College Arkadelphia
Hendrix College Conway

Ouachita Baptist University Arkadelphia
Southern State College Magnolia
State College of Arkansas Conway
University of Arkansas Fayetteville
University of Arkansas at Little Rock
Westark Junior College Fort Smith

COVER PHOTO: Laboratory Science Building on the campus of Arkansas State University, site of the 1973 paper sessions of the Arkansas Academy of Science.
Secretary's Report

MINUTES OF THE FIFTY-SEVENTH ANNUAL MEETING - APRIL 6-7, 1973

FIRST BUSINESS MEETING

The first business meeting of the 57th Annual Meeting of the Arkansas Academy of Science was called to order by Dr. Eugene Wittlake, President of the Academy, at 10:30 a.m., April 6, 1973, at Arkansas State University, Jonesboro. Dr. Wittlake welcomed the members to the meeting and announced that Dr. Carl Reng, President of Arkansas State University, would formally welcome the membership to the campus at the banquet to be held on the evening of April 6 in Reng Center, Arkansas State University.

President Wittlake then called for reports from the officers of the Academy and from representatives of organizations sponsored by the Academy.

Secretary:

The Secretary reported that the minutes of the 56th meeting held at the University of Arkansas, April 7-8, 1972, were being printed in the Proceedings, Volume 26, which was in preparation. Mimeograph copies of the minutes were being distributed at the registration table. A motion to approve the minutes would be made at the second business meeting.

The Secretary discussed membership by section. There were 189 dues-paying members in 1970, 136 in 1971, and 144 in 1972. The 1972 dues-paying members were distributed among the following sections with some members indicating a preference for more than one section.

- Anthropology: 3
- Biology: 80
- Chemistry: 30
- Mathematics: 6
- Geology: 6
- Physics: 14
- Science: 29

Treasurer:

Copies of the financial statement and summary were distributed by Dr. W. L. Evans, Treasurer, who briefly discussed the report. Dr. Evans' motion to accept the Treasurer's Report was seconded and the motion passed. The financial statement and summary follow.

Financial Statement
Arkansas Academy of Science
March 31, 1973

Cash balance in checking account, April 1, 1972 $ 142.00
Reserve funds (certificate & savings account) 1,587.31
Total assets, April 1, 1972 $1,729.31

Receipts (April 1, 1972 - March 31, 1973)

1. Individual memberships $1,529.00
2. Institutional memberships 650.00
3. Sales of Proceedings 853.00
4. Service for Academy meeting 152.30
5. Page charges for Proceedings 246.20
Total receipts $3,430.50

Expenditures (April 1, 1972 - March 31, 1973)

1. Arkansas Union - signs for annual meeting $ 7.45
3. Wm. C. Guest - stamps and envelopes 32.00
4. Mellroy Bank - charge for new checks 5.52
5. Univ. of Arkansas - medallions 10.30
6. Univ. of Arkansas - programs for 1972 meeting 152.30
7. Acme Typewriter Exchange - duplicator repair 17.00
8. UA Division of Continuing Ed. - 1972 meeting 215.68
9. Univ. of Arkansas - office supplies 5.03
10. Emily P. Tompkins - editorial assistant 89.70
11. Internal Revenue Service - tax withheld 7.30
12. Emily P. Tompkins - editorial assistant 39.60
13. Dept. of Finance & Admin. - state tax withheld 1.00
14. Frances E. Clayton - Travel to AAAS 100.00
15. Emily P. Tompkins - editorial assistant 45.50
16. Wm. C. Guest - travel & secretarial expense 47.27
17. Ark. U. Museum - paper, phone & stamps 16.02
19. Eugene B. Wittlake - stamps 24.00
20. Dept. Finance & Admin. - state tax withheld .95
21. Postmaster, Fayetteville - stamps 8.00
22. Eugene B. Wittlake - postage 23.62
23. Postmaster, Fayetteville - stamps 10.56
24. Paul Raines, Junior Academy - support 200.00
26. Univ. of Arkansas - copy work 21.25
27. Noel Rowbotham, Collegiate Academy - support 150.00
28. Association of Academies of Science - dues 10.00
30. Eugene B. Wittlake - postage 31.20
Total expenditures $1,343.06
Secretary's Report

Summary

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original balance, cash &amp; reserve, April 1, 1972</td>
<td>$1,729.31</td>
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<tr>
<td>Total receipts, April 1, 1972 - March 31, 1973</td>
<td>$3,430.50</td>
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<tr>
<td>Less expenditures</td>
<td>$1,343.06</td>
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<tr>
<td>Balance</td>
<td>$3,816.75</td>
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<tr>
<td>Interest on reserve funds</td>
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<tr>
<td>Total assets</td>
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</table>

Balance in checking acct., March 31, 1973         $2,229.44
Reserve fund balance, March 31, 1973              $1,699.80
Total assets, March 31, 1973                      $3,929.24

Editor:

Dr. James Wickliff, Editor, reported that the President, at his request, has named the following persons to the Editorial Board of the Proceedings: J.L. Dale, Joe Nix, E.B. Smith, L.C. Howick, Jack Wood Sears, and J.K. Beadles. In addition to the board, the Editor plans to call on outside reviewers as needed. Eighteen papers were accepted for publication after review by the Editor and the Editorial Board.

For Volume 26 of the Proceedings, bids were requested and four were received. One was considerably lower than the others and was accepted. Copy was sent to the printer in October and proofs will be sent to the authors in April. The Editor discussed the probable costs of reprints and page changes if printing costs can be held down. Distribution is expected to be very soon.

For Volume 27, it is hoped to get copy to the printer during the summer. The Editor requested assistance in finding reviewers for papers.

Historian:

Dr. Dwight Moore, Historian, reported that this meeting was the third held in Jonesboro. He also reported that at the last meeting four past presidents had received special recognition and that one of the four, Dr. T.L. Smith, College of the Ozarks, recently had passed away.

State Science Fair:

Professor Robert Saunders reported that after a lapse of two years, the State Science Fair was revived in 1972 on the campus of Arkansas State University independent of the Arkansas Academy of Science. Participation was good with 114 projects certified. The 1973 State Science Fair is being held in conjunction with the Arkansas Academy of Science and attendance is improved with a total of 191 projects certified. Finances have been adequate to take care of all preliminary expenses for this year. This is the 20th State Science Fair. Four of the eight state regions are very active.

A.A.A.S. Council:

Dr. Frances Clayton, A.A.A.S. Council representative for the Arkansas Academy of Science, reported that with the approval of the new A.A.A.S. Constitution and By-Laws on December 30, 1972, the state academies no longer have a representative on the Council. The state academies will participate in the Association of Academies of Science which is composed of two representatives from each of the affiliated academies of science. Under the new constitution officers of A.A.A.S. will be elected by the membership voting through their designated section of interest. Council representatives no longer have to be Fellows and the Academy as such no longer nominates members as Fellows.

Junior Academy of Science:

Dr. Wayne Everett reported for the Junior Academy. He noted that the group was in good financial condition with a balance of $218.32. He pointed out that the Junior Academy has been in a state of disarray for some months but is the process of reorganization. There are 17 local chapters with 225 members. Sixty-seven papers were presented at regional meetings. The membership figures may be somewhat inflated because there is a Science Fair and participants in the fair may also participate in the Junior Academy. Planning is in progress to revive the visiting scientist program and other programs of the Academy.

Nominating Committee:

Dr. P.M. Johnston, Chairman, reported that the following persons were being nominated for President-Elect and that the election would take place at the second business meeting: E.E. Dale, Jewel Moore, Denver Prince, Arthur Johnson, and John E. Stuckey.

Junior Science and Humanities Symposium:

Dr. E.B. Wittlake, Director, reported that 103 students and 53 teacher delegates attended the November 16-18, 1972, meeting at the Grady Manning Hotel in Little Rock. The six student delegates chosen came from Harrison, Benton, Hazen, Bay, and Fayetteville (2) High Schools. These delegates were to attend the National Symposium at West Point, N.Y., in May. Principal support continued to come from sponsorship by the Army Research Office, Pine Bluff Arsenal, Arkansas Power and Light Company, and Weyerhaeuser Lumber Company. Interest in the Symposium continues to grow but there are financial problems due to increasing costs and the limited support available from business and industry.

Unfinished Business:

The President reported that because the Junior Academy of Science was not represented at the 56th business meeting, 1972, a request for funds to assist in the support of the Junior Academy was not made. The Executive Committee met and approved the granting of $200 for the use of the Junior Academy. This is the sum which the Arkansas Academy of Science has made available to the Junior Academy in the past. The President requested a motion from the floor approving the granting of $200 to the Junior Academy for 1972. Such a motion was made and seconded and the motion passed.

New Business:

President Wittlake recognized Mr. Bill Shepard, Arkansas Planning Commission, Wilderness Area Projects. Mr. Shepard
spoke briefly about the activities of the Planning Commission and of its interest in preserving natural areas in the state and requested the support of the members of the Academy in locating such areas. He pointed out that the Planning Commission plans, as one of its activities, the publication of a list of endangered species of animals and plants in the state.

President Wittlake recognized Dr. W.L. Evans who moved that $500 be set aside for next year by the Arkansas Academy of Science for awarding research stipends not to exceed $100 to any one member of the Academy for supporting research investigations, and further that the Executive Committee shall be the committee for formulating the rules governing the procedures for applying, screening the applications, and making the awards. It was understood as an inherent part of the motion that members of the Executive Committee will be ineligible to receive this research stipend. The motion was seconded and after a discussion it was moved and seconded that the motion be tabled until the second business meeting. The motion to table was approved.

Dr. Wittlake appointed the following committees:

Audit Committee - Clark McCarty, Chairman, Maxine Hite, Arthur Johnson.
Constitutional Review Committee - George Templeton, Chairman, Neal Buffaloe, Dwight Evans, W.L. Evans.
Resolutions Committee - E.E. Dale, Chairman, Jewel Moore, Kelly Oliver.
1974 Meeting Place Committee - Peggy Dorris, Chairman, Neal Buffaloe, Jim Fribrough, Frances Clayton, Kenneth Beadles, Charles Johnson, Henry Robison, Tom L. Pallo.
Screening Committee for Junior Academy of Science - W.L. Evans, Chairman, George Harp, Kenneth Beadles.

President Wittlake recognized the Secretary, Dr. W.C. Guest, who read two sections of the Constitution (Article III, Sections 2 and 3) concerning types of membership in the Academy and By-Law Number 10 which specifies the dues for the various types of membership. He then moved that the By-Laws (Number 10) be amended to read as follows:

"Dues for members of the Academy shall be $8.00 per year for Regular Members and $10.00 or more for Sustaining Members and will entitle the Member to receive a copy of the Proceedings. A copy of an Institutional Member shall be established by the Executive Committee and approved by the Membership of the Academy. Institutional Members shall be entitled to a copy of the Proceedings. Dues of an Associate Member shall be $4.00 per year and will entitle the Associate Member to a copy of the Proceedings." (portion changed in heavy type.)

The motion to amend the Constitution and By-Laws was seconded. The Secretary pointed out that the discussion and vote on the proposed amendment would take place at the second business meeting because the Constitution requires an amendment to be introduced at one business meeting and voted on at a later one.

There being no further business, President Wittlake adjourned the first business meeting at 11:45 a.m.

SECOND BUSINESS MEETING

President Wittlake called the second business meeting of the Arkansas Academy of Science to order at 11 a.m., April 7, 1973.

The President recognized the Secretary who moved that the minutes of the 56th Annual Meeting, 1972, be approved as distributed. The motion was seconded and passed.

Dr. W.L. Evans moved that his motion, which was tabled at the first business meeting, April 6, 1973, be brought to the floor for consideration. The motion was seconded and passed. Dr. Evans read the motion and it was discussed. Dr. Templeton offered the following substitute motion: "The Treasurer shall place an additional $500 in the reserve fund with the interest from the reserve fund to be used for grants in aid of research. The grants are to be made by the Executive Committee to active members with the members of the Executive Committee ineligible for such grants." The substitute motion was seconded and the substitute motion carried.

Dr. Wittlake recognized Dr. Maxine Hite who discussed the activities of the Junior Academy of Science and asked for continued support of the senior Academy. Dr. Beadles moved that the Academy grant $200 to the Junior Academy of Science to help support their program. The motion was seconded and passed.

The President recognized Mrs. Willie B. Johnson, the Director of the Collegiate Academy, who outlined briefly the activities of the Collegiate Academy and requested the continued financial support of the senior Academy. It was moved and seconded that the Academy make $150 available to the Collegiate Academy to help support their program. The motion carried.

Dr. James Wickiff, Editor of the Proceedings, requested that authors submit their manuscripts to the Editor at the earliest convenience. The Editor then requested a continuation of the editorial assistance that was provided during the preceding year. It was moved and seconded that up to $500 be made available to the Editor for editorial assistance during the fiscal year. The motion carried.

The President recognized Dr. W.C. Guest who moved that the amendment to the Constitution and By-Law introduced at the previous business meeting be approved. The Secretary read for the members the constitutional provision that three-fourths of the members present must approve an amendment to the Constitution and By-Laws. The amendment to By-Law Number 10 as read at the first business meeting was approved.

Dr. Wickiff announced that the winner of the Science Fair would go to the International Science Fair but that funds were not available to send the alternate as has been done in the past. Professor Saunders estimated that because the winner and alternate were from the same school expenses for the alternate would be about $100 and requested Academy assistance. Dr. Wickiff moved that the Academy pay $100 toward the travel expenses of the alternate to attend the International Science Fair. The motion was seconded and passed.

The President asked for the report of the Meeting Place Committee. Dr. Frances Clayton reported for the Committee. It was moved and seconded that the Academy accept the invitation from State College of Arkansas, Conway, for the 1974 meeting. The motion was approved.

The President recognized Dr. Johnston who reported for the Nominating Committee. The following persons were nominated for President-Elect: E.E. Dale, Jewell Moore, Denver Prince, Arthur Johnson, and John Stuecky. It was moved and seconded that the nominations be closed. The motion passed. Dr. E.E. Dale was elected President-Elect.

Dr. Wittlake called on Dr. E.E. Dale who reported for the Resolutions Committee. The following Resolutions were approved:

Be It Resolved, that the Arkansas Academy of Science express its sincere thanks to our host of...
President Wittlake asked for a report from the Audit Committee. Dr. McCarty reported that the Committee had examined the books and financial records of the Treasurer and had found them to be in good order. The report of the Audit Committee was accepted.

Dr. Wittlake made a brief statement about his term as President and about the future of the Academy. He introduced the President-Elect, Dr. Clark McCarty, and passed the gavel to him. Dr. McCarty appointed a Nominating Committee of Dr. L.C. Howick, Chairman, Dr. Joe Guenter, and Dr. Neal Buffaloe to report at the next meeting.

President McCarty adjourned the 57th business meeting at 12 noon.

Respectfully submitted,

William C. Guest, Secretary
Panel Discussion: ENVIRONMENTAL PROBLEMS IN ARKANSAS

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

ENVIRONMENTAL SURVEYS
Dr. Edward E. Dale, Jr., Department of Botany and Bacteriology, University of Arkansas

LANDFILL FOR SOLID WASTE DISPOSAL
S. Eugene Gardner, Director of Public Works, City of Jonesboro

FARM POLLUTION PROBLEMS
Dr. Roy Grizzle, State Biologist, U.S. Soil Conservation Service

ARKANSAS SCIENCE AND TECHNOLOGY COUNCIL

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

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

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

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

MR. ROGER CHAMBERLAIN
Plant Manager
Dow Chemical Company
Magnolia, Arkansas

MR. HAROLD R. MUIENZMAIER
General Manager, Reinforced Plastics Dept.
A. D. Smith Company
Little Rock, Arkansas

MR. ARMAND DE LAURELL
Acting Director, Arkansas Dept. of Planning
Capitol Building
Little Rock, Arkansas

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

*Past President, Arkansas Academy of Science.

Arkansas Academy of Science Proceedings, Vol. XXVII, 1973
SECTION PROGRAMS

AGRICULTURAL SECTION
Chairman: Lew Brinkley

INTENSIVE N-K FERTILIZATION ON CATION ACTIVITY IN A SOIL PROFILE.
R. A. Allured and Lyell F. Thompson

EXTRACTIBLE NUTRIENTS AND pH VALUES FROM NINE SOIL ASSOCIATIONS OF ARKANSAS.
A. W. Tennille

CHEMICAL ANALYSIS OF A CANNED RICE PRODUCT SUPPLEMENTED WITH TEXTURED VEGETABLE PROTEIN AND EVALUATION OF ITS GROWTH PROMOTING PROPERTIES IN RATS.
E. R. Cockrill and C. Carroll

THE OCCURRENCE OF GROUND BEETLES IN COTTON AND SOYBEAN FIELDS OF ARKANSAS.
Robert T. Allen

PRESENT AND FUTURE SOYBEAN VARIETY RESEARCH AT ARKANSAS STATE UNIVERSITY.
G. A. Berger, R. D. Hexem, and A. J. Langlois

INITIATION OF DIAPAUSE IN THE BOLL WEEVIL (Anthonomus grandis Boheman) AS RELATED TO PHYSIOLOGICAL CHANGES IN THE COTTON PLANT.
F. L. Carter and J. R. Phillips

ANTHROPOLOGY SECTION
Chairman: Dan F. Morse

INTERNATIONAL TOURISM AND CULTURE CHANGE IN THE WESTERN CARIBBEAN: TEMPORARY NON-ACCULTURATIVE SYSTEMS.
William V. Davidson

REPORT ON A STRING OF SHELL BEADS FOUND IN A POTTERY VESSEL IN NORTHEAST ARKANSAS.
Michael J. Pecotte

THE ARKANSAS FLUTED POINT SURVEY.
Dan F. Morse

A COLLECTION OF DALTON POINTS FROM YELL COUNTY, ARKANSAS.
Robert L. Brooks

CULTURE CHANGE OF THE AQUARUNA.
Lila Robinson

A PROPOSED SCHEME OF ARCHEOLOGICAL-PHYSIOGRAPHICAL PROVINCES IN THE SOUTHERN OZARKS.
Kenneth W. Cole

LATE ARCHAIC SETTLEMENT PATTERNS IN THE EASTERN ARKANSAS OZARKS: NEW DATA AND SOME HYPOTHESES.
John H. House

PRELIMINARY NOTES ON AN INVESTIGATION OF POTTERY MANUFACTURE IN THE NODENA PHASE (c. A.D. 400-1100) OF NORTHEAST ARKANSAS.
Michael G. Million

BIOLOGICAL SCIENCES SECTION I
Chairman: George L. Harp

SUCCESS OF NATIVE-TRAPPED COMPARED TO CAPTIVITY-RAISED TURKEYS IN RESTORING WILD POPULATIONS TO NORTHERN ARKANSAS.
Douglas James, L. Glen Fooks, and John P. Preston

STATUS OF THE MOUNTAIN LION IN ARKANSAS.
John A. Sealeander and Philip S. Gipson

DISTRIBUTION, MOVEMENTS, AND STATUS OF THE CHIROPTERA OF BLANCHARD SPRINGS CAVERNS AND VICINITY.
Michael J. Harvey

INVESTIGATIONS IN CRYOPRESERVATION OF FRESHWATER FISH SPERMATOZOA.
Thomas B. DeClerk, Jr., and John K. Beadles

A CHECKLIST OF ARKANSAS FISHES.
Thomas M. Buchanan

PRELIMINARY SURVEY OF THE FISHES OF COLUMBIA COUNTY, ARKANSAS.
Henry W. Robison

ICHTHYOFAUNAL DIVERSIFICATION AND DISTRIBUTION IN AN OZARK STREAM.
William D. Jackson and George L. Harp

PRELIMINARY OBSERVATIONS ON OCCURRENCE OF Loxosceles reclusa IN ARKANSAS STATE PARKS.
Peggy Rae Dorris

RESPIRATION RATES OF TWO MIDGE SPECIES AT DIFFERENT TEMPERATURES.
George L. Harp and Robert S. Campbell

A COMPARISON OF SERUM PROTEINS BY USING DISC ELECTROPHORESIS OF A HYBRID PEAFOWL-GUINEA CROSS WITH THE PEAFOWL, GUINEA FOWL, AND DOMESTICATED CHICKEN.
Earl L. Hanebrink, Charles Gruver, and Richard Van Grouw

SPECIES COMPOSITION AND HERON AND EGRET BEHAVIOR IN THE BURDETTE HERONRY.
Robert T. Singleton and Earl L. Hanebrink

BIOLOGICAL SCIENCES SECTION II
Chairman: Larry A. Olson

THE EXTENT OF NATURAL OUTCROSSING IN THE TOMATO IN NORTHWEST ARKANSAS.
A. F. Reeves II

THE EFFECTS OF ANHYDROUS AMMONIA ON NATIVE VEGETATION, PASTURES, AND HAY MEADOWS NEAR...
FLORAL, INDEPENDENCE COUNTY, ARKANSAS.
Edward E. Dale, Jr.

THE FOREST VEGETATION OF THE MIDDLE WHITE RIVER AREA IN THE ARKANSAS OZARKS.
Edward E. Dale, Jr.

GASTRIC CONCENTRATION OF NITRATE IN RATS.
Jerry R. Hersey

ROLE OF MUCUS IN NITRATE CONCENTRATION BY THE GASTRIC MUCOSA OF RATS.
Jerry R. Hersey

DRY MATTER AND MINERALS IN LOBLOLLY PINE PLANTATIONS ON FOUR ARKANSAS SOILS.
Timothy T. Ku

HEMATOLOGY OF THE SPOTTED SKUNK, Spilogale putorius.
Gary A. Heidt and James Hargraves

DIMORPHISM IN Basidiobolus.
James A. Hutchison and James E. Fitzpatrick

PROTEINASE IN LARVAL STAGES OF Ascaris suum.
Lawrence W. Hinck and Michael H. Ivey

ECOLOGY OF FLOATING BOGS IN A CYRPESS SWAMP.
Robert Terry Huffman

TREE-RING DATING OF THE BALDCYPRESS, Taxodium distichum (L.) Rich., IN THE MISSISSIPPI VALLEY.
Lynne J. Bowers

MATHEMATICS SECTION
Chairman: Dean B. Priest

GROUP THEORY AND QUANTUM MECHANICS.
E. Ray Keown

HIGHER ORDER DIFFERENTIABLE STRUCTURES.
Robert H. Bowman

AN APPLICATION OF COMBINATORIAL GROUP THEORY TO TOPOLOGY.
Arnold C. Shilepsky

SOME COMPLETE SUBLATTICES OF THE LATTICE OF ALL RADICALS.
Robert F. Rossa

SOME BIOMATHEMATICAL MODELS FOR CANCER THERAPY.
James R. Thompson

SUBALGEBRAS AND CONGRUENCE RELATIONS OF UNIVERSAL ALGEBRAS.
Thomas P. Whaley

ASYMPTOTICALLY MINIMAX POINT ESTIMATION PROCEDURES.
Robert P. Smith

CONCERNING THE SOLUTIONS OF A CERTAIN NON-LINEAR DIFFERENTIAL EQUATION.
Marshall P. Williams

PHYSICS AND CHEMISTRY SECTION
Chairman: Larry A. Mink

ASTROPHOTOGRAPHY USING AN 8-INCH SCHMIDT-CASSEGAIN TELESCOPE.
H. E. McCloud and J. W. Eason

THE IONIZATION POTENTIAL OF COPPER PHTHALOCYANINE.
Tommy J. Barber and J. Edward Bennett

MAGNETORESISTANCE IN ZINC TELLURIDE CRYSTAL.
W. F. Wei

OSCILLATING FLOW IN A STRAIGHT TUBE.
Lawrence A. Davis, Jr.

YIELDS OF LOW-MASS PRODUCTS IN THE FISSION OF 232th BY 14.8 Mev NEUTRONS.
Leslie R. Battles and David M. Chittenden

A LOGICAL TRANSITION FROM MAGNETIC POLES TO CURRENT LOOPS.
H. E. McCloud

SCIENCE EDUCATION SECTION
Chairman: Earl L. Hanebrink

ECOLOGY AND THE REGULATORY AGENCY.
A. Robinson, Jr.

PHOTOGEOLOGY OF THE MERIDIANI SINUS REGION FROM MARINER 6 AND 7 IMAGERY.
R. A. DeHon

NATURAL AREAS AND REFERENCE COLLECTIONS FOR ENVIRONMENTAL EDUCATION IN SOME ARKANSAS SCHOOLS.
Jewel E. Moore
MINUTES OF THE BUSINESS MEETING, 7 APRIL 1973
The Arkansas Collegiate Academy meeting was called to order by the presiding President, Ronnie Sexton. The minutes of the last meeting were read and approved. The following officers were elected for the year 1973-74:

President — Eddie Reed, Philander Smith College
President-Elect — Mike Wish, College of the Ozarks
Secretary — Linda Watson, Philander Smith College
Treasurer — David Taylor, Hendrix College
Sponsor — Mrs. W. B. Johnson, Philander Smith College
Co-sponsor — Dr. Mike Condrew, College of the Ozarks

There being no further business, the meeting was adjourned by the new President, Eddie Reed.

Respectfully submitted,
Linda Kaye Watson, Secretary

ABSTRACTS OF PAPERS

BIOLOGICAL SCIENCE

JULIE CONNELLY (Hendrix College, Conway, Arkansas): On the Trematodes of Arkansas Reptiles.

Very little research has been done on the trematodes parasitic in reptilian hosts of Arkansas. About 300 reptilian hosts representing 20 species were collected from 14 Arkansas counties. This paper presents a view of the trematode fauna collected from Arkansas reptiles, and includes five families, five subfamilies, 12 genera and 30 species. The species are: Styphlodora agkistrodonis, Prostes chapmanii, Prostes angustus, Ochetosoma aniarum, O. serpentinis, O. wardi, O. acutabularis, O. validus, O. septicids, O. drymarchon, O. georgianus, O. ornita, O. kansensis, Dasymeria nicollii and villaeae. Zeugorchis synomentera, Telorchis auridistomae, T. singularis, T. diminuus, T. stunkardi, T. eortic, Auridistomum georgianum, Ochetosoma laterotrema, Heronimus cheyneyi, Polystomoides coronatum, Polystomoidella oblongum, Polystomoides whartonii, Neopolystoma obiculata, Pneumatophilis leidy i, and P. variabilis.

All 30 species have been studied and previously described; however, only one, Ochetosoma serpentinis (Schmidt and Hubbard, 1940), has been reported from an Arkansas reptile.

EDDIE REED AND BEVERLY BUTLER (Philander Smith College, Little Rock, Arkansas): Effects of Acetaminophen on the Metabolism of the Golden Hamster.

Acetaminophen is an aspirin substitute that is available on the open market. When given subcutaneously to golden hamsters at a dosage of 200 mg/kg wt, it was found to lower rectal temperature. All general metabolic effects were sought to be recognized. The results of this investigation imply that acetaminophen may block the action of an enzyme system necessary for normal recovery from injury; and/or that it may act on the hypothalamus so as to reduce appetite to a point of severe detriment to the organism.

STEVE VENABLE (Hendrix College, Conway, Arkansas): Acid Phosphatase Levels in the Livers of Albino Mice Infected with Ehrlich Ascites Tumor.

Male albino mice were injected intraperitoneally with E. subline Ehrlich ascites. Concentrations of cells injected ranged from 1.8x10^7 to 4.2x10^8. The intent of the experiments was to determine whether or not the levels of hepatic acid phosphatase (EC 3.1.3.2) in ascites infected mice varied significantly from those levels in non-infected mice over a period of 10 to 14 days. Analysis of data collected indicates that there is no significant deviation in hepatic acid phosphatase levels as the ascites proliferates in infected mice. Also, the pattern of hepatic acid phosphatase levels measured over the 10-14 days in the infected mice did not differ significantly from the pattern in non-infected mice.

TOM JONES, JOHN WERNER, AND MICHAEL WISH (College of the Ozarks, Clarksville, Arkansas): Preliminary Studies on the Host-Parasite Relations of Acantharia sp. (Lecithodendridae: Trematoda) in Bats from Boxley, Arkansas.

In ecological studies on the little brown bat, Myotis lucifugus, collected from Bat Cave near Boxley, Arkansas, all bats examined were found to be parasitized with the trematode Acantharium sp. in several stages of development in the small intestine. The presence of a spinous genital atrium suggests that this trematode fits properly into the genus Acantharium (Faust, 1919). Further studies are in progress to determine the species and the life cycle which is presumed to involve a snail (first intermediate host), an insect (second intermediate host), and the little brown bat (definitive host).
PHYSICAL SCIENCE AND MATHEMATICS

JERRY W. HAMLING (Hendrix College, Conway, Arkansas): Applications of High Vacuum Techniques in the Field of Physics.

The mechanics of operation for a high vacuum system is explained and described. Determinations of the pumping speed and isotherms of type 13X zeolite under different inert gas environments are presented.

DENNIS E. GO (Hendrix College, Conway, Arkansas): Attempted Synthesis of \(\alpha\)-Amino Ethyl \(n\)-Propylacetic Acid.

Synthesis of the named amino acid was attempted three times by the Strecker method. Positive ninhydrin tests were obtained in the second and third attempts, but the only substance obtained in crystalline form was the substituted hydantoin.

RONALD K. PEARSON (University of Arkansas at Monticello): Fugue for Computer in C-Major.

A Fortran program for the composition of a simple 3-part contrapuntal piece is presented. The program is divided into component segments, each of which is discussed separately. An evaluation of the results is given along with suggestions for modification.

JOHN N. LOVETT, JR. (Hendrix College, Conway, Arkansas): Lebesgue's Theorem and Sets of Measure Zero.

In this paper I have discussed the concept of a set of measure zero in detail and have proven Lebesgue's theorem, which states that every monotonic function possesses a finite derivative almost everywhere. My primary source is Riesz and Sz.-Nagy's *Functional Analysis*, sections 2 and 3 of Chapter I. Without using general measure theory, I have defined a set of measure zero and proven several subsequent propositions. I have then presented a more suitable definition of such a set, and have shown this second definition equivalent to the first. Next I have introduced the standard Cantor set as an example of an uncountable set of measure zero. I have discussed the construction, elements, and properties of this set. Then I have constructed the Cantor function from the Cantor set in the interval \([0,1]\). Employing the fact that this function is continuous and nondecreasing, I have shown that its graph has length 2 in the interval \([0,1]\). In addition, I have proven that the Cantor function is differentiable at no point of the Cantor set. With the Cantor function as a guide, I have defined a "generalized" function over any set of measure zero which possesses properties similar to the Cantor function. This function establishes the fact that the hypothesis of Lebesgue's theorem cannot be weakened. Finally, I have proven the theorem of Lebesgue with the aid of my previous results but without general measure theory.

JOHN GILLEAN (Hendrix College, Conway, Arkansas): Crystal Structure Determination of Thioxanthene by X-Ray Diffraction Techniques.

The objective was the determination of the molecular structure of thioxanthene (C\(_{13}\)H\(_{18}\)S) by single-crystal x-ray diffraction techniques. Of particular interest was the dihedral angle, or the angle of fold, and its implication on the nature of the interaction of the sulfur atom in the pi-ring of the aromatic system. By multiple-film Weissenberg techniques, 558 independent reflections were observed, using Cu K\(\alpha\) radiation (\(\lambda=1.5418\)). The intensities of the reflections were estimated visually. The unit cell is orthorhombic, with \(a=20.8\) \(\AA\), \(b=7.69\) \(\AA\), and \(c=6.00\) \(\AA\). The space group is \(P 2_1 2_1 2_1\) (\(D_{2h}\) no. 19) with four molecules per unit cell, as indicated by density measurements. A Patterson vector map was used to generate a trial structure, which was then refined by Fourier and least-squares methods.

CALVIN R. CRIM (Harding College, Searcy, Arkansas): The Mean-Stieltjes Integral.

For the Riemann-Stieltjes integral \(\int f(x) \, dg(x)\) to exist, common discontinuities from the right or from the left for \(f\) and \(g\) must be avoided. R. E. Lane has defined the mean-Stieltjes integral \(\frac{1}{m} \int f(x) \, dg(x)\) which overcomes these difficulties. This integral has applications in the field of actuarial science. Lane's proof of the existence of the integral depends upon step-functions. This paper gives a proof which is independent of the use of step-functions.
International Tourism and Culture Change in the Western Caribbean: Temporary Non-Acculturative Systems

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ABSTRACT

The few studies on international tourism and culture change have emphasized the direct effects of tourism on the host society. Recent research on western Caribbean islands indicates that under the stimulation of economic developments arising from tourism, in-migration from adjacent mainland has effectively stifled, at least temporarily, the onslaught of acculturation by North Americans. On Cozumel Island, Mexico, Mayan-speakers from the Yucatán Peninsula have fortified Cozumeleno culture; in the Bay Islands, Honduras, Spanish-speaking mainlanders are the primary change agents.

INTRODUCTION

This paper directs attention to a new and rapidly emerging agent of culture change: international tourism. International tourism 1 is a relatively recent global phenomenon that is playing an increasingly important role in the affairs of man. It has innumerable anthropological aspects that might be studied, and, in particular, many social and economic ramifications that are yet little understood.

To date, research on international tourism has been dominated by economists. They primarily have been concerned with tourism as an agent of economic development, and international organizations such as the World Bank, the International Monetary Fund, and the United Nations have supported the research (for examples see Artus, 1972; Ball, 1971; Davis, 1968; and Krapf, 1968). The prominence of an economic approach is understandable because (1) the major source of research funds has been the United States, whose reputation for an economic orientation is universal, and (2) the role of international tourism as an income-producer is grandiose indeed. It is the single largest item in international trade, amounting to more than $15 billion for 1970 (Fiabane, 1971) . 2 Tourism has been so successful in its expansion that it makes a major contribution to one-fourth of the world's state economies. At least 10 countries can expect to gross more than $1 billion annually from international tourism by 1975 (Aldine Univ. Atlas, 1969).

Unfortunately, tourism's contribution to national economies is proportionately greatest in the so-called developing world, a fact that is of particular significance to anthropologists. It has been a well-established theme that wherever economic developments have occurred, changes in culture have not been long in following. 3 Therefore, it should be among the cultures of the developing world that the most massive effects of tourism will be felt.

Anthropologists have indicated only slight interest in tourism as an agent of culture change. Professor James Silverberg of Milwaukee organized a symposium entitled, "Tourism: A Neglected Area of Culture Change Research and Applied Anthropology," for the 1964 meeting of the Central States Anthropological Society, but the seven papers presented have not been published. Sociologists have a slightly better record, including the seminal works of Forster (1964), Sutton (1967), and Cohen (1972). However, most of these writers have limited their thrust to categorizing tourist types and to discussing the effects of tourism on members of the host country. The usual model presupposes some degree of direct acculturation of the recipient society by the dominant group of international tourists.

The writer's paper is the first to his knowledge to suggest alternatives to the standard acculturation model by introducing a geographic variable. Specifically, the discussion covers cases in which economic developments on offshore tourist islands attract native laborers from adjacent mainland. Such in-migration should impede the normally rapid acculturation of the previously isolated islanders. For illustration of this point, two locations were selected in the western Caribbean where the effects of recent tourism still can be easily discerned.

COZUMEL ISLAND, MEXICO

Cozumel is a flat, heavily forested, coraline island about 12 mi off the northeastern coast of the Yucatan Peninsula. Its dimensions are 9 by 25 mi and total land area is just over 150 sq mi. Before tourism, the island was home for 3,500 Spanish- and Mayan-speaking Mexicans. They earned their livelihoods primarily from fishing, although there were bits of milpa agriculture and some lucrative contraband activities. The only multiracial settlement, San Miguel, was a perfect model of a "sleepy Mexican port," at least during the daylight hours when no smuggling was taking place.

Then tourism came to Cozumel. The island fell quickly before an aphorism of scholars of tourism, "tourism abors a vacuum" (Anonymous, 1935; p. 509). Let people learn of a spot that tourists have never visited, and watch it develop into a resort overnight. First, popular accounts appeared in Holiday, Saturday Evening Post, and the New York Times—"Come to one of the last remaining unspoiled Caribbean paridises" (Jackson, 1970). Next, skin-divers discovered that the clearest waters in the world surrounded the island. A former President of Mexico, Lopez Mateos, built a retreat, and Jackie Kennedy vacationed there. Meanwhile, international tourists, almost exclusively North Americans, increased from 24,000 in 1967 to about 100,000 in 1972.

Since 1965, the writer has visited the island at least once each year to keep informed on the consequences of the onslaught of tourism. First went the lobsters, prey to the spear-fishermen; then most of the other reef-life died. So far, this disruption of the natural life systems has not been reversed. The first studies indicated as well that some acculturation was occurring because of tourism. The writer separated islanders into categories according to occupation and to where they spent their time to determine the opportunity for and degree of...
contact with tourists. There was evidence that changes in language, dress, economic status, and life goals were due to tourism in varying degrees throughout the sample population. However, during the last five years the disruption has not continued in island life as it has in the natural systems. The explanation for the retardation of change apparently is related to the massive in-migration of laborers from the nearby mainland. When tourism developed to the stage that public infrastructure and services beyond those provided for normal domestic needs were essential, a construction boom stimulated the local economy. Farmers from Yucatan then immigrated to Cozumel to take advantage of the better economic opportunities. The total Mexican population of the island today is about 10,000, half of which has recently come from the mainland. These people are the reason for a revitalization of the "old island ways." Native Mayan dresses (huipiles) can be seen more frequently in the square, and the use of the Mayan language is on the increase.

BAY ISLANDS, HONDURAS

The second study area is a chain of eight islands and 65 cays with a total land area of just less than 100 sq mi. The Bay Islands are one political department of the Spanish-speaking Republic of Honduras. Roatan, the largest and most centrally located island, is approximately 40 mi offshore and accounts for more than half of the area. These are the only islands in the western Caribbean that are of continental structure. They, too, with their clear waters, fringing reefs, and mild tropical climate, undoubtedly will be called an "island paradise" in the travel guidebooks.

In their cultural composition the Bay Islands are more diverse than Cozumel. English-speaking Anglo- and Afro-Antilleans account for 85% of the present 10,000 population, and there are remnant groups of Black Caribs, North Americans, Miskito Indians, and Spanish Hondurans. For the last 50 years economic activities have been oriented around the sea. Trading and boatbuilding have provided most of the cash income, but recently merchant sailing has become the most widespread source of revenue.

Tourism, still clearly in the incipient stages of development, was introduced on a significant scale only within the last five years. As an indication of the economic changes accompanying the new North American tourists, the average cost of a one-acre waterfront plot grew from $75 to $300 between 1967 and 1970. During the same period the rates for native manual labor increased from $1.50 to $3.50 for an eight-hour day. Such changes are easily understood in view of the additional income available in the islands. An estimated $1.5 million entered the islands' economy from tourist-related construction costs alone. In addition, approximately $20,000 is paid annually in the form of wages to local hotel workers.

As in the case of Cozumel, the developing economy offshore has attracted mainland folk in phenomenal numbers. Most newcomers from the mainland enter to sell Honduran-made goods, to work in the new industries and hotels, and to take governmental positions. Some come as sojourners, others plan to settle permanently.

This immigration from the mainland is all the more significant because of the bitter feelings that have existed for centuries between islanders and the coastal peoples. The historic Spanish-Indian and Spanish-English feuds, the cultural differences, and the lack of communication have engendered mutual prejudicial attitudes. By their continued ties with Belize, the Cayman Islands, and the United States, and their retention of the English language and Protestantism, most islanders have successfully isolated themselves from Spanish Honduran influences.

However, the isolation is no longer complete. There is no doubt in the writer's mind that the Hispanicization of the English-speaking Bay Islanders is now underway. Particularly in the island landscapes one can see the first indications of the imposition of a new culture: a new Catholic church building, soccer fields, slaughter houses on cattle-less islands, and above all, the Spanish-language signs that hang throughout the islands. These features show well the new and growing presence of Spaniards from the coast of Honduras.

SUMMARY AND CONCLUSION

This paper suggests geographic situation to be a primary consideration in acculturation studies. In the two study areas, Cozumel and the Bay Islands, tourist-induced culture change has not followed the standard model of direct acculturation of the host society by tourists. Instead, in both locations because of the proximity to mainland, the North American tourism that stimulated local island economies has resulted in the emigration of native workers from adjacent mainland. This has blunted the normal impact of foreign tourism. On Cozumel, in-migrations have caused the direct reinforcement of traditional island life. In the Bay Islands, Spanish immigration has stifled North American acculturation, and is bringing instead the indirect acculturation of the English-speaking island population.

Under such conditions, a lag of a few years should be expected before direct acculturation by North Americans again occurs on a widespread basis. Apparently, a certain length of time must pass before the economy stabilizes and large-scale immigration terminates. It is ironic that by the end of such a lag, mass tourism will perhaps have destroyed the pleasant physical environment and removed one of the primary motives for touring, causing North Americans to cease their visits. Otherwise, international tourism may eventually be a most effective agent of culture change even in these locations.

NOTES

1. International tourism concerns the movement of foreigners to and within countries other than their own. In an attempt to standardize a definition for international tourist the United Nations has suggested "a non-resident in a foreign country for more than 24 hours" (OECD, 1966; p. 7). International tourism is isolated here for study because it holds greater consequences for culture change than does tourism by nationals within their own borders.

2. Perhaps the best source of the latest statistical information on international tourism is the Organisation for Economic Co-operation and Development, Paris.

3. Perhaps the best source of studies is the journal, Economic Development and Culture Change, now in its twentieth year from the University of Chicago.

4. Information on Cozumel was collected primarily for the writer's study on the settlement patterns there (see Davidson, 1967).

5. Data on the Bay Islands were collected primarily for the writer's study on the historical geography of the islands (see Davidson, 1973).
LITERATURE CITED


Effects of Intensive N-K Fertilization on Exchangeable Ca and K in a Soil Profile

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ABSTRACT

Over a 4-yr period fertilizers having three N and five K levels in a factorial arrangement were applied in a replicated, randomized complete block design to coastal bermudagrass (Cynodon dactylon L.) growing on a Pembroke silt loam just north of Fayetteville. In the spring of the fifth year (1972) soil samples were taken from a 3.67-m profile of each plot. Nine depth samples from the profile of each plot were analyzed for exchangeable K and Ca. Potassium fertilizer, especially at the higher rates, and where no N was applied, greatly increased exchangeable K levels only in the top 45 cm of the profile; however, exchangeable Ca levels were decreased markedly in these same upper soil layers, and increased greatly at lower levels in the profile. The first increment of N reduced this effect of K fertilizer on exchangeable Ca, probably because of increased plant growth that resulted from N fertilization. This increased growth removed a larger portion of the fertilizer K. At the higher N rate the net change in exchangeable Ca was greater, but more varied between K treatments, with the highest level of N and K resulting in a net loss of Ca from the 3.67-m profile sampled.

INTRODUCTION

During the summer of 1968 a nitrogen-potassium soil fertility experiment was initiated to study the effect of fertilization on winter hardiness of coastal bermudagrass (Cynodon dactylon L.). Fifteen different fertilizer treatments were used, ranging from no fertilizer to very high rates of both N and K. Early in the fifth year the question arose of the effects of these treatments, especially the higher fertilizer rates, on the environment of the soil profile; therefore, a chemical analysis of the soil profile under each fertilizer treatment was undertaken.

Changes in the chemical environment of a soil profile as a result of the addition of salts have been reported by several workers. Hileman (1972) of the University of Arkansas conducted a laboratory leaching experiment using 2-ft (60-cm) undisturbed soil columns. Chicken litter was applied at rates ranging from 2 to 40 tons per acre. He reported that very high concentrations of K remained in the soil column and amounts of Ca in excess of 800 ppm were found in the leachate. Hileman stated that ammoniacal N released from the chicken litter, as well as the K, "was probably strongly involved" in this Ca leaching. The data obtained for total N in the leachate tended to verify his hypothesis, because the nitrate concentration in the leachate was fairly constant whereas the total N in the leachate varied greatly with rate of litter application. Mathers et al. (1973), of the USDA Southwestern Great Plains Research Center, added feedlot manure containing 1,580 lb of K at a rate of 50 tons per acre yearly to a sorghum field during a 3-yr period. He found that most of the salts from the manure, as measured by electrical conductance, remained in the upper 18 in. (45 cm) of the profile. Cooke (1967) stated that N fertilizer applied to a permanent grass sward reduced exchangeable soil K in the A horizons and increased it in the B horizons, resulting in no net K change within the profile. Cooke also stated that ammonium salts displaced exchangeable Ca from soil colloids, and that this Ca was lost in percolating water. He believes it is likely that high rates of K must increase losses of Ca, though there is no recent literature on this phenomenon. Munson and Nelson (1964) reported that on silt loams and heavier soils K leaching losses are normally negligible.

MATERIALS AND METHODS

Fifteen fertilizer treatments were applied to a coastal bermudagrass sod growing on a Pembroke silt loam during a 4-yr period. Three nitrogen rates of 0, 336, and 672 kg N (NO, N1, N2) and five potassium rates of 0, 84, 168, 336, and 672 kg K (KO, K1, K2, K3, K4) per hectare annually, composing a 3×5 factorial arrangement, were used in a randomized and replicated complete block design. All N was applied as NH4NO3, and all K was applied as KCl.

In the spring of the fifth year each plot was sampled to a depth of 3.67 m with a 76-mm power-driven core sampling device. Samples from nine soil horizons within each profile were collected and analyzed for exchangeable cations, principally K and Ca, by S-52 Technical Committee Procedures (1965). These data were analyzed statistically by the analysis of variance procedure to determine the effect, if any, the treatments had on the chemistry of the soil profile. In this paper the term significant(ly) implies statistical significance at or beyond the 5% level of probability.

RESULTS

The effects of fertilizer applications on exchangeable soil K levels in the top four horizons sampled are given in Table I. The values show the deviation from the NO-K0 treatment for each soil horizon. Potassium fertilizer increased exchangeable soil K levels only in the top 45 cm. Increasing rates of K generally increased the amount of K accumulation, especially in the NO treatments where plant growth was sparse and K removal was minimal, but even in the NO-K4 treatment there was no potassium accumulation below the 45-cm depth.

At the higher K rates nitrogen significantly reduced exchangeable soil K levels in the 0-15-cm horizon and significantly increased exchangeable soil K at the 30-45-cm depths (Table I). Exchangeable soil K was significantly lower in the K1 and K2 treatments at the 60-90, 120-180, and 180-215-cm horizons, all of which were observed to be zones of massive root development. Also, the net potassium balance in the 3.67-m profile at these two lower K rates was negative, indicating a net loss of K from the soil profile.

Nitrogen and potassium both were found to have a highly
significant effect on exchangeable calcium. This is illustrated in Table II which gives the net change in exchangeable soil Ca due to N and K fertilization. All fertilizer treatments resulted in a reduction of exchangeable Ca in the 0-15-cm horizon. The N1 and N2 treatments also significantly reduced exchangeable Ca in the 15-30-cm horizon. Increasing increments of K significantly increased exchangeable soil Ca in the 60-90, 180-240, and 240-300-cm and lower horizons where no N was applied (Fig. 1). However, with the N2 fertilizer rate, Ca accumulation was significant only in the 60-90-cm horizon and the 3.67-m profile showed a net loss of more than 1,000 ppm Ca.

Table I. Net Change in Exchangeable Potassium in Four Soil Horizons from Fertilized vs. Nonfertilized Treatments

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Potassium Fertilizer Treatments</th>
<th>Nitrogen Fertilizer Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KO</td>
<td>NO</td>
</tr>
<tr>
<td>0-15</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>K1</td>
<td>40</td>
<td>24</td>
</tr>
<tr>
<td>K2</td>
<td>134</td>
<td>52</td>
</tr>
<tr>
<td>K3</td>
<td>295</td>
<td>174</td>
</tr>
<tr>
<td>K4</td>
<td>515</td>
<td>292</td>
</tr>
<tr>
<td>15-30</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>K1</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>K2</td>
<td>39</td>
<td>29</td>
</tr>
<tr>
<td>K3</td>
<td>125</td>
<td>135</td>
</tr>
<tr>
<td>K4</td>
<td>285</td>
<td>227</td>
</tr>
<tr>
<td>30-45</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>K1</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>K2</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>K3</td>
<td>56</td>
<td>58</td>
</tr>
<tr>
<td>K4</td>
<td>126</td>
<td>153</td>
</tr>
<tr>
<td>60-90</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>K1</td>
<td>-8</td>
<td>-13</td>
</tr>
<tr>
<td>K2</td>
<td>-7</td>
<td>-18</td>
</tr>
<tr>
<td>K3</td>
<td>4</td>
<td>-7</td>
</tr>
<tr>
<td>K4</td>
<td>-1</td>
<td>-2</td>
</tr>
</tbody>
</table>

Table II. Net Change in Exchangeable Calcium in Four Soil Horizons from Fertilized vs. Nonfertilized Treatments

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Potassium Fertilizer Treatments</th>
<th>Nitrogen Fertilizer Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KO</td>
<td>NO</td>
</tr>
<tr>
<td>0-15</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>K1</td>
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<td>-304</td>
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<td>K2</td>
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<tr>
<td>K3</td>
<td>-122</td>
<td>-310</td>
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<td>K4</td>
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<td>-419</td>
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<td>15-30</td>
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<td>0</td>
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<tr>
<td>K1</td>
<td>22</td>
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<td>K2</td>
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<td>K4</td>
<td>-234</td>
<td>-269</td>
</tr>
<tr>
<td>30-45</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>K1</td>
<td>32</td>
<td>-7</td>
</tr>
<tr>
<td>K2</td>
<td>53</td>
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<td>K3</td>
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<td>-91</td>
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<td>K4</td>
<td>-75</td>
<td>-125</td>
</tr>
<tr>
<td>60-90</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>K1</td>
<td>-73</td>
<td>-33</td>
</tr>
<tr>
<td>K2</td>
<td>96</td>
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<td>K4</td>
<td>613</td>
<td>405</td>
</tr>
</tbody>
</table>

DISCUSSION

As shown in Table I, K did not move down through the soil profile but accumulated in the top 45 cm of soil, apparently replacing Ca on the soil exchange complex in this zone. Where no N was applied the K accumulation was most evident in the top 30 cm because of minimal plant growth and K uptake. At the N1 and N2 fertilizer rates, K tended to accumulate in the 30-45-cm level, possibly because of preferential absorption of NH₃ by the colloids in the top 30 cm of soil. The lower exchangeable K levels observed for the K1 and K2 rates in the 60-90, 120-180, and 180-215-cm horizons (data on lower two horizons not given in Table I) where N was applied probably were due to stimulated plant root growth which allowed the plants to more efficiently mine the soil of K, because more K was removed in the forage harvested from these areas than was applied. Ca accumulated in the 60-90-cm horizon and in the lower regions of the sampled profile. At the N1 level where
plant growth was vigorous the K accumulation in the upper 45 cm was somewhat reduced, as were Ca displacement and accumulation. This also is most likely attributable to increased plant growth and uptake of both K and Ca. But plant uptake and removal of K and Ca were not sufficient to account for all of the difference in Ca accumulation between the NO and N1 nitrogen levels as shown in Figure 1. This difference could have been caused by (1) the interaction of the ammonium ion with the exchange complex, and (2) the reduced K:Ca ratio in the top 45 cm of soil due to plant uptake of K. In this experiment it may have been the high K:Ca ratio which caused the replacement of Ca by K to the degree observed. At the N1 level most of the N applied was taken up by the plant, leaving very little NH₄⁺ to interact in the soil. However, at the N2 rate plant growth was not significantly increased; thus less than half the applied N was removed by the plants, and large amounts of N, probably in NH₃ form, were left to interact with the other soil cations. In this case Ca movement was probably influenced by the NH₄⁺ K:Ca ratio (or the monovalent to divalent cation ratio). At the N2 rate only the K3 and K4 treatments showed significant K accumulation in the profile, and only the KO and K2 rates showed significant Ca accumulation in the profile. The net loss of Ca observed at the N2-K4 rates probably was caused by high monovalent to divalent cation ratio which caused the Ca to be moved out of the sampled profile.

Rates of both N and K which were in excess of what the plants could utilize caused very significant chemical changes throughout the soil profile to the 3-m depth. These changes, especially at the N2 and K4 levels, were great enough to reduce yields significantly after only four years. This indicates that in an intensive forage management program care must be taken to apply enough fertilizer for maximum plant growth without depletion of native soil fertility, as occurred at the N1, K1, and K2 rates, but not to greatly exceed fertilizer rates which the plant can utilize. Also, more attention needs to be given to the effects of continuous intensive management on the chemical environment of the soil profile.

LITERATURE CITED


Diapause in the Boll Weevil, Anthonomus grandis Boheman, As Related to Fruiting Activity in the Cotton Plant

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ABSTRACT

Studies in Arkansas show that boll weevil diapause is related to changes in fruiting activity of the cotton plant. Generally, when larval development took place while fruiting levels were increasing or being held at a high level, diapause in resulting adults was low (0-20%). Diapause was approximately 20-50% when larval development coincided with decreasing fruiting levels, and was 50-100% as true cut-out approached. Regrowth cotton generally lowered diapause incidence and as fruiting levels decreased, diapause increased. Therefore, the boll weevil not only responds to short photoperiods that are characteristic during the fall in the temperate zone, but also may respond throughout the season to changes in fruiting activity of the cotton plant.

INTRODUCTION

Diapause, as defined by Hanson (1962), is a period of suspended growth and development and reduced metabolism in the life cycle of many insects in which the organism is more resistant to unfavorable environmental conditions than during other periods. A more concise definition states that diapause is a state of arrested growth and development that is not reversed upon any amelioration of the environment (Simmonds, 1948). The latter definition separates diapause from cold or heat stapor or aestivation.

Hibernation in the adult boll weevil was recognized as a means of overwintering as early as 1903 (Sanderson, 1907). However, diapause as a physiologic phenomenon was not defined until 1959 (Brazzel and Newsom, 1959). Diapause was characterized in this insect by a cessation of gametogenesis and atrophy of gonads, increase in fat content, decrease in water content, and decrease in respiratory rate. Since 1959, the term diapause has been used extensively in boll weevil studies.

Earle and Newsom (1964) found that diapause in the boll weevil could be induced by 11-hr photoperiods and suppressed by 13-hr photoperiods. The immature stages were sensitive to photoperiod but the adults were not. The response to photoperiod was modified by temperature and food.

Lloyd et al. (1967) listed five environmental stimuli that are conducive to diapause in the boll weevil: (1) exposure of the larval and pupal stages to an 11-hr photoperiod, (2) exposure of adults to night temperature of 10 C, (3) adult diet of bolls, (4) limitation of the quantity of squares fed to adults, and (5) larval diet of bolls.

In previous years, boll weevil diapause initiation has been considered to occur primarily in the fall. However, recent field studies have shown that diapause initiation is not restricted to the fall, and that a midseason incidence of diapause consistently occurs. Brazzel and Newsom (1959) found diapausing boll weevils in ground trash each month of the year except June and July. They detected diapause in field individuals as early as 30 July and movement to winter quarters was observed to begin as early as 16 August during 1957. Brazzel and Hightower (1960) observed increased reproductive activity in boll weevils on September regrowth cotton and Beckham (1962) reported that the time of entry into diapause was related to maturity of the cotton plant. Findings similar to these have been reported by Lloyd et al. (1964), Mitchell and Mistic (1965), and Walker and Batrell (1970).

The foregoing findings, in addition to reports on other insects regarding the influence of plant growth substances on insect growth and development (Carlisle et al., 1965; Nation and Robinson, 1966) and the influence of host plant maturity on diapause initiation (Gambino, 1954; Geyspitz, 1953), led to the following studies in Arkansas on the effect of plant growth substances on boll weevil diapause.

Kimbrough (1970) found that incidence of diapause in the boll weevil could be increased or decreased when certain plant growth substances were incorporated into the artificial diet. Kinetin and ortho-chlorophenoxyacetic acid supplied in this manner reduced diapause incidence. Kimbrough also found that the adult weevil does not need to feed as an adult prior to attaining diapause. Continuing this work, Otwell (1970) also observed that kinetin and ortho-chlorophenoxyacetic acid reduced diapause incidence. Diapause reduction, when these compounds were used in a 2:1 combination, approached 44%. Kinetin and gibberellic acid (GA) in a 1:1 combination also reduced diapause incidence. In late September and early October field studies, Otwell observed that diapause initiation was earlier on Rex cotton (a determinate variety) than on DPL cotton (an indeterminate variety).

Because the incidence of diapause at midseason relates directly to the reproductive potential of boll weevil populations, the ability to control, alter, or even predict the seasonal incidence of diapause would prove valuable in managing boll weevil populations. Therefore, work was begun in 1971 to evaluate the influence of host plant condition on boll weevil diapause. This paper summarizes recent work.

MATERIALS AND METHODS

Diapause incidence was compared on indeterminate and determinate lines of cotton during September and October of 1971. Mated female weevils were reared over squares and bolls of two determinate lines of cotton (Stripper 31 and Yugo 11) and an indeterminate (DPL) cotton and allowed to oviposit. Squares and bolls with ovispositional punctures were tagged, allowed to remain on the plant until abscission, then held in the laboratory until adult emergence. Adults were maintained at 25 C and a 12-hr photoperiod and fed the larval food source. Weevils were dissected for diapause determination at the end of 14 days. In male weevils criteria for diapause were the atrophy...
of the gonads and the absence of sperm packets; in the female, the criterion was atrophied ovaries with no indication of oogenesis.

Samples of squares and bolls were collected from Rex and DPL varieties in different stages of maturity. They were freeze-dried and incorporated into a modified Vandersant's diet (Vanderzant et al., 1959) at the rate of 30 g freeze-dried sample per 1000 ml diet. Diapause response was measured in weevils reared on these test diets to detect possible alterations in diapause tendencies as a result of maturity differences. Weevils were reared as immatures and held as adults at 21 C with 10.5, 11.5, 12.5, and 13.5-hr photoperiods. Adults were fed the same diets as larvae and were dissected after 21 days.

Twelve cotton entries, selected to give varying fruiting patterns and degrees of earliness, were planted near Newport, Arkansas, in 1972. Squares infested by field populations of weevils were collected from these cottons on 27 July and 7 September. A 16 August collection was obtained by artificially implanting weevil eggs in squares. The infested forms were collected after abscission and held in an open-air insectary. Adult weevils were then fed on squares from the respective cotton entries for 21 days prior to dissection.

A second objective during 1972 was to evaluate diapause response to controlled flower bud density in both determinate and indeterminate varieties of cotton. Fruiting levels of 75,000 squares per acre were maintained in one indeterminate cotton (DPL) and three determinate cottons (IX5-56, Yugo 11, and Arkugo 1). The normal fruiting level in each entry was used as control. Infested squares were collected from each of the plots and treated in the same manner as those discussed heretofore.

RESULTS

Results show that maturity of the host is reflected in incidence of boll weevil diapause (Table I). Average diapause in squares and bolls in an actively growing DPL variety was 26.7% compared to 36.1% for Stripper 31 and 45.5% for Yugo 11. The latter two were in more advanced stages of maturity. A chi-square test with diapause incidence on the DPL cotton as the expected value showed highly significant differences (P < 0.005) in diapause incidence between DPL cotton and the two determinate lines.

Results of laboratory tests to bioassay weevil diapause response to diet-incorporated plant parts samples collected from Rex cotton in advanced maturity and an actively fruiting DPL cotton are shown in Table II. Findings in this series of tests substantiate the field observations that host plant maturity has considerable influence on the initiation of diapause in the boll weevil. For example, cut-out stage Rex bolls effected 55% diapause in contrast to 24% in peak-fruiting DPL bolls when tests were conducted under a 12.5-hr photoperiod. With the exception of tests with Rex bolls and DPL bolls at 11.5-hr, results were similar at the other three photoperiods. Mean percent diapause at all four photoperiods shows that Rex bolls effected 66% diapause, whereas DPL bolls effected 45%. More weevils (55%) diapause from Rex cut-out stage squares than from vegetative stage DPL bolls (45%). Larval and/or adult diets have been thought to be conducive to diapause. The DPL incorporated diets, however, did not reduce diapause in comparison to diapause incidence in the standard diet controls.

Table III shows the average seasonal fruiting counts of 12 cotton entries and the average diapause initiation in boll

Table I. Late Season Incidence of Diapause in Boll Weevils Reared in Bolls and Squares of an Indeterminate Cotton (DPL) and in Two Determinate Cottons (Stripper 31 and Yugo 11), Fayetteville, Arkansas, 1971

<table>
<thead>
<tr>
<th>Entry</th>
<th>Squares</th>
<th>Bolls</th>
<th>Percent Diapause</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPL</td>
<td>37.2</td>
<td>14.3</td>
<td>26.7</td>
</tr>
<tr>
<td>Stripper 31</td>
<td>56.2</td>
<td>20.0</td>
<td>36.1</td>
</tr>
<tr>
<td>Yugo 11</td>
<td>50.0</td>
<td>42.8</td>
<td>45.5</td>
</tr>
</tbody>
</table>

*26.7 is significantly different (P < 0.005) from 36.1 and from 45.5.

Table II. Diapause Incidence in Boll Weevils Reared on Artificial Diet Incorporated with Lyophilized Squares and Bolls from Cut-Out Rex Cotton and an Actively Growing DPL Cotton, Fayetteville, Arkansas, 1971.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Diapause (%) at 4 Photoperiods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Std. diet</td>
</tr>
<tr>
<td>Rex sq.</td>
<td></td>
</tr>
<tr>
<td>DPL sq.</td>
<td></td>
</tr>
<tr>
<td>Rex bolls</td>
<td></td>
</tr>
<tr>
<td>DPL bolls</td>
<td></td>
</tr>
</tbody>
</table>

Table III. Mean Fruiting Activity of 12 Cotton Entries and Mean Diapause Incidence in the Boll Weevil on These Cottons at the Dates Indicated, Newport, Arkansas, 1972.

<table>
<thead>
<tr>
<th>Date</th>
<th>X Sq/A (1000's)</th>
<th>X Percent Diapause</th>
</tr>
</thead>
<tbody>
<tr>
<td>29 June</td>
<td>37</td>
<td>21</td>
</tr>
<tr>
<td>5 July</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>12 July</td>
<td>137</td>
<td></td>
</tr>
<tr>
<td>19 July</td>
<td>197</td>
<td></td>
</tr>
<tr>
<td>27 July</td>
<td>139</td>
<td>21</td>
</tr>
<tr>
<td>3 August</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>11 August</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>16 August</td>
<td>41</td>
<td>3</td>
</tr>
<tr>
<td>23 August</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>30 August</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>7 September</td>
<td>19</td>
<td>87</td>
</tr>
</tbody>
</table>
Diapause in the Boll Weevil, Anthonomus grandis Boheman, As Related to Fruiting Activity in the Cotton Plant

A drought during June and July induced a decline in square formation after 19 July. Irrigation and rainfall in mid-August initiated a resumption of fruiting and a second fruiting peak was reached on 23 August. Weevils collected on 27 July developed from eggs deposited in squares at or subsequent to the 19 July peak fruiting. Mean diapause incidence in this collection of weevils was 21% and the incidence ranged from 5 to 40% in the 12 entries. Diapause frequencies were generally low (5-28%) on individual entries where fruiting was heavy and the plants were growing, but were higher (33-40%) in cottons that were fruiting moderately and beginning to show drought stress earlier than other entries. Diapause seemed to be influenced by drought-induced maturity of these cottons.

The 16 August group of weevils was collected 9-11 days after irrigation and rainfall. The immatures in this group of weevils were reared on plants growing and fruiting rapidly. The incidence of diapause in weevils developing on this type of plant growth ranged from 0-14% with an average of 3% on the 12 entries. These figures are based on a total of 78 weevils obtained by implanting eggs.

The 7 September group of weevils developed on cotton in advanced stages of maturity at a time when environmental stimuli were also conducive to diapause. The incidence of 87% diapause on this sample date reflects responsiveness of the weevil to these conditions.

Diapause response to adjusted versus normal fruiting level plots of determinate and indeterminate cottons is shown in Table IV. Fruiting levels were adjusted by taking weekly square counts and removing squares in excess of 75,000 squares/acre. This practice maintained plants in a more vegetative state with a high fruiting capacity. Even though excess squares were removed at weekly intervals, the adjusted fruiting level plots showed a seasonal fruiting curve similar to that of the controls.

For this reason, the comparisons in Table IV are made between diapause incidence and the fruiting rate tendencies during the time of larval development on the plant. Diapause incidence was 50% on normal fruiting DPL-16 cotton with a decreasing fruiting rate compared to 44.4% on the controlled fruiting level plot with an increasing fruiting rate. Illustrations of this relationship can be seen in similar comparisons in the other cottons. The relationship of fruiting rate changes to initiation of diapause is shown in the three groups of weevils obtained from the Arkugo 1 plots. On 27 July, the normal fruiting rate was decreasing whereas the fruiting rate was heavy on the controlled plot. Diapause on the two plots was 27% and 0% respectively. On 11 August, the normal plot induced 28.6% diapause while its fruiting rate was decreasing. In contrast, the controlled plot induced 20% diapause as it was beginning regrowth after irrigation. The 16 August samples showed both plots with lower incidences of diapause as a result of their increasing fruiting rates due to regrowth. Diapause incidence was consistently higher on the normally fruiting plots, with the exception of the IX6-56 samples. Conversely, the controlled fruiting level plots generally had higher fruiting rates and less diapause.

Table IV. Comparison of Boll Weevil Diapause with Fruiting Activity in Four Cotton Entries Adjusted Weekly to Two Fruiting Levels, Normal (Level A) and 75,000 Squares Per Acre (Level B), Newport, Arkansas, 1972

<table>
<thead>
<tr>
<th>Cotton Entry</th>
<th>Fruit Level</th>
<th>Date</th>
<th>Fruiting Rate</th>
<th>Percent Diapause</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPL-16</td>
<td>A</td>
<td>27 July</td>
<td>decreasing</td>
<td>50.0</td>
</tr>
<tr>
<td>DPL-16</td>
<td>B</td>
<td>27 July</td>
<td>increasing</td>
<td>44.4</td>
</tr>
<tr>
<td>IX6-56</td>
<td>A</td>
<td>27 July</td>
<td>heavy</td>
<td>0.0</td>
</tr>
<tr>
<td>IX6-56</td>
<td>B</td>
<td>27 July</td>
<td>increasing</td>
<td>12.5</td>
</tr>
<tr>
<td>Yugo 11</td>
<td>A</td>
<td>27 July</td>
<td>decreasing</td>
<td>16.6</td>
</tr>
<tr>
<td>Yugo 11</td>
<td>B</td>
<td>27 July</td>
<td>heavy</td>
<td>0.0</td>
</tr>
<tr>
<td>Arkugo 1</td>
<td>A</td>
<td>27 July</td>
<td>decreasing</td>
<td>27.3</td>
</tr>
<tr>
<td>Arkugo 1</td>
<td>B</td>
<td>27 July</td>
<td>heavy</td>
<td>0.0</td>
</tr>
<tr>
<td>Arkugo 1</td>
<td>A</td>
<td>11 August</td>
<td>decreasing</td>
<td>28.6</td>
</tr>
<tr>
<td>Arkugo 1</td>
<td>B</td>
<td>11 August</td>
<td>regrowth</td>
<td>20.0</td>
</tr>
<tr>
<td>Arkugo 1</td>
<td>A</td>
<td>16 August</td>
<td>regrowth</td>
<td>16.7</td>
</tr>
<tr>
<td>Arkugo 1</td>
<td>B</td>
<td>16 August</td>
<td>regrowth</td>
<td>14.0</td>
</tr>
</tbody>
</table>
DISCUSSION

Observed changes in diapause incidence seem likely to be either a direct or an indirect response to plant growth substances which bring about changes in plant growth, fruiting, and maturity. The weevil seems to respond with a low incidence of diapause when plant growth and fruiting are stimulated. Conversely, a higher incidence of diapause is associated with slowed fruiting rates, retarded growth, and/or induced maturation of the host plant. Thus weevils respond throughout the season to these changes in plant growth and fruiting.

Midseason diapause occurs as a host plant response under conditions of long photoperiods and high temperatures which normally inhibit diapause. Fruiting activity and growth of the host plant therefore should be included in those environmental stimuli conducive to diapause. Furthermore, upon detailed study of boll weevil diapause, it seems likely that the weevil would be found to possess an array of faculties to cope with less than favorable conditions, whether they be high or low temperatures, temporary shortage of food, mature cotton host, etc. Therefore, it is apparent that the term diapause is being used in its broadest sense to include the various means of the boll weevil to circumvent a wide range of unfavorable conditions.

The data presented support Sterling's (1972) observation that plant maturity may be more useful than photoperiod in attempts to predict seasonal incidence of diapause in the boll weevil. The wide range of in-season rates of weevil population increase reported in the literature (Sterling and Adkisson, 1970) possibly could be explained by better understanding of this relationship. Midsummer diapausing weevils, as well as other types of diapausing weevils, should be given detailed study.

Boll weevil diapause has been shown to be related to changes in fruiting activity of the cotton host plant, especially during the time of larval development on the plant. Generally, when larval development took place while fruiting levels were increasing to a peak or when a peak was being maintained, diapause incidence was low (0-20%). Diapause was approximately 20-25% when larval development took place coincident with decreasing fruiting levels, and was highest (50-100%) as true cut-out approached. Diapause incidence on cotton rapidly fruiting as a result of regrowth was generally low (0-20%) and as fruiting rates decreased, diapause increased. Therefore, diapause in the boll weevil is not only a response to short photoperiods that are characteristic during the fall in the temperate zone, but it is also a season-long response to changes in fruiting activity, growth, and maturity of the cotton plant.

ACKNOWLEDGEMENT

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LITERATURE CITED

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Diapause in the Boll Weevil, Anthonomus grandis Boheman, As Related to Fruiting Activity in the Cotton Plant


Dry Matter and Minerals in Loblolly Pine Plantations On Four Arkansas Soils

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ABSTRACT

Average contents of N, P, K, Ca, and Na and total aboveground dry matter were determined in 19-year-old unthinned loblolly pine (Pinus taeda L.) plantations in southeastern Arkansas. Three stands were sampled on each of four sites: well and poorly drained coastal plain soils and well and poorly drained loessial soils. Total dry weights, determined from 15 felled trees on each of the 12 plots, ranged from 127,000 kg/ha on poorly drained loessial soil to 173,300 kg/ha on poorly drained coastal plain soil. Ranking of sites, in descending order of production of dry matter, P, K, and Na was: coastal plain poorly drained, coastal plain well drained, loess well drained, and loess poorly drained. Quantity of Ca in stemwood and stembark was 36% higher on well than poorly drained soils; P was 30% higher on coastal plain than loess soils. Results permit calculation of nutrient drain in timber harvests. Bark in 19-year-old plantations contained 44, 44, 25, and 50% of total N, P, K, and Ca in the stems.

INTRODUCTION

Increasing intensity of timber management and tree utilization leads to a need for accurate information on the nutrient budget and dry matter production levels in pulpwood plantations on different site classes. Quantities of minerals in trees may be expected to differ between sites; Wells (1965) found highly significant correlations between foliar N, P, K, Ca, and Mg percentages in 3-year-old loblolly pines and the concentrations of these elements in the soil. Switzer et al. (1966) harvested five trees in each of five size classes, from saplings to sawtimber, on good and poor sites. Accumulation rates of dry matter and nitrogen in stemwood and total trees were roughly twice as great on the good as on the poor sites; N percentages in foliage, branches, stemwood, and stembark were nearly the same on both sites. Metz and Wells (1965) harvested 10 trees of different sites, 7-21 years old, and found distribution of N, P, K, Ca, and Mg on a weight basis by tree parts related to tree size but not necessarily to age. Bark contained 15-20% of the elements, regardless of tree size.

To obtain data on dry matter production and nutrient immobilization for the four land types most commonly planted to loblolly pine in southeastern Arkansas, a study was begun in February 1967. The study also yielded information on weight and volume of total and merchantable wood per acre, which will be published in another paper.

MATERIAL AND METHODS

Field. The 12 stands of loblolly pine (Pinus taeda L.) selected for sampling had the following attributes: age 19 from seed germination, 6x7-ft spacing, good survival, uniform canopy height, and homogeneous soil morphology. Three plantations were selected on each of four sites: well and poorly drained coastal plain soils (Savannah and Caddo series) and well and poorly drained loessial soils (Calloway and Crowley series).

In each plantation a square 0.1-acre plot was laid out, and diameter at breast height (d.b.h.) of every tree was measured with a diameter tape. Fifteen trees in each plot, representing all d.b.h. classes present, were felled; total height was measured and boles were bucked into 63-in. bolts up to 4-in. top diameter outside bark. The stem portion above this 4-in. diameter is called the leader.

Fresh weights of felled trees were determined on site. All bolts, plus leader, of each tree were weighed to obtain stemwood plus stembark weight. Live branches with foliage and then dead branches were weighed. Foliage weight was obtained as a fraction of live branches by sampling; live branches were selected from the upper, middle, and lower crown; all needles were plucked from these branches and weighed.

A 2-in. thick sample disk with bark was cut from the base of the basal bolt and from the upper end of each additional bolt to determine dry weight/fresh weight ratio.

For nutrient determinations, three codominants were selected from the 15 felled trees—those whose basal areas were nearest the plot mean. A sample disk 2 in. thick, complete with bark, was cut at breast height and at the midpoint between the 4-in. diameter and the apical bud. The complete ring of bark and a sample sector of wood were taken from each disk. A composite sample of needles was collected from all shoots in the uppermost whorl.

Laboratory. Fresh weight of each sample disk was obtained, with and without bark, and samples were oven-dried. Foliage plucked from live sample branches was oven-dried.

Tissue samples for chemical analysis were oven-dried at 105 C and ground in a Wiley mill. Total N was determined by a macro-Kjeldahl procedure, P by a vanadomolybdic-nitric acid method, K and Na by flame photometry with a magnesium acetate-ammonium acetate solution (Jackson, 1958), and Ca by flame photometry (Wells and Corey, 1960).

Calculations. Dry weights of wood and bark in each bolt were calculated by using fresh weights and the average moisture content of the sample disks at each end of the bolt. Dry weights of wood and bark in each leader were calculated by using fresh weights and the moisture content of the sample disk at the 4-in.-diameter outside bark.

Equations expressing dry weight of foliage, live branches, dead branches, stemwood, stembark, and total aboveground tree for each of the four soil sites were derived by the form.
RESULTS AND DISCUSSION

**Dry Matter Production.** On the basis of stemwood or total tree production, the ranking of the four soil groups, from greatest to least, was: coastal plain poorly drained, coastal plain well drained, loess well drained, and loess poorly drained (Table I). Stemwood production was 52% greater on the best

Table I. Dry Weights of Aboveground Tree Parts by Soil Groups

<table>
<thead>
<tr>
<th>Tree Part</th>
<th>Coastal Plain Soil</th>
<th>Loessial Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poorly Drained</td>
<td>Well Drained</td>
</tr>
<tr>
<td>Foliage</td>
<td>6,800</td>
<td>5,000</td>
</tr>
<tr>
<td>Live branches</td>
<td>15,500</td>
<td>14,000</td>
</tr>
<tr>
<td>Dead branches</td>
<td>8,000</td>
<td>6,600</td>
</tr>
<tr>
<td>Stembark</td>
<td>15,400</td>
<td>14,300</td>
</tr>
<tr>
<td>Stemwood</td>
<td>128,900</td>
<td>114,600</td>
</tr>
<tr>
<td>Total tree</td>
<td>173,300</td>
<td>159,100</td>
</tr>
</tbody>
</table>

1 Each entry in the table was derived from a separate regression equation; therefore, the weights of tree parts are not additive. Total tree weights will not equal arithmetic sums of part weights.

Table II. Weights of Dry Matter of Aboveground Tree Tissues: Significant Differences Between Site Means According to Duncan’s New Multiple Range Test

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Coastal Plain Soil</th>
<th>Loessial Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Poorly Drained</td>
<td>Well Drained</td>
</tr>
<tr>
<td></td>
<td>Stembark</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15,400 *</td>
<td>14,400 *</td>
</tr>
<tr>
<td></td>
<td>13,300 *</td>
<td>9,300</td>
</tr>
<tr>
<td></td>
<td>Stemwood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>128,900 *</td>
<td>114,600 *</td>
</tr>
<tr>
<td></td>
<td>103,500 *</td>
<td>84,700</td>
</tr>
<tr>
<td></td>
<td>Entire tree</td>
<td></td>
</tr>
<tr>
<td></td>
<td>173,300 *</td>
<td>159,100 *</td>
</tr>
<tr>
<td></td>
<td>143,800 *</td>
<td>127,200 *</td>
</tr>
</tbody>
</table>

1 Any two means in the same row not denoted by same letters are significantly different at \( P < 0.05 \).

than on the poorest sites. Dry weight in total trees was 36% greater on the most productive than on the least productive sites. These differences were significant at the 0.05 level (Table III).

Relative efficiency of stands on different sites is indicated by their proportions in photosynthetic apparatus (foliage plus live branches). This averaged 12% of total stand dry weight on coastal poorly drained, 14% on coastal well drained, 14% on loess well drained, and 18% on loess poorly drained soils. Switzer et al. (1966) likewise found stemwood forming a greater percentage of stand total dry weight on good than on poor sites.

Ten to 11% of the dry weight of entire stems (wood plus bark) was in bark on all sites.

Mean annual rates of net accumulation of dry matter in stems and in entire trees in these plantations are very high (Table III). Loblolly pine is a very efficient fiber crop; cotton

Table III. Mean Annual Rates of Dry Matter Accumulation in Stemwood and Entire Tree by Soil Group

<table>
<thead>
<tr>
<th>Soil Group</th>
<th>Coastal Plain Soil</th>
<th>Loessial Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poorly Drained</td>
<td>6,780</td>
<td>6,030</td>
</tr>
<tr>
<td>Well Drained</td>
<td>5,450</td>
<td>4,460</td>
</tr>
<tr>
<td>Entire tree</td>
<td>9,120</td>
<td>8,370</td>
</tr>
</tbody>
</table>

(Gossypium spp.) on these soils probably would not produce nearly as much dry fiber.

The Official Soil Series Descriptions of the Soil Conservation Service give site index for loblolly pine on these soils as Caddo 90, Savannah 88, Calloway 90, and Crowley 90. These figures indicate that the four soil series would be similar in productivity class with stands at age 50. However, results from this study showed that the ranking of dry matter production is not the same as the ranking of mean total height at age 19 which was 61, 53, 55, and 49 ft for Caddo, Savannah, Calloway, and Crowley soil series, respectively.

Other workers have found instances in which stands having the same site index at age 50 showed sharp differences in height-age relations in early youth (Carmean, 1961; Spurr, 1964). Site index ratings for soil series deal with the general, whereas the writers are dealing with the particular.

**Mineral Fraction.** Concentrations of N, P, K, and particularly N, were higher in apical than in breast-height stemwood and stembark. Ovington (1959) also found these elements increasing with height up the stem in Scotch pine (Pinus sylvestris L.) plantations.

Analysis of variance was computed for each of the five elements in each of the tree tissues. Foliar P was the only tissue nutrient that varied in the same order as total production among the four sites. Significant differences were found among site means for other nutrients, but their rankings were not the same as the ranking of stemwood production (Table IV). On the basis of these findings, foliar analysis appears unlikely to provide a useful guide to site productivity in loblolly pine plantations on soils such as those studied.

Accumulation of minerals in stemwood and stembark is shown in Table IV. Weights of P, K, and Na varied in the same order as total production. Calcium in wood and bark was significantly higher on well than on poorly drained soils, and on coastal plain soil than on loess. Phosphorus fractions were
significanty greater (0.05 level) on coastal plain than on loessial soil, but were not different between drainage classes. Phosphorus availability ordinarily is increased by waterlogging (Black, 1968; Redman and Patrick, 1965), but enhanced availability apparently does not lead invariably to increased uptake in all crop species alike.

The values shown in Table IV are the quantities of nutrients likely to be removed in tree-length pulpwood harvests. Nitrogen in total stems ranges from 111 kg/ha on well drained loess to 156 kg/ha on poorly drained coastal plain soils. Calcium is second in abundance and first in variability: 76 kg/ha on poorly drained loess to 138 kg/ha on well drained coastal plain soils. Phosphorus is the nutrient accumulated in boles in least quantity: 11-18 kg/ha.

CONCLUSIONS

Unthinned pulpwood plantations on the four soil groups most commonly planted to loblolly pine in southeastern Arkansas accumulated dry matter at rates of 6,700-9,100 kg/ha. Coastal plain poorly drained soils are the most productive, loessial poorly drained soils are least; coastal plain well drained and loessial well drained soils are intermediate. Productivity of the best sites is more than 50% greater than that of the poorest. Uncut stands at age 19 contain substantial quantities of N and Ca in stemwood and stembark. More than 10% of the dry weight of tree stems is bark. In view of the substantial expenditures for fertilizer application by some paper industries, it is interesting to note that debarking on site would lessen removal of N and Ca by 44 and 50%.

LITERATURE CITED


Table IV. Quantities of Nutrients in Stemwood, Stembark, and Entire Boles by Soil Group: Significant Differences Between Site Means According to Duncan's New Multiple Range Test

<table>
<thead>
<tr>
<th>Soil Group</th>
<th>Tissue Type</th>
<th>N (kg/ha)</th>
<th>P (kg/ha)</th>
<th>K (kg/ha)</th>
<th>Ca (kg/ha)</th>
<th>Na (kg/ha)</th>
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<tbody>
<tr>
<td>Coastal plain</td>
<td>Wood</td>
<td>105</td>
<td>11</td>
<td>69</td>
<td>83</td>
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<tr>
<td>poorly drained</td>
<td>Bark</td>
<td>51</td>
<td>7</td>
<td>21</td>
<td>34</td>
<td>*2</td>
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<tr>
<td>Entire bole</td>
<td></td>
<td>156</td>
<td>*9</td>
<td>*90</td>
<td>117</td>
<td>16</td>
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<tr>
<td>Loess</td>
<td>Wood</td>
<td>82</td>
<td>9</td>
<td>53</td>
<td>86</td>
<td>12</td>
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<tr>
<td>well drained</td>
<td>Bark</td>
<td>40</td>
<td>3</td>
<td>15</td>
<td>52</td>
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<tr>
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<td></td>
<td>122</td>
<td>*12</td>
<td>*68</td>
<td>138</td>
<td>14</td>
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<tr>
<td>Loess</td>
<td>Wood</td>
<td>74</td>
<td>8</td>
<td>52</td>
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<td>13</td>
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<td>poorly drained</td>
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<td>37</td>
<td>4</td>
<td>13</td>
<td>48</td>
<td>1</td>
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<tr>
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<td>111</td>
<td>*12</td>
<td>*65</td>
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<tr>
<td>Average</td>
<td>Wood</td>
<td>89</td>
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<tr>
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<td>128</td>
<td>13</td>
<td>70</td>
<td>114</td>
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*Any two means in the same column not denoted by same letters are significantly different at P 0.05.
An Observation on Natural Outcrossing in the Tomato (Lycopersicon esculentum L.) in Northwest Arkansas

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ABSTRACT
A single tomato plant homozygous for the recessive anthocyaninless mutant, ae, was grown in the middle of an experimental tomato plot at the University of Arkansas Agronomy Experimental Station Farm in Fayetteville. Progeny tests of seeds harvested from this plant indicated that only 0.7% of the seeds were the result of outcrossing to other plants.

In genetic studies on tomato at the University of Arkansas it has been common to produce F1 generations by establishing the F, plants in field plots and allowing them to set seed. These seeds were presumed to have resulted from self pollination, and the progeny to have represented a true F1 family. Recently such practice was questioned when, in explaining low yields of the mutant Cu from field grown F1 plants, Alexander et al. (1971) noted that "in this area (Wooster, Ohio), most if not all tomato flowers are pollinated by bumblebees."

Jones (1916) reported a minimum of 2-3% outcrossing in Connecticut. Lesley (1924) showed that the length of the style was a factor in the extent of outcrossing in California: 5% for the long styled variety Magnus and 0.6% for the short styled Dwarf Champion. Bumblebees were seen to visit the flowers in this experiment. The role of the short style in facilitating self pollination has since been shown by Schneck (1928), Robbins (1931), Rick and Dempsey (1969), and Free (1970).

Myers and Lewis (1930) reported only 0.53% outcrossing in Pennsylvania. Young (1940) found up to 1.8% in Texas and even 0.7% in greenhouse plants. Currance and Jenkins (1942) compared the degree of outcrossing in South Carolina with that in Minnesota. Both areas gave a maximum of 5% outcrossing with 6-ft separations between plants. This amount decreased with an increase in distance from the foreign pollen; no outcrossing was seen beyond 72-90 ft.

Rick's (1947) observations substantiated these findings. He reported that the solitary bees which pollinate tomato flowers in northern California work over small areas before returning to the hive. This resulted in 4% seed set on male sterile plants only 6 inches removed from a fertile plant, but reduced amounts of fruit set on male sterile plants separated from the pollen source by more than 6 inches.

Much higher rates of outcrossing can be obtained with male sterile plants in different localities (Rick, 1949). In certain areas with plants 4'/2-5 ft apart, 47% of the normal seed set was obtained. Two factors are involved: proximity to pollen vector and lack of competition for self fertilization. The studies of Richardson and Alvarez (1957) eliminated the second factor; they used a recessive leaf shape mutant rather than male steriles to test for outcrossing. At certain times of the year 17% outcrossing was obtained in areas near good pollinator habitats. (The pollinator was the halictid bee, Augochloropsis ignita Sm.) However, in some areas only 0.3% outcrossing was found, even with plants as close as 1 m to the pollen source. In Peru a similar study showed from 15 to 26% outcrossing (Rick, 1958).

It appears that although the stigma position, proximity of foreign pollen, and competition of pollen from the same plant all play a role in determining the amount of outcrossing, the activity of the pollinators is the most important factor. Therefore, one might expect great differences between different areas. However, all of the studies in the United States east of the Rocky Mountains have shown less than 5% outcrossing, indicating uniformly low pollen vector activity.

MATERIALS AND METHODS
A recessive anthocyaninless mutant, ae, in the genetic background of Lycopersicon esculentum cv Kokomo was chosen for study. Throughout the summer of 1972 (28 April to 28 August) a single plant homozygous for ae was grown in the middle of a 76-m row of tomatoes being used in other genetic studies at the University of Arkansas Agronomy Experimental Station Farm, Fayetteville, Arkansas. This row was bounded on either side by two or three rows of additional tomato plants. The unstaked plants were 46-61 cm apart and were allowed to intertwine on the ground between and within rows. Flowering time of the experimental plant was completely overlapped by the flowering time of one or more adjacent plants. Although the other plants in the plot represented several mutants and several varieties, there is no reason to suspect any incompatibilities between them. None of the other plants carried the ae gene in homozygous or heterozygous condition.

The stigmas of the test plant flowers were effectively exerted up to 1 mm beyond the tips of the anthers. (Most of the extension was due to the reflexed tips of the anthers rather than to a greatly elongated style.)

Seeds of the test plant were harvested on 28 August 1972 and sown in the greenhouse to screen for progeny having the ability to produce anthocyanin. Those progeny producing anthocyanin were presumed to have arisen by outcrossing, although no observations of pollen vector activity were recorded.

RESULTS
From the one ae plant 660 seeds were harvested and sown. Of these only 420 germinated. Three (0.7%) of the 420 progeny had the ability to produce anthocyanin. To rule out the possibility that these were due to accidental seed mixture, each of these plants was selfed by hand in the greenhouse and F2 progenies raised. All three F2 populations contained approximately 25% green stemmed plants.

The three plants presumed to have resulted from outcrossing were among the earliest germinating and most vigorous of the 420 progeny. Thus the effect, if any, of the low rate of...
germination was probably to inflate the value obtained for outcrossing.

Previous workers (Jones, 1916; Lesley, 1924; Rick, 1958) have applied correction factors to their data, stating that some crossing between flowers on the same plant or between plants carrying the same recessive allele must have occurred. Because crossing between flowers of the same plant was not considered outcrossing in the writer’s study, and because all other plants in the area were known not to contain the ae allele, no correction factor was applied.

The degree of outcrossing found in the study would lower the expected percentage of homozygous recessives in an F₂ from 25 to 24.8%, a difference which would not be detectable unless very large numbers of progeny were raised. Hence the present practice of obtaining F₂ families from open pollinated F₁ plants can be expected to give reliable results.

Production of seed without significant outcrossing may be accomplished with a minimum of separation between plants of different varieties.

LITERATURE CITED


Logical Transition from Magnetic Poles to Current Loops

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ABSTRACT

Consideration of the relationship between the magnetic field produced by a magnetic shell and that produced by a current loop requires the evaluation of the line integral $\oint \mathbf{H} \cdot d\mathbf{l}$, where a portion of the path must cross the dipole layer. The correct line integral to be evaluated must be $\oint \mathbf{B} \cdot d\mathbf{l}$. The evaluation of this integral leads immediately to the correct Maxwell equation in $\nabla \times \mathbf{H}$. Gaussian units are used.

The assumption of the existence of magnetic poles leads to Maxwell's fourth electromagnetic equation by the evaluation of the line integral

$$\oint \mathbf{H} \cdot d\mathbf{l},$$

where a portion of the path must traverse a magnetic dipole layer. In the Gaussian system of units, the magnetic field $\mathbf{H}$ is defined as the force per unit of magnetic charge. Using techniques familiar in electrostatics, one defines a magnetic potential $\mathbf{V}$ such that $\mathbf{H} = \nabla \mathbf{V}$ and for the dipole layer the potential is given by

$$\mathbf{V} = -\Phi \mathbf{O},$$

$\Phi$ being the solid angle subtended by the double layer of magnetic charge at the point of the potential and $\Phi$ being the strength of the dipole layer. The work necessary to carry a unit of magnetic charge from one side of the dipole layer to the other is found to be

$$4\pi \Phi.$$

The transition from magnetic effects attributed to magnetic poles to those attributed to Amperian currents usually is passed over lightly or ignored completely. Page (1952) makes the assumption that for a dipole layer the path integral for $\mathbf{H}$ is given by

$$\oint \mathbf{H} \cdot d\mathbf{l} = 4\pi \Phi.$$

This assumption leads to difficulties when Amperian currents are included in the theory. The inclusion of these currents, forces a redefinition of the field $\mathbf{H}$ if Maxwell's equation for curl $\mathbf{H}$ is to be derived correctly. The redefinition of $\mathbf{H}$, if carried back through the equations, leads to inconsistencies.

The fault lies with the assumption by Page (1952) that the closed path integral is equal to $4\pi \Phi$. Examination shows that the integral should not be taken over a closed path, but must be written as

$$\int \mathbf{H} \cdot d\mathbf{l} = 4\pi \Phi,$$

where $\mathbf{l}$ is an arbitrary open external path leading from the side of lower to the side of higher potential for the dipole layer. If the path is to be closed, allowance must be made for that portion of the path passing through the dipole layer. No matter how thin the layer becomes, even in the limit of zero thickness, one must allow for the finite discontinuity in the potential as discussed by Stratton (1941).

It is easily shown that the $\mathbf{H}$ field within the dipole layer is given by

$$\mathbf{H} = -4\pi \mathbf{M}.$$

Thus for the case of the closed path integral for $\mathbf{H}$, one finds

$$\oint \mathbf{H} \cdot d\mathbf{l} = \int \mathbf{H} \cdot d\mathbf{l} - \oint \mathbf{M} \cdot d\mathbf{l},$$

The closed path integral may be used on the right hand side as $\mathbf{M} = 0$ in the region external to the dipole layer. It is now evident that for the case of a magnetic dipole layer the path integral must be written as

$$\oint \mathbf{B} \cdot d\mathbf{l} = 4\pi \Phi,$$

and not $\oint \mathbf{H} \cdot d\mathbf{l}$ as Page (1952) assumes. The magnetic potential is that which results from all currents, both conduction and bound if such exist.

The Amperian point of view for magnetism requires that bound current be given by the expression

$$\mathbf{i} = \frac{k}{l} \oint \mathbf{M} \cdot d\mathbf{l}$$

as derived by Page (1952). Thus using $\mathbf{i} = 1/e$, the path integral for $\mathbf{B}$ may be written as

$$\oint \mathbf{B} \cdot d\mathbf{l} = 4\pi (i + i_b)/e$$

and substituting the value for $i_b$ into the equation yields

$$\oint \mathbf{H} \cdot d\mathbf{l} = 4\pi i/e$$

which is the correct integral form for Maxwell's equation in curl $\mathbf{H}$ for the static field case.

Consideration of the path integral as it penetrates the magnetic dipole layer gives a smooth transition from a theory based on the existence of magnetic poles to one requiring only currents produced by the motion of electric charge. In achieving the transition, the magnetic field $\mathbf{H}$ is defined precisely as the force per unit of magnetic pole and requires no redefinition when Amperian currents are included and magnetic pole density is set equal to zero.

LITERATURE CITED


Checklist of Arkansas Fishes

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ABSTRACT

Arkansas has a large, diverse fish fauna consisting of 193 species known to have been collected from the state's waters. The checklist is an up-to-date listing of both native and introduced species, and is intended to correct some of the longstanding and more recent erroneous Arkansas records.

INTRODUCTION

The fish fauna of Arkansas is large and diverse. The last attempt to list the fishes of the state was that of Black (1940). Many taxonomic and distributional changes have occurred since Black's list appeared, and many additional species have been found in Arkansas. More recently, Buchanan (1973) presented a key to Arkansas fishes with distribution maps. The writer's checklist is an up-to-date listing of the fishes of Arkansas and incorporates several taxonomic additions and changes not included in Buchanan's recent work.

The following checklist contains 193 species of fishes known to have been collected from the state's waters. Both native and introduced species are included. Each introduced form is indicated by an asterisk. This list also is intended to correct some of the longstanding and recent erroneous Arkansas records. The harelip sucker, Lagochilus lacera Jordan and Bratton, was once present in the White River drainage, but is now extinct and, therefore, not included in the checklist.

At least three impeding taxonomic changes eventually will produce alterations in the checklist; also, additional state records undoubtedly will be discovered in the future, necessitating further revision. With two exceptions, the common and scientific names used are those approved by the American Fisheries Society Committee on Names of Fishes (Bailey et al., 1970). The writer follows Pflieger (1971) in recognizing Campostoma oligolepis Hubbs and Greene as a separate species, and Moore (1968), Eddy (1969), and Hubbs (1972) in recognizing Notropis percobromus Cope) as a separate species. The family designations follow Moore (1968).

CHECKLIST

Family Petromyzontidae (lampreys)
1. Ichthyomyzon castaneus Girard ............ chestnut lamprey
2. Ichthyomyzon gagei Hubbs and Trautman ........ southern brook lamprey
3. Lampetra lamottei (Lesueur) ........ American brook lamprey

Family Polyodontidae (paddlefishes)
4. Polyodon spathula (Walbaum) ........ paddlefish

Family Acipenseridae (sturgeons)
5. Acipenser fulvescens Rafinesque ........ lake sturgeon
6. Scaphirhynchus albus (Forbes and Richardson) ........ pallid sturgeon
7. Scaphirhynchus platyrhynchus (Rafinesque) ........ shovelnose sturgeon

Family Amiidae (bowfins)
8. Amia calva Linnaeus ............... bowfin

Family Lepisosteidae (gars)
9. Lepisosteus oculatus (Winchell) ........ spotted gar
10. Lepisosteus osseus (Linnaeus) ........ longnose gar
11. Lepisosteus platostomus Rafinesque ........ shortnose gar
12. Lepisosteus spatula Lacepede ........ alligator gar

Family Clupeidae (herring)
13. Alosa chrysochloris (Rafinesque) ........ skipjack herring
14. Dorosoma cepedianum (Lesueur) ........ gizzard shad
15. Dorosoma petenense (Gunther) ........ threadfin shad

Family Salmonidae (trouts)
16. *Salmo gairdneri Richardson ........ rainbow trout
17. *Salmo trutta Linnaeus ........ brown trout

Family Umbriidae (mudminnows)
18. Umbra limi (Kirtland) ........ central mudminnow

Family Esocidae (pikes)
19. Esox americanus Lesueur ........ grass pickerel
20. *Esox lucius Linnaeus ........ northern pike
21. Esox masquinongy Mitchill ........ muskellunge
22. Esox niger Lesueur ........ chain pickerel

Family Hiodontidae (mooneyes)
23. Hiodon alosoides (Rafinesque) ........ goldeye
24. Hiodon tergisus Lesueur ........ mooneye

Family Cyprinidae (minnows and carps)
25. Campostoma anomalum (Rafinesque) ........ stoneroller
26. Campostoma oligolepis Hubbs and Greene ........ largescale stoneroller
27. *Carassius auratus (Linnaeus) ........ goldfish
28. Chionobrycon idellus Cuvier and Valenciennes ........ grass carp
29. Cyprinus carpio Linnaeus ........ carp

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<table>
<thead>
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<th>Number</th>
<th>Taxonomy</th>
<th>Common Name</th>
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<td>creek chub</td>
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<tr>
<td>78</td>
<td>Catostomus carpio (Rafinesque)</td>
<td>river carpsucker</td>
</tr>
<tr>
<td>79</td>
<td>Catostomus latipinnis (Lesueur)</td>
<td>quillback</td>
</tr>
<tr>
<td>80</td>
<td>Catostomus velifer (Rafinesque)</td>
<td>highfin carpsucker</td>
</tr>
<tr>
<td>81</td>
<td>Catostomus commersoni (Lacepede)</td>
<td>white carpsucker</td>
</tr>
<tr>
<td>82</td>
<td>Ctenogobius elongatus (Lesueur)</td>
<td>blue carpsucker</td>
</tr>
<tr>
<td>83</td>
<td>Erimyzon oblongus (Mitchill)</td>
<td>creek chubcarpsucker</td>
</tr>
<tr>
<td>84</td>
<td>Erimyzon succetta (Lacepede)</td>
<td>lake chubcarpsucker</td>
</tr>
<tr>
<td>85</td>
<td>Hybopsis australis (Rafinesque)</td>
<td>smallmouth buffalo</td>
</tr>
<tr>
<td>86</td>
<td>Hybopsis niger (Rafinesque)</td>
<td>black buffalo</td>
</tr>
<tr>
<td>87</td>
<td>Mystrema melanops (Rafinesque)</td>
<td>spotted chub</td>
</tr>
<tr>
<td>88</td>
<td>Mystropectus anisurum (Rafinesque)</td>
<td>silver chub</td>
</tr>
<tr>
<td>89</td>
<td>Mystropectus macrocephalus (Rafinesque)</td>
<td>golden chub</td>
</tr>
<tr>
<td>90</td>
<td>Mystropectus guryus (Rafinesque)</td>
<td>channel chub</td>
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<td>91</td>
<td>Mystropectus gelatus (Rafinesque)</td>
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</tr>
<tr>
<td>92</td>
<td>Mystropectus notatus (Lesueur)</td>
<td>black chub</td>
</tr>
<tr>
<td>93</td>
<td>Mystropectus nebulosus (Rafinesque)</td>
<td>brown chub</td>
</tr>
<tr>
<td>94</td>
<td>Mystropectus punctatus (Rafinesque)</td>
<td>channel chub</td>
</tr>
<tr>
<td>95</td>
<td>Mystropectus olivaceus (Girard)</td>
<td>slender chub</td>
</tr>
<tr>
<td>96</td>
<td>Mystropectus olivaceus (Storer)</td>
<td>slender chub</td>
</tr>
<tr>
<td>97</td>
<td>Mystropectus piceus (Rafinesque)</td>
<td>slender chub</td>
</tr>
<tr>
<td>98</td>
<td>Mystropectus piceus (Rafinesque)</td>
<td>slender chub</td>
</tr>
<tr>
<td>99</td>
<td>Mystropectus piceus (Rafinesque)</td>
<td>slender chub</td>
</tr>
<tr>
<td>100</td>
<td>Mystropectus piceus (Rafinesque)</td>
<td>slender chub</td>
</tr>
</tbody>
</table>

**Family Anguillidae (freshwater eels)**

101. Anguilla rostrata (Lesueur) | American eel

**Family Ictaluridae (freshwater catfishes)**

102. Ictiobus catus (Linnaeus) | white catfish
103. Ictiobus lewisi (Rafinesque) | black bullhead
104. Ictiobus natalis (Lesueur) | yellow bullhead
105. Ictiobus nebulosus (Lesueur) | brown bullhead
106. Ictiobus punctatus (Rafinesque) | channel catfish
107. Noturus albater Taylor | Ozark madtom
108. Noturus eleutheroides Jordan | mountain madtom
109. Noturus exilis Nelson | slender madtom
110. Noturus flavus Taylor | checkered madtom
111. Noturus flavus Rafinesque | stonecat
112. Noturus cyprinoides (Mitchell) | tadpole madtom
113. Noturus lineatus Taylor | Ouachita madtom
114. Noturus nitidus Jordan | brindled madtom
115. Noturus nutritus Jordan and Gilbert | freckled madtom
116. Noturus phaeus Taylor | brown madtom
117. Noturus taylori Douglas | Caddo madtom
118. Pyodictis olivaris (Rafinesque) | flathead catfish

**Family Cyprinodontidae (killifishes)**

119. Fundulus heteroclitus (Jordan) | northern stunk fish
120. Fundulus chrysops (Jordan) | golden topminnow
121. Fundulus notatus (Rafinesque) | blackstripe topminnow
122. Fundulus chrysops (Agassiz) | starhead topminnow
123. Fundulus olivaceus (Storer) | blackspotted topminnow

**Family Poeciliidae (livebearers)**

124. Gambusia affinis (Baird and Girard) | mosquito fish

**Family Amblyopsidae (cavefishes)**

125. Amblyopsis rosenbachi (Eisenmaster) | Ozark cavefish
126. Typhlichthys subterraneus Girard | southern cavefish

**Family Aphredoderidae (pirate perchs)**

127. Aphredoderus sayanus (Gilliams) | pirate perch

**Family Atherinidae (silversides)**

128. Labidesthes siculus (Cope) | brook silverside
129. Menidia beryllina Hay | Mississippi silverside
Checklist of Arkansas Fishes

Family Percichthyidae (temperate basses)

130. Morone chrysops (Rafinesque) ................................ white bass
131. Morone mississippiensis Jordan and Eigenmann ................ yellow bass
132. Morone saxatilis (Walbaum) .................................................. striped bass

Family Centrarchidae (sunfishes)

133. Ambloplites rupestris (Rafinesque) ................................... rock bass
134. Centrarchus macropterus (Lacepede) ................................. flier
135. Lepomis auritus (Linnaeus) .................................................. redbreast sunfish
136. Lepomis cyanellus Rafinesque ............................................. green sunfish
137. Lepomis gulosus (Cuvier) ..................................................... warmouth
138. Lepomis humilis (Girard) .................................................... orange-spotted sunfish
139. Lepomis macrochirus Rafinesque ......................................... bluegill
140. Lepomis marginatus (Holbrook) ........................................... dollar sunfish
141. Lepomis megalotis (Rafinesque) ......................................... longear sunfish
142. Lepomis microlophus (Gunther) .......................................... redbear sunfish
143. Lepomis punctatus (Valenciennes) ....................................... spotted sunfish
144. Lepomis symmetricus Forbes .............................................. bantam sunfish
145. Micropterus coosae Hubbs and Bailey ................................. redeye bass
146. Micropterus dolomieu/Lacepede .......................................... smallmouth bass
147. Micropterus punctulatus (Rafinesque) .................................. spotted bass
148. Micropterus salmoides (Lacepede) ....................................... largemouth bass
149. Pomoxis annularis Rafinesque ............................................. white crappie
150. Pomoxis nigromaculatus (Lesueur) ..................................... black crappie

Family Elassomatidae (pygmy sunfishes)

151. Elassoma zonatum Jordan .................................................. banded pygmy sunfish

Family Percidae (perches)

152. Ammocrypta aspella (Jordan) ............................................. crystal darter
153. Ammocrypta clara Jordan and Meek ................................ western sand darter
154. Ammocrypta vivax Hay ....................................................... scaly sand darter
155. Etheostoma asparginae (Forbes) ........................................... mud darter
156. Etheostoma blemnoideos Rafinesque ................................ greenside darter
157. Etheostoma caeruleum Storer .............................................. rainbow darter
158. Etheostoma chlorosomum (Hay) ......................................... bluntnose darter
159. Etheostoma colletti Birdsong and Knapp ................................ creole darter
160. Etheostoma euzonum (Hubbs and Black) .............................. Arkansas saddled darter
161. Etheostoma flavellare Rafinesque ....................................... fantail darter
162. Etheostoma fasiiforme (Girard) .......................................... swamp darter
163. Etheostoma gracile (Girard) ................................................ slough darter
164. Etheostoma histrio Jordan and Gilbert ................................ harlequin darter
165. Etheostoma juliae Meek ........................................................ yoke darter
166. Etheostoma micropsica Jordan and Gilbert .......................... least darter
167. Etheostoma moorei Raney and Suttkus ................................ yellowcheck darter
168. Etheostoma nigrum Rafinesque .......................................... johnny darter
169. Etheostoma pulilidorsum Distler and Metcalf .......................... paleback darter
170. Etheostoma parvipinne Gilbert and Swain ........................... goldstripe darter
171. Etheostoma proliare (Hay) ...................................................... cypress darter
172. Etheostoma punctulatum (Agassiz) ...................................... stipped darter
173. Etheostoma radiosum (Hubbs and Black) ................................. orangebell darter
174. Etheostoma spectabile (Agassiz) ........................................ orangethroat darter
175. Etheostoma stigmateum (Jordan) ......................................... speckled darter
176. Etheostoma whipplei (Girard) ............................................. redfin darter
177. Etheostoma zonale (Cope) .................................................. banded darter
178. Percina caprodes (Rafinesque) ............................................. logperch
179. Percina copelandi (Jordan) .................................................. channel darter

180. Percina evides (Jordan and Copeland) ............................... gilt darter
181. Percina maculata (Girard) ................................................... blackside darter
182. Percina nasuta (Bailey) ........................................................... longnose darter
183. Percina pantherina (Moore and Reeves) .............................. leopard darter
184. Percina phoxocephala (Nelson) .......................................... slenderhead darter
185. Percina sciera (Swain) ........................................................... dusky darter
186. Percina shumardi (Girard) .................................................... river darter
187. Percina uranidea (Jordan and Gilbert) ................................ stargazing darter
188. Stizostedion canadense (Smith) ............................................ sauger
189. Stizostedion vitreum (Mitchell) .............................................. walleye

Family Sciaenidae (drums)

190. Aplodinotus grunniens Rafinesque ................................... freshwater drum

Family Cottidae (sculpins)

191. Cottus bairdi Girard .............................................................. mottled sculpin
192. Cottus carolinus (Gill) ......................................................... banded sculpin

Family Mugilidae (mullets)

193. Mugil cephalus Linnaeus ...................................................... striped mullet

ACKNOWLEDGMENTS

This checklist was compiled with the help of many persons who provided specimens for examination, verified some of the writer’s identifications, provided records of specimens in their care, or assisted in the field work. Some of those who made particularly significant contributions were: Robert C. Cashner, Bruce A. Thompson, and Royal D. Suttles of Tulane University; Kirk Straw of Texas A & M University; Clark Hubbs of the University of Texas; Neil H. Douglas of Northeast Louisiana University; Henry W. Robison of Southern State College; Robert E. Jenkins of Roanoke College; John K. Beadles and George L. Harp of Arkansas State University; Donald Cloutman and Larry Olmsted of the University of Arkansas; and William E. Keith, Larry Rider, and Sammy Barkley of the Arkansas Game & Fish Commission.

LITERATURE CITED


Collection of Dalton Points from Yell County, Arkansas

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ABSTRACT

The hypothesis that projectile points serve functions other than use as a head for a missile was examined by Morse and Goodyear in regard to Dalton points. The writer reexamined this hypothesis in light of a significant collection of Dalton points from Yell County, Arkansas, and further substantiates the hypothesis formulated by Morse and tested by Goodyear.

INTRODUCTION

The first knowledge of Dalton came from the collection of Judge S. D. Dalton in Missouri (Chapman, 1948). Judge Dalton had been collecting the points from a single site for several years. It was from this location that “Dalton Culture” — the lithic assemblage which accompanies the Dalton points — first was defined. At the site of Judge Dalton it is early Archaic with the following attributes: lanceolate serrated Dalton points, expanding base drills, oval scrapers, projectile points reworked for scrapers, and also corner-notched, side-notched, and stemmed points (Chapman, 1948, p. 138). It is obvious that some mixing of materials was present, but it is also important to note that Dalton was already being viewed as a distinct point style and culture (Goodyear, 1971, p. 3).

Chapman (1948) attributes Dalton to an early Archaic manifestation which has its roots in the “Folsom” points style. The Dalton point recently has been assigned a relative temporal span of 8000 to 5000 B.C. The early date assigned the Dalton point may also be associated with this point style in other early sites. Graham Cave has Dalton points in levels 5 and 6 (Logan, 1952, p. 73). The importance of the Graham Cave finds is in relation to three radiocarbon dates from the lower levels which give Dalton a comparatively early time level. One sample from level 6 yielded a date of 7,750 ± 500 B.C. (M-130), a second from level 6 gave 6,880 ± 500 B.C. (M-131), and one from level 4 gave 5,850 ± 500 B.C. (Crane, 1956, p. 667). There are Dalton points in the lower levels of other sites as well: Modoc Rock (Fowler, 1959), Stanfield-Worley (DeJarnette et al., 1962), and Rodgers Shelter (MacMillan, 1965).

The purpose of this study was to examine a collection of Dalton points from Yell County, Arkansas. Because the history of the Dalton point is no more explicit in Arkansas than in any other section of the Dalton horizon, a brief summary of the Dalton point in Arkansas is presented.

The Dalton point has been collected in Arkansas for a long time with little realization of its cultural-historical significance. Although Dalton points with an accession date of 1929 are cited in this paper, there is no evidence that Dalton points were recognized as a distinct style until the work by Chapman in 1948. The first large-scale inquiry into Dalton culture in Arkansas was conducted by James Ford and Alden Redfield. Their Dalton Project Survey in 1961-1962 was an attempt to locate Paleo-Indian sites in the Mississippi alluvium (Redfield, 1971).

In 1962 Raymond Wood opened excavations at Breckenridge Shelter. Wood (1962, p. 90) defines a Dalton culture with points he typed as Breckenridge. This was somewhat confusing until the work of Thomas in 1969. Thomas (1969) considers the points Wood defined as Breckenridge to be of a general Dalton-Meserve typology. There have been numerous citations of Dalton points since the Ford-Redfield study in 1961-1962. The Lace Place study by Redfield and Moselage (1970) is especially important for it led indirectly to the hypothesis and testing by Morse and Goodyear.

The Lace Place, a site in Poinsett County, Arkansas, yielded a fair number of Dalton points. Redfield and Moselage postulate that Dalton point variation is due mainly to a temporal shift or variation through time. Using the data from the Dalton Project, they conducted a factor analysis of 116 concave-based lanceolate points, then worked the 116 points into a dendogram. The conclusions reached by Redfield and Moselage (1970) were: (1) the Dalton point has a great deal of regional variation, and use of a horizon for Dalton may be questionable; “It obscures the local relationships that may be found” (p. 39); and (2) the Dalton occupies a temporal span and variation is a result of change through time (p. 28). It was in answer to these contentions that Morse and Goodyear’s hypothesis was formulated.

The writer discusses mainly Goodyear’s testing of the hypothesis formulated by Morse, because the Master’s thesis written in 1971 by Goodyear describes the resharpening analysis in much greater depth than does the edited publication by Morse (1971).

DALTON RESHARPENING HYPOTHESIS

Goodyear (1971, p. 37) states,

The use of the term projectile point or Dalton point does not necessarily mean tools in this class were used as a head for a missile, Dalton Point is used here in the conventional descriptive sense to mean a bifacially worked artifact with basal haft preparation and a distal end which converges at a sharp angle to form the tip.

From this statement Goodyear built the following hypothesis. For Dalton the type definition is expressed mainly in condition of the base. According to Goodyear the body (blade) of the Dalton is open to variation.

The diagnostic attributes described for the Dalton base are: (1) parallel to concave stem edges in initial through advanced stages which are heavily ground; (2) ears on the basal corners which usually flare outward but may hang parallel with the point’s axis and are usually heavily ground; (3) a basal concavity that is ground in the preform stage but only to facilitate the removal of thinning flakes, is ground basally and laterally in the initial stage, and varies in depth but is always concave; and (4) basal thinning with one or more flute-like flakes originating in the basal concavity and running up the axis of the point (Goodyear, 1971, p. 37-38).

The body of the Dalton point must not be viewed in terms of consistent typing, but rather in a functional context.
variation in Dalton body size and shape is a result of resharpening. When the body is resharpened the body size and shape are in actuality altered and modified. Morse and Goodyear attribute the various and distinctive styles of Dalton points to the number of times the body has been resharpened. The first evidence to support this postulation of resharpening was found in the Hawkins Cache (Morse, 1971), where 18 Dalton points of various dimensions were found within a 2-sq-ft. area. It is quite possible that this material is the tool kit of a single individual.

The basic style for the Dalton point of the Hawkins Cache is a lanceolate, right-hand beveled, serrated point. Of the 18 points discovered, 16 fall into three distinct groups. The five points in what is termed group A have convex serrated body edges, the five points in group B have straight serrated body edges, and the six points in group C have a drill-like appearance. The two remaining points were used as burins according to Morse (1971, p. 10). The burin-stage point is reworked from an exhausted Dalton. Morse also conducted measurement analysis on the Dalton points from the Hawkins Cache and was able to make some general statements. First, there is a consistent 4-mm loss through the stages he proposed. As the body was undergoing this 4-mm loss there was no apparent loss in width of the base. Morse also observed an increase in the blade or body edge angle from group A to group C. These observations confirm his placing the points into distinct groups, for they are morphologically distinct. In conclusion, Morse believes this variation to be the result of body resharpening and not the result of regional or temporal variation.

**MATERIALS AND METHODS**

A collection of Dalton points from Yell County, Arkansas, was used in this reexamination of the Morse and Goodyear resharpening hypothesis. The points were examined by the basic tests of Morse (1971) and Goodyear (1971) to classify the points into five stages: (1) a completed preform stage, (2) an unresharpened stage, (3) an initial stage of resharpening, (4) an advanced stage of resharpening, and (5) a final stage of resharpening. In addition, measurements were made of point length, stem length, thickness, subjective body width, objective body width, objective stem width, width at the ears, basal depth, and angle of the blade. The measurements of stem length, point length, and thickness are self-explanatory. Subjective body width was measured where the body edge tapers off the shoulder, objective body width was measured at exactly half the length of the point, objective stem width was measured at half the length of the stem, width at the ears was the maximum distance between the ears or from ear tip to ear tip, and basal depth was measured from the deepest section of the concavity. The blade angle was measured by the method Goodyear cited (p. 52), by bending a wire around the body edge then measuring the angle of the bent wire. The results of this analysis are shown in Tables I-III.

**RESULTS AND DISCUSSION**

The data in Tables I-III are meaningful only if used in conjunction with the data from Goodyear's metric analysis. Most data in the tables are in general agreement with Goodyear's. The variance between the sample ranges and the sample means in several cases is to be expected. When testing a certain phenomenon, in this case resharpening, deviance must be expected. What is being tested is not actual identical characteristics, but rather similar general characteristics. In

<table>
<thead>
<tr>
<th>Point Characteristic</th>
<th>Number of Points</th>
<th>Mean Dimension (mm)</th>
<th>Dimension Range (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point length</td>
<td>41</td>
<td>49</td>
<td>70-38</td>
</tr>
<tr>
<td>Stem length</td>
<td>41</td>
<td>15.5</td>
<td>21-10</td>
</tr>
<tr>
<td>Basal concavity</td>
<td>41</td>
<td>03.5</td>
<td>8-01</td>
</tr>
<tr>
<td>Preform basal width</td>
<td>01</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>41</td>
<td>07</td>
<td>09-05</td>
</tr>
<tr>
<td>Objective stem width</td>
<td>41</td>
<td>21</td>
<td>30-16</td>
</tr>
<tr>
<td>Width at ears</td>
<td>41</td>
<td>23.5</td>
<td>33-19.5</td>
</tr>
</tbody>
</table>

| Subjective body width      |                 |                     |                      |
| Final stage                | 17              | 15                  |                      |
| Advance stage              | 07              | 16.5                |                      |
| Initial stage              | 11              | 20.5                |                      |

| Objective body width       |                 |                     |                      |
| Final stage                | 17              | 10.5                |                      |
| Advance stage              | 07              | 12.5                |                      |
| Initial stage              | 11              | 19                  |                      |

**Table II. Distribution of Physical Characteristics Among Yell County Dalton Points**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Number Of Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal grinding</td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>38</td>
</tr>
<tr>
<td>Absent</td>
<td>03</td>
</tr>
<tr>
<td>Lateral grinding</td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>39</td>
</tr>
<tr>
<td>Absent</td>
<td>02</td>
</tr>
<tr>
<td>Beveling</td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>21</td>
</tr>
<tr>
<td>Absent</td>
<td>20</td>
</tr>
<tr>
<td>Body cross section</td>
<td></td>
</tr>
<tr>
<td>Rhomboid</td>
<td>22</td>
</tr>
<tr>
<td>Biconvex</td>
<td>18</td>
</tr>
<tr>
<td>Plano-convex</td>
<td>01</td>
</tr>
<tr>
<td>Material</td>
<td></td>
</tr>
<tr>
<td>Novaculite</td>
<td>18</td>
</tr>
<tr>
<td>Flint-chert</td>
<td>21</td>
</tr>
<tr>
<td>Quartzite</td>
<td>02</td>
</tr>
</tbody>
</table>
Table III. Blade Resharpening Characteristics of Yell County Dalton Points

<table>
<thead>
<tr>
<th>Formative Stage</th>
<th>Number of Points</th>
<th>Blade Angle (degrees)</th>
<th>Body Edge Wear (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final</td>
<td>17</td>
<td>52</td>
<td>1.5</td>
</tr>
<tr>
<td>Advanced</td>
<td>07</td>
<td>46</td>
<td>4</td>
</tr>
<tr>
<td>Initial</td>
<td>11</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Completed preform</td>
<td>01</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

Goodyear's study 5.5-mm losses in body width from stage initial to stage advanced and 5.0-mm losses from stage advanced to the final stage were indicated. The findings from Yell County are not quite in line with these. There is a 4.0-mm loss from the initial stage to the advanced stage and a 1.5-mm loss from the advanced stage to the final stage. Although the reductions are not as great as those in Goodyear's analysis, they retain the general reduction in body width.

Approximately 64% of the initial stage points, 71% of the advanced stage points, and 29% of the final stage points show wear on the body edge. This information is in general agreement with that mentioned in Goodyear's study. Three final stage points show distal-end wear suggesting some function similar to use as asls or drills. However, microscopic examination of the distal end revealed no evidence of rotary wear.

DALTON VARIANTS

In this investigation two distinct categories—Dalton endscrapers and Dalton burins—were omitted from the tables because they fail to provide information relevant to the resharpening hypothesis. Because both Dalton burins and Dalton endscrapers are reworkings on Dalton bases, their affinity to resharpening is not particularly relevant without preceding remarks concerning the resharpening hypothesis. However, some general statements can be made in regard to these Dalton variants. Dalton endscrapers are not limited to any one stage of resharpening, but are not found in the final stage. There are examples of endscrapers in the preform complete stage, the initial stage, and the advanced stage. Apparently the final stage is not morphologically functional as an endscraper. In the case of Dalton burins there is a positive correlation with final stage points. The data indicate that only final stage Daltons have been reworked into burins. Regrettably, no analysis of wear patterns on the burin edge was possible because of luck of time.

SUMMARY AND CONCLUSIONS

The results of Morse and Goodyear's testing of the resharpening hypothesis were compared with test data from Yell County Dalton points. The writer believes that the data further substantiate the hypothesis formulated by Morse and tested by Goodyear.

1. Although the metric data are not identical to those of Morse and Goodyear, they demonstrate the same characteristics. As in the points of the Hawkins Cache and Brand Site, the basal width remains constant throughout the various stages.
2. From the numerous cases of consistent body edge wear from initial through advanced stages, it is apparent that some material was abraded on the body edge. According to Semonov (1964) this type of wear is observed when the artifact is used in a knife-like fashion.
3. The Dalton base is found supporting an endscraper in 12 cases and a burin in five cases, in addition to the body edge wear. It is suspected that the Dalton people were using the Dalton point to process faunal remains, using the point in a knife-like fashion.

LITERATURE CITED


REDFIELD, ALDEN, and JOHN MOSELAGE. 1970. The Lace Place, a Dalton Project site in the western lowlands in eastern Arkansas. Arkansas Archeologist 11(2):21-44.


Taxonomic Relationship of Hybrid Peafowl-Guineafowl: Preliminary Study of Serum Proteins

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ABSTRACT

Disc electrophoresis of serum proteins was conducted for the peafowl, guineafowl, peafowl-guineafowl hybrid, and domesticated chicken. The four birds analyzed are of the same order but family status has been questioned.

Serum protein patterns for all birds were similar in the anodic regions but different in the cathodic regions. The peafowl-guineafowl hybrid showed a pattern more similar to that of the peafowl than to that of the guineafowl. In morphologic characters the hybrid also was more similar to the peahen than to the guineafowl. In the cathodic region the serum protein pattern of the guineafowl was more unlike the patterns of the other three birds.

INTRODUCTION

The consequence of one or more isolating mechanisms is that birds of different species or genera either do not mate or mate rarely (Dobzhansky, 1951). Ecologic and zoogeographic isolation has kept the peafowl (Pavo cristatus) and common guineafowl (Numida meleagris) apart in the wild as the guineafowl is native to the Ethiopian zoogeographic realm and the peafowl to the Oriental realm. However, under domestication these two species have been brought together by man. Both the common guineafowl and the peafowl belong to the order Galliformes, but usually they are classified as members of different families. The peafowl has been placed with the domesticated chicken (Gallus gallus) in the family Phasianidae, whereas the guineafowl is placed in the family Numididae (Storer, 1971; Wetmore, 1960). Mainardi (1959) in his paper on immunologic distances among gallinaceous birds recommended grouping of all species of the families Numididae, Meleagrididae, Tetraonidae, and Phasianidae into one family, namely Phasianidae. Mainardi's paper is in agreement with Yamashina's (1952) cytologic studies and Sibley's (1960) electrophoretic analysis of egg-white proteins. Storer's (1971) classification includes the grouse, quail, pheasant, turkey, peafowl, and chicken in the family Phasianidae but retains the family Numididae for the guineafowl, Wetmore (1960) has retained four families in the superfamly Phasianoidae — Tetraonidae, Phasianidae, Numididae, and Meleagrididae.

The objective of this study was to compare the blood serum proteins of a cross between a peacock and female guineafowl with the blood serum proteins of a guineafowl, peafowl, and domesticated chicken. These comparisons might indicate some basis for reclassifying these birds.

METHODS AND MATERIALS

About 4 cc of whole blood was drawn by hypodermic needle from the wing vein of each of the four birds: peacock, guinea, peafowl-guineafowl cross, and domesticated chicken. The blood was allowed to clot and was centrifuged for 5 min. The serum was removed by a transfer pipette and frozen. Two different samples were taken from each bird and four replicate electrophoretic separations for each sample were investigated.

Disc electrophoresis procedures followed those of Davis (1964). The analyses were performed with an eight-column electrophoresis apparatus utilizing graphite electrodes and two circular reservoirs (5 cm deep and 15 cm in diameter) constructed from 15-cm acrylic tubing. Acrylamide gels (0.8 cm wide by 5.5 cm long) and TRIS buffer at pH 8.3 were used. Separation of serum proteins was conducted at 25 C and 25 mA for 40 min. After separation had occurred, the gels were stained for 20 hr with amido Schwartz stain. Destaining was done by a current of 40 mA until the excess stain was removed (about 1 hr). Gels were stored in a solution of glacial acetic acid and water. The best electrophoretic patterns were obtained by using a serum sample of 5 u/.

Blood samples were taken from only one of each of the birds and the hybrid cross for comparisons. A study by Snow et al. (1969) with three breeds of domesticated pigeons showed some individual differences among members of a particular breed. It was the writers' purpose to compare samples of serum proteins with those of the peafowl-guineafowl cross.

The hybrid peafowl-guineafowl cross (Fig. 1) was hatched from a guineafowl egg under natural conditions. This specimen was reported (Hanebrink, 1973) and behavioral and morphologic characters were described.

RESULTS AND DISCUSSION

Electrophoresis of proteins has not provided extensive information for avian systematics particularly at the generic and species levels because of much variability as to sex, age, health, or condition of the specimens (Baker and Hanson,
The study results are shown best by the electrophoretic patterns in Figure 2. The peacock has a definite double starting band whereas the guineafowl and hybrid cross have narrow separations barely visible at this point. The domesticated chicken has a single starting band. The greatest difference in the serum protein bands of the four birds is in the region from 4 to 27 mm measured from the cathode end. The four birds have basically the same bands in the region from 27 mm to the bottom of the gel. A close analysis of electrophoretic patterns as shown in Figure 2 reveals more similarities in pattern for the peafowl, hybrid cross, and domesticated chicken than for the guineafowl which is generally placed in a different family. The pattern of serum protein bands of the hybrid is more like that of the peafowl than that of the guineafowl. Morphologic characters are intermediate for the hybrid but general appearance (Fig. 1) is more nearly like that of the hen peafowl (Hanebrink, 1972).

The ease with which some crosses naturally occur among the Phasianoidae at the family level suggests a regrouping of the four families into one, namely Phasianidae. However, serum protein patterns as shown are different and this lends support to Storer’s (1971) recent classification in the retention of two distinct families in this superfamily. Additional research is needed to clarify this point.

ACKNOWLEDGEMENTS

The writers express their appreciation to Dr. Bob Johnson of the Biological Sciences Division at Arkansas State University for his advice, supervision of laboratory work, and reading of the manuscript, and to John and Roney Friday of Fredricktown, Missouri, for loaning the peafowl-guinea hybrid for study.

LITERATURE CITED


Natural Areas and Reference Collections for Environmental Education in Some Arkansas Schools

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Biology Department, State College of Arkansas, Conway, Arkansas 72032

ABSTRACT
A survey of 20 school campuses throughout Arkansas showed that most lack natural areas for outdoor environmental education. For most Arkansas schools no checklists of local plants are available, and there are no reference collections at the schools. Projects are underway at State College of Arkansas to establish herbaria for the woody plants of Arkansas and the vascular plants of Faulkner County.

Those who teach botany realize that it has become increasingly difficult to find adequate collection sites for plant materials. As our urban areas enlarge and Arkansas becomes more industrialized, it is also much more difficult to locate areas for studying relationships within natural communities of plants and animals. When such areas are found, permission for doing the study must be obtained from the owners of the property, and this may be difficult. At the same time, it is necessary that these aspects of biology be taught to larger numbers of people, for decisions about environment are constantly being made by all citizens and problems about the environment will increase in the future. For these reasons the schools and colleges must provide space for learning ecologic principles. For most classes, the school campus must become part of the classroom (Brainerd, 1971).

To assess the campus environment for outdoor studies in biology, a survey of 20 school campuses (Table I) was made by 20 botany students during spring vacation in March 1973.

Table 1. Types of Schools Used in Survey: Description of School Community

<table>
<thead>
<tr>
<th>School Number</th>
<th>Population of Town</th>
<th>Location of Town in Arkansas</th>
<th>Grades Taught in School</th>
<th>School Population</th>
<th>Type of School</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>150,000</td>
<td>Central</td>
<td>1-5</td>
<td>500</td>
<td>Public</td>
</tr>
<tr>
<td>2</td>
<td>4,000</td>
<td>South</td>
<td>4-6</td>
<td>—</td>
<td>Public</td>
</tr>
<tr>
<td>3</td>
<td>650</td>
<td>South</td>
<td>1-6</td>
<td>350</td>
<td>Public</td>
</tr>
<tr>
<td>4</td>
<td>7,000</td>
<td>Central</td>
<td>1-12</td>
<td>300</td>
<td>Church</td>
</tr>
<tr>
<td>5</td>
<td>1,500</td>
<td>North</td>
<td>1-6</td>
<td>400</td>
<td>Public</td>
</tr>
<tr>
<td>6</td>
<td>10,000</td>
<td>Central</td>
<td>1-6</td>
<td>—</td>
<td>Public</td>
</tr>
<tr>
<td>7</td>
<td>7,000</td>
<td>Central</td>
<td>1-6</td>
<td>500</td>
<td>Public</td>
</tr>
<tr>
<td>8</td>
<td>1,000</td>
<td>North</td>
<td>4-6</td>
<td>200</td>
<td>Public</td>
</tr>
<tr>
<td>9</td>
<td>60,000</td>
<td>South</td>
<td>1-4</td>
<td>350</td>
<td>Public</td>
</tr>
<tr>
<td>10</td>
<td>260,000</td>
<td>Central</td>
<td>1-8</td>
<td>700</td>
<td>Church</td>
</tr>
<tr>
<td>11</td>
<td>4,000</td>
<td>South</td>
<td>1-4</td>
<td>500</td>
<td>Public</td>
</tr>
<tr>
<td>12</td>
<td>3,000</td>
<td>Central</td>
<td>9-12</td>
<td>700</td>
<td>Public</td>
</tr>
<tr>
<td>13</td>
<td>11,000</td>
<td>South</td>
<td>9-12</td>
<td>1,500</td>
<td>Public</td>
</tr>
<tr>
<td>14</td>
<td>2,500</td>
<td>North</td>
<td>1-12</td>
<td>1,500</td>
<td>Public</td>
</tr>
<tr>
<td>15</td>
<td>500</td>
<td>North</td>
<td>1-6</td>
<td>150</td>
<td>Public</td>
</tr>
<tr>
<td>16</td>
<td>9,000</td>
<td>North</td>
<td>1-6</td>
<td>450</td>
<td>Public</td>
</tr>
<tr>
<td>17</td>
<td>60,000</td>
<td>South</td>
<td>1-6</td>
<td>350</td>
<td>Public</td>
</tr>
</tbody>
</table>
Emphasis was on the campus environment, with special reference to the availability of plants for study by pupils. The wildflowers which were identified using Fernald (1950) are listed in Table II.

Although in all cases the appearance of the school buildings was rated as good or excellent, only 13 campuses were reported good to excellent in appearance of the lawns, and seven were reported bleak and/or bare. The total campus environment usually needed attention. Only five school campuses had cultivated flowers, which included roses, iris, and daffodils. Thirteen campuses were adequately landscaped with shrubs. Numbers of trees on the campuses ranged from approximately 200 to only three. On all campuses there was adequate space for play, although not all schools had the space “developed” with equipment.

On only two campuses were there natural areas for outdoor education, and at these schools the various teachers utilized the areas for class studies. At eight schools some outdoor education could be done with the limited space, primarily by using the campus trees; however, on 10 campuses no space was available for environmental education. Table II indicates how inadequate the 20 school campuses would be in the study of wildflowers of Arkansas. A look at the number and kinds of wildflowers which bloom on these campuses shows that there is a great need for natural areas where wildflowers can be maintained. Learning to recognize the plants of such an area would be only part of the environmental learning which could occur (Dale, 1967).

The results of another study by a botany class also emphasize the need for proper management of campuses so that organisms will be available for students in the future. Wildflowers were collected from the school campuses in Conway, Arkansas (Table III). The number of kinds of

<table>
<thead>
<tr>
<th>School Number</th>
<th>Population of Town</th>
<th>Location of Town in Arkansas</th>
<th>Grades Taught in School</th>
<th>School Population</th>
<th>Type of School</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>60,000</td>
<td>Central</td>
<td>1-6</td>
<td>400</td>
<td>Public</td>
</tr>
<tr>
<td>19</td>
<td>20,000</td>
<td>Central</td>
<td>1-6</td>
<td>1,000</td>
<td>Public</td>
</tr>
<tr>
<td>20</td>
<td>60,000</td>
<td>South</td>
<td>5 and 6</td>
<td>400</td>
<td>Public</td>
</tr>
</tbody>
</table>

Table II. Wildflowers Collected from School Campuses Throughout Arkansas, March 5-10, 1973

<table>
<thead>
<tr>
<th>Name of Plant</th>
<th>School Campus Number</th>
<th>Total No. of Schools Where Wildflower was Found</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antennaria: everlasting</td>
<td>x</td>
<td>1</td>
</tr>
<tr>
<td>Cardamine: bitter cress</td>
<td>x x</td>
<td>3</td>
</tr>
<tr>
<td>Claytonia: spring beauty</td>
<td>x x</td>
<td>7</td>
</tr>
<tr>
<td>Galium: bedstraw</td>
<td>x</td>
<td>1</td>
</tr>
<tr>
<td>Houstonia: bluet</td>
<td>x x x x x x</td>
<td>7</td>
</tr>
<tr>
<td>Lamium: henbit</td>
<td>x x x x x x x x x x x</td>
<td>5</td>
</tr>
<tr>
<td>Ranunculus: buttercup</td>
<td>x x x x x x</td>
<td>6</td>
</tr>
<tr>
<td>Stellaria: chickweed</td>
<td>x x x</td>
<td>3</td>
</tr>
<tr>
<td>Taraxacum: dandelion</td>
<td>x x x x x x x x x x x</td>
<td>9</td>
</tr>
<tr>
<td>Trifolium: clover</td>
<td>x x x x x x x x x x x</td>
<td>5</td>
</tr>
<tr>
<td>Verbena: Verbena</td>
<td>x</td>
<td>1</td>
</tr>
<tr>
<td>Vicia: Vetch</td>
<td>x</td>
<td>1</td>
</tr>
<tr>
<td>Viola: johnny-jump-up</td>
<td>x x</td>
<td>3</td>
</tr>
</tbody>
</table>

Total number of wild flowers found at school: 7123411361051431000000
wildflowers is directly proportional to the length of time a school has been in operation on its site.

For most Arkansas schools, no checklists of local plants are available for use by the teacher and the pupils, and there are no reference collections at the schools.

No assessment of the college campuses was made. Currently, the botany class at State College of Arkansas is continuing the project of making a reference collection of the woody plants of Arkansas. Plants in this herbarium are available for use by beginning students in botany and general biology who could use such help. This collection, primarily of trees, at present contains only 96 species, less than a third of those native to the state (Moore, 1972). However, these are samples of the trees most frequently seen by students and, hopefully, are the trees which grow most abundantly in the state. Many species are represented by several specimens, collected from various parts of Arkansas, and these enable the students to study the variability within the species.

Renewed effort is being expended to complete the State College of Arkansas herbarium collection of the vascular plants of Faulkner County so that a well-documented annotated checklist of these plants can be available when needed by researchers. Such a checklist is greatly needed at the present time for environmental inventory studies and environmental impact statements. The vascular plant collection includes 14 pteridophytes in 5 families, 3 gymnosperms in 1 family, and 790 angiosperms: 12 monocotyledonous families with 144 species and 94 dicotyledonous families with 646 species. This total of 812 species may sound complete, but several groups need reexamining and many obvious omissions need to be added. Botany students are involved in this work and are making valuable contributions to the herbarium.

LITERATURE CITED


Table III. Wildflowers Collected from School Campuses in Conway, Arkansas (Faulkner County), April 6-10, 1970

<table>
<thead>
<tr>
<th>Name of Plant</th>
<th>School Campus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brassica: wild mustard</td>
<td>SJ, CHS</td>
</tr>
<tr>
<td>Capsella: shepherd's purse</td>
<td>CHS</td>
</tr>
<tr>
<td>Cardamine: bitter cress</td>
<td>SJ, I, S, E, JH, CHS</td>
</tr>
<tr>
<td>Cerastium: mouse-eared chickweed</td>
<td>E, JH, CHS</td>
</tr>
<tr>
<td>Claytonia: spring beauty</td>
<td>SJ, I, S, JH, CHS</td>
</tr>
<tr>
<td>Duchesnia: Indian strawberry</td>
<td>JH</td>
</tr>
<tr>
<td>Erigeron: fleabane</td>
<td>CHS</td>
</tr>
<tr>
<td>Helianthus: sneezeweed</td>
<td>CHS</td>
</tr>
<tr>
<td>Horatia: bluet</td>
<td>SJ, I, S, E, JH, CHS</td>
</tr>
<tr>
<td>Lamium: henbit</td>
<td>SJ, S, JH, CHS</td>
</tr>
<tr>
<td>Muscaria: grape hyacinth</td>
<td>S</td>
</tr>
<tr>
<td>Nothoscordum: false garlic</td>
<td>S</td>
</tr>
<tr>
<td>Ranunculus: small-flowered buttercup</td>
<td>SJ.</td>
</tr>
<tr>
<td>Ranunculus: large-flowered buttercup</td>
<td>L, S, CHS</td>
</tr>
<tr>
<td>Senecio: ragwort</td>
<td>CHS</td>
</tr>
<tr>
<td>Stellaria: chickweed</td>
<td>S, CHS</td>
</tr>
<tr>
<td>Taraxacum: dandelion</td>
<td>SJ, I, S, E, JH, CHS</td>
</tr>
<tr>
<td>Vicia: vetch</td>
<td>CHS</td>
</tr>
<tr>
<td>Viola: johnny-jump-up</td>
<td>S, JH, CHS</td>
</tr>
<tr>
<td>Viola: blue violet</td>
<td>SJ, I, CHS</td>
</tr>
</tbody>
</table>

St. Joseph Elementary School (SJ), Ida Burns Elementary School (I), Sallie Cone Elementary School (S), Ellen Smith Elementary School (E), Conway Jr. High School (JH), Conway Senior High School (CHS).
Status of the Mountain Lion in Arkansas

JOHN A. SEALANDER and PHILIP S. GIPSON
Department of Zoology, University of Arkansas, Fayetteville, Arkansas 72701

ABSTRACT

Two authenticated kill records of the mountain lion, Felis concolor, in Arkansas are reported as well as numerous reliable sight records spanning an approximately 30-year period. The cougar probably never was extirpated in Arkansas but it still may be considered endangered.

Until 1949 it was believed that the mountain lion (or cougar), Felis concolor, was extinct in Arkansas. Young and Goldman (1946) listed the last reported occurrence in Franklin County on September 25, 1920, but in 1949 an adult cougar was killed near Sims, Montgomery County, and one (or more) was reported near Warren, Bradley County (Sealander, 1951). Since 1949 numerous mountain lion sightings have been made in Arkansas and adjoining states (Lewis, 1969, 1970; Sealander, 1956). In recent years sightings have become more frequent in Arkansas, and in 1969 another adult lion was killed about 6 mi east of Hamburg, Ashley County (Noble, 1971).

The more numerous sightings in recent years indicate that the cougar is holding its own in Arkansas and may even be increasing in numbers. The cougar population in Arkansas probably reached a low point in the late nineteen-twenties when the population of one of its staple foods, the white-tailed deer, was also at its lowest level. In the nineteen-thirties and forties, with the establishment of state and federal game refuges, a deer restocking program, improved deer habitat, and strictly enforced hunting regulations, the deer population increased rapidly from about 500 animals to more than 60,000. Today the statewide deer population, calculated from the 1970 deer kill, may be nearly 250,000 (Wilson and Sealander, 1972). Apparently the mountain lion has benefitted by the increase in its major prey item and also has increased in the state. Since 1945 the deer population has roughly doubled every decade, reaching about 120,000 by 1965 according to Arkansas Game and Fish Commission legal kill records. The latest available estimate (Fig. 1) indicates a population of about 325,000.

During the nineteen-thirties the U. S. Forest Service bought many of the farms in the areas now encompassed by the Ozark and Ouachita National Forests. The reduced hunting pressure (legal and illegal) in these areas, which resulted from removal of much of the rural population, combined with conditions favoring an increase in the deer population undoubtedly contributed to the survival of a small cougar population. Mountain lion sightings and kills in Arkansas are listed in Table 1 and shown in Figure 1. It is believed that the increased frequency of reports during the last decade reflects an actual increase in the cougar population. At present there appear to be four areas in the state with small cougar populations. They are centered near the Saline and Ouachita River bottomlands in southeastern Arkansas, the White River National Wildlife Refuge near the confluence of the White and Arkansas Rivers, the western Ozark Mountains north of the Arkansas River, and the Ouachita Mountains in westcentral Arkansas south of the Arkansas River. Scattered reports elsewhere in the state may represent dispersing young. All four areas, except the Ozark Mountains, have large deer populations. Southeastern Arkansas where lion reports have been most numerous in recent years has the highest deer population in the state. Hornocker (1970) who studied mountain lion predation on deer and elk in Idaho found a ratio of 1 lion to 201 prey animals (deer and elk). Adjusting for different weights of deer and elk, he estimated the lion to deer ratio would be 1:353. The fact that density of lions in the area of his study remained the same despite an increase in prey species suggests the numbers of lions were determined by factors other than food supply. Reports of lions from various areas of Arkansas indicate a substantially lower population than could be supported by the available food supply. It seems likely that the few lions now present in the state do not have a significant influence on the size of the deer herd. If anything they contribute to a healthier herd by removing crippled, aged, and diseased animals. The annual increase in the deer herd is probably not affected significantly by the small number of newborn fawns which may fall prey to lions.

Hornocker (1969, 1970) found that female mountain lions occupied ranges of 5-20 sq mi and that males had ranges of 25 sq mi or more. He stated that territoriality was an extremely important regulator of mountain lion numbers. Although lions are known to live close to human habitations in other parts of the United States and Canada, even invading the suburbs of Vancouver, it seems likely that rugged wilderness areas harboring good deer populations meet their requirements best. Such areas are disappearing rapidly in Arkansas and elsewhere. Although the mountain lion apparently never was exterminated in Arkansas it may still be considered endangered because of attitudes of hunters, stockmen, and rural residents.
Figure 1. Mountain lion records in Arkansas from 1945 to 1972: ★ kill record; ■ 1945-50 sightings; ● 1951-60 sightings; ▲ 1961-70 sightings; ★ 1971-72 sightings. Shaded symbols represent reliable observations and unshaded symbols represent unconfirmed reports. Shaded areas on map correspond to estimated white-tailed deer populations calculated from the 1972 deer kill, assuming a 10% annual harvest (figures rounded to nearest 1,000).
as well as reduction in optimal habitat. Therefore, it is important that it receives full protection and that as much information as possible is gathered about it if its small numbers are to remain a part of our wildlife heritage for future generations.

LITERATURE CITED


Table I. Mountain Lion Sightings and Kills in Arkansas (1945-1972)

<table>
<thead>
<tr>
<th>Date and Location</th>
<th>Evidence and Observer(s)</th>
<th>Date and Location</th>
<th>Evidence and Observer(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1945-1946 Acorn and Eagleton, Polk Co.</td>
<td>Adult and 2 young — several sightings, Mrs. O. B. Witherspoon</td>
<td>March 1953</td>
<td>Between Ash Flat and Hardy, Sharp Co.</td>
</tr>
<tr>
<td>Fall 1946</td>
<td>Adult — Mrs. O. B. Witherspoon and Mrs. Pierre Redman</td>
<td>November 11, 1953</td>
<td>15 mi NE Monticello, Drew Co.</td>
</tr>
<tr>
<td>Mid-November 1946</td>
<td>Adult — Mr. John P. Radman (professional zoologist)</td>
<td>December 1953</td>
<td>Near Batesville, Independence Co.</td>
</tr>
<tr>
<td>November 1949</td>
<td>Adult killed — Mr. Virgil McKinney and Mr. Tom Dillard (hunters)</td>
<td>December 1953</td>
<td>Cushman Junction, Independence Co.</td>
</tr>
<tr>
<td>April 1950 Chickalah Mountain, Yell Co.</td>
<td>Adult — Mr. &amp; Mrs. Morgan Scott and Mr. Lee McCulloch (farmers)</td>
<td>December 31, 1953</td>
<td>8 mi S Malvern, Hot Spring Co.</td>
</tr>
<tr>
<td>Spring 1951 Chickalah Mountain, Yell Co.</td>
<td>Adult — Mrs. Orra Scott and Mrs. Clauzel Scott (farmers)</td>
<td>January 18, 1954</td>
<td>Between Humnoke and Stuttgart, Lonoke Co.</td>
</tr>
<tr>
<td>Summer 1951</td>
<td>Half-grown lion — Mr. &amp; Mrs. Morgan Scott (farmers)</td>
<td>October 1954</td>
<td>Hot Spring County</td>
</tr>
<tr>
<td>1955</td>
<td></td>
<td>Winter 1957-58</td>
<td>Chickalah Mountain, Yell Co.</td>
</tr>
<tr>
<td>1956</td>
<td></td>
<td>1956</td>
<td>Shady Lake Recreational Area, Polk Co.</td>
</tr>
<tr>
<td>1957</td>
<td></td>
<td>October 1959</td>
<td>10 mi SW Malvern, Hot Spring Co.</td>
</tr>
<tr>
<td>1958</td>
<td></td>
<td>November 1959</td>
<td>8 mi W Malvern, Hot Spring Co.</td>
</tr>
<tr>
<td>1959</td>
<td></td>
<td>1959</td>
<td>Bradley County</td>
</tr>
<tr>
<td>1960</td>
<td></td>
<td>1959</td>
<td>Near Slevins, Hempstead Co.</td>
</tr>
<tr>
<td>1960</td>
<td></td>
<td>August 31, 1960</td>
<td>Near Narrows Dam, Pike Co.</td>
</tr>
<tr>
<td>1961</td>
<td></td>
<td>August 1960</td>
<td>Chickalah Mountain, Yell Co.</td>
</tr>
<tr>
<td>1961</td>
<td></td>
<td>1960</td>
<td>Sunny Acres, Polk Co.</td>
</tr>
<tr>
<td>1962</td>
<td></td>
<td>1960</td>
<td>Hasty (1) and Boat Mountain (2), Newton Co.</td>
</tr>
<tr>
<td>1965</td>
<td></td>
<td>1960</td>
<td>Chickalah Mountain, Yell Co.</td>
</tr>
<tr>
<td>1968</td>
<td></td>
<td>1960</td>
<td>Clear Creek E Cass, Franklin Co.</td>
</tr>
<tr>
<td>1970</td>
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<td>1954</td>
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<td>Adult — Mr. T. N. Rush (state trapper)</td>
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<td>1954</td>
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<td>1954</td>
<td>Adult — Mr. W. W. Barnett (farmer)</td>
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<td>1954</td>
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<td>1973</td>
<td></td>
<td>1954</td>
<td>Adult — Mr. W. M. Elvins (farmer)</td>
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<td></td>
<td>1954</td>
<td>Adult — report of hunter to Mr. Harold Alexander (biologist, Ark. Game &amp; Fish Comm.)</td>
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<td>1973</td>
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<td>Adult — Mr. H. Wallen (farmer)</td>
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<td>Tracks — Mr. W. M. Elvins (farmer)</td>
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<td>1973</td>
<td></td>
<td>1954</td>
<td>Adult — Mrs. Morgan Scott (farmer)</td>
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<td>1973</td>
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<td>1954</td>
<td>Adult — sightings by several people, reported by Mr. Ernest Williams (wildlife officer)</td>
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<td>1954</td>
<td>Adult — sightings by different people, reported by Mr. Robert D. Bonds (wildlife officer)</td>
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<td>Adult — one sighting, Mr. Angus R. More (wildlife officer)</td>
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<td>Adult — one sighting, Mr. George Parks (wildlife officer)</td>
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<td>Adult — black or red phase — letter to Dr. D. James (zoologist, U. of A.) by George Hofman</td>
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<td>Screaming — Mr. Morgan Scott’s son, Jerry</td>
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<td>Gazette news item, Nov. 19, 1961</td>
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<td>Adult — Mr. &amp; Mrs. Morgan Scott (farmers)</td>
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<td>Adult — Mr. David T. Hyst (professional forester) and Mr. James Sanders (hunter)</td>
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<td>Adult — Mr. Tom Wells and Mr. Grady Morriss (forest rangers)</td>
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<td>1973</td>
<td></td>
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<td>Adult — Mr. Farr (farmer)</td>
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January 1969
Sandbar on river 4 mi upstream from Fulton, Hempstead Co.

April 1969
Between Mineral Springs and Lowgap (6 mi E Hwy 71 near West Fork), Washington Co.

Spring 1969
Long Pool Recreation Area on Big Piney Creek, Pope Co.

November 1969
Carthage, Dallas Co.

December 8, 1969
8 mi E Hamburg, Ashley Co.

April 17, 1970
About 2 mi W Interstate 30 and Ark. Hwy 183, Saline Co.

Mid-November 1970
11 mi SE Fayetteville, Washington Co.

December 16, 1970
3 mi downriver from Sylamoire, Stone Co.

December 25, 1970
Near Glade, Benton Co.

Spring 1971
Near Luna Landing N of Lake Village, Chicot Co.

Spring 1971
Hwy 71, 5 mi N Waldron, Scott Co.

1971
Near Paris, Logan Co.

1971

June 3, 1971
Near Nevada and Clark Co. line, Nevada Co.

Adult, tracks — Mrs. Brine Harper and Mr. Edgar Spears (state trooper)

Adult — Dr. Paul R. Noland (professional biologist, U. of A.)

Adult — Mr. Tom Taylor (biologist, Ark. Game & Fish Comm.) with brother and uncle

Adult & one sighting, Mr. Ernest Dodd (Arkansas Gazette news item Dec. 14, 1969)

Adult killed — Mr. Harold Watts (hunter)

Adult tread, tracks — woman observer (not identified) interviewed by Mr. Robert G. Leonard (Chief, Game Div, Ark. Game & Fish Comm.) and Mr. Rocky Lynch (game biologist)

Adult, tracks — Dr. & Mrs. John L. Bowers (professional biologist), Dr. Paul R. Noland (professional biologist), Mr. Everett (regional forester), Mr. Thomas O. Duncan (professional biologist)

Adult, tracks — dear hunters, Mr. Mitchell Rogers (game biologist, Ark. Game & Fish Comm.)

Adult — Mr. Willie Morrison (farmer)

Adults (2) — Mr. George Purvis (Chief, Information & Education, Ark. Game & Fish Comm.)

Young adult — Dr. Jack Goode and Mr. Everett Goode (plant pathologists, U. of A.)

Adult — Mr. Solon Dodson (forest ranger)

Adult — sightings by several people, reports to District Forest Rangers Mr. William D. Walker and Mr. Charles L. Noble

Adult (trapped, escaped) — Mr. Edgar Spears (state trooper)

August 16, 1971
6 mi W Mollwood on White River levee, Phillips Co.

Fall 1971
Hurricane Lake public hunting area, White Co.

January 1972
Near mouth of Big Creek, Newton Co.

Early spring 1972
1/2 mi S Hwy 82 bridge on Ouachita River, Ashley Co.

March 30, 1972
7 mi SSW Boxley, Newton Co.

April 5, 1972
11 mi N and 8 mi W Mollwood, Phillips Co., on White River levee

April 8, 1972
Between Mineral Springs and Lowgap, Washington Co. (near West Fork)

April 20, 1972
Base of White River levee, Phillips Co.

May 15, 1972
4 mi N Ark. Hwy 4 bridge on Saline River, Drew Co.

Spring and summer 1972
Cadron Creek bottomslands, NE of Conway, Conway Co.

July 7, 1972
Near Altheimer, Jefferson Co., on Mr. Fasupelo's farm

August 19, 1972
2 mi S Stuttgart, Arkansas Co.

Summer 1972
N of Hwy 82 bridge on Saline River, Ashley Co.

Early fall 1972
Coal Hollow, Washington Co.

Adult — Mr. Richard Golden and Mr. Donald Doffman (wildlife officers)

Adult, tracks — Mr. Gordon Dunnham, Monticello (hunter)

Tracks — Mr. Larry Dablemont (Chief Naturalist, Ark. State Parks)

Adult — Mr. Frank Allen and father (Georgia Pacific Corp., Cresset)

Scat (confirmed by authors) — Dr. Neil Compton (physician)

Adult — Mr. Raymond McMaster (refuge manager, White River National Wildlife Refuge)

Adult — Dr. Paul R. Noland (professional biologist, U. of A.)

Adult — timber cutter

Adult — owner of Exxon service station, Monticello

Tracks — Mrs. Clark Hightower

Tracks, attacks on hogs, and killing of four hogs — report to Ark. Game & Fish Comm. by Mr. Don Aker (biologist)

Adults (2) appeared black and cub brown — Measrs. Richard and Tom Roth (farmers), reported to Dr. Roth (professional zoologist)

Tracks — Mr. Frank Allen (Georgia Pacific Corp.)

Adult and cub — Mr. Thomas O. Duncan (professional biologist)
Ichthyofaunal Diversification and Distribution in an Ozark Stream in Northe-central Arkansas

WILLIAM DALE JACKSON\(^1\) and GEORGE L. HARP
Division of Biological Sciences, Arkansas State University, State University, Arkansas 72467

ABSTRACT

The distribution and diversity of the ichthyofauna of Arkansas are poorly known. This study is part of a continuing effort to elucidate the natural history of Arkansas. Big Creek is a relatively small, clear, cool-water stream in the Ozark Plateau of northern Arkansas. Big Creek and its tributaries drain into Lake Norfork, an impoundment on North Fork River. A total of 6,779 fish of 30 species was collected. Dominant pool species included Notropis boops, Fundulus catenatus, F. olivaceus, Labidesthes sicculus, and Campostoma anomalum; dominant riffle species included Etheostoma spectabile, E. caeruleum, Notropis boops, Fundulus catenatus, and Campostoma anomalum. The numerical standing crop ranged from 1.3 to 2.6 fish/m² in the pools and riffles, respectively. The relative uniformity of substrate and soil types throughout the watershed, and the absence of rooted aquatic plants, limited the diversity of species found. The concomitant reduction in competition and predation probably explains the relatively large numerical standing crop.

INTRODUCTION

Modern drainage and land clearing equipment is allowing conversion of wetlands to farmlands at an exponential rate (Holder, 1970). The industrial development of Arkansas is also accelerating. The environmental impact of these and related efforts is seen in every part of Arkansas, and it may be expected to intensify in the future. It is of immediate concern, therefore, that the natural history of Arkansas be documented before these changes become so widespread that the original biotic interrelationships cannot be discerned.

Big Creek is a relatively small, clear, cool-water stream contained entirely in Fulton County, in northeastern Arkansas, in the midst of the Ozark Mountains. Fishing pressure along the stream is light and it is used sparsely as a water source for cattle and swine. Shipman Creek is its only named tributary. The waters of Big Creek and its tributaries empty into Lake Norfork, an impoundment on the North Fork River constructed by the U.S. Army Corps of Engineers in 1944. The North Fork River is a tributary of the White River. Although no studies have been done on Big Creek itself, studies on similar tributaries of the White River have been done by Meek (1894), Keith (1964), and Cashner (1967).

The waters of Big Creek arise as three unnamed tributaries within 4.5 km of Viola. The stream flows 35.4 km through Fulton County and empties into Lake Norfork east of Elizabeth, Arkansas. Shipman Creek arises northwest of Viola and flows 6 km to its confluence with Big Creek southwest of Viola.

The stream channel averages 3.7 m in width. The predominant pool substrate is rocks 5-15 cm in diameter; the riffle substrate is coarse gravel. The stream banks are lined alternately with mixed forests of oak and hickory and pasture lands. No species of rooted aquatic plants were noted in the stream.

Elevation in the main channel of the stream drops from 283 to 198 m; mean gradient is 8.1 m/km. The topography of the watershed is developed over limestone and dolomite ridges of the Salem Plateau in the Ozark Mountain physiographic province (Fenneman, 1938). The dominant geologic units are Jefferson City dolomite and Powell limestone (Croneis, 1930).

The major soils adjacent to Big Creek and its tributaries are of the Razort-Pembroke and Agnos associations. Soils of the Razort-Pembroke association are deep, well-drained, moderately permeable, neutral to acid, loamy soils on level to gently sloping flood plains of terraces and streams. Soils of the Agnos association are deep, well-drained, slowly permeable, acid loamy soils on gently sloping ridgetops and moderately steep hillsides (SCS, 1972).

METHODS AND MATERIALS

Thirteen stations were spaced appropriately for adequate coverage of the watershed. Eight were on Big Creek, two on Shipman Creek, and three on unnamed tributaries (Fig. 1). Each station was sampled three times. Sampling was standardized as to unit effort expended in seining at each station. The series were taken during 8-21 August 1970, 20-31 December 1970, and 4-9 April 1971.

On each sampling date, the following determinations were conducted at each station in both pool and riffle areas. Dissolved oxygen determination was by the sodium azide modification of the Winkler method (APHA, 1960). Analysis of alkalinity and carbon dioxide content was by standard limnologic procedures (Welch, 1948). A Beckman pH meter was used to determine the hydrogen ion concentration. Turbidity was determined with the aid of a Jackson turbidimeter and light penetration was determined by a floating disk over a known distance.

Fish samples were procured by a 9.1x1.8-m seine with 0.5-cm bar measure mesh, a gill net 5.5x1.2 m with a 2.5-cm mesh, and a hoop net 0.8 m in diameter and 4.6 m long with a 3.8-cm mesh. The collected specimens were preserved temporarily in 10% formalin. After several days they were washed in water, identified, and preserved in 40% isopropyl alcohol. Nomenclature is in accordance with Bailey et al. (1970).

\(^1\) Present address: Big Creek Resort, Route 1, Elizabeth, Arkansas.
Ichthyofaunal Diversification and Distribution in an Ozark Stream in Northcentral Arkansas

Figure 1. Big Creek Watershed, Fulton County, Arkansas.

RESULTS

Big Creek and its tributaries were alkaline, range 40-232 ppm, mean value 132 ppm. Nophenolphthalein alkalinity was present. Oxygen values varied seasonally from 6.0 to 13.8 ppm, but percentage saturation was always high (94-99%). Carbon dioxide was not detected at any station. The mean pH of the stream was 7.1, but ranged from 6.5 to 8.1. Current speed ranged from 10 to 61 cm/sec in the riffles. Turbidity was less than 25 ppm at all stations on all occasions.

Except for current, pool and riffle areas showed only slight differences in physicochemical conditions. No appreciable physicochemical differences were observed from station to station. Except for temperature readings (4-33.6 C) and oxygen values, seasonal variation was slight.

A total of 6,779 fish of 30 species was collected (Table I). The pools yielded 5,091 fish of 28 species; the riffles yielded 1,688 fish of 21 species. The mean density was 1.3 and 2.6 fish/m² in the pools and riffles, respectively. There were more fish per square meter in the riffles than in the pools at every station.

The pools at station B-7 yielded the largest number of fish with a total of 625 fish of 15 species. Other pools yielding large quantities of fish were at stations B-2, B-8, and S-1 with 609, 589, and 575 fish, respectively. Station U-2 yielded the lowest number of fish with only 108 being taken. On an areal basis station B-7 had the greatest density with 3.4 fish/m². Stations B-8, S-1, and S-2 yielded 2.1, 2.1, and 2.0 fish/m², respectively. The lowest density was 1.2 fish/m² at station B-1.

The highest yielding riffles on Big Creek and its tributaries were at station B-7, where 269 fish of seven species were collected. Other riffles yielding large numbers of fish were at B-3 (201) and B-1 (166). The greatest density was at station B-7, which yielded 5.6 fish/m². Other stations yielding a large number of fish per square meter were S-2 (3.9) and B-6 (3.6). The lowest number for a riffle was at station B-1, which yielded 1.1 fish/m².

Nine species limited strictly to the pools of Big Creek and its tributaries were Notropis zonatus, N. telescopus, Lepomis humilis, Ictalurus natalis, I. punctatus, Micropterus salmoides, Moxostoma erythrum, Erimyzon oblongus, and Esox lucius. Species preferring the pool habitat are so designated in Table I. Of the six species found predominantly in riffle habitat, Etheostoma blennioides and Cottus carolinae were found only in the riffle.

Although most species were found throughout the watershed, 15 species were taken at three or fewer stations. Most of these were limited to a headwater environment (Table I).

DISCUSSION

Most Ozark streams flow through several soil types (Croneis, 1930). There are but two soil types in the Big Creek watershed and 10 of the 13 stations sampled lie within one of these, the Razort-Pembroke association. This factor and the sameness of the substrate at all stations probably account for the relative uniformity of the physicochemical data throughout the watershed. No correlations between physicochemical data and fish distribution could be demonstrated.

Arkansas Academy of Science Proceedings, Vol. XXVII, 1973
Table I. Number and Species of Fish Collected, Big Creek and Tributaries, Fulton County, Arkansas, 8 August 1970 - 9 April 1971 (*Predominantly pool forms, **Predominantly riffle forms).

<table>
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<tr>
<th>Taxa</th>
<th>B-1</th>
<th>B-2</th>
<th>B-3</th>
<th>B-4</th>
<th>B-5</th>
<th>B-6</th>
<th>B-7</th>
<th>B-8</th>
<th>S-1</th>
<th>S-2</th>
<th>U-1</th>
<th>U-2</th>
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Totals: 459 734 509 433 514 311 894 730 671 283 529 175 537
Big Creek and its tributaries contain a relatively large numerical standing crop of fish with limited diversity. Keith (1964) collected 72 species from the upper White River drainage of Arkansas and Cashner (1967) collected 108 species from the entire White River drainage, whereas 30 species were taken in the writers' study. All of the species collected in this study were reported by Cashner (1967) for the White River drainage.

The continuity of substrates and soil type within the Big Creek watershed reflected in the relative uniformity of species composition throughout the watershed. With the exception of station U-2, a headwaters tributary from which only nine species were taken, the number of species at each station ranged from 15 to 17. Burton and Odum (1945), Kuehne (1962), and Sheldon (1968) reported that there was normally an increase in the number of species as one moved downstream. This was not the case in the Big Creek watershed because of the reappearance of similar habitat, an observation supported by the uniformity of the physicochemical data. Longitudinal zonation, therefore, should not be thought of in terms of a uniform, continuous change, because specific conditions and populations may reappear at intervals, as was indicated by the discontinuous distribution of some species.

The absence of rooted aquatic plants accentuates the pattern of uniform distribution of fish species. Their absence was due to the coarse nature of the substrate and rapid current. Similar results have been reported in other Ozark-type streams (Robison and Harp, 1971). The lack of muddy bottoms and organic debris has resulted in a lack of species normally associated with such conditions and an abundance of species associated with clean gravel bottoms.

The limited species composition of the Big Creek watershed has resulted in a relatively large standing crop. Robison and Harp (1971) reported 0.11-0.39 and 0.02 fish/m² in riffle and pool communities, respectively. The mean density of fish in the writers' study, approximately 10 times that of Robison and Harp (1971), was probably a result of reduced competition and predation because of limited species diversity.

The fish of Big Creek and its tributaries can be divided into two groups, pool and riffle forms, on the basis of habitat preference (Table 1). Because of their mobility and migratory habits, this separation is not always absolute. Twenty-seven species comprising 75% of the total number of fish collected were procured from the pools, whereas 21 species comprising 25% were procured from the riffles. Factors contributing to a larger and more diverse group of fish in the pools include the absence of the limiting factor of current (Kendlegh, 1961); and the presence of more macroinvertebrates and the accumulation of drift organisms which provide a greater and more accessible supply of food (Robison and Harp, 1971); also the absolute number of fish collected in pools was larger because a relatively larger area was sampled.

The population of fish was greater on an areal basis in the riffles. Because of the optimal conditions of light and oxygen, riffles were more productive of aquatic and benthic fauna than pools, thus providing a better food supply for those fish best adapted to cope with the current (Robison and Harp, 1971).

Notropis hoops, Fundulus catusiens, F. olivaceus, Labidesthes sicula, and Campostoma anomalum were the prevalent forms, constituting 40, 14, 11, 10, and 8%, respectively, of the fish collected in the pools. They are all species indicative of small, clear-water streams of high alkalinity (Moore, 1968; Trautman, 1957). All of these species except Campostoma anomalum are topwater feeders (Trautman, 1957). This suggests potential interspecific competition, but the large numbers indicate that competition was minimal, probably because of abundance of food. Campostoma anomalum is normally a riffle species, but it was found primarily in the pools. Trautman (1957) stated that it becomes a pool species in streams of moderate to high gradient in which there is considerable current in the pools.

The dominant centrarchids found in the pools were Lepomis megalotis and Micropterus dolomieu. Both were species of wide distribution (Table 1). Lepomis megalotis is mostly indigenous to small streams, preferring the larger, clear-water pools (Trautman, 1957). The lack of large pools at stations B-5, U-1, and U-2 coincided with an absence of L. megalotis at those stations.

The presence of large numbers of Notropis hoops and Fundulus catusiens, normally considered pool species, in the riffle collections may have been due to their migration from one pool to another, feeding, or the lack of distinct riffles at some of the lower stations. Other dominant riffle forms, such as Etheostoma spectabile and Etheostoma caeruleum, are uniquely adapted to the swift waters by streamlined bodies, enlarged pectoral fins, and degenerate swim bladders (Reid, 1961).

Longitudinal zonation of the fish was characterized by a decrease in number per square meter from the headwater stations to the downstream stations. Thompson and Hunt (1930) found that the number of individuals decreased downstream but the size of the fish increased, so that biomass density remained about the same. No biomass recordings were made in this survey, but personal observation showed that within a given species the specimens taken downstream were considerably larger than those taken in the headwaters.

Erimyzon oblongus. Phoxinus erythrogaster, and Semotilus atromaculatus definitely preferred the headwaters of Big Creek and its tributaries (Table 1). Erimyzon oblongus prefers streams whose bottoms are mostly sand and gravel. After spawning or in early summer the adults migrate downstream. Phoxinus erythrogaster remains in headwater areas the year round. Semotilus atromaculatus prefers the headwaters of small streams, but will migrate to larger pools in the summer (Trautman, 1957).

Several species of fish were distributed sparsely throughout Big Creek and its tributaries. One specimen of Esox lucius was collected at station B-2. Its presence there was seemingly out of place in terms of both habitat preference and range (Trautman, 1957; Moore, 1968). In 1970 the Arkansas Game and Fish Commission stocked about 6,000 Esox lucius in Lake Norfork, and its presence probably was due to its being trapped after having migrated from Lake Norfork to feed.

Three cyprinids, Notropis latens, N. telescopus, and N. zonatus, were collected in small numbers and had a very limited distribution. Notropis latens is an uncommonly collected species in the clearer Ozark streams. Competition from close relatives (e.g. N. galuscrurus) may be an important factor controlling its distribution (Pflieger, 1971). Notropis zonatus and Notropis telescopus are both fish common to Ozark uplands, preferring the clear-water pools of headwater streams (Moore, 1968).

Two species of leukidiids, Ictalurus natalis and I. punctatus, were limited in distribution in Big Creek and its tributaries (Table 1). Nine specimens of Ictalurus natalis were taken from three stations (Table 1). This species normally prefers low-gradient brooks which contain clear water and some aquatic vegetation (Trautman, 1957). The high gradient and lack of rooted aquatic plants probably limited its numbers in Big Creek and its tributaries. Ictalurus punctatus seldom is present in beds of aquatic vegetation and is highly migratory,
ascending small streams for the purpose of spawning
(Trautman, 1957). The one specimen collected was taken at
station B-1, the lowest station and the closest to Lake Norfork.

Three specimens of *Etheostoma blennioides* were taken from
the riffles of station B-5. These riffles were composed of large
rocks and were covered with an algal growth not common to
most of the riffles. This environment resembles the preferred
habitat of this species (Trautman, 1957).

One specimen of *Cottus carolinae* was taken from the riffles
at station B-4. It is normally a species of widespread
distribution in upland spring-fed streams (Moore, 1968).

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Extractible Nutrients and pH Values from Nine Soil Associations of Arkansas

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ABSTRACT

Soil samples from the 0-10-cm and 10-20-cm depths were obtained from nine of the 11 soil associations of Arkansas. Sites sampled had a heavy forest cover and showed no evidence of cultivation. Routine soil tests showed that pH values ranged from a low of 4.38 for the Loessial Hills to 5.83 in the Ozark Highlands. Potassium ranged from 69 to 206 kg/ha. Phosphorus was very low in nearly all sites; the extremes were 9 and 83 kg/ha, but most values were less than 30 kg/ha. Calcium ranged from 122 to 1,523 kg/ha. The data indicate that when woodland areas are cleared for cultivation in these nine soil association areas, the soil fertility level will be low.

Large trees commonly are thought to be indicative of a fairly high soil fertility level. A study was undertaken to determine some of the extractible nutrients and the pH values in wooded areas with large trees in nine of the soil associations in Arkansas.

METHODS AND MATERIALS

Site selection was accomplished by using the generalized soils map of Arkansas (SCS, 1967) which gives the boundaries of the soil association groups. After determining which Arkansas counties are included in each of the nine different soil associations, the writers selected physical sites for sampling. Each site selected was in native vegetation and showed no evidence of cutting or cultivation. It also was of sufficient size that four different sampling areas of 83.6 m² could be obtained. Soil samples were taken randomly from the top 10 cm and the 10-20-cm zone of each area, labeled, and stored in plastic bags for transportation to the laboratory. Two or more different sampling sites were selected in each soil association area.

Soil sample preparation involved air drying and crushing to pass through a 10 mesh sieve to obtain a uniform size sample.

Soil pH values and extractible potassium, calcium, and phosphorus were determined according to the procedures described in the Southern Cooperative Series Bulletin No. 102 (Page, 1965). Soil pH values were determined by pH meter from a 1:1 soil-water dilution. Potassium and calcium were determined by extraction with neutral ammonium acetate with a shaking time of 5 min. After filtration the bases were determined by flame analysis.

Phosphorus was extracted by 0.03 normal ammonium fluoride in 0.025 normal hydrochloric acid with a shaking time of 0.67 min. The filtrate was treated with ammonium molybdate and 1.2,4-aminonaphthol sulfonic acid, and the blue color developed was read in a colorimeter.

The soil analysis values from each soil association were averaged and are given in Tables I and II.

RESULTS AND DISCUSSION

Table I shows that all pH values were below 6.00. The highest pH value was 5.83 for the Ozark Mountains 0-10-cm sample and the lowest pH value was 4.38 in the Loessial Hills 10-20-cm sample.
The amounts of extractible potassium ranged from a low of 55 kg/ha to a high of 206 kg/ha as shown in Table II. The Ozark Highlands had less than 100 kg/ha in both the 0-10-cm and 10-20-cm samples. All other soil association areas had more than 100 kg/ha of potassium in the 0-10-cm samples. Only one soil association area had more than 200 kg/ha, the Ozark Mountain area.

Extractible calcium, as shown in Table III, generally varied directly with the pH values for each soil association area. Areas with low pH values were also low in extractible calcium content. The 0-10-cm samples had the greatest amount of calcium. The lowest amount found was 272 kg/ha in the Ozark Highlands and the greatest amount was 1,523 kg/ha in the Ozark Mountains. The 10-20-cm samples were even lower in extractible calcium. The Ozark Highlands with only 122 kg/ha was low. The greatest amount found, 1,194 kg/ha, was in the Ozark Mountains.

Table IV gives the average kilograms per hectare of extractible phosphorus. One area, the Bottomlands, had 83 and 71 kg/ha of phosphorus in the 0-10-cm and 10-20-cm samples. The Ouachita Mountains association was also higher in phosphorus than most of the other soil associations; it contained 32 kg/ha in the 0-10-cm sample and 41 kg/ha in the 10-20-cm sample. The lowest value was 9 kg/ha in the 10-20-cm sample from the Loessial Hills; the Loessial Terrace 0-10-cm sample had 27 kg/ha.

**SUMMARY**

In the nine soil association area sampled, it was found that pH values and calcium, potassium, and phosphorus content were lower than those soil test values normally found in cultivated and improved grasslands soils in the same soil associations. The findings indicate that when woodland areas first are cleared in Arkansas the native soil fertility level will be low.

**LITERATURE CITED**


Respiration Rates of Two Midge Species at Different Temperatures

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ABSTRACT

Respiration values for Chironomus n. sp. ranged from 0.11 mm³ O₂/mg/hr at 5°C to 0.44 mm³ O₂/mg/hr at 25°C. The range for Chaoborus punctipennis was from 0.15 mm³ O₂/mg/hr at 5°C to 0.56 mm³ O₂/mg/hr at 25°C. These low respiratory rates allow the two species to withstand low oxygen tensions for extended periods of time. Reflecting this ability, both species attained their greatest numerical and biomass values in the profundal regions of three strip-mine lakes whose lower waters become oxygen depleted during thermal stratification.

INTRODUCTION

Respiration accounts for most of the energy losses between trophic levels (Odum, 1959). Smalley (1960) determined that 63.3% of the energy assimilated by grasshoppers in a salt marsh was released through respiration. Teal (1957) reported the fraction of assimilated energy which various macroinvertebrates transform to heat ranges from 12 to 84%, with a mean value of 71% for the entire community.

 Respirational values define the influence of oxygen content of the water on distribution of macroinvertebrates. Kasatkina (1960) reported respiratory values of 1.54 and 1.24 mm³ O₂/mg live wt/hr for stream inhabitants Cricotopus bicinctus (Meigen) and C. sylvestris (Fabr.), respectively, at 20°C. Tanypus characterizes the oxygen-rich oligotrophic lake and has a respiratory rate of 0.52 mm³ O₂/mg/hr at 17°C (Walshe, 1947). Tendipes plumosus (L.), which characterizes the oxygen-poor eutrophic type lake, may have a respiratory rate as low as 0.12-0.19 mm³ O₂/mg/hr (Harnisch, 1930). Between these extremes, other midge larvae characterize additional lake types, as Suctochironomus lakes and Sergentia lakes (Ruttner, 1966). Hence, investigation of the rates of respiration of benthic macroinvertebrates can provide important information concerning the oxygen economy and production of a lake.

The purpose of this study was to measure rates of respiration at different temperatures in Chaoborus punctipennis (Say) and Chironomus n. sp.

METHODS

Organisms were acclimated at the experimental temperature for 24 hr prior to determinations. Seventeen measurements for each species were distributed as follows: for Chironomus n. sp., four replicates at 5.9°C, four at 12.5°C, five at 13.5°C, and four at 24°C; for Chaoborus punctipennis, four replicates at 6.7°C, three at 10°C, five at 14.8°C, three at 19°C, and two at 24°C. Each replicate of 100-150 individuals was placed in a 100-cc syringe filled with lake water (Ewer, 1941). The chironomids were first removed from their tubes. The oxygen content of the water before and after incubation was measured by the azide modification of the Winkler method (APHA, 1960). After the initial oxygen determination, the syringes were placed in lighted incubators at various temperatures from 6 to 24°C for 2-3 hours, a period of time long enough for a measurable change in oxygen to occur but not sufficiently long to lower oxygen tension detrimentally. During the experimental runs, temperature fluctuation did not exceed ±1°C of the stated value. The syringes were rotated periodically to insure equal distribution of oxygen. After the final oxygen determination, the organisms were removed and weighed. Oxygen consumption was converted to calories by the average oxycaloric coefficient of Ilev (1934), 3.38 cal/mgO₂.

RESULTS

The rates of respiration for both C. n. sp. and C. punctipennis were shown to increase exponentially with increased temperature (Fig. 1). The respiratory rate of Chaoborus was greater than that of Chironomus at all temperatures and differed by a factor of 1.3 at 24°C.

![Figure 1. Rates of respiration for Chironomus n. sp. and Chaoborus punctipennis at various temperatures, expressed as cal/cal/month. The curves were drawn by inspection.](https://example.com/f1.png)
DISCUSSION

The rates of respiration determined for Chironomus n. sp. and C. punctipennis fall at the lower end of the range reported in the literature for other benthic fauna (Berg et al., 1962; Kasatkina, 1960; Teal, 1957). Walshe-Maetz (1953) reported that respiratory values for T. plumosus could be erroneously high if the larvae were out of their tubes and the level of dissolved oxygen fell below 25% saturation. As the dissolved oxygen values in this study were never so low this potential source of error can be ignored.

At a given temperature the higher respiratory rates are characteristic of species which require well oxygenated water (Walshe, 1947). Those species with lower respiratory rates can withstand lower oxygen tensions for protracted periods of time (Harnisch, 1930; Walshe, 1950). Chironomus n. sp. and C. punctipennis are of the latter group.

The two midge species were collected from three coal strip-mine lakes in central Missouri. Chironomus n. sp. was the only midge present in Lake A, pH 3.2-4.1. It formed 93.6, 98.1, and 99.7% by number and 46.4, 68.8, and 99.1% by weight of the total benthos at 0.25, 1.5, and 4.0 m (deepest), respectively. The major factor determining the dominance of this species is its tolerance to mineral acidity (Harp and Campbell, 1967). However, within the lake its relative abundance at various depths coincided more nearly with the degree of oxygen depletion during thermal stratification (Campbell and Lind, 1969).

Chaoborus punctipennis was the major benthic species in the two alkaline lakes. In Lake B (pH 6.3-7.8) it formed 0.7, 17.1, and 90.7% by number and 0, 0.3, and 54.2% by weight of the total benthos at 0.25, 2, and 5 m, respectively. In Lake D (pH 6.6-7.4) it formed 0.1, 2.3, and 78.8% by number and 0, 0.1, and 37.2% by weight of the total benthos at 0.25, 2, and 4 m, respectively. Dissolved oxygen concentrations and patterns of the two alkaline lakes were those of similar dimictic temperate lakes.

The large numerical and biomass standing crops established by the two midge species in the three coal strip-mine lakes are the result of a combination of factors. Chironomus n. sp. is one of the few benthic forms that can withstand mineral acid environments such as Lake A (Harp and Campbell, 1967). Relatively few benthic forms have respiratory rates as low as those found for Chironomus n. sp. and Chaoborus punctipennis (Kasatkina, 1960; Walshe, 1950). Given the conditions, in the presence of reduced predation (e.g. fish) and reduced competition (e.g. other benthic fauna), the two midge species are able to increase their populations greatly.

A final consideration is the expression of respiration values in energy units. The study of community metabolism is one means of making a functional analysis of an ecosystem. Respiration is the major pathway of energy transformation between trophic levels. Energy units are preferable to biomass units in such studies because there is recirculation of matter in the ecosystem and because the rates of turnover are so different for different sizes and species of organisms (Teal, 1957).

Further, at least in terms of energy flow, in a comparison of respiration values expressed as mm 3 O 2 /mg, one must assume a similar energy value for each species per unit biomass. Unfortunately, this is far from the actual situation. For these reasons respiration values expressed in energy units, rare in the literature to date, will be of greatest value in future community metabolism studies.

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