ARKANSAS ACADEMY OF SCIENCE

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ARKANSAS ACADEMY OF SCIENCE

Fiftieth Annual Meeting
Little Rock, Arkansas
April 1-2, 1966

OFFICERS

President .............................................. Dr. James H. Fribourgh
President-elect ........................................ Dr. Howard Moore
Secretary .............................................. Dr. George E. Templeton
Treasurer .............................................. Dr. Victor J. Hoff

SECRETARY’S REPORT

The first business was called to order by President Fribourgh at 11:00 a.m., April 1, 1966.

As the Secretary’s Report was already published in the Proceedings, reading of the report was omitted and the report was accepted as published. The Treasurer’s Report was submitted to the Auditing committee by the Treasurer, Dr. Victor J. Hoff.

I was reported that the 1965 Proceedings had been distributed.

The President reported that: (1) The Academy co-sponsored a Science Teaching Improvement Committee with the Arkansas Science Teachers Association, (2) The Academy was represented on the Science Activities Committee. The purpose of the Committee was to coordinate the activities of secondary school science interest groups as outlined in a 1965-66 proposal to the National Science Foundation, (3) The Academy was represented in the inauguration of Dr. Clifton Ganus as President of Harding College, and (4) The Academy co-sponsored the Science Youth Career Day with the State Department of Education and Arkansas Power and Light Company.

The AAAS fellowship committee, under the chairmanship of Dr. Dwight Moore reported that the committee would submit a report at the second business meeting.

Dr. Roy Rom reported that the Science Teaching Improvement Committee had presented a report at the Science Teachers Section of the
Arkansas Academy of Science Proceedings

AEA Convention and would present a second report at the Science Education section of the Academy meetings.

There was a general discussion of the many affiliations, sponsorships and cosponsorships with the Academy which include the Valley Education and Research Foundation, Science Youth Career Day, Junior Academy of Science, and Arkansas Science Fair Association.

It was moved by Dr. Everett and seconded by Dr. McCarty that the President appoint a committee to investigate the affiliations of the Academy. The motion passed.

Dr. Fribourgh appointed the following ad hoc committees:

<table>
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<tr>
<td>Nominations</td>
<td>Dr. D. M. Moore</td>
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<td>Dr. Robert Shideler</td>
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<td>Dr. I. A. Wills</td>
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<td>Dr. H. L. McMillan</td>
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<td>Dr. E. C. McCarty</td>
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<td>Dr. J. E. Bennett</td>
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<td>Meeting Place for 1967</td>
<td>Dr. J. H. Stevenson</td>
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<td>Dr. A. R. Nisbet</td>
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<td>Mr. M. L. Lawson</td>
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There being no further new business, the meeting was adjourned.

The second business meeting was called to order by President Fribourgh at 12:30 p.m., April 2, 1966.

The minutes of the first business meeting were read and approved.

COMMITTEE REPORTS

The Nominating Committee presented the following slate: President Elect — Dr. John Chapman; Treasurer — Dr. John P. Jones. The motion was made and seconded that the slate of officers presented by the Nominating Committee be elected. They were elected by acclamation.

Dr. Bennett reported that the Auditing Committee had examined the financial records of the Academy and were satisfied that they are correct and in order.

Mr. Lawson reported for the Committee on a meeting place for 1967. He moved that the Fifty-first Meeting of the Academy be held in Jonesboro with Arkansas State College as the host institution. Dr. John Chapman seconded the motion and the motion was passed.

Dr. Dwight Moore read the names of 17 Academy members who were being considered for fellowship status in the American Association for Advancement of Science. He then moved that these 17 people be nominated as fellows. The motion was seconded and approved.

Dr. James Dale, editor of the Proceedings, indicated that the excess
copies of Proceedings would continue to be available to libraries in the state for $3.00 per copy, or at cost, whichever is higher.

There was a continuation of the discussion which began at the first business session concerning the separation of the State Science Fair, and the Junior and Senior Academy meetings. A motion was made, seconded and passed that the Executive Committee be empowered to hold the meetings separately if the parties involved agree to this arrangement.

Dr. Lyell Thompson moved that the officers prepare a statement concerning the Academy's position on the anti-evolution law. The motion was defeated.

Dr. Chapman made a motion that we go on record as making a statement that it is the province of the state to determine what shall be taught, but it is not the province of the state to determine what shall not be taught. The motion was defeated.

Dr. Fribourgh expressed appreciation to the Treasurer, Dr. Hoff, who is relinquishing his post to go to Stephen Austin College.

Dr. Fribourgh turned over his office to Dr. Howard Moore, the incoming President.

The meeting was adjourned.

Respectfully submitted,
George E. Templeton
Secretary
PROGRAM

Friday, April 1

11:00 a.m. Business Meeting, State Room

12:00 noon to 1:30 p.m. Lunch

12:30 p.m. to 4:00 p.m. Junior Academy, Forum Room, Court Room, and Rendezvous Room

1:00 p.m. to 2:00 p.m. Collegiate Academy Luncheon. Guest speaker — Dr. Frank A. Brown, Professor of Biology, Northwestern University.

2:00 p.m. to 4:00 p.m. Collegiate Academy, Assembly Room and East Room

4:00 p.m. to 5:00 p.m. Conference of Participating Scientists in NSF Visiting Scientist Program of the Academy, State Room

4:00 p.m. to 5:30 p.m. Science Talent Search Program, Forum Room

5:30 p.m. to 7:00 p.m. Academy Banquet, Continental Room. "History of the Arkansas Academy of Science," Dr. Dwight Moore, Arkansas Polytechnic College

7:00 p.m. to 8:30 p.m. Awards Program, Forum Room

8:30 p.m. to 9:30 p.m. "Biological Rhythms and Clocks," Dr. Frank A. Brown, Professor of Biology, Northwestern University.
PROGRAM

Saturday, April 2

8:00 a.m. to 9:30 a.m.  Arkansas Science Teachers Association Breakfast, State Room.

8:00 a.m. to 12:00 noon  Arkansas-Oklahoma-Kansas Section of the American Association of Physics Teachers, Assembly Room.

9:30 a.m. to 12:00 noon  Section Meetings

12:00 noon  Lunch — Arkansas-Oklahoma-Kansas Section of the American Association of Physics Teachers Luncheon, East Room.

12:30 p.m. to 1:30 p.m.  Business Meeting, Court Room.

1:30 p.m. to 3:30 p.m.  Section Meetings
SECTIONAL PROGRAM

BIOLOGY AND AGRICULTURE

Chairman: William Evans
Little Rock University

Session I

AGRONOMIC EVALUATIONS OF AN ARKANSAS ROCK PHOSPHATE. Lyell Thompson, University of Arkansas.

VEGETATIVE NUCLEAR BEHAVIOR OF NEUROSPORA CRASSA SHEAR AND DODGE. Charles L. Wilson, John A. Brushaber, and James R. Aist, University of Arkansas.


OBSERVATIONS ON OCCURRENCE AND RANGE OF THREE SPECIES OF DENTARIA (CRUCIFERAE) IN THE OUACHITA MOUNTAINS. Miss Aileen L. McWilliam, Mena High School.

ADDITIONAL INFORMATION ON BASICLADIA CRASSA, HOFFMAN AND TILDEN. Clarence B. Sinclair, Little Rock University; and Robert G. Anderson, University of Missouri at Kansas City.

MODIFICATION OF THE KNOTTED LEAF MUTANT IN ZEA MAYS WITH GROWTH HORMONES. Billy B. Rhodes and Oval Myers, Jr., University of Arkansas.

PERSISTANT VIRAL INFECTION OF A STABLE MAMMALIAN CELL LINE. Mrs. Ruth Jarman, University of Arkansas School of Medicine.

A SUSPECTED INTERGENERIC HYBRID IN THE FRINGILLIDAE: PROBABLY WHITE-THROATED SPARROW (ZONOTRICHA ALBICOLLIS) X SLATE-COLORED JUNCO (JUNCO HYEMALIS). Douglas James, University of Arkansas; and Mr. and Mrs. M. L. Jones, Dover, Arkansas.

DECOY-NETTING OF NESTING ROBINS, TURDUS MIGRATORIUS L. Jay N. Dykstrah, University of Arkansas.

THE EFFECTS OF HYDROXYUREA ON CULTURED SOMATIC CELLS OF THE CHINESE HAMSTER, CRICETULUS GRISEUS. Charlotte Neill, University of Arkansas.

Session II

HEAT RESISTANCE EXPERIMENTS WITH LONGEARN SUNFISH, LEPOMIS MEGALOTIS (RAFINESQUE). William H. Neill, Jr., Kirk Strawn, and James E. Dunn, University of Arkansas.
GROWTH RATES AT VARIOUS TEMPERATURES OF THE ORANGE-THROAT DARTER, ETHEOSTOMA SPECTABILE (AGASSIZ). Boyce W. West, University of Arkansas.

A STUDY OF THE "KILLING PHENOMENON" IN ISOLATED GROUPS OF ETHEOSTOMA SPECTABILE (AGASSIZ). Thomas M. Buchanan, University of Arkansas.

DEFECT PLASMOPTYSIS: A MECHANISM OF POLYENE DAMAGE TO FUNGUS CELLS. Dwight E. Talburt and G. T. Johnson, University of Arkansas.

GROWTH AND PIGMENTATION OF PSEUDOMONAS CHLORORAPHIS. James C. Hill and G. T. Johnson, University of Arkansas.

BIOLOGICAL CONTROL IN ARKANSAS ROW CROPS. J. W. Steward and W. H. Whitcomb, University of Arkansas.

SOME PARASITES OF ARKANSAS WOLF AND LYNX SPIDERS. Ruth Eason and W. H. Whitcomb, University of Arkansas.

TRANSPIRATION CHANGES IN OAT PLANTS INFECTED WITH CROWN RUST. Purushottam Amatya and John P. Jones, University of Arkansas.


THE LABIATAE OF ARKANSAS. James M. Lang, University of Arkansas.

ENHANCED PHAGOCYTOSIS OF BACTERIA WITH HYPOAGGLUTINATING MOUSE ANTISERA. Jack Lockhart and Leo J. Paulissen, University of Arkansas.

CHEMISTRY

Chairman: W. J. Broach
Little Rock University

Session 1

AN OXYGEN-18 TRACER STUDY OF THE QUESTION OF ACID-AND BASE-CATALYZED EXCHANGE BETWEEN WATER AND p-SUBSTITUTED NITROBENZENES. Martha Lusser and Arthur Fry, University of Arkansas.

KINETIC AND OXYGEN-18 EXCHANGE STUDIES OF THE REARRANGEMENT OF BENZOPINACOL TO BENZOPINACOLONE. Willoughby F. Meek, Bessie R. Sparks and Arthur Fry, University of Arkansas.

A COMPARISON OF THE STEREOCHEMISTRY OF DIIMIDE REDUCTIONS OF CYCLOOLEFINS WITH CATALYTIC HYDROGENATION. Samuel Siegel and Deborah Johnson, University of Arkansas.

DIMERIZATION CONSTANTS OF ORGANIC ACIDS BY THE METHOD OF DISTRIBUTION. Dan Mathews, Graduate Institute of Technology.

Session II

THE MAGNETIC SUSCEPTIBILITY ISOTHERM OF CHROMIA ON SILICA-ALUMINA CRACKING CATALYSTS. Don Brown and Alcuin F. Gremillion, Graduate Institute of Technology.

A NEW MAGNETIC SUSCEPTIBILITY ISOTHERM OF CHROMIA-ALUMINA CATALYSTS. Earl Adkins and Alcuin F. Gremillion, Graduate Institute of Technology.

REACTIVATION OF REDUCED RIBONUCLEASE BY ALLOXAN. Larry Rudel, University of Arkansas Medical Center.

EFFECT OF VITAMIN E DEFICIENCY ON IN VITRO INCORPORATION OF ¹⁴C-LABELED AMINO ACIDS INTO MUSCLE PROTEIN. George Nichoalds, University of Arkansas.

EFFECTS OF VITAMIN E DEFICIENCY AND DENERVATION ON THE PERMEATION OF THIOUREA IN SKELETAL MUSCLE. Robin R. Jones, University of Arkansas Medical Center.

GEOLOGY

Chairman: Don E. Williams
U. S. Forest Service, Hot Springs

Session I

ECONOMIC GEOLOGICAL OUTLOOK FOR ARKANSAS. Norman F. Williams, Arkansas Geological Commission.


GEOLOGICAL METHODS AND PROBLEMS IN THE SITING AND CONSTRUCTION OF DAMS IN ARKANSAS. C. J. Wells, Geology and Materials Section, Little Rock District Corps of Engineers.

Session II

PITKIN REEFS AND ASSOCIATED SEDIMENTS. Kern C. Jackson, University of Arkansas.

ALLUVIUM AND AQUIFER OCCURRENCE ALONG MOUNTAIN FORK CREEK, CRAWFORD COUNTY, ARKANSAS. H. Filmore Garner, University of Arkansas.


OZARK FRONTAL FAULT. Albert H. Giles, Arkansas Polytechnic College.

HISTORY AND POLITICAL SCIENCE
Chairman: Keith S. Petersen
University of Arkansas

SELECTED STUDIES IN TRANSITIONS IN TWENTIETH CENTURY POLITICAL THOUGHT. Charles M. Evans, Arkansas State Teachers College.

THE INTELLECTUALS: A CRITIQUE. Leon J. Apt, University of Arkansas.

CARL BROWNE, SOME NOTES ON A RADICAL OF THE POPULIST WORLD. Wayne Delavan, Henderson State Teachers College.

THE INVIOLABILITY CONTROVERSgy IN THE TRIAL OF LOUIS XVI. Ronald Hayworth, Arkansas College.

PHYSICS
Chairman: John Petz
Little Rock University

Session I

TEMPERATURE DETERMINATIONS OF PLASMA PRODUCED BY EXPLODING WIRES. D. P. Ross, University of Arkansas.

SOME PRELIMINARY RESULTS IN THE INVESTIGATION OF A SIMPLE PLASMA GUN. J. R. Crawford, University of Arkansas.

SHOCK PHENOMENA IN METALS. C. E. Canada, University of Arkansas.

INVESTIGATIONS OF REAL FOIL SURFACES. O. H. Zinke, University of Arkansas.

Session II

CURRENT VIEWS ON EXTRA TERRESTRIAL COMMUNICATION. Dave S. Warren, Graduate Institute of Technology.

POSSIBLE MECHANISMS FOR THE ACCELERATION OF PLASMA. D. W. Collier, University of Arkansas.
ACTIVATION CROSS-SECTIONS AND MASS ASSIGNMENTS FOR 14.7 MeV NEUTRON INDUCED REACTIONS ON Dy AND Gd ISOTOPES. Philip H. Merrell and R. A. Harlan, University of Arkansas.

INTRODUCTION TO FLUIDAMPLIFIERS. P. McCloud, Graduate Institute of Technology.

MATHMATICS
Chairman: Bill Attebery
University of Arkansas

Session I
Speaker from Committee on the Undergraduate Program in Mathematics.
Panel on mathematics program for first two years of college.

Session II
A SINGULAR MATRIX OF FIBONACCI NUMBERS AND ITS RELATED LAMBDA FUNCTION. Curtis McKnight, Harding College.
Panel on Advanced Calculus.

SCIENCE EDUCATION
Chairman: Irvin A. Wills
John Brown University

Session I
REPORT OF SCIENCE TEACHING IMPROVEMENT COMMITTEE. Sponsored by the Arkansas Academy of Science and the Arkansas Science Teachers Association. Roy Rom, University of Arkansas.


UNDERGRADUATE EDUCATION IN THE BIOLOGICAL SCIENCES. Earl D. Hanson, Chairman CUEBS, Shanklin Laboratory of Biology, Wesleyan University, Conn.

THE UNDERGRADUATE CURRICULUM IN CHEMISTRY. Lester C. Howick and Richard Porter, University of Arkansas.

REPORT OF EXPERIMENTAL COURSES IN ENGINEERING PHYSICS. Glen Clayton, University of Arkansas.

UNDERGRADUATE RESEARCH PARTICIPATION PROGRAM IN THE DEPARTMENT OF PLANT PATHOLOGY, UNIVERSITY OF ARKANSAS. John P. Jones, University of Arkansas.

Session II
Panel Discussion — THE COOPERATIVE USE OF COMPUTERS ON A STATE-WIDE BASIS. W. Everett, Chairman, Ouachita Baptist University.
AGRONOMIC EVALUATIONS OF AN ARKANSAS ROCK PHOSPHATE

Lyell Thompson
University of Arkansas

Raw rock phosphate is the name of fertilizer made from finely ground calcium phosphate rock; its general formula is \( \text{Ca}_{10} \left( \text{PO}_4 \right)_6 \left( \text{F}, \text{Cl}, \text{OH} \right)_{2} \).

During earlier decades such material was rather widely used as a phosphorus fertilizer. But in modern agriculture only an insignificant percentage of the total phosphorus fertilizer is applied in this form. Most of the commercial phosphorus fertilizer now marketed is manufactured by treating the ground rock phosphate with sulfuric acid, or otherwise processing it, so that the orthophosphate ion exists as the more soluble \( \text{H}_2\text{PO}_4^- \) or \( \text{HPO}_4^{2-} \) rather than as the insoluble \( \text{PO}_4^{3-} \) form which is found in native rock phosphate.

It has been known for three quarters of a century that several north Arkansas counties contained calcium phosphate deposits. At least one of these deposits was being mined at the turn of the century (1). But phosphate rock mining had been discontinued for many years prior to 1962 when a deposit located near Peyton Creek just off U. S. Highway 65 on the Searcy-Van Buren County border was opened for commercial exploitation.

The four greenhouse phosphorus plant uptake experiments described here were undertaken in an attempt to compare this Peyton Creek ground rock phosphate with other rock phosphates and with monocalcium phosphate. Numerous comparisons between ground rock and processed phosphorus fertilizers have been made, with widely varying soils and plant species, during the last century.

Rogers et al. (5) in 1953 gave an extensive review of the literature comparing the agronomic value of ground rock phosphate and superphosphate fertilizer. Hinkle (3), summarized the results of a 40 year crop rotation experiment on a Zanesville-Waynesboro silt loam in northwest Arkansas where rock phosphate was applied at 1.6 to 2.0 times the \( \text{P}_2\text{O}_5 \) rate of superphosphate. He reported that superphosphate was superior to rock phosphate the first two to three rotation cycles (8-12 years) for both corn and oats on soils not otherwise limed or fertilized; however rock phosphate was equal to or better than superphosphate on these crops during the remaining cycles. On plots that had been limed, and fertilized with nitrogen and potassium, superphosphate was superior to rock phosphate during the first four rotation cycles for corn, eight cycles for oats and throughout the entire 40 years for wheat and red clover. There have been two recent publications

1Published with the approval of the Director of the Arkansas Agricultural Experiment Station.
reporting field studies: Moschler and Jones (4) summarized the results from a number of Virginia experiments and found that one pound of $P_2O_5$ from superphosphate was equivalent to 1.9 pounds of $P_2O_5$ from rock phosphate for corn, 4.2 pounds for wheat, 2.0 for red clover and 1.7 for alfalfa. They concluded that annual applications of superphosphate supplemented with rock phosphate at 6-year intervals generally produced higher yields than either source along. Ensminger and Pearson (2) conducted a series of experiments in several southeastern states and concluded that, (a) the effectiveness of rock phosphate varied widely among the soils of the region but was seldom more than one-fourth that of superphosphate applied at the same rate of P, (b) the residual effect of rock phosphate was less or no better than that of superphosphate applied at one-half the rate of P, (c) extrapolation of yield curves indicated that maximum yield could not be reached at any rate of P with rock phosphate as the source.

MATERIALS AND METHODS

During 1963 to 1965 several greenhouse tests were conducted comparing Peyton Creek ground rock phosphate with other ground rock phosphates, with ordinary superphosphate fertilizer and a monocalcium phosphate reagent. The fertilizers used were:

a. Peyton Creek Rock Phosphate obtained from the mine near Leslie, Arkansas. This material contained 9.42% P.

b. Tennessee Brown Rock Phosphate containing 13.30% P.

c. Florida Hard Rock Phosphate containing 14.17% P.

d. Colloidal Soft Phosphate containing 8.75% P. Colloidal Phosphate is a trade name applied to a by-product of the hydraulic mining of rock phosphate. The material is a mixture of rock phosphate and colloidal clay.

e. Monocalcium phosphate reagent containing 24.60% P.

f. Ordinary superphosphate (0-20-0) fertilizer containing 8.73% P; phosphorus in this fertilizer is in the form of monocalcium phosphate.

Test No. 1 was conducted in 1963 on topsoil taken from an acid, infertile Parsons silt loam. The phosphorus fertilizer was mixed with 3 kgm of soil before potting. Rates and forms of phosphorus used are given in table 1. Successive crops of soybeans, and German millet (Setaria italica) were grown. The test was completely randomized with 3 repetitions.

Test No. 2 was similar to the first; the phosphorus fertilizers, (Table 2) equivalent to 130 ppm P were mixed with 1.36 kgm of topsoil taken from a slightly acid, moderately fertile Waynesboro silt loam. German millet was planted and two forage harvests were made. The plant material was dried, ground and analyzed for total P. The test was completely randomized with 5 repetitions. In tests 1 and 2 nitrogen,
Evaluations of Arkansas Rock Phosphate

potassium and trace element fertilizers were added as needed. Tests No. 3 and 4 employed the Stanford-DeMent (6) short term nutrient absorption technique. In test No. 3 the oats were planted in a 12 oz. bottomless cardboard squat (cottage cheese type) cup filled with a weighed quantity of pure white sand and fertilized with a-P nutrient solution. Sixteen days after planting, and when the oat roots had ramified the sand, the bottomless cup with its sand and growing oats intact was placed inside of a similar cup containing 200 grams of soil. The treatment variables included five fertilizer sources (graph 1) and five rates; 0, 10, 20, 50 and 100 mgm of P from each source were mixed with the 200 grams of soil. The oats were permitted to grow another 7 days, during which time the roots of the phosphorus deficient plants exploited the soil for 'plant available' phosphorus. The plant tops were then harvested, dried, ground and analyzed for total P. Test No. 4 varied from the above procedure in that the oat seed was planted in white sand in an intact cup. Pure rock phosphate (no soil was used) was layered in the bottom of the cups. These experiments were also completely randomized with 5 repetitions.

RESULTS AND DISCUSSION

The data in table 1 indicate the rate at which the various forms of phosphorus were added to the soil and the forage yields of soybeans and millet crops. The rock phosphates were applied at rates of 500 and 1500 pounds of fertilizer per 2 million pounds of soil (weight of 1 acre to plow depth), but since the % P of these fertilizers varied the amount of P applied varied. Nevertheless, it is apparent that superphosphate, and Tennessee, Florida and colloidal rock phosphates applied at the high rates, were the only treatments that significantly increased plant yields. The last three columns give the soil test values 75 days after planting.

<table>
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<th>phosphorus source</th>
<th>yield, gm d.m./pot</th>
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<td>19.4</td>
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<td>Colloidal</td>
<td>58.5</td>
<td>22.3</td>
<td>1.8</td>
</tr>
<tr>
<td>superphosphate</td>
<td>7.2</td>
<td>22.7</td>
<td>2.5</td>
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<td>4.1</td>
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<tr>
<td>superphosphate</td>
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<tr>
<td>LSD, 05</td>
<td>2.53</td>
<td>1.55</td>
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</table>

Table 1. Effect of source and quantity of phosphorus on plant growth and on residual available soil phosphorus in test No. 1.
after the phosphorus fertilizers were mixed with the soil. None of fertilizers had any appreciable effect on the soil acidity or the quantity of exchangeable calcium. The phosphorus values represent the plant available fraction that is leached from the soil by a 0.03 N NH₄F—0.025 N HCl extracting solution. Most of the fertilizer phosphorus added to this acid soil remained in, or was converted into, an unavailable form.

The results of test No. 2 are given in table 2. The German millet was permitted to grow until maximum growth was obtained, it was clipped 2 inches above soil level and regrowth was permitted to develop for a second harvest. The forage yields and the plant phosphorus reported in this table are the sum of both clippings. Only the monocalcium reagent significantly increased yields or was absorbed by the plants in significant quantities. The rock phosphates had only a negligible effect on the quantity of available phosphorus present in this soil at the end of the test, but the monocalcium phosphate had more than doubled the phosphorus fertility of this slightly acid soil.

<table>
<thead>
<tr>
<th>source</th>
<th>yield gm d.m./pot</th>
<th>P absorbed ppm</th>
<th>available P ppm</th>
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<tr>
<td>none</td>
<td>4.85</td>
<td>6.46</td>
<td>35</td>
</tr>
<tr>
<td>Peyton Creek</td>
<td>5.34</td>
<td>8.46</td>
<td>39</td>
</tr>
<tr>
<td>Tennessee</td>
<td>4.43</td>
<td>7.43</td>
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</tr>
<tr>
<td>Florida</td>
<td>5.22</td>
<td>7.63</td>
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<tr>
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<td>20.16</td>
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<tr>
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<td>2.70</td>
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Table 2. Effect of four phosphorus fertilizers added at the rate of 130 ppm P on millet yield, P absorbed by plants and residual available soil P level in test No. 2.

Test No. 3, involving 125 individual cardboard cup plantings, was the most extensive of the greenhouse tests. The results, given in graph 1, show that the rock phosphates, at whatever rates, were no improvement over the no-phosphorus check; the mono-calcium phosphate, however, was readily adsorbed by the oat plants even when low rates were applied. The dry weight clippings of each culture weighed approximately one gram. No weight differences resulted from the phosphorus treatments. The phosphorus content in the forage of the no-phosphorus and rock phosphate treatments was approximately 0.14% while the P content of the high monocalcium treatment was approximately 0.5%.

Test No. 4 was similar to test No. 3 except that the oat plants grew in a pure sand fertilized with a -P nutrient solution. In the bottom of the growing cartons, beneath the white sand, rock phosphate fertilizer, in quantities equivalent to 1.88 gms of P, was layered. After the oat plants germinated the roots grew into these rock phosphates. The oats were harvested near the sand level 19, 35 and 50 days after planting. The plant samples from the first harvest were lost in analysis, but the samples from the second and third clippings were analyzed for phos-
Evaluations of Arkansas Rock Phosphate

\[ P \text{ absorbed by plants, } \text{mgm P/culture} \]

\[ \text{mgm of P added/culture} \]

Graph 1. Source and rate of fertilizer on P absorbed by young oat plants in test No. 3.

Phosphorus. The total quantity of P in the aerial portion of the oat plants for these two clippings was 0.5, 0.5, 1.2, 0.9 and 1.7 mgms for the no-phosphorus check, Peyton creek, Tennessee, Florida, and Colloidal rock phosphates, respectively. The dry-weight yield of an oat clipping from each carton was approximately 1 gram; thus the phosphorus content of the oat forage in test 4 was abysmally low, ranging from about 0.03 to 0.1%. Under the short term growth conditions that existed in this test the oat roots were able to absorb little or none of the phosphorus from the rock phosphate even though their roots were in direct contact with it.

The results of these greenhouse tests show that these four sources of rock phosphate are approximately equally unsatisfactory sources of P under the conditions of these tests. There is no single adequate method of measuring phosphorus availability to plants. Admittedly, short-term uptake tests, such as those reported here usually show rock phosphate to be inferior to processed phosphate fertilizer as a source of plant available phosphorus. These tests do indicate that short term crops, having a high phosphorus requirement, should not be fertilized with
rock phosphate. And certainly rock phosphorus is not an adequate source of fertilizer to be placed in a band near the seed row; during this critical period when the young plant needs an abundant supply of a plant available form of P, rock phosphate will have little value. These tests do not evaluate rock phosphate for those perennial or permanent plant species that do not have a high phosphorus requirement; nor do they evaluate the practice of using rock phosphate as a long term investment in soil fertility in contrast to the fertilization of the current seasons crop.

SUMMARY AND CONCLUSIONS

Four greenhouse tests comparing the fertilizer value of an Arkansas rock phosphate with 3 other more-or-less widely known rock phosphates and with a mono-calcium phosphate source are reported.

The Peyton Creek rock phosphate from near Leslie, Arkansas was no better than the other rock phosphates in increasing plant yields, in being absorbed by the plants, or in increasing the 'available' phosphorus level in the soil. The monocalcium phosphate source was markedly superior to the rock phosphates as measured by these tests.

LITERATURE CITED

PROPOSED MECHANISMS OF ASEXUAL NUCLEAR DIVISION IN NEUROSPORA CRASSA SHEAR AND DODGE

Charles L. Wilson, John A. Brushaber, and James R. Aist
University of Arkansas

INTRODUCTION

Perhaps no other biological phenomenon has as many different current explanations as does asexual nuclear division in Neurospora crassa Shear and Dodge. It is surprising that the nuclear behavior of an organism used so extensively in genetics would remain enigmatic. However, asexual nuclear behavior in the fungi is controversial and needs more study. In general, two schools of thought have developed concerning the mechanism of asexual nuclear division in N. crassa. One theory proposes that division occurs similarly to mitosis in higher plants (8, 9). The other contends that a mechanism basically different from classical mitosis is operative (3, 4, 6, 7, 10, 11, 12). Proponents of this latter theory have presented varied interpretations of this process (Fig. 1).

Somers et al. (8), and Ward and Ciurysek (9) propose that the chromosomes of N. crassa become arranged on a metaphase plate and divide by migrating to opposite poles. They failed to find a definite achromatic apparatus but maintained that the presence of a spindle was strongly suggested. The pictorial evidence presented by these workers is not convincing. This may be explained by the extremely rough treatment given their material before fixation. Ward and Ciurysek (9) state that in the preparation of their material "The light mycelial mat which developed was washed with distilled water to remove the culture medium and homogenized. Films of homogenate were spread over microscopic slides, air dried, ..." All of this was done before the nuclei were fixed. Somers et al. (8) centrifuged their material twice before fixing it. It seems that homogenization, centrifugation, and drying prior to fixation should be avoided, since these procedures would be expected to disrupt living processes such as mitosis. One should also expect extreme physical distortion to result from drastic treatment.

Bakerspigel (4), Weijer (10), Weijer et al. (11), and Dowding and Weijer (7) contend that division in the vegetative hyphae of N. crassa differs from classical mitosis, but they disagree radically in their interpretation of what happens. In fact, J. Weijer and D. L. Weijer in three separate publications present what are apparently three different interpretations of division (7, 10, 11).
Bakerspigel (4) interprets asexual nuclear division as follows: "This is another example of a fungus in which the vegetative nuclei do not appear to divide in the manner of classical mitosis. Instead, as division proceeds, the chromatin forms complexes of chromosomal filaments which then contract. At the end of division the contracted chromatin constricts and pulls rapidly apart without the aid of a visible spindle. Individually recognizable chromosomes were not observed to align themselves on a metaphase plate. In the vegetative Mycelium of \textit{N. crassa} the central body elongates and divides by constriction at the mid-region. Thus at the end of division each of the sister nuclei is composed of a portion of the original chromatin and central body. It is suggested that both the elongated central body and the densely strained granule in the chromatin of these nuclei play significant roles during nuclear division."

Dowding and Weijer (7) studying stained material state that "We too have found that mitosis in \textit{Neurospora} mycelium is unlike that in higher plants and animals and that there is no spindle; but we have observed also that the nuclei are filamentous and that they divide by splitting longitudinally."

Weijer et al. (11) observing living material under phase-contrast present a radically different interpretation of nuclear division. They do not attempt to consolidate this work with their previous interpretations of stained material. Prior to division the chromatin is arranged into a double-ring structure out of which protrudes a balloon-like membrane which eventually separates from the now compacted chromatin and disappears. The chromatin then changes to a bar-like structure with a nucleolus at one end. The chromatin bar splits longitudinally to form the daughter nuclei.

This paper presents still another interpretation of the asexual nuclear behavior of \textit{N. crassa}. More detailed information on asexual nuclear behavior in \textit{N. crassa} will be presented in additional papers, and it is anticipated that this information will help clarify the current dilemma.

MATERIAL AND METHODS

Preparations for this study of \textit{N. crassa} were made according to the HCL-Giemsa technique described by Aist and Wilson (1). Wild-type cultures of \textit{N. crassa} were used.

RESULTS

We have found that asexual nuclear division in \textit{N. crassa} occurs in a manner not previously described for this organism. Nuclear division in the thallus of \textit{N. crassa} is similar to that described for \textit{Ceratocystis fagacearum} (Bretz) Hunt and other plant pathogens (1, 2, 5). It occurs perpendicular to the longitudinal axis of the hyphae (Fig. 3). Metaphase chromosomes are associated lineally to form a bar-shaped metaphase plate (Fig. 2). Anaphase movement is usually unilateral and not synchronized. Spindles are usually seen only between chromatids or groups of chromatids which have already separated.
**FIG. 1** DIFFERENT EXPLANATIONS OF ASEXUAL NUCLEAR DIVISION IN *NEUROSPORA CRASSA*

<table>
<thead>
<tr>
<th>AUTHORS</th>
<th>PROPHASE</th>
<th>DIVISION</th>
<th>DIVISION</th>
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<th>SEPARATION</th>
<th>DAUGHTER NUCLEI</th>
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<td><img src="image2" alt="Image" /></td>
<td><img src="image3" alt="Image" /></td>
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</tr>
<tr>
<td>(CLASSICAL MITOSIS)</td>
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<td></td>
<td></td>
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<td>WILSON BRUSHABER AIEST (1966)</td>
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</table>
Asexual nuclear division in *N. crassa* occurs within an enlarged nuclear envelope (Figs. 2, 3, 4). After the nucleus divides within the envelope, a new membrane is formed around each daughter nucleus, and the daughter nuclei migrate out of the old envelope (Fig. 5). The old nuclear envelope eventually disappears (Fig. 1). Nuclei migrating out of the envelope may become considerably attenuated.

**DESCRIPTION OF FIGURES**

Figure 2. Metaphase with particulate chromatin. Nuclear membrane is visible in original preparation.

Figure 3. Anaphase within nuclear envelope. Division oriented perpendicular to longitudinal axis of hypha. Note point at which nuclear envelope extends beyond dividing chromatin (arrow). Only part of the chromatin is in focus.

Figure 4. Late anaphase or early telophase.

Figure 5. Nucleus (arrow) migrating out of nuclear envelope. The other daughter nucleus is still within the envelope.

**DISCUSSION**

We found no indications that vegetative nuclei of *N. crassa* divide by classical mitosis. Workers who propose this type of division have not presented clear pictorial evidence to support their contentions (8, 9).

The mechanisms of division proposed by Bakerspigel (4), Weijer et al. (11), and Dowding and Weijer (7) have features which are consistent with certain of our findings. We believe that the constricting and dividing nuclei reported by Bakerspigel may have resulted from a staining of the nuclear matrix within the envelope as well as the chromatin. When we overcast we get similar figures. As the daughter nuclei migrate out of the nuclear envelope, the envelope is stretched.
Nuclear Division in Neurospora crassa

and figures are produced comparable to those illustrated by Bakerspigel as divisional stages.

Weijer et al. (11) and Dowding and Weijer (7) have shown the chromosomes to be associated lineally into a filament of chromatin. They interpret division as the splitting of this filament into two strands of lineally associated chromosomes which then separate. We find the chromosomes associated into a filament of double stranded chromatin prior to division. A spindle then develops between separating chromatids and appears to push them apart.

LITERATURE CITED


OBSERVATIONS ON OCCURRENCE AND RANGE OF THREE SPECIES OF DENTARIA (CRUCIFERAE) IN THE OUACHITA MOUNTAINS

Aileen McWilliam

Several interesting aspects of speciation and distribution present themselves in the genus Dentaria (Cruciferae) in the Ouachita Mountains of Arkansas and Oklahoma. Two species, D. laciniata Muhl. and D. heterophylla Nutt., are of quite widespread occurrence in the area, but with little overlapping. A third species, D. multifida Muhl., has been found only in a narrowly restricted area and habitat.

D. laciniata is distinguished from the other two species by the absence of basal leaves at flowering time, and by the more or less hirsute stem and rachis of the raceme. The cauline leaves are in a whorl of three. These leaves are divided into three leaflets, variously toothed or slashed, with the lateral two leaflets deeply two-parted, giving an appearance of five leaflets. The leaflets are sessile. The lacination of the leaves is quite variable. The flowers are pale, white to purplish, with pale green sepals (Fernald 1950; Gleason 1952). This is the most robust of the three species.

D. heterophylla is distinguished by the basal leaves, usually present at flowering time. These leaves are trifoliate, with oblong to rhombic entire or toothed leaflets, purple on the underside. The cauline leaves are usually two, opposite, with sessile, toothed leaflets, not divided. The rachis of the inflorescence is glabrous to only slightly pubescent. The flowers are pink to purple, with purple sepals. This species is generally lower-growing then the other two (Fernald 1950; Gleason 1952).

D. multifida is as tall as D. laciniata at anthesis, but is much more slender. Basal leaves, usually present, resemble the cauline leaves. The two or three cauline leaves are divided into three long-stalked leaflets which are dissected into very fine, long linear segments which may be toothed or further divided. The rachis of the inflorescence is entirely glabrous. The flowers are white to pinkish (Fernald 1950; Gleason 1952).

All three species are plants of rich, moist woods, wooded stream bottoms, and shaded rocky banks.

D. laciniata is eastern to middle-western in its range, occurring from Quebec and Vermont through Minnesota and Nebraska south to Florida and Louisiana (Fernald 1950). It is the species of the Ozarks (Steyermark 1964) and is the only species listed by Waterfall for Oklahoma (Waterfall 1962). In the Ouachita Mountains it is found in great abundance on the top of Rich Mountain and down the north slope in

1 Biology Teacher, Mena High School
very rocky, but exceedingly rich soil of the hardwood forest. It is also found on adjacent mountains of the Jackfork Sandstone formation. Its range is interrupted to the east, but it is found again in Montgomery County in rich, cherty soil of the Novaculite Uplift. There seems to be no intermingling with D. heterophylla on Rich Mountain, but on the headwaters of the Ouachita River, which rises from springs at the foot of Rich Mountain, D. heterophylla is the prevalent species, and D. laciniata is not found. In one small area on Big Fork Creek, near the Polk-Montgomery County line, the two species are growing in association, with about equal numbers of each species. This location supports an exceedingly rich and varied flora.

D. heterophylla is somewhat more eastern in its range than D. laciniata, occurring from New Jersey to southern Ohio, and south to Georgia and Tennessee (Fernald 1950). In the Ouachitas it is widespread and common along the Ouachita River and in the stream valleys and on rocky banks of the area south and east of Mena in the Ouachita National Forest. Here it apparently does not occur in association with D. laciniata. It is especially prevalent in the beech forests, but by no means limited to them.

The range of D. multifida is similar to that of D. heterophylla, but somewhat more southern, from southern Ohio and Indiana to Georgia and Alabama. On March 29, 1964, a well-established small colony of this species was found on the headwaters of Blaylock Creek, which flows into the Little Missouri River. This find was brought to the attention of Dr. Dwight M. Moore, who reported it to the Arkansas Academy of Science in his discussion of "New Records of Arkansas Flora" at the April meeting of the Academy that year. These plants are all located in a narrow ravine in beech forest, and all are within a few feet of a cold, swift stream. Blooming was almost past at the time they were found, March 29, though D. heterophylla in the same location was just coming into bloom. Later a few scattered plants of D. multifida were found a short distance down Blaylock creek from the first location.

The disseminules of these plants are the seeds, which are scattered mainly by the mechanical propulsion of the opening silique and perhaps to some extent by small birds and mammals, and the rhizomes, which in all three species are constricted into short fusiform segments, very loosely attached. The rhizomes are deep-seated, but may perhaps be carried about by burrowing animals.

The occurrence of D. laciniata on Rich Mountain and elsewhere, and of D. heterophylla to the south and east of Rich Mountain might be determined as being based on geological divisions, except for the presence of D. laciniata on Big Fork Creek and in western Montgomery County on the Novaculite formations, and the presence of D. heterophylla along the Ouachita River in the Jackfork Sandstone areas.

D. heterophylla evidently is disjunct, and thus should probably be considered a relict species from a time when the Ouachita Mountain forest was continuous with the Appalachian forest. There are a num-
ber of such disjunct and probably relict species in the Ouachitas. D. multifida is surely a very much shrunken relict. It is possible, however, that this species may be found to have a more extensive distribution since its presence in the area is known. The fact that D. multifida has been found only in a narrow band of woodland very close to a cold, spring-fed stream may be an indication of a habitat restriction that has limited it to very cool, humid situations.

REFERENCES CITED


ADDITIONAL INFORMATION ON BASICLADIA CRASSA
HOFFMANN AND TILDEN

Robert G. Anderson and Clarence B. Sinclair

The University of Missouri at Kansas City and
Little Rock University, respectively

The alga Basicladia was given generic status by Hoffman and Tilden (1930) following the work of Collins (1907) and Tiffany (1926). Hoffmann and Tilden described the two species B. crassa and B. chelonum, the latter having been identified by Collins (1907) as Chaetomorpha chelonum. Tiffany (1926), as well as Hoffmann and Tilden (1930), described reproduction by means of biflagellated zoospores. The latter authors, as well as Smith (1950, p. 218), apparently were in doubt as to whether these biflagellated cells were zoospores; but, none the less, used the term "zoospores." Leake (1938) saw biflagellated motile cells but was uncertain whether they were zoospores or gametes. She indicated the filaments would not grow in water culture. Leake (1946) later described aplanospore and zoospore germination within 3-4 days in hanging drop preparations. Kusunoki (1944) described and illustrated developing sporangia and the release of large and small zoospores through lateral papillae.

Hamilton (1948), using a series of line drawings, described the reproductive process as the release of biflagellated, spindle-shaped gametes from a parent-cell. These gametes were of the same approximate size as the motile cells described by Leake (1938). The gametes fused anteriorly to result in a spindle-shaped zygote with four (4) anterior flagella. If the gametes failed to fuse, they swam for 1-3 minutes, became spherical, lost their flagella, and degenerated in a few hours.

Ducker (1958) described B. ramulesa as a new species obtained from the back of an Australian fresh water turtle. She pointed out an increasing morphological complexity from B. chelonum → B. crassa → B. ramulesa, with B. ramulesa being more highly branched and filamentous than the other two species. Ducker did not, however, include in this series B. sinensis as described by Gardner (1937).

Up to this point Basicladia has been described as growing only on the carapace of turtles. Proctor (1958) succeeded in culturing Basicladia on an inorganic-soil extract agar medium. The organism also grew on sponge and carapace, and "spread by means of zoospores, and possibly gametes." These flagellated structures were seen to migrate to the walls of the glass container and to make loose attachment from which they were easily dislodged resulting in death of the alga. Proctor suggested that the physical structure rather than the chemical composition of the shells of turtles was important in limiting the distribution of the alga. He stated that pure cultures of the organism were needed for accurate information on possible nutritional requirements. Normandin
and Taft (1959) showed that B. vivipara, a new species, grew on the shell of the snail Viviparus malleatus Reeve. Explants of the alga from the snail grew well on culture media containing scrapings of turtle carapace. The reverse situation, i.e., Basicladia from turtles' backs, showed no appreciable growth in culture on shell scrapings of snail. The authors suggested the possibility of a minimum and specific growth substance existing in the snail shell material. They also stated that the cells releasing reproductive cells "should probably be considered as being sporangia."

In a motion picture study produced in 1964 by the Film Production Unit and the Department of Botany and Plant Pathology at Iowa State University, the release of the zoospores of Basicladia was well illustrated. (Liberation of zoospores in the alga Basicladia. The Ealing Corporation, Cambridge, Mass.)

It seems obvious to the writers that the true nature of the flagellated cells is unknown and for this reason these cells will be referred to in this work as reproductive cells.

This paper will present new evidence and illustrations of certain morphological features of B. crassa. This investigation was carried out at the University of Missouri at Columbia during the summers of 1962-1963 on material from Du Quoin, Ill., supplied by David Norton, a graduate student in the N. S. F. Summer Institute. Acknowledgement is extended to him for his valuable assistance.

The turtles upon which the alga was growing were identified as male specimens of the western painted turtle, Chrysemys picta bellii (Gray), by Dr. R. S. Campbell of the Zoology Department of the University of Missouri at Columbia. The turtles were collected at the fairground lake in Du Quoin, Ill., placed in a small darkened aerated container and transported to Columbia in the trunk of a car. The alga from the turtles was examined after being in darkness for periods of eight (8) to thirty-two (32) hours, and photographs were made. The pH of the water in which the turtles were maintained and in which the alga was examined ranged from 6.9-9.0. All photographs were made with a Spencer AO Microstar Microscope on Panatomic-X film.

The general vegetative morphology observed is the same as that previously described by Hoffmann and Tilden (1930), Hamilton (1948) and Smith (1950, p. 217). The alga has a rhizoidal system, modified as a holdfast, from which arise infrequently-branched multicellular filaments. The cells have a reticulate chloroplast and intercalary cell division was observed by the writers. Nowhere in the literature, however, is there mention of the cytokinetic process in the vegetative cells of Basicladia. Fig. 4 shows that wall formation proceeded centripetally. This process pinched the chloroplast and cytoplasm into two nearly equal portions. A few terminal portions of the filaments were observed, and the shape of the terminal and adjacent cells suggests terminal cell division.
Information on Basicladia crassa

The rhizoidal system of a single filament was highly interwoven with those of other filaments. A complete individual rhizoidal system was difficult to observe for the above reason. In a few cases chloroplasts were observed in the rhizoidal outgrowths, but photographs showing these chloroplasts could not be obtained. Walls of cells near the rhizoidal system were thicker than cell walls in the upper portions of the filaments, and these walls were lamellated. Lamellated cell walls were not as apparent on the vegetative and parent-cells as on cells in the basal regions.

Reproduction is initiated by the transformation of a vegetative cell into a parent-cell. These parent-cells develop one or more papillae at various loci through which the motile cells may eventually escape. Papillae develop simultaneously on numerous adjacent cells. A papilla begins development as a blunted angular protrusion but soon becomes somewhat dome-shaped. Wall thickness of the papilla and that of the reproductive cell from which it is produced are approximately the same throughout. The terminal portion of the dome-shaped projection completed its development 12-15 minutes after slide preparation and gellingalized preparatory to reproductive cell release. That more than one papilla per cell may develop was observed in a few cases, and cells with two (2) open papillae were observed. The parent-cell prior to eruption was highly granular, making it difficult to recognize individual reproductive cells, and there were no apparent swimming movements.

The most commonly observed method of release of reproductive cells was the forcible eruption of flagellated motile cells. The earliest released cells were surrounded by a gelatinous membrane which soon disintegrated; latter members from the same parent-cell escaped individually by swimming movements and were compressed while moving through the cell aperture (Figs. 1, 2). Measurements of the cell aperture of an individual parent-cell in enlarged photographs showed an increase in diameter during this escape; however, the length and width of the parent-cell remained essentially the same. Thus it would seem that the wall material surrounding the aperture is not of the same consistency as the adjacent wall material. Figs. 1 and 2 show part of the release sequence. The above release sequence was photographed after the alga had been subjected to a twenty-seven (27) hour dark period. Similar release sequences were observed after an eight (8) hour dark period and after dark periods ranging through thirty hours.

The motile reproductive cells are biflagellated, spherical to slightly ellipsoidal, with a somewhat crescent-shaped red eyespot and appear to contain many irregularly shaped parietal chloroplasts arranged posteriorly to give a cuplike form. The flagella are located at the anterior end which is devoid of chloroplasts (Fig. 6). The red eyespot was observed at different locations in the cell on both sides of the equatorial plane, but not at the extreme anterior or posterior ends. These motile cells vary in diameter from 10-20 μ. Hamilton (1948) stated that the reproductive cells escaped with flagella trailing, but after escaping, swam anterior end first. This observation was confirmed by the writers.
(Fig. 2); however, cells were also observed leaving the parent-cell flagellar end foremost (Fig. 1).

The writers also observed, after a thirty-two (32) hour dark period, a rather unusual release of reproductive cells. This consisted of the release, through the pore of the papillae, of various sized masses of flagellated cells which adhered to each other without subsequent disjunction. These did not exit forcefully, but were released in a slow, outpouring manner, with each mass being constricted as it passed through the pore (Fig. 3). Each cellular mass was surrounded by a gelatinous material. The most striking characteristic of this entire group of cells was the absence of flagellar activity, although flagella were definitely present. It has been suggested to the writers that the release of these cellular masses was the result of a physiological imbalance induced by the unusual environmental conditions. Actively swimming cells were rarely seen after a thirty-two (32) hour dark period.

Some reproductive cells, which were never released, were also observed in parent-cells which had either closed or open papillae.

In the summer of 1963, quadriflagellated reproductive cells with red eyespots were seen on several occasions and were photographed (Fig. 5a, b). This is the first recorded evidence of quadriflagellated reproductive cells in Basicladia. The release sequence for these cells was similar to that of the biflagellated cell release.

DISCUSSION

Many writers — Leake (1948), Hoffmann and Tilden (1930), and Smith (1950) — indicated that the biflagellated reproductive cells which escaped from the parent cell of Basicladia were zoospores. However, Hamilton (1948) recorded the fusing of these same types of structures and stated that they were gametes. Hamilton also stated that the organism was homothallic. Smith (1950, page 214) stated that Cladophora reproduced asexually by means of quadriflagellate zoospores. Fritsch (1956) stated that certain species of Cladophora and Rhizoclonium produce biflagellated zoospores. Prescott (1962) stated that biflagellated zoospores are common, especially in Cladophora. These organisms, along with Basicladia, all belong to the Order Cladophorales (Smith, 1950; Fritsch, 1956; & Prescott, 1962). Hamilton (1948) did not report the presence of zoospores in Basicladia in his studies. At no time during our investigations did we see fusion of any reproductive cells although two (2) to several cells were observed adhering in masses. The presence of both biflagellated and quadriflagellated reproductive cells without subsequent fusion only further serves to indicate the lack of understanding of the nature and function of these cells. The aplanospores described by Leake (1946), and the captive cells seen by Hamilton (1948) may very well be different time stages of the same type structure. We did not observe and nowhere in the literature is mention made of the presence of akinetes.
The factors responsible for the forceful and/or extrusive release of reproductive cells are unknown. Actively swimming reproductive cells which remained within the parent-cell eventually escaped by autonomous movements. Although there was some apparent synchronization of release of biflagellated cells from groups of three or four parent-cells, there was no observable acropetal or basipetal sequence of release. It is probable that this release of reproductive cells is the result of light stimulus (Hamilton, 1948). The time of actual reproductive cell formation (prior to, or after, light stimulus) within the parent cell is not known. The authors have shown that papillae formation occurs during the first 15 minutes of the light period.

**SUMMARY**

Observations and photographs of *Basicladia crassa* are presented. The vegetative cells have a reticulate chloroplast and divide by constricive cytokinesis; cell division is intercalary and also appears to be terminal. Rhizoidal outgrowths from the basal cell may or may not have chloroplasts. The reproductive parent-cells were formed from vegetative cells and were seen to release both biflagellated and quadriflagellated motile cells. Quadriflagellated reproductive cells are reported for the first time for this organism. The flagellated cells were released through pores of rapidly formed papillae by means of forceful expulsion and by autonomous swimming movements, and an extrusive, slowly escaping movement. Some reproductive cells were never released from the parent-cells.

**LITERATURE CITED**


Information on Basicladia crassa

Figs. 1-6. -Figs. 1-2. Two cells in normal release sequence. -Fig. 1. Anterior end foremost. X43 obj. -Fig. 2. Posterior end foremost. X43 obj. -Fig. 3. Extrusive release of clumps of reproductive cells. X43 obj. -Fig. 4. Centripetal wall formation dividing reticulate chloroplast and cell into two (2) unequal parts. X20 obj. -Fig. 5. Quadriflagellated reproductive cells at a and b. X90 obj. -Fig. 6. Biflagellated reproductive cells with crescent shaped red eyespot at a. X90 obj.
EFFECT OF GROWTH SUBSTANCES ON PHENOTYPIC
EXPRESSIONS OF THE KNOTTED (Kn) GENE OF ZEA MAYS

Oval Myers, Jr., and Billy B. Rhodes*
University of Arkansas

INTRODUCTION

The mutant gent Knotted (Kn) in Zea mays is so named because it is responsible for bulges and outgrowths, or so-called "knots", associated with the lateral veins of the leaf blade. These knots may be clustered near the base of the blade or somewhat diffused to more distal portions of the blade. Knots may occur on the abaxial or adaxial surface of the leaf, but are predominant on the abaxial surface. The vascular bundles that pass through the knots are not disrupted nor distorted (1). The appearance of these abnormal growths, or knots, is only one of several phenotypic effects of the gene. Other expressions include dwarfing, decrease in length and increase in width of leaves, and decreased pollen production.

Bryan and Sass (1) reported this gene to be a simple dominant located on the first chromosome between floury_1 and brown-midrib_2. Nelson and Postlethwait hypothesized that knotting was due to a dispersion of the cells of the intercalary meristem. According to their hypothesis, meristematic cells are pushed outward as they divide, as dictated by the restraints of surrounding, differentiated cells. Other effects, such as dwarfing, they termed "secondary" to the knotting effect.

Rhodes and Myers (4) found that dwarfing regularly preceded the appearance of knots. They also found significant differences in the time and amount of dwarfing, length and width of leaves, and the time and amount of knotting between homozygous (KnKn) plants and heterozygous (Kn+) plants. On the basis of these findings they suggest a definite dosage effect of the Kn gene for these phenotypic expressions.

Phinney (3) found that the gibberellin, GA_3, induced normal growth in four Zea mays dwarf mutants, d_1, d_2, d_3, and d_5, while other growth substances failed to elicit such a response. He suggested that these GA_3-responding mutants might be controlling different steps in a biochemical pathway leading to the production of naturally occurring gibberellin similar to GA_3, and necessary for normal growth.

Nickerson (2) applied growth hormones to Kn mutants and succeeded in modifying the effects of the gene with naphthalenacetic acid and

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gibberellic acid. Development of knots in four strains of maize carrying the gene was completely inhibited by daily treatment of 500 µg of naphthalenacetic acid. Other effects produced by these treatments included suppression of flowering, reduction of the abnormal thickness of knotted leaves, and the formation of flanges by the brace roots, with a single stele for the entire group. The dwarfing associated with the gene, however, was not altered by naphthalenacetic acid. Plants having the Kn gene were only one-half to two-thirds as tall as normal plants. The gibberellic acid, GA₃, produced similar, but less pronounced, results.

This study was undertaken in an attempt to clarify Nickerson's work and to elucidate the role of certain growth hormones in modifying the dwarfing and knotting expressions of the knotted gene.

MATERIALS AND METHODS

The material used in this study was derived from seed obtained from the Maize Genetics Cooperative in 1964, and is in a genetic background related to the single cross M14/W23.

The growth hormone experiment diagramed in Figure 1 was conducted in the fall of 1965. Two hundred and twenty-five, five inch pots were prepared and placed in rows of five in the greenhouse. The entire arrangement consisted of 15 groups, each group consisting of 15 pots. On September 27, normal (++), heterozygous (Kn+), and homozygous (KnKn) seed were planted. Plants began to emerge on October 3, and were later thinned to one plant per pot. Five treat-
ments, namely, indoleacetic acid (IAA), kinetin (K), gibberellic acid (GA₃), naphthalenacetic acid (NAA), and the control (C), were applied, beginning on October 6. Each treatment consisted of 10 μg. of one of the above substances dissolved in 1.0 ml distilled water. The control consisted of 1.0 ml distilled water. Sodium carbonate was used in small amounts to dissolve kinetin. Each treatment was applied by means of a pipette to the hollow formed by the first unfolding leaf. The first five groups were given twelve treatments, one every two days, beginning on October 6 and ending on October 28. The second five groups were given eight treatments, beginning on October 6 and ending on October 20. The third five groups were given four treatments, beginning on October 6 and ending on October 12. Groups 1, 6, and 11 received indoleacetic acid; groups 2, 7, and 12 received kinetin; groups 3, 8, and 13 received gibberellic acid; groups 4, 9, and 14 received naphthalenacetic acid; and groups 5, 10, and 15 received control treatments.

Solutions were freshly prepared each week and stored in the refrigerator.

Plant height and the number of knots were recorded every two days after emergence for a four week period. Height was designated as that distance from the base of the plant at soil level to the uppermost part of the plant. A knot was counted as a single visible protuberance on either side of the leaf blade.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F value found</th>
<th>F value required</th>
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<td>3.6**</td>
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<td>3,182.3</td>
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</table>

** Highly significant.

Table 1. Analysis of variance of height of plants treated with growth hormones.
Dwarfing. An analysis of variance for height is shown in Table 1. Highly significant F values were obtained for treatments, genotypes, genotype x treatment interaction, and genotype x treatment x time interaction. Time periods, with the exception of the genotype x treatment x time interaction, were not significant. This would seem to indicate that the duration of the treatments had little effect on the results obtained.

A ranking of means from all significant sources of variation is shown in Table 2. Duncan's new multiple range test was used to

<table>
<thead>
<tr>
<th>Genotype x Treatment x Time Period</th>
<th>Naphthaleneacetic Acid</th>
<th>Indoleacetic Acid</th>
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</thead>
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<td>C</td>
</tr>
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<td>Kineth</td>
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<td>C</td>
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<td>= 8t = 8t = 8t = 8t = C</td>
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<td>= 8t = 8t = 8t = 8t = C</td>
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</table>

Table 2. Ranking of height means.
determine significant differences between means. Genotypes were significantly different at the 5% level of probability. In respect to treatments, height differences between NAA, K, and IAA were not significant, but all three treatments produced plants significantly shorter than control plants. Genotype x treatment means indicate that relative differences in height due to genotype are not eliminated by treatments. NAA, IAA, and K did not eliminate dwarfing, but GA significantly increased height of KnKn plants above the KnKn controls, Kn+ plants to the height of untreated ++ plants, and ++ plants to approximately one and one-fourth their normal height. Genotype x treatment x time means are ranked according to treatments. The relationship of genotype to height regardless of treatment is evident. There seems to be no relationship between genotype or treatment, and time period.

Knotting. An analysis of variance for knots is shown in Table 3. Since knots occur only on KnKn and Kn+ plants, the number of plants in the analysis is 150 rather than the 225 considered for height.

<table>
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<tr>
<th>Source of variation</th>
<th>Degrees of freedom</th>
<th>Sum of squares</th>
<th>Mean square</th>
<th>F value obtained</th>
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<tr>
<td>Replication</td>
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<td>8.65</td>
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<td>Time Period</td>
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<td></td>
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</tr>
<tr>
<td>Treatment</td>
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<td>69.2</td>
<td>4.87**</td>
<td>3.74</td>
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<td>Treatment x Time</td>
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<td>16.9</td>
<td>1.19</td>
<td>2.90</td>
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<td>679.6</td>
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<td>174.9</td>
<td>48.58**</td>
<td>7.08</td>
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<td>Genotype x Time</td>
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<td>1.59</td>
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<td>34.2</td>
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<td>3.65</td>
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<td>Gen. x Treat. x Time</td>
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<td>179.9</td>
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<td>6.25**</td>
<td>2.82</td>
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<td>Error C</td>
<td>60</td>
<td>218.1</td>
<td>3.6</td>
<td></td>
<td></td>
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</table>

** Highly significant.

Table 3. Analysis of variance of number of knots on mutant plants treated with growth hormones.

Highly significant F values were obtained for the same means as those for height. The duration of treatment had little effect on the amount of knotting on the plants of this experiment.
Knotted (Kn) Gene of Zea mays

A ranking of the means for all significant sources of variation is shown in Table 4. Since the final count of knots was made four weeks after emergence when knotting was slight, differences in some instances, were not discernable. Differences that are valid statistically using Duncan's new multiple range test are shown in Table 4. All treatments

Table 4. Ranking of knot means.
reduced the total number of knots when compared to the control population. KnKn plants had more knots when averaged over all experimental situations than Kn+ plants. NAA virtually eliminated knotting on both KnKn and Kn+ plants. IAA inhibited knotting to a lesser extent than NAA, but inhibited both genotypes to about the same degree.

The effects of NAA and IAA seemed to be primarily on knotting, with leaves returning to normal in respect to length and width. Plants treated with GA3 and K had fewer knots in most instances than control plants, but other drastic effects produced suggest that the reduction of knotting was not due to the same mechanism involved in knot reduction by NAA and IAA. K-treated plants had necrotic leaves bearing a white compound, presumably the sodium carbonate used to keep K in solution. GA3-treated plants were extremely spindly, with very long, narrow leaves.

In view of the fact that NAA treatments virtually eliminate knotting while not eliminating dwarfing, it seems that knotting is not responsible for dwarfing, but that these are separate and wholly independent expressions of the same gene or closely linked genes.

SUMMARY

The growth hormones gibberellic acid, indoleacetic acid, kinetin, and naphthalacetic acid were tested for their effect on the knotting and dwarfing expressions of the Knotted (Kn) gene in *Zea mays*. Naphthalacetic acid almost completely suppressed the production of knots. Gibberellic acid, indoleacetic acid, and kinetin reduced knotting to a lesser degree. Naphthalacetic acid, indoleacetic acid, and kinetin did not eliminate dwarfing, but gibberellic acid significantly increased the height of both heterozygous and homozygous plants.

LITERATURE CITED

HEAT RESISTANCE EXPERIMENTS WITH THE LONGEAR SUNFISH, LEPOMIS MEGALOTIS (RAFINESQUE)

William H. Neill, Jr., Kirk Strawn, and James E. Dunn
University of Arkansas

INTRODUCTION

A fish withstands the lethal effects of an intolerably high temperature for a certain period of time; this resistance time (Brett, 1952) depends on the severity of the temperature and the previous thermal history of the fish. The pattern formed by a plot of median-log-resistance times and the higher test temperatures has generally been found to be described by a single straight line (Fry, Hart, and Walker, 1946; Brett, 1952; Hart, 1952). At lower test temperatures an abrupt change in slope of the response pattern occurs giving a new line which is more nearly parallel to the time axis. The intercept of this line and the other, more steeply sloped line marks the transition from resistance to tolerance (Brett, 1956). Gibson (1954), in experiments with the guppy, Poecilia reticulata Peters, remarked that in the lower range of lethal temperatures near this transition (incipient-upper-lethal temperature), the mortality pattern was not complete even after 10,000 minutes exposure. Brett (1952) obtained comparable results for the chum salmon, Oncorhynchus keta (Walbaum).

The second author and his associates, in past experiments involving several orders of fishes, became aware of additional complexities in the upper-lethal-temperature response. These observations were instrumental in the conception and design of the present experiment whose object was to determine more precisely the nature of this response and to investigate the upper-lethal-temperature relationships of Lepomis megalotis (Rafinesque), a centrarchid which has been previously neglected as a subject for lethal-temperature experimentation. Fish acclimated to three different temperatures were tested because it was suspected that the characteristics of the three resistance patterns might differ.

METHODS AND MATERIALS

The experimental fish were reared from eggs collected from nests in the shallow, upper reaches of the Middle Fork of the White River, two and one half miles south of Sulphur City, Washington Co., Arkansas (T15N-R29W-Sec34), during May and June, 1964. The eggs, upon arrival at the laboratory, were placed in constant-temperature tanks filled with aged and aerated tap water. The fry were fed (twice daily), first, brine shrimp and later, as they grew larger, various combinations of brine shrimp, mosquito larvae, and a cooked mixture consisting of high-protein baby cereal and blended calf liver (Gordon, 1950). Both

1Participant-Undergraduate Research Participation Program in Zoology, NSF Grant GE-4218.
eggs and young fish were subjected to constant, "cool-white" fluorescent light. The hatching and rearing temperatures, although varied in some cases, never exceeded the final acclimation temperatures.

When the young fish had reached a convenient size (standard length of 12 mm or more), they were assigned to either an acclimation temperature of 25.0, 30.0, or 35.0°C. Duration of acclimation periods prior to testing was at least one week. Acclimation temperatures, checked by thermometer twice or more daily, never deviated more than \( \pm 0.1°C \), and deviation to even this extent was rare. Fish to be used in proximal experiments were separated from the others by placing them in a net suspended in the acclimation tank, and they were not fed for 24 hours or more before being subjected to lethal temperatures.

A modification of the method described by Brett (1952) was used to determine resistance times. Lethal baths — 2-gallon goldfish drums filled with heated water from Great House Springs (4 miles north of Fayetteville) — were arranged in a graded series, the water of each differing 0.1°C from that in the bowl on either side. Lethal test temperatures ranged from 35.0 to 36.9°C for fish acclimated to 25.0°C, from 36.0 to 39.0°C for fish acclimated to 30.0°C, and from 37.3 to 41.5°C for 35.0°C-acclimated fish.

Constant water temperature of each lethal bath — as in the acclimation tanks — was maintained by strong aeration and an aquarium heater controlled by a contact thermometer through a relay. A standardized thermometer calibrated in intervals of 0.1°C was used to check bath temperatures. Variation of bath temperature did not exceed \( \pm 0.05°C \) from the set value. Any deviation was corrected as soon as it was detected.

Samples of 10 (20 in tests of fish acclimated to 30.0°C) individuals were taken randomly from the holding nets and placed directly into the lethal baths. A continuous watch was kept the first few days of each experiment, and the resistance time of each fish was recorded to the nearest 5 seconds. [See Brett (1952) for description and criteria of heat-death.] After the first few days of the experiments, the fish were checked at intervals not exceeding 12 hours. The dead fish were removed from the goldfish drum, and standard length was measured and recorded. The separating of these young fish by sex was considered impractical.

Inspection of the plotted resistance times on a per fish basis (semilogarithmic axes) for each acclimation group indicated that a statistical scrutiny of sample variances was appropriate.

It was assumed that the resistance time, \( t \), had the log-normal density function,

\[
 f(t) = \left( \frac{\beta}{2 \pi} \right)^{1/2} \exp \left\{ - \left( \ln t - \ln \alpha \right)^2 / 2 \beta^2 \right\}
\]

where \( \alpha, \beta > 0; t > 0 \)

i.e., the logarithm of the resistance time was normally distributed. This
Heat Experiments with Longear Sunfish

resulted in mean resistance time and variance of the resistance time being, respectively,
\[ E(t) = \alpha \exp(\beta^2/2) \quad \text{and} \quad \text{var}(t) = \alpha^2 \exp(2\beta^2) - \alpha^2 \exp(\beta^2). \]

However, letting \( z = \ln e t \), then \( E(z) = \ln \alpha \), and
\[ \text{var}(z) = \beta^2, \text{or, if } y = \log_{10} t = \log_{10} e \cdot \ln e t, \]
\[ E(y) = \log_{10} e \cdot \ln \alpha \text{ and var}(y) = (\log_{10} e)^2 \beta^2. \]

If the assumptions were correct, then either \( \log_{10} t \) or \( \ln t \) had a normal distribution, the only difference being that the parameters differed by a scale factor, \( \log_{10} e \); i.e.,
\[ \ln t \sim N[\ln \alpha, \beta^2] \quad \text{and} \quad \log t \sim N[\log_{10} e \cdot \ln \alpha, (\log_{10} e)^2 \beta^2]. \]

In order to test for heterogeneity of variance, sample variances were calculated in the usual manner from log resistance times for samples of size \( n \) drawn at random from \( K \) normal populations. The common degrees of freedom associated with each \( s^2 \) were then \( n - 1 \). The test statistic used for testing \( H_0: \sigma_1^2 = \sigma_2^2 = \ldots = \sigma_K^2 \) was the maximum F-ratio,
\[ F_{\max} = \frac{s^2_{\max}}{s^2_{\min}}. \]

For \( K \leq 12 \), the 0.05 critical values used for this test statistic were those given by David (1952). For \( K > 12 \), a normal approximation suggested by Hartly (1950) was applied. This approximation suggested that
\[ \ln s^2 \sim N[\ln \sigma^2, 2/(v - 1)], \text{approximately}, \]
\[ \ln F_{\max} = \ln s^2_{\max} - \ln s^2_{\min} \sim N(0,1). \]

Hence,
\[ z = W, \text{ i.e., when } H_0: \sigma_1^2 = \sigma_2^2 = \ldots = \sigma_K^2 \]
\[ \sigma^2 \text{ is true}, \text{ then } \ln F_{\max} \sim N(0,1) \text{ is distributed as the range of } \]
\[ K N(0,1) \text{ variates}. \]
Hence, if \( W \) is taken to be the \( 1 - \alpha \) percentage point for the distribution of range, then
\[ \Pr \left[ F_{\max} = \frac{s^2_{\max}}{s^2_{\min}} \leq e^{W(K)} 1 - \alpha \sqrt{2/(v - 1)} \right] = 1 - \alpha \]
so that \( \exp \left[ W(K) \sqrt{2/(v - 1)} \right] = \Lambda_{(K) 1 - \alpha} \) provides an ap
proximate $1 - \alpha$ percentage point for using $s^2_{\max}/s^2_{\min}$ as a test statistic.

In actual practice $\Delta_{(K)}$, calculated by this approximation $\alpha_{(K)}$, was too small so that the probability of rejecting $H_0$ in error was somewhat larger than $\alpha$ when these approximate critical values were used. The most accurate values of $W_{(K)}$ appeared to be those by Harter, Clemm, and Guthrie (1959). Percentage points of the studentized range were given but for d.f. $= + \infty$, the percentage points were actually those of the range $W$.

With a consideration of these factors in mind, multiple range tests for equality of variances were performed. We reverted to the Newman-Keuls procedure of holding $1 - \alpha$ constant regardless of $K$ rather than following Duncan's approach of using $1 - (1 - \alpha)^{K-1}$ as the significance level for a test involving $K$ variances (cf. Duncan, 1955).

In order to determine whether fish size was associated with resistance to upper-lethal temperatures, Kendall's rank-correlation test (Siegel, 1956) was applied for each test sample.

![Figure 1. Median-resistance times for young longear sunfish acclimated to 25.0°C (o), 30.0°C (o), and 35.0°C (x).](image)
RESULTS

A semilogarithmic plot of sample-median-resistance times versus test temperatures indicated the general nature of the response of the three acclimation groups to upper-lethal temperatures (Figure 1). The scatter of the plotted medians reflected the variability of individual resistance times.

Medians could be determined only for those samples in which at least n/2 + 1 fish had died before that experiment was terminated. All fish acclimated to 35.0°C and subjected to resistance tests eventually died; at 37.3°C, the lowest test temperature, the last fish died after 24,831 minutes, the longest resistance time for any 35.0°C-acclimated fish. Some 25.0° and 30.0°C-acclimated fish survived more than 11 and more than 8 days, respectively, at the lower test temperatures (Table 1).

<table>
<thead>
<tr>
<th>25.0°C Acclimation</th>
<th>30.0°C Acclimation</th>
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</thead>
<tbody>
<tr>
<td>Test Temp. (°C)</td>
<td>No. Test Survi-</td>
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<tr>
<td></td>
<td>ed (Min.)</td>
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<tr>
<td>35.8</td>
<td>10</td>
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<tr>
<td>35.7</td>
<td>10</td>
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<tr>
<td>35.6</td>
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<tr>
<td>35.1</td>
<td>10</td>
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<td>35.0</td>
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</table>

TABLE 1

Numbers of fish acclimated to 25.0 and 30.0°C surviving tests at less severe test temperatures.

Using the 14-hour-test duration criterion of Fry, Brett, and Clawson (1942), the incipient-upper-lethal temperatures (Fry et al., 1946) were estimated to be 35.5, 36.6, and 38.2°C for fish acclimated to 25.0, 30.0, and 35.0°C, respectively. For this range of acclimation temperatures, the incipient-upper-lethal temperature of young longear sunfish increased about 1.3°C for a 5.0°C increase in acclimation temperature.

In general, sample variances of individual logarithmic resistance times were lowest for fish acclimated to 35.0°C and were highest for fish acclimated to 25.0°C (Figures 2 and 3). Excluded from these figures were samples in which one or more fish were still alive at the end of the experiment. Also, the 39.0°C-test sample from the 30.0°C-acclimation group was not included here (nor in the statistical analysis).
since it consisted of 10, rather than 20 fish as in all other tests for this acclimation.

Figure 2. Variances of individual logarithmic-resistance times of young longear sunfish acclimated to 25.0°C (left) and 30.0°C (right).

The sample variances of the 25.0°C-acclimation group were accepted as homogeneous at the 5% level of significance. The 30.0°C-acclimation group had heterogeneous variances (p < 0.05) which were found to represent 5 populations of variances at the 5% level of significance. The 35.0°C-acclimated fish displayed an even greater differentiation of sample variances than did the 30.0°C group; these heterogeneous (p < 0.05) variances were found to comprise 6 variance populations (p < 0.05).

In general, larger fish were more resistant to the upper-lethal-test temperatures. Although smaller size was correlated to greater resistance in a few samples from each acclimation group, no negative correlation was significant at the 5% level of confidence. For the 25.0°C-acclimation group, significant (p < 0.05), positive correlation was exhibited in samples tested at 36.2 and 36.8°C. Larger size was significantly (p < 0.05) correlated with greater resistance in the 30.0°C-acclimated fish tested at 36.7, 36.9, 37.1, 37.2, 37.3, 37.4, 37.5, 37.7, 37.8, 38.1, and 38.8°C; and, in the 35.0°C-acclimated fish tested at 38.4, 38.9, 39.0, 39.2, 39.3, 39.6, 39.8, 39.9, and 41.0°C.
Heat Experiments with Longear Sunfish

DISCUSSION AND CONCLUSIONS

Hart (1952) has estimated incipient-upper-lethal temperatures of two centrarchids — the bluegill, *L. macrochirus* Rafinesque, and the largemouth bass, *Micropterus salmoides* (Lacepède). For bluegills from Welaka, Florida, 33.8°C was the tentatively estimated upper lethal of fish acclimated to 30.0°C. The upper-lethal temperatures of largemouth bass from Put-in-Bay, Ohio, were reported to be 34.5 and 36.4°C for acclimation temperatures of 25.0 and 30.0°C, respectively. (No information was reported for 25.0°C-acclimated bluegills nor for either species acclimated to 35.0°C.) Young longear sunfish were more heat tolerant than either of these fishes; the longear is a species typical of shallow, sunny, headwater habitats in which summer temperatures are higher than in usual habitats of bluegill and largemouth bass.

For young longear sunfish the increase in incipient-upper-lethal temperature for a 5°C increase in acclimation temperature was about 1.3°C. Using Hart's (1952) estimates of upper-lethal temperatures for acclimations of 25.0 and 30.0°C, this value was 1.9°C for largemouth bass.

The upper-lethal response of young longear sunfish acclimated to higher temperatures (30.0 and 35.0°C) was characterized by heterogeneous variances of log resistance times. Variances of different magnitudes were associated with different regions in the test-temperature range, forming a variance pattern. This phenomenon was more ap-
parent in the 35.0°C-acclimation group than in the 30.0°C group (Figures 2 and 3). The variance pattern of the former became more evident when it was noted that the high variances at 38.4, 38.5, and 39.8°C were caused by the abnormally low resistance time of one fish in each of these samples. The variance pattern of the fish acclimated to 35.0°C, then, consisted of at least 5 regions: (1) 41.5-41.4°C, (2) 41.3-40.1°C, (3) 40.0-38.8°C, (4) 38.7-38.3°C, and (5) 38.2-37.3°C. Region (3) may have constituted two separate variance regions. Region (4) marked the most evident "break" in the variance pattern (and, therefore, in the resistance pattern) and might be termed an "isthmus" of resistance. This region, or at least the lower part of this region, seemed to be synonymous with the transition point discussed by Brett (1956).

A similar pattern of variability was reflected in unpublished data collected by the second author and his associates on the heat resistance of the Ozark minnow, *Dionda nubila* (Forbes); the black bullhead, *Ictalurus melas* (Rafinesque); the channel catfish, *I. punctatus* (Rafinesque); the mosquito fish, *Gambusia affinis* (Baird and Girard); and the green sunfish, *Lepomis cyanellus* Rafinesque — fishes representing three orders.

One hypothesis that can be formed to explain the phenomenon of temperature-variance association to form a pattern is that the observations leading to a particular sample variance all arose from a single normal population, but that the distribution of individual resistance times simply "spread out" or "clumped" in response to the particular test temperature for some unaccountable reason.

A second and perhaps more appropriate hypothesis takes the following form: Suppose \( \mathbb{E} \{ s^2_{\text{min}} \} = \sigma^2 \). Suppose then that the observations leading to \( s^2_{\text{max}} \) did not all have a common mean, but that they represented a sample from a mixture of \( p \) normal populations, each with variance \( \sigma^2 \) but with means \( \mu_1, \mu_2, \ldots, \mu_p \), with \( n_1 \) observations having arisen from population with mean \( \mu_1 \), \( n_2 \) from population with mean \( \mu_2 \), etc. It was required that \( \sum_{i=1}^{P} n_i = n \), the total sample size. If this sampling hypothesis is true, then

\[
\mathbb{E} \{ s^2_{\text{max}} \} = \sigma^2 (v + 2\lambda) / v
\]

where
Heat Experiments with Longear Sunfish

\[
\lambda = \sum_{i=1}^{p} n_i (\mu_i - \gamma)^2 / 2 \sigma^2
\]

where

\[
\gamma = \sum_{i=1}^{p} n_i \mu_i / n
\]

(the average mean)

Hence,

\[
\mathcal{E}\{s_{\text{max}}^2\} = \sigma^2 + \sum_{i=1}^{p} n_i (\mu_i - \gamma)^2 / \nu
\]

It is noteworthy that the second term is non-negative and has a value of zero only if \(\mu_1 = \mu_2 = \ldots = \mu_K\) in which case \(\mathcal{E}\{s_{\text{max}}^2\} = \sigma^2\).

The more the \(\mu_i\) are dispersed, the greater this second term and hence \(s_{\text{max}}^2\). But if \(\mathcal{E}\{s_{\text{max}}^2\}\) is large, then the probability is small that \(s_{\text{max}}^2\) is small or that \(s_{\text{max}}^2 / s^2\) is small enough not to exceed the critical value so that \(H_0\) is accepted.

If this second hypothesis is true, we can only assume that test temperatures in the low variance regions created or, more precisely, discovered, one or a few physiological populations. On the other hand, test temperatures in the high variance regions allowed the expression of a greater number of populations.

If this, in fact, represents the actual situation, best-fit lines do not fully describe the upper-lethal-temperature response. Perhaps a series of overlapping regression lines would lend more meaningful expression to patterns of upper-lethal-temperature resistance.

In general, young longear sunfish of larger size were more resistant than smaller individuals to upper lethal temperatures. This indicated that thermal resistance may have changed during development. (Hart (1952) found that larger bluegills (\textit{L. macrochirus} Rafinesque) were more resistant to upper lethal temperatures than smaller individuals.

The size-resistance correlation was strongest in the test-temperature region (region 3) associated with high variances just above the isthmus region (region 4).
SUMMARY

Upper-lethal-temperature experiments with young longear sunfish, *Lepomis megalotis* (Rafinesque), reared from eggs in the laboratory were performed to determine more precisely the nature of the upper-lethal-temperature response in fishes and to determine the upper-lethal-temperature relationships of this centrarchid.

The young fish were reared in constant-temperature baths and, prior to lethal tests, were acclimated a minimum of 1 week to one of three temperatures — 25.0, 30.0, and 35.0°C. Upper-lethal tests were performed at 0.1°C intervals in a manner similar to that employed by Brett (1952). Constant light was maintained during growth, acclimation, and testing.

The incipient-upper-lethal temperatures of young longear sunfish were estimated to be 35.5, 36.6, and 38.2°C for fish acclimated to 25.0, 30.0, and 35.0°C, respectively.

A maximum F-ratio test indicated that sample variances of log-resistance times were heterogeneous for fish acclimated to either 30.0 or 35.0°C, but not for fish acclimated to 25.0°C. The sample variances of 30.0- and 35.0°C-acclimated fish represented several variance populations.

Size of variance was associated with test temperature in the 35.0°C-acclimated fish (to a lesser extent, in the 30.0°C-acclimated fish), forming a variance pattern. It is suggested that different test temperatures allowed the expression of different numbers of physiological populations.

In general, larger young longear sunfish were more resistant to upper lethal temperatures than their smaller siblings of similar age.

LITERATURE CITED


Heat Experiments with Longear Sunfish


GROWTH RATES AT VARIOUS TEMPERATURES OF THE ORANGE-THROAT DARTER *ETHEOSTOMA SPECTABILE* (AGASSIZ)

Boyce W. West
University of Arkansas

INTRODUCTION

This paper demonstrates the effect temperature has upon the growth rate of the orangethroat darter *Etheostoma spectabile* (Agassiz). There is a tremendous literature on the effect of temperature on the growth of fishes in their native habitat. Until recently very little had been done in the laboratory under rigidly controlled conditions. In the last score of years papers have begun to appear relating growth rates of fishes at various temperatures. Gibson and Hirst (1955), working with pre-adult guppies *Lebistes reticulatus* (Peters), found that the most rapid growth occurred at 23 and 25°C with less rapid growth at 20, 30, and 32°C. Kinne (1960), studying the eurythermal and euryhaline desert pupfish *Cyprinodon macularius* Baird and Girard, found that the growth rate was dependent upon both temperature and salinity and that the combination of the two factors was of supreme importance. Growth rate, in salinity 35 °/oo, decreased in this order: 30, 25, 35, 20, and 15°C. The effect of salinity was shown at 30°C where the growth rates decreased in this order of salinity: 35, 15, 55 °/oo, and fresh water. Strawn (1961) studied the growth of the largemouth bass, *Micropterus salmoides* (Lacepede), and found maximum growth to occur at 27.5 and 30.0°C, with less rapid growth at 25.0, 22.5, 20.0, and 17.5°C, decreasing in that order. The present study illustrates that the growth rate of the orangethroat darter may be accelerated or retarded through the control of temperature.

MATERIALS AND METHODS

Adult *Etheostoma spectabile* were collected from Clear Creek, upstream from county road crossing, 1/4 mile SW of Johnson, Washington County, Arkansas [R 30 W T 17 N Sec. 21] on March 17, 1965. The fish were taken to the laboratory and the eggs and sperm were stripped into a pan by gently pressing on the ventral side of the fish with a backward motion from the pectoral fin to the vent (Strawn and Hubbs, 1956). All of the fertilized eggs were covered with aged tap water at 21.0°C overnight in the open pan. After hardening, the eggs were freed from the pan and placed in a submerged gallon jar with an airstone bubbling gently at 21.0°C until they hatched. Dead eggs, characterized by a dull milky color, were removed daily. The eggs began hatching on March 23, 1965. The larvae were measured for total length and placed in constant temperature tanks on March 26, 1965 when it appeared they were ready to begin feeding (the yolk-sac had been absorbed). Sixty individuals were placed in each tank. The
Growth Rates of Orange-Throat Darter

Tanks were constructed of plywood and covered with polyester resin to make them waterproof. The inside dimensions of the tanks were as follows: 41 inches long by 26 inches wide by 14 inches deep. About three inches of washed sand covered two 12 inch by 23 inch undergravel filters. The tanks were lighted by cool white fluorescent bulbs suspended above the tanks. The temperature was controlled by thermostators, sensitive to 0.01°C temperature changes, connected to transistorized relay units. Water was heated by using 150 watt submersible heaters connected to the relay units. Temperature was measured with thermometers calibrated to 0.1°C. Airstones were used to aerate and circulate the water and to aid in maintaining a constant temperature throughout the tank. The temperatures used were: 13.0, 15.0, 17.0, 19.0, 21.0, 23.0, 24.0, 25.0, 26.0, and 27.0°C. Single degree intervals at the upper end of the range were used because it was suspected that maximum growth would occur in this part of the range and this would better pinpoint the optimum temperature for maximum growth.

The fish were fed larvae of the brine-shrimp *Artemia salina* twice daily.

Samples of ten fish from each tank were caught each week by dragging an aquarium net through the middle of the tank. The fish were then measured for total length using dividers and a three inch piece of transparent plastic tubing fitted on a medicine dropper which functioned as a syringe for picking up the fish. The fish, clearly visible in the tubing, was measured to the nearest 0.1 millimeter. At the end of the sixth week all of the fish were preserved in 10 per cent formalin and measured.

RESULTS AND DISCUSSION

The fish had a mean total length of 6.0 millimeters at the time of transfer to the experimental temperatures. Maximum growth rate occurred at 26.0°C with growth rate decreasing in this order: 26.0, 25.0, 24.0, 21.0, 27.0, 23.0, 19.0, 13.0, and 15.0°C (Figure 1). All of the fish at 17.0°C died on the tenth day of the experiment due to an accident. The rate of growth of the fish at higher temperatures became more rapid during the second week. This increase in growth rate may be due to either of two factors: (i) acclimation of the fish to the respective temperature, or (ii) increased temperature tolerance with increasing age. Hubbs and Armstrong (1962), have shown evidence that the latter is true for this species. Several of the measurements at the fifth week exceed the mean length of the fish at the sixth week, (Figure 1). Apparently this is due to the method of sampling the population. This method appears to be selective for the larger *E. spectabile*. The points at the sixth week include all of the fish from that respective tank, while at the fifth week only ten fish were measured.
Figure 1. Growth curves of *Etheostoma spectabile*. Time in weeks is plotted against length in millimeters. Points at 1-5 represent mean lengths of ten fish. Points at 6 represent mean lengths of all fish in the tank.

It may be concluded from this data that the growth rate of *E. spectabile* is increased, with temperature as a variable, to 26.0°C. It may also be concluded that as the age of the fish increased, so did its temperature tolerance.

**SUMMARY**

The growth rate of *Etheostoma spectabile* (Agassiz) at various temperatures was studied. Larvae averaging 6.0 millimeters total length were placed in tanks regulated to the following temperatures: 13.0, 15.0, 17.0, 19.0, 21.0, 23.0, 24.0, 25.0, 26.0, and 27.0°C. The fish were measured weekly for six weeks and the data indicates the maximum rate of growth occurred at 26.0°C. There is some indication that the larger fish are more easily captured, thus adding a bias to small samples. There is evidence that with increasing age temperature tolerance is increased.

**ACKNOWLEDGMENTS**

I would like to thank the Department of Zoology at the University of Arkansas, and especially Dr. Kirk Strawn for the use of equipment and for invaluable help throughout the study.
LITERATURE CITED


A STUDY OF THE "KILLING PHENOMENON" IN ISOLATED GROUPS OF ETHEOSTOMA SPECTABILE (AGASSIZ)

Thomas M. Buchanan
University of Arkansas

INTRODUCTION

Very little is known concerning the behavior of the Etheostomatinae (darters). The ethology of various other groups of fishes, e.g., Cichlidae, has been studied extensively by European workers (Baerends et al., 1950), but whether or not the results obtained by them are useful in an attempt to analyze the behavior patterns exhibited by darters is highly questionable.

The genus Etheostoma contains many species with a wide range of ethological responses, and even within a species, great variation in response to stimuli may be seen, due to differences in environment, genetics, or a combination of the two (Winn, 1958).

It was noted by Strawn (personal communication) that when an adult male and female orangethroat darter, Etheostoma spectabile (Agassiz), were placed together in a gallon jar, the male fish would eventually kill the female. Upon further investigation, it was found that this "killing phenomenon" occurred to a greater extent in some populations of E. spectabile than in others, and that it was also prevalent in other species of Etheostoma.

The object of this investigation was an attempt to characterize this behavior pattern in the orangethroat darter.

METHODS AND MATERIALS

The E. spectabile used in this study were obtained from the Little Wildcat tributary of the Illinois River, just below a spring. The average width of the stream was approximately four feet, with depths up to three feet. The stream bed was generally rocky with little siltation occurring, and in places, the channel was choked with watercress. There were few species of fish present, but many individuals. The other darters commonly present besides E. spectabile were E. flabellare, the fantail darter, and E. punctulatum, the stippled darter.

Most male fish used in this study yielded milt when light pressure was applied to the abdominal region. The females varied widely in their degrees of ripeness.

Several collecting trips were made between October 16, 1964, and May 3, 1965. The fish were captured with a ten foot seine of

1This investigation was carried out in cooperation with the University of Arkansas and the National Science Foundation Undergraduate Research Participation Program under direction of Dr. Kirk Strawn.
¼ inch mesh. The greatest concentration of *E. spectabile* was found in pool areas in the fall and winter months, but in early spring more were located in the swift-flowing upstream areas where they bred in great numbers. The captured fish were placed in styrofoam containers for transport to the laboratory.

On arrival at the laboratory, the fish were divided as evenly as possible among three acclimation tanks at 11, 16, and 26°C. The darters were acclimated at these temperatures for at least two weeks before they were used in experiments. Chopped earthworms were fed to the fish once a day, with an occasional supplement of brine shrimp, and city water was added periodically. Tadpoles were placed in the acclimation tanks to act as scavengers.

Three tanks kept at 16, 21, and 26°C, were used for most experiments. Ten one-gallon, widemouth jars, which had been made translucent by sandblasting, were filled approximately ¾ full of aged tap water and were floated in each tank. The sandblasting was done in order to prevent fish in adjacent jars from seeing each other. A layer of sand and an air stone were placed in the jars. Air stones were also placed in the tanks, among the jars to circulate water and maintain a constant temperature throughout the tank. Additional tests were run at the three previously mentioned experimental temperatures using completely transparent gallon jars.

During most of the tests, temperatures in the experimental tanks varied by no more than 0.1° from the desired levels; however, during one test involving fish acclimated at 26°, the temperature varied by as much as 6° for a short time.

Each test consisted of ten replicates of fish acclimated at one temperature (either 11, 16, or 26°C) and tested at one temperature (either 16, 21, or 26°C). Nine tests were performed using one male and one female per jar, three tests were performed using two females per jar, three tests were made using two males per jar, and three tests used one male and two females per jar. In addition to these tests, one test using one male and one female was performed in transparent glass jars. These fish were acclimated at 16° and were tested in 21° water. Additional experiments were performed at 21° using an entire tank for a single pair of darters.

Each testing period lasted from nine to twenty one days. The jars were checked for deaths at twelve hour intervals, and the fish in them were fed from two to five times during the testing period. Measurements of dead fish were made by means of dividers, and standard length was recorded in millimeters. The temperature in each test tank was recorded at twelve hour intervals.

Chi-square and t-tests for samples with unpaired numbers of observations and unequal variances were employed in statistical analysis of the data.
RESULTS AND DISCUSSION

Dead fish were characterized by shredded fins, chiefly the dorsal and caudal, and by open wounds on the body, especially in the caudal region. Many females were badly mutilated.

It was generally true that males which killed females were in bright breeding coloration and exhibited a ripe condition, whereas those that did not kill females were usually poorly colored, small, and not ripe. In a very few cases, males were killed by females, and in tests using individuals of the same sex a considerable number of kills resulted.

Experiments carried out in clear jars showed no significantly different results than those run in sandblasted jars.

Four tests were run in which one male and one female were placed by themselves in an experimental tank at 21°C. A female was never killed by a male in any of these tests, possibly because there was ample room for the female to escape the attacks of the male. However, when the tank was checked, the two fish were often very close to each other.

A definite correlation exists between difference in size and non-occurrence of killing. In other words, a ripe male is more likely to kill a female if she is closer to his size than if a large size difference exists between the two. A t-test which was significant at the .01 level of probability indicates that this is true.

In tests involving one male and two females per jar nineteen males killed females; of these, ten killed two females.

In all tests involving one male and one female per jar, 33 males killed females, while four females killed males. To be certain that this phenomenon involves males killing females almost entirely, rather than random numbers of kills between the sexes, a chi-square test of significance was performed. This test was highly significant, and supported the previous conclusion.

Any explanation of the “killing phenomenon” exhibited by the orangethroat darter would be highly tentative on the basis of the above data. It is known that individual aggressiveness, as shown by threatening or fighting, plays a central role in vertebrate societies and populations. Individual aggression in vertebrates is frequently expressed in two special forms: (1) defense of a given area, and (2) hierarchies of precedence within social groups (Collias, 1944).

Defense of a given area involves territoriality, which is generally concerned with breeding season. In territorial fishes, the male will defend his breeding area from the intrusions of all other males, but will be receptive to females. Dominance relations between the sexes must often be established for harmony, but excessive aggressiveness toward the opposite sex is probably an obstacle to mating. Courtship
frequently serves to ameliorate the dominance relations and promote tranquility between the sexes. Therefore, male darters would not be expected to kill females when they are in breeding condition.

In nature, the breeding of *E. spectabile* occurs on riffles with many other darters around. The males migrate to the breeding riffles first, to be followed by the females later. When the female enters an area occupied by a male, he follows her and defends an area around her. This chase is usually terminated by the spawning act (Winn, 1958). In this study, the darters were subjected to confinement and environmental conditions entirely unlike those encountered in nature. It could be speculated that the killing of the female by the male is a displacement activity (Tinbergen and Lersel, 1947) resulting from frustration. Bastock et al. (1953) state that a displacement activity may be performed by an animal in which one drive is, at the same time, both activated and thwarted. A drive may be thwarted in several ways. The consummatory act may be physically prevented by some factor in the external environment, or possibly, the indispensable releasing stimuli may be entirely absent. The primary function of a displacement activity seems to be the relieving of surplus excitation in the central nervous system.

Braddock (1945) found that a male *Platypoecilus*, if frustrated in its attempt at copulation, may punish the female.

Winn (1958) states that the dominated school, the dominated territorial school, and the hierarchical school are not represented in the darters. Yet it seems probable that some sort of hierarchical arrangement occurs in *E. spectabile* since females were observed to kill males in rare instances, and, more commonly, to kill other females.

The difference in aggressive behavior of males and females is partly explainable by differences in sex hormones (Collias, 1944). Male pugnacity is probably not completely dependent upon male hormone from the gonads: this is more true of some species than others. Castrated male swordtails are said to maintain their social position from one to six and one half months. Treatment with androgens stimulated aggressive behavior in spayed and normal female swordtails (Noble and Borne, 1940).

Few morphological effects of sex hormones are so consistent in the vertebrate series as is this stimulation of aggressive behavior by androgens. However, in some species the importance of psychological and extra-gonadal factors may outweigh the usual effects of sex hormones.

**SUMMARY**

It was noted by Strawn (personal communication) that when an adult male and female orangethroat darter, *Etheostoma spectabile* (Agassiz), were placed together in a gallon jar, the male would eventually kill the female.
The object of this investigation was an attempt to characterize this "killing phenomenon" exhibited by the orangethroat darter.

It was concluded that in close confinement, males show a strong tendency to kill females, although a few females killed males. A correlation is indicated between degree of breeding condition of the male and the occurrence of killing.

LITERATURE CITED


TRANSPIRATION CHANGES IN OAT PLANTS INFECTED WITH CROWN RUST

Purushottam Amatya and J. P. Jones
University of Arkansas

Water, which is vital in the metabolism of plants, is lost in considerable amounts in normal plant growth. It is lost in two ways: as vapor in the process of transpiration, or as liquid by guttation. Transpiration occurs as evaporation of water from the moist cell walls into the intercellular spaces and then through natural openings such as stomata and lenticels into the outside atmosphere. Some examples of factors that influence the rate of transpiration are: amount of leaf area, leaf structure, orientation of leaves, water content of leaves, temperature, relative humidity, light and wind (5). Abnormal increases in transpiration are usually detrimental to plants resulting in decreased growth.

Investigations of several types of rust diseases have shown that transpiration usually increases with infection and this increase is believed correlated with the rupture of the host epidermis which occurs when the fungus sporulates (1, 2, 6, 9).

The objective of this study was to test the rupture hypothesis using oat plants infected with the crown rust fungus *Puccinia coronata*, Cda. var. *avenae* Fraser and Led. (7). The approach was to use a fully susceptible variety of oats which when infected would produce sporulating pustules that rupture the epidermis, and also a resistant variety that would produce only flecks with no sporulation and epidermal rupture.

MATERIALS AND METHODS

Plants of the susceptible oat variety Lee and the resistant line Cl 7998 were grown in half-strength Hoagland's solution in either sealed glass or plastic containers. Glass containers were 100 ml beakers painted black and covered with black plastic covers containing 5 evenly spaced holes 10mm in diameter. The plastic covers were sealed to the top of the beakers with modeling clay. Plastic containers were one-half pint polyethylene refrigerator jars painted black with 10 holes cut in each of the tops. Plants selected for uniformity were inserted into the holes and held in place with polyurethane foam plugs. In each experiment comparable control containers without plants were maintained to correct for water loss through the polyurethane plugs. The solution in all the containers was changed every third day. No apparent difference in growth response was noted between plants in the glass and plastic containers.

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

2Mr. Amatya was formerly a graduate student and Dr. Jones is Associate Professor in the Department of Plant Pathology.
The experiments were carried out in a growth chamber at 60°F. Alternating periods of 14 hours light and 10 hours darkness were maintained using "Gro-Lux" VHO florescent lamps which produced 450-500 foot-candles at plant height.

Plants were inoculated with uredospores of crown rust race 216. Spores were mixed 1:10 with talc and dusted onto the primary leaves of the plant which were then lightly sprayed with distilled water containing 0.5% "Tween 20." The plants were placed in a saturated atmosphere in the dark for 16 hours then transferred to the growth chamber.

Water loss was determined by differential weight loss of plants and containers weighed to the nearest 0.01 gm. daily at 8:00 a.m. and 9:00 p.m. Measurements were made for 9 days which permitted full sporulation of the fungus. At the end of the experiment the plants were divided into three parts: primary leaves, second leaves, and roots then dried for 36 hours at 100°C and weighed to the nearest mg.

RESULTS

The symptom pattern of crown rust infection was observed in the susceptible Lee oats as follows: on the fourth day following inoculation light flecking appeared which developed into heavy flecking with a few sporulating pustules on the fifth and heavy sporulation and rupture on the sixth and seventh days. On the resistant CI 7998 very faint flecking appeared on the fourth day and increased in size and intensity through the fifth and sixth with the whole leaf becoming chlorotic then necrotic through the seventh and eighth days. In no instance were sporulating pustules that ruptured the epidermis produced on the resistant CI 7998.

The water loss data from four separate experiments using 75 inoculated and non-inoculated plants each of the susceptible Lee were pooled and are shown in graphic form in Figure 1. The pooled data were also subjected to analysis of variance and are presented in summary in Table 1.

The graph shows that infected plants on the second to fourth day after inoculation lost less water than uninoculated plants. This reduction was apparent during the day, but not during the night. Five days following inoculation, the infected plants began to show a greater water loss than the uninoculated controls. This pattern increased in magnitude and persisted until the ninth or final day. The increased water loss was apparently associated with the rupture of the epidermis, since pustules began to appear on the fifth day and increased in size and number from that day onward. Analysis of the data shows the day x treatment interaction (Table 1) to be highly significant which indicates that the change from the fifth day onward was a true relationship.
Figure 1. The effect of crown rust race 216 and time on the day and night water loss of plants of the susceptible variety LEE. Graph constructed from averages of four experiments.
Table 1. This effect of crown rust race 216 on the water loss of the susceptible variety Lee. Data presented from four experiments in analysis of variance summary table.

ANALYSIS OF VARIANCE

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>ss</th>
<th>ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>143</td>
<td>54.03</td>
<td></td>
</tr>
<tr>
<td>Rep.</td>
<td>3</td>
<td>2.76</td>
<td></td>
</tr>
<tr>
<td>Treat.</td>
<td>3</td>
<td>35.89</td>
<td></td>
</tr>
<tr>
<td>Inocu. vs. Checks</td>
<td>1</td>
<td>0.33</td>
<td>0.33</td>
</tr>
<tr>
<td>Day vs. Night</td>
<td>1</td>
<td>35.52</td>
<td>35.52**</td>
</tr>
<tr>
<td>Treat. vs. Time of Day</td>
<td>1</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Error (A)</td>
<td>9</td>
<td>3.00</td>
<td>0.33</td>
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<tr>
<td>Days</td>
<td>8</td>
<td>5.74</td>
<td>0.72**</td>
</tr>
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<td>Days vs. Treat.</td>
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<td>0.18**</td>
</tr>
<tr>
<td>Error (B)</td>
<td>96</td>
<td>2.25</td>
<td>0.02</td>
</tr>
</tbody>
</table>

The daily difference in water loss of the diseased plants as percent of non-diseased controls of the susceptible Lee is presented in graphic form in Figure 2. There is a great difference percentage wise in water loss between the two groups, with the greatest differential occurring at night.

Dry weights of the tissues of the susceptible Lee are given in Table 2. The infected primary leaves were 71 percent heavier than the non-infected, however, the second leaves and roots of the diseased plants were 21 and 35 percent lighter, respectively. Total weight of the parasitized plants was less than the non-parasitized. When the dry weight of tissue was calculated on the basis of amount of water loss, the infected plants produced 27 percent less dry matter per gram of water loss than the healthy. It is obvious that the metabolic efficiency of the diseased plants was reduced.

Water loss data from two separate experiments using 35 inoculated and and non-inoculated plants each of the resistant Cl 7889 were pooled and are shown in graphic form in Figure 3. The data were subjected to analysis of variance and are presented in summary in Table 3.

No difference in water loss was observed between the inoculated and non-inoculated resistant plants until the sixth day after inoculation. Following this time the diseased plants lost less water during the day than the healthy through to the final day. Examination of the days x treatment interaction (Table 3) shows this value to be highly significant which indicates that the reduction in water loss represents an actual relationship. No marked difference in nighttime water loss was observed between the two groups of plants.

Consideration of the dry weight data (Table 3) shows that the fungus did damage the resistant oat plants although the weight reduc-
Transpiration Changes in Oat Plants

Transpiration was not nearly as great as in the susceptible Lee plants. Furthermore, the parasitized CI 7998 showed greater efficiency in converting water loss to production of dry matter than did Lee.

Figure 2. Percent difference in daily rate of water loss between inoculated and non-inoculated plants of the susceptible LEE. Graph constructed from averages of four experiments.
Table 2. Dry weight of plant parts of the inoculated and non-inoculated varieties used in the water loss experiment.

<table>
<thead>
<tr>
<th></th>
<th>Primary Leaves in mg</th>
<th>Secondary Leaves in mg</th>
<th>Total dry weight in mg</th>
<th>Total water loss in mg</th>
<th>One Gram water loss produces dry weight in mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Checks</td>
<td>14.21</td>
<td>89.02</td>
<td>46.81</td>
<td>150.04</td>
<td>48.55</td>
</tr>
<tr>
<td>Inoculated</td>
<td>24.33</td>
<td>70.20</td>
<td>30.49</td>
<td>125.11</td>
<td>55.51</td>
</tr>
<tr>
<td>% Difference</td>
<td>+71.22</td>
<td>-21.04</td>
<td>-34.86</td>
<td>-16.61</td>
<td>14.33</td>
</tr>
<tr>
<td>CI 7998</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Checks</td>
<td>8.29</td>
<td>56.94</td>
<td>15.25</td>
<td>80.48</td>
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<tr>
<td>Inoculated</td>
<td>6.47</td>
<td>53.94</td>
<td>11.78</td>
<td>72.19</td>
<td>28.13</td>
</tr>
<tr>
<td>% Difference</td>
<td>-21.95</td>
<td>-5.27</td>
<td>-22.75</td>
<td>-10.30</td>
<td>-7.25</td>
</tr>
</tbody>
</table>

Figure 3. The effect of crown rust race 216 and time on the day and night water loss of plants of the resistant line CI7998. Graph constructed from averages of two experiments.
Transpiration Changes in Oat Plants

Table 3. The effect of crown rust race 216 on the water loss of the resistant line Cl 7998. Data presented from two experiments in analysis of variance summary table.

<table>
<thead>
<tr>
<th>ANA LYSIS OF VARIANCE</th>
<th>df</th>
<th>ss</th>
<th>ms</th>
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<tbody>
<tr>
<td>Total</td>
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</tr>
<tr>
<td>Rep.</td>
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<td>0.01</td>
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</tr>
<tr>
<td>Treat.</td>
<td>3</td>
<td>17.21</td>
<td></td>
</tr>
<tr>
<td>Inoc. vs. Checks</td>
<td>1</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>Day vs. Night</td>
<td>1</td>
<td>17.07</td>
<td>17.07**</td>
</tr>
<tr>
<td>Treat. vs. Time of Day</td>
<td>1</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Error (A)</td>
<td>3</td>
<td>0.06</td>
<td>0.02</td>
</tr>
<tr>
<td>Days</td>
<td>8</td>
<td>9.56</td>
<td>1.19**</td>
</tr>
<tr>
<td>Day vs. Treat.</td>
<td>24</td>
<td>4.58</td>
<td>0.19**</td>
</tr>
<tr>
<td>Error (B)</td>
<td>32</td>
<td>0.11</td>
<td>0.003</td>
</tr>
</tbody>
</table>

DISCUSSION

The data show that there is increased water loss in susceptible crown rust infected oat plants. This increase appears to be correlated with sporulation of the fungus and the consequent rupture of the epidermis since it begins and increases during this period. This conclusion is further supported by the fact that this increase was observed during the night when the major avenues of transpiration, the stomata, were closed. These results agree with the observations of other workers (1, 2, 6, 9, 10).

The nighttime water loss in the susceptible Lee was proportionately greater than the daytime loss which corresponds to the findings of Johnston and Miller with leaf rust of wheat (3, 4). This effect is undoubtedly due, for the most part, to the lack of stomatal transpiration during the night and its confounding effect during the day.

A reduction in water loss such as occurred in the inoculated susceptible Lee on the second through fourth day was also reported by Gerwitz and Durbin to occur in bean plants affected with rust (2). This reduction is apparently associated with stomatal transpiration since it did not occur during the night periods when the stomata were closed. It is possible that this reduction in water loss is due to the plugging of the intercellular spaces and stomata with fungal tissue, such as described by Rothman (8), so that the normal movement of water vapor to the exterior of the leaf is blocked.

The reduction in water loss that occurred in infected resistant Cl 7998 plants from the time of flecking onward corresponds to the reduction in the susceptible Lee during the flecking stage. It would appear that there is a common transpirational reaction to rust infection by both susceptible and resistant plant types prior to and during the flecking stage, but this changes markedly upon sporulation of the fungus and
rupture of the susceptible host epidermis. Further evidence that rupture is important in increased water loss is indicated by the fact there was no increase in nighttime loss in inoculated plants of CI 7998 in which rupture did not occur (Figure 3).

The tremendous increase in the weight of the infected primary leaves of the susceptible Lee contrast sharply with the marked decrease in the corresponding resistant CI 7998 (Table 3). Part of the increase in Lee was undoubtedly due to the weight of the fungal tissue, but the exact amount could not be calculated. When the decrease in weight of the non-infected second leaves and roots of Lee is considered, it would seem that there was a preferential translocation of metabolites from these organs to the infected primary leaves. This preferential translocation apparently did not occur in comparable degree in the resistant CI 7998.

It is clear from the data (Table 3) that the rust fungus adversely affects growth in both types of oat plants, although the effect is much less in the resistant CI 7998. The results also show that the pathogen affects the whole plant and not just the infected tissue in which it resides.

LITERATURE CITED


A CURSORY EXAMINATION OF THE CHIRONOMIDAE OF ARKANSAS (DIPTERA: INSECTA)

Anthony J. Iovino
University of Arkansas

PREFACE

It has been the policy of the Department of Entomology of the University of Arkansas to encourage work of a systematic nature, in order that the insect fauna of Arkansas be better known. In keeping with this policy, the species list herein is presented. It should, however, not be regarded as complete, but a list to which additional species will later be added. Moreover, as the Nearctic fauna of Chironomidae has received little study, the need for work of a regional nature is greatly commanded.

INTRODUCTION

That the North American fauna of Chironomidae has received little attention is unfortunate, for members of the taxon are everywhere to be found. Terrestrial environments play host to larval midges (Thienemann and Kruger, 1939a, b) as do littoral marine habitats. A number of chironomid larvae thrive in hot springs at temperatures up to 120°F (Brues, 1927, 1928) and some dwell in glacial melt water. Certain cricotopine species, in a supposed obligate association, have been reared from colonies of *Nostoc parmeloides* (Wirth, 1957) and Berg (1949, 1950) has called attention to a number of leaf miners and leaf burrowers feeding on the mesophyll and epidermis of *Potomogeton*.

The majority of immature Chironomidae are to be found in freshwater situations, both lentic and lotic, in extremes from mountain torrents to the oxygenless waters of deep eutrophic lakes. Most of the forms are tubiculous, while others, such as the majority of the Tanytaspinae, are free-living predators. The size of larval midges coupled with their relatively rapid life cycle and large numbers lends to the family an essential role in energy conversion within aquatic situations. Their importance as fish food organisms has long been realized and there is increasing recognition of their utility as indicator species in water quality surveys.

At sunset, large aerial swarms of adult midges are a frequent sight, the wing beat of the individuals being compounded to create a humming which may be heard for great distances. These large numbers in many areas have initiated retaliation in the form of abatement programs. Fortunately, the adults of the majority of species are innocuous, bearing non-functional mouthparts.

Adult Chironomidae superficially resemble mosquitoes and ceratopogonids, but may be distinguished by lacking a forked medial vein.

1Graduate Student, Department of Entomology, University of Arkansas.
Chironomidae of Arkansas

lacking squamiform setae on the wings, bearing a groove on a prominent postscutellum, and possessing lengthened prothoracic legs which are often raised from the substrate when at rest. The larvae bear a complete head capsule which has apposable mandibles. Anterior and posterior prolegs are present and developed to varying degrees, or are completely lacking.

METHODS OF COLLECTION, PRESERVATION & STUDY

As adult midges come readily to light, the major collection device utilized was a modified light trap of the New Jersey type. The majority of the determinations herein were based on imaginal instars. During the day, sweeping marginal vegetation along banks proved productive. Immature forms were collected by various techniques including dredging, use of Surber samplers, and washing of aquatic vegetation into a receptacle. Whenever possible, attempts were made to rear larvae to adulthood.

Methods of preserving adults leave much to be desired, as no truly satisfactory method has been devised. Both pinned specimens and specimens in alcohol were utilized. Pinned specimens are satisfactory in that they can be manipulated for study. Specimens collected into alcohol are collected easily and easily stored, but their colors tend to fade, setae and appendages fall off, wing veins become transparent, and they are manipulated with difficulty.

Depending upon the method of collection, two main methods of preparation for study were used. Specimens collected into spirits were mounted on microscope slides. The wings were carefully amputated and flattened under a coverslip which was adhered to the slide by placing four small spots of clear fingernail polish on the corners of the coverslip, after the alcohol had evaporated. This resulted in a dry wing mount. Genital segments of the male were clipped from the abdomen, placed in a 10% solution of caustic potash overnight, washed in warm water, dehydrated and cleared, and mounted on the slide in a resinous medium. Pale terminalia were stained in eosin y or acid fuchsin.

For features used in identification, the reader is referred to Freeman (1955), Johannsen and Townes (1952) and Fittkau (1962). Immature forms are treated by Roback (1957).

NOMENCLATURE

In this paper, the terminology of Freeman (1955-1958) is essentially employed. Within the Tanypodinae, the tribal classification of Fittkau (1962) is employed.

Presently, much confusion exists in chironomid taxonomy. The controversy concerned with the Meigen names of 1800 and 1803 is well known. Within the Orthocladiinae the terminology is in a particularly confused state. Edwards (1929) set rather wide generic limits defining
Numerous subtaxa within the group and many later authors have not agreed with this "large genus concept." Within the group exists a high degree of morphologic intergrade and a revision is greatly needed. Fittkau's work on the Tanypodinae demands a reexamination of the Nearctic types.

Complex synonomies have been produced by the renaming of earlier described European species, a difficulty imposed by a ubiquitous faunal element. The lack of association between larval and imaginal instars, moreover, has produced confusion. Further confusion is generated by the schism which exists between European and American workers in setting generic limits, for most European workers rely heavily upon immature characteristics while British and American workers have placed emphasis upon adult characters in their study.

**SCOPE OF THE STUDY**

The material examined is from three sources which include personal collections, museum collections, and collections from contributors. Collections were made from the following Arkansas counties: Benton (1)**, Carroll (2), Washington (3), Crawford (4), Pulaski (5), Lonoke (6), Searcy (7), Desha (8) and Arkansas (9). Only the described species of Chironomidae are listed, the apparently new species being reserved for further study. A study made by Sublette (1956), has yielded several species of midges. Species given by him and not collected by the author will appear with an asterisk.

**Arkansas Chironomidae**

*Chironomidae (Tendipedidae)*

**Subfamily: Tanypodinae (Pelopiinae)**

**Tribe: Coelotanypodini**

**Genus: Coelotanypus Kieffer**

**Species:**
- concinnus (Coquillett) 1, 2, 7
- scapularis (Loew) 1, 2, 3
- tricolor (Loew) 5, 6

**Tribe: Pentaneurini**

**Genus: Pentaneura Philippi**

**Subgenus: Pentaneura Philippi**

**Species:**
- flavifrons (Johannsen)* 1, 2, 3
- planensis Johannsen 4, 3
- pilosella (Loew) 1, 4, 3

**Genus: Ablabesmyia Johannsen**

**Species:**
- aequifasciata (Dendy & Sublette) 8, 9
- rhamphe Sublette 1, 3, 4, 8

**Tribe: Macropelopiini**

**Genus: Procladius Skuse**

**Counties are designated by number in the list.**
Chironomidae of Arkansas

Subgenus: Procladius Skuse
Species: culiciformis (Linnaeus) 1, 3

Subgenus: Psilotanytus Kieffer
Species: bellus (Loew) 1, 2, 3, 5, 6

Tribe: Tanypodini
Genus: Tanypus Meigen
Species: punctipennis Meigen 3

Subgenus: Psilotanypus Kieffer
Species: bellus (Loew) 1, 2, 3, 5, 6

Subfamily: Diamesinae
Genus: Diamesa Waltl
Species: fulva Johannsen 3

Subfamily: Orthocladiinae
Tribe: Orthocladiini
Genus: Brilla Kieffer
Species: flavifrons (Johannsen) 1, 5, 6, 8, 9
Genus: Nanocladius Kieffer
Species: alternantherae Dendy & Sublette 8
Genus: Cricotopus Wulp
Species: absurdis (Johannsen) 2, 3, 7
bicinctus (Meigen) 1, 3
remus Sublette 1, 9
Genus: Cardiocladius Kieffer
Species: sp. near obscurus (Johannsen)* 3
Genus: Orthocladius Wulp
Species: spp.* 3

Tribe: Metriocnemini
Genus: Metriocnemus Wulp
Species: sp. near lundbeckii* Johannsen 3
Genus: Smittia Holmgren
Species: aterrima (Meigen) 1, 3, 7, 8, 9

Tribe: Corynoneurini
Genus: Corynoneura
Subgenus: Thienemanniella Kieffer
Species: sp.* 3

Subfamily: Chironominae
Tribe: Chironomini
Genus: Chironomus Meigen
Subgenus: Chironomus Meigen
Species: attenuatus Walker 1, 2, 3, 4, 5, 6, 7, 9
chelonia (Townes) 1, 3
crassicaudatus Malloch 5, 6
fulvipilus Rempel 3
plumosus (Linnaeus) 5, 6
stigmaterus Say 1, 4, 7
Subgenus: Cryptochironomus Kieffer
Species: carinatus (Townes) 8
demorsus (Townes) 8
fulvus Johannsen 1, 2, 3, 4, 7
galeator (Townes) 4, 6
monochromus Wulp 1, 2, 3, 8
nigrovittatus Malloch 1, 3, 8, 9

Subgenus: Dicrotendipes Kieffer
Species: fumidus Johannsen 1, 2, 3, 5, 6, 9
neomodelus Malloch 1, 2, 3, 4, 5, 6

Subgenus: Endochironomus Kieffer
Species: nigricans Johannsen 1, 2, 3, 5, 7
subtendens (Townes) 3

Subgenus: Kiefferulus Goetghebuer
Species: dux Johannsen 1, 2, 3, 4, 6, 8, 9

Subgenus: Tribelos Townes
Species: jucundus Walker 1, 2, 3, 4

Subgenus: Xenochironomus Kieffer
Species: xenolabis Kieffer 1, 3, 6

Genus: Microtendipes Kieffer
Species: pedellus (DeGeer) 1, 3, 7, 8

Genus: Glyptotendipes Kieffer
Subgenus: Phytotendipes Goetghebuer
Species: lobiferus (Say) 1, 2, 3, 4, 5, 6, 8
meridionalis Dendy & Sublette 1, 3
paripes (Edwards) ? 5

Genus: Paratendipes Kieffer
Species: albimanus (Meigen) 1, 2, 3

Genus: Polypedilum Kieffer
Subgenus: Polypedilum Kieffer
Species: aviceps Townes 1, 2, 3, 8, 9
digitifer Townes 1, 2, 3, 4, 6, 9
fallax (Johannsen) 1, 2, 3
halterale (Coquillett) 1, 2, 3
illinoense (Malloch) 1, 2, 3
nigritum Townes 1, 3
obtusum Townes 1, 2, 3
ontario (Walley) 1, 2, 3, 6, 7
trigonus Townes ? 3

Genus: Pseudochironomus Malloch
Species: aix Townes 1, 2, 3
chen Townes 1
fulviventris (Johannsen) 1, 8
pseudoviridis (Malloch) 1, 2, 3, 7
rex Hauber 2, 3
richardsoni Malloch 1, 3
Chironomidae of Arkansas

Genus: Stenochironomus Kieffer
   Species: macateei (Malloch) 1, 3

Tribe: Tanytarsini
   Genus: Micropsectra Kieffer
       Species: nigripila (Johannsen) 1, 2, 3

Genus: Tanytarsus Wulp
   Subgenus: Tanytarsus Wulp
       Species: buckleyi Sublette 8, 9
               confusus Mallach 9
               neoflavellus Malloch 6, 8
               xanthus Sublette 9

   Subgenus: Cladotanytarsus Kieffer
       Species: viridiventris Malloch 1, 2, 3, 6, 8, 9

LITERATURE CITED


THE LABIATAE OF ARKANSAS

James M. Lang

University of Arkansas

INTRODUCTION

Information about various taxa of the Labiatae in Arkansas has been known for many years, but a study of the entire family as it occurs in the state has not been made. Furthermore, the distribution of species and varieties in the state and information on the habitats in which they usually occur are sketchy. Also, the pertinent literature is widely scattered.

The objective of this study was to bring together this information on the Labiatae of Arkansas.

Grateful acknowledgment is made to Dr. Edward E. Dale, Jr., Department of Botany and Bacteriology, University of Arkansas, for direction of this work. Thanks are also due the director of the herbarium at Arkansas College and the curator of the herbarium of the Missouri Botanical Garden for permission to examine their specimens.

HISTORY

The first known record of the Labiatae in Arkansas was reported by Bradbury (1817). He collected one species that he called Stachys Foeniculum Pursh., or what is now known as Agastache Foeniculum (Pursh.) Ktze. (Fernald, 1950). Since Fernald describes the southern distributional limits of A. Foeniculum as Illinois and Iowa, and since no other investigator has reported it as being present in the state, it seems likely that the plant was mis-identified. It was probably A. nepetoides (L.) Benth., which is the only Agastache known to occur in Arkansas at present. Unfortunately the specimen identified by Bradbury is not available for purposes of verification.

Thomas Nuttall (1821), in his travels up the Arkansas River in 1819, included four species belonging to the Labiatae in his collection. He added ten more as a result of his collection from 1821 to 1835 (Nuttall, 1837).

Eleven new species were reported by Lesquereux (1860) as a result of the second botanical and geological survey of Arkansas, and an additional species was included in a report of additions to the flora of Arkansas by Butler (1877).

Branner and Coville (1888) compiled a checklist of the plants of Arkansas in which twenty-four genera and fifty-four species of Labiatae were recorded. Buchholz and Palmer (1926) in their supplement to the
flora of Arkansas added four species new to the state, and Moore (1951) reported the most recent new addition.

County or area floras such as those of Giles, (1935) and Pyle (1939) and the ecological studies of Hite (1960), Bullington (1962), and Fullerton (1964) have added much information about the distribution and habitat of the Labiatae of Arkansas, but no taxa new to the state were reported.

MATERIAL STUDIED

This investigation is based primarily on the examination of approximately 4,810 herbarium specimens at the University of Arkansas, Arkansas College, and Missouri Botanical Garden. Also, specimens cited in the literature were noted.

The field studies helped augment distributional data and made possible a better understanding of the plants in relation to their environment. The months of June, July, and August, 1963, were spent in the field making extensive collections and studying the habitats. The late blooming specimens were collected on more infrequent trips made the following fall.

GEOGRAPHIC DISTRIBUTION

Species found in Arkansas are characterized in most instances by a cosmopolitan distribution. An exception to this is Sideritis montana, a plant native to Europe, which is known to occur in North America only in Fulton County, Arkansas (Moore, 1951). Almost a fourth of the Arkansas species are native to Europe.

The distribution of the various taxa are fairly well known in northwest Arkansas, but taxa in the remainder of the state have been poorly collected. For this reason, any broad conclusions as to the distribution of species within the state based solely on present known collections are likely to be unsound. Further studies will undoubtedly show a much wider distribution of most taxa.

ANNOTATED LIST OF TAXA

In the list that follows, where possible the names employed are the same as those used in the most recent revisions or monographs.

In taxa for which no intensive studies have been made, those names used by Fernald (1950), Gleason (1952), or Steyermark (1964) have been followed.

Each name is followed by a brief description of the usual habitat, areas, or counties where the plant occurs and citations of representative herbarium specimens. Plants deposited in the herbarium of the University of Arkansas are indicated by (UA), Arkansas College, (AC), and Missouri Botanical Garden, (MBG).
If a revision or monograph of any genus has been made, the citation follows the generic epithet.

**Agastache** Clayton (Lint & Epling, 1945)

*Agastache nepetoides* (L.) Ktze. — Benton, Garland, Polk, and Washington counties. Low open woods, thickets, and at the base of bluffs. D. Demaree, 4591, Benton County (UA); D. Demaree, 16453, Garland County (MBG).

**Blephilia** Raf.

*Blephilia ciliata* (L.) Benth. — Known throughout the state. Limestone glades, open woods, clearings, and along roadsides. Delzie Demaree, 6758, Benton County (UA); E. J. Palmer, 5582, Carroll County (MBG).

*B. hirsuta* (Pursh.) Benth. — Marion and Stone counties. Moist rich valleys and moist areas at base of bluffs. D. M. Moore, 451887, Stone County (UA).

**Collinsonia** L.

*Collinsonia canadensis* L. — Present in Arkansas on rich, rocky, limestone-derived soils, slopes, in woods, and ravines. This plant was not seen, but is cited in Gleason (1952) and Fernald (1950).

**Cunila** L.

*Cunila origanoides* (L.) Britt. — Known throughout the state. Upland slopes, bald hills, rocky or open woods, and prairies. D. M. Moore, 30G023, Carroll County (UA); Delzie Demaree, 13868, Drew County (MBG).

**Glechoma** L.

*Glechoma hederacea* L. — Benton, Independence, Little River, Washington, and White counties. Low meadows, woodland, near streams, and springs. W. L. Ellison, 307, Independence County (AC); Delzie Demaree, 6653, Benton County (UA).

**Hedeoma** Pers.

*Hedeoma hispida* Pursh — Known throughout the state. Prairies, limestone glades, and fallow fields. D. M. Moore, 330188, Baxter County (UA); Delzie Demaree, 17151, Drew County (MBG).

*H. pulegioides* (L.) Pers. — Known throughout the state. Dry sandy soils, ridge tops, upland slopes, clearings, and glades. D. M. Moore, 43229, Newton County (MBG).

**Isanthus** Michx.

*Isanthus brachiatus* (L.) BSP. — Known from the western half of the state. Limestone glades, bald hills, prairies, and gravel bars. D. M. Moore, 308071, Marion County (UA).
Lamium L. (Jorgensen, 1927; Bushnell, 1937)

Lamium amplexicaule L. f. amplexicaule. — Known throughout the state. Old fields, pastures, lawns, meadows, and waste ground. W. L. Ellison, 344, Independence County (AC); H. R. Gregg, 31, Hot Spring County (UA).

L. amplexicaule L. f. albiflorum D. M. Moore. — Garland, Hot Spring, Pope, Washington, and Woodruff counties. This plant shows a homozygous recessive condition according to Bushnell (1936). D. M. Moore, 430083, Pope County (UA).

L. purpureum L. — Benton, Independence, and Washington counties. Lawns, pastures, meadows and waste ground. White flowered forms have been observed growing in Washington County. D. M. Moore, 400003, Washington County (UA).

Leonurus L.

Leonurus Cardiaca L. — Benton, Hot Spring, Independence, and Washington counties. River banks, old fields, waste ground, the roadsides. Delzie Demaree, 17462, Hot Spring County (MBG); Dr. C. C. Smith, Independence County (AC).

Lycopus L.


L. rubellus Moench var. arkansanus (Fresn). Benner — Known throughout the state. Low wet woods, thickets along streams, ditches, and flood plains. E. M. Merrill, 1023, Pulaski County (UA).

L. rubellus Moench var. lanceolatus Benner — Carroll County. Low wet woods, thickets, and flood plains. D. M. Moore and H. H. Ilitis, 328, Carroll County (UA).

L. rubellus Moench var. rubellus Moench — Ashley and Washington counties. Thickets along streams, ditches, and flood plains. Delzie Demaree, 18586, Ashley County (UA).

Marrubium L.

Marrubium vulgare L. — Benton, Carroll, Independence, Marion, Newton, Pulaski, and Washington counties. Fields, pastures, waste ground, exposed bluffs, and roadsides. Lang and Smith, Independence County (AC); H. H. Ilitis, 4461, Newton County (UA).

Melissa L.

Melissa officinalis L. — Baxter, Carroll, Newton, and Polk counties. Thickets, wooded slopes, waste ground, abandoned fences, and near old homesites. Delzie Demaree, 23590, Baxter County (MBG); H. H. Ilitis, 5436, Newton County (UA).
Mentha L. (Dewolf, 1954)

**Mentha citrata** Ehrh. — Benton and Garland counties. Wet meadows and springs. D. M. Moore, 410420, Garland County (UA).

**M. piperita** L. — Benton, Fulton, Pulaski, and Washington counties. Wet ground bordering streams, ponds, ditches, meadows, and roadsides. Delzie Demaree, 15587, Hot Spring County (MBG).

**M. spicata** L. — Boone, Miller, Montgomery, Polk, and counties. Wet ground bordering springs, streams, ponds, and meadows. James H. Moore, Washington County (UA).

**Monarda** L. (McClintock & Epling, 1942)

**Monarda Bradburiana** Beck — Known throughout the state. Ravines, dry bluffs, and borders of glades. E. J. Palmer, 27003, Washington County (MBG); W. L. Ellison, 340, Independence County (AC).

**M. citriodora** Cerv. — Benton, Carroll, Howard, Hempstead, Miller, and Pulaski counties. Limestone glades, bald knobs, and rocky prairies. B. F. Bush, 14884, Carroll County (MBG); Hugh H. Ilitis, 5137, Howard County (UA).

**M. fistulosa** L. — Known throughout the state. Dry open woods, pastures, roadsides, and railroad embankments. Jewell H. Moore, 674, Conway County (UA); Delzie Demaree, 17547, Ashley County (MBG).

**M. punctata** L. var. **arkansana** McClintock and Epl. — Known throughout the state. Prairies, dry fields, and open ground. Delzie Demaree, 23857, Bradley County (MBG); J. E. Moore, Polk County (UA).

**M. Russeliana** Nutt. — Franklin, Garland, Hot Spring, Little River, Polk, and Washington counties. Open woods, dry hill sides, and borders of glades. E. J. Palmer, 24892, Garland County (MBG); Delzie Demaree, 2991, Washington County (UA).

**Nepeta** L. (Dewolf, 1955)

**Nepeta Cataria** L. — Known throughout the state. Old fields, waste ground, open woodland, along roadsides, and near old dwelling. G. M. Merill, 529, Pope County (UA).

**Perilla** L.

**Perilla frutescens** (L.) Britt. — Known throughout the state. Stream beds, pastures, meadows, and gravel bars. E. J. Palmer, 4437, Carroll County (MBG); G. M. Merrill, 1016, Pulaski County (UA).

**Prunella** L.

**Prunella vulgaris** L. — Known throughout the state. Old fields, roadsides, waste ground, prairies, and low woodland. E. J. Palmer, 27127, Garland County (MBG); Mary Stewart, Independence County (AC); W. M. Giles, 1, Freeman Springs (UA).
Pycnanthemum Michx. (Grant & Epling, 1943)

Pycnanthemum albescens T. & G. — Known throughout the state. Rocky open woods, thickets, and roadsides. Delzie Demaree, 14472, Hazen (UA); E. J. Palmer 43850, Boone County (MBG).


P. muticum (Michx.) Pers. — Known throughout the state. In grassy open places and low or dry woodland. Delzie Demaree, 3728, Craighead County (MBG); Jewel E. Moore, 1031, Conway County (UA).

P. pilosum Nutt. — Benton, Carroll, Marion, Newton, Stone, and Washington counties. Prairies, open upland, woodland, and thickets. Delzie Demaree, 23478, Stone County (MBG); D. M. Moore, 350135, Marion County (UA).

P. tenuifolium Schrad. — Known throughout the state. Open woods, dry fields and prairies, thickets, meadows, and gravel bars. Winell Gipson, Independence County (AC); J. E. Moore and A. McWilliams, Polk County (UA); Delzie Demaree, 22209, Prairie County (MBG).

Physostegia Benth.


P. intermedia (Nutt.) Engelm. & Gray — Known throughout the state. Moist prairies and swamps. H. Eggett, Green County (MBG).

P. virginiana (L.) Benth. — Known throughout the state. Moist thickets, river banks, and waste places. May be cultivated. Delzie Demaree, 5089 Craighead County (UA).

Salvia L.

Salvia lanceifolia Poir. — Known from only one specimen from Marion County. Plains and fallow fields. D. M. Moore, 350136, Marion County (UA).

S. lyrata L. — Known throughout the state. Dry sandy woods and thickets. John Kellog, Howard County (MBG); G. M. Merrill, 1623, Pulaski County (UA).

S. Pitcheri Torr. — Known throughout the state. Dry prairies. May be cultivated. Delzie Demaree, 9975, Pike County (MBG); H. R. Pyle, 572, Logan County (UA).

Satureja L. (Steyermark, 1964)

Satureja arkansana (Nutt.) Briq. — Known in the northwestern half of the state. Limestone glades, rocky openings, limestone bluffs, wet meadows, and gravel bars. Delzie Demaree, 22223, Newton County (MBG); J. T. Buchholz, 992, Faulkner County (UA); Dr. C. C. Smith, Independence County (AC).
**Labiatae of Arkansas**

*S. Calamintha* (L.) Scheele var. *Nepeta* (L.) Briq. — Benton, Clark, Hot Spring, Saline, Sevier, and St. Francis counties. Waste places, old fields, and roadsides. Sidney McDaniel, 829, St. Francis County (UA); E. J. Palmer, 8424, Saline County (MBG).

**Scutellaria L.** (Epling, 1942; Penland, 1924)

*Scutellaria australis* (Fassett) Epl. — Known throughout the state. Meadows, rocky fields, open woods, bluffs, ridges, and prairies. R. G. French, 394, Washington County (UA); B. F. Bush, 1435, Fulton County (MBG).

*S. Bushii* Britt. — Found only in Baxter County. Limestone glades, and bald knobs. D. M. Moore, 330163, Baxter County (UA).

*S. cardiophylla* Engelm. & Gray. — Garland, Hempstead, and Hot Spring counties. Open woods and prairies. E. J. Palmer, 10503, Hempstead County (MBG); F. L. Harvey, Hot Spring County (UA).

*S. elliptica* Muhl. — The northwestern half of the state. Steep wooded areas. D. M. Moore, 52052, Franklin County (UA); Delzie Demaree, 21187, Magnet Cove (MBG).

*S. incana* Biehler — Benton, Lawrence, Newton, Stone, and Washington counties. Open woods, bluffs, wooded slopes, roadsides, thickets, and along streams. D. M. Moore, 510379, Stone County (UA).

*S. integrifolia* L. — Known throughout the state. Thickets, dry sandy soil, open ground, and along roadsides. Delzie Demaree, 23102, Conway County (MBG).

*S. lateriflora* L. — Known throughout the state. Wet woods, swampy meadows, gravel bars, flood plains, bordering sloughs, streams and swamps. Delzie Demaree, 7056, Craighead County (UA); Delzie Demaree, 9343, Pulaski County (MBG).

*S. Leonardi* Epl. — Benton, Fulton, Marion, Pope, and Pulaski counties. Glades, meadows, waste ground, exposed ledges, and along roadsides. D. M. Moore, 32610, Marion County (UA).

*S. ovata* Hill. — According to Epling (1942), there are three subspecies: *S. ovata* subsp. *mississippiensis*, *S. ovata* subsp. *bracteata*, and *S. ovata* subsp. *versicolor*. These are considered to be varieties by other authors.

*S. ovata* Hill subsp. *bracteata* Epl. — Known throughout the state. Bald hills, waste ground, and roadsides. H. R. Pyle, 500, Logan County (UA).

*S. ovata* Hill subsp. *mississippiensis* Epl. — Known throughout the state. Rocky glades and exposed ledges. G. M. Merrill, 1052, Pulaski County (UA).

S. parvula Michx. — Benton, Baxter, Izard, Marion, Nevada, and Prairie counties. Meadows, rocky fields, open woods, bluffs, ridges, and prairies. Delzie Demaree, 14709, Ashley County (MBG); Lang 2, Independence County (AC).

Sideritis (Tourn.) L.

Sideritis montana L. — Fulton County. Limestone glades, and roadsides. D. M. Moore, 510613, Fulton County (UA).

Stachys L.


Teucrium L. (McClintock & Epling, 1946)

Teucrium canadense L. — Known throughout the state. Old fields, prairies, meadows, woodlands, and along roadsides, Mary H. Steward, Independence County (AC); D. M. Moore, Pope County (UA); Delzie Demaree, 23559, Baxter County (MBG).

Trichostema L. (Lewis, 1945)

Trichostema dichotomum L. — Known throughout the state. Limestone glades, bald hills, prairies, and alluvial soils. G. M. Merrill, 1078, Pulaski County (UA); E. J. Palmer, 29061, Garland County (MBG).

LITERATURE CITED


ENHANCED PHAGOCYTOSIS OF SALMONELLA ENTERITIDIS WITH HYPOAGGLUTINATING MOUSE ANTISERA

Jack Lockhart* and Leo J. Paulissen
University of Arkansas

It has been well documented that in humans a typhoid infection due to Salmonella typhosa is accompanied by the formation of serum antibodies which will agglutinate the bacteria in vitro. Furthermore the presence of the agglutinins has been correlated with resistance to the disease. Animal (e.g. rabbit) inoculation with the organism S. typhosa also results in the production of serum agglutinins. It was with some surprise, then, that Paulissen and Shechmeister (9) discovered that mouse inoculation with Salmonella enteritidis was not followed by production of agglutinins in amounts usually considered significant. The surprise was even greater when Hatch (4) showed that agglutinins were produced in mice against another Gram-negative organism Proteus morganii and that these agglutinins were protective. Gorer and Schütze (3) while able to demonstrate agglutinins against S. enteritidis in mice were unable to correlate resistance of the mice with them. The apparent differences in all these responses could be due to differences among the species and, regarding mice in particular, differences among the strains.

With respect to the particular strain of mice (NAMRU) and strain of S. enteritidis (1891) that Paulissen and Shechmeister worked with (9) it was speculated that either the standard agglutination test was inadequate or sensitive enough, or, that perhaps another kind of immune mechanism may be operating. The work presented here shows that protective factors are present in sera of mice and that they, or others, enhance phagocytosis of the organism even though no "significant" agglutinin titer could be demonstrated.

MATERIALS AND METHODS

Experimental animals: — Ten-to-sixteen week old male and female NAMRU (2) strain mice were used in this study. The mice, caged in glass jars, were fed Ralston-Purina Laboratory Chow exclusively and provided water, both ad libitum.

Test organism and preparation of vaccine: — Growing the organism for challenge and the preparation of the vaccine was done in essentially the same manner as previously described (9). The organism was Salmonella enteritidis 1891 (II, XI . . ., g,m) and originally came as culture 64 of the University of Kentucky. It was stored in ampoules as noted in (9).

Antisera: — Using two groups of mice, two separate pools of antisera were prepared at different times. No difference of reactivity was detected between the separate pools of sera. Each mouse received

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three injections on alternate days during a six-day period. Each injection consisted of 0.2 ml of vaccine containing approximately \(4.4 \times 10^8\) organisms, making a total of 0.6 ml of vaccine per mouse. Fifteen to sixteen days elapsed between the last immunizing dose and the collection of the antiserum.

Collecting the blood was done by lightly anaesthetizing the mice with ether, then, severing the jugular vein with dressing scissors, allowing the blood to drop into a small test tube. Between 1.0 and 1.2 ml of blood per mouse were obtained in this manner. Pooled blood was held at room temperature for two hours after which time it was centrifuged and the sera drawn off. The immune sera were stored in sterile screw-capped test tubes at 4.6°C.

**PROCEDURES AND RESULTS**

Before attempting to determine the presence of antibodies in mouse sera it was decided first to see if such sera conferred protection. A group of six mice was passively immunized with "immune" mouse sera, 0.2 ml intraperitoneally per mouse, and another group of six was given sera from non-immunized mice. Each group was challenged intraperitoneally with approximately \(4.4 \times 10^8\) organisms contained in 0.2 ml saline \(\text{LD}_{50}\) previously determined to \(4.4 \times 10^6.3\) 30 minutes after treatment.

**Table I.**

<table>
<thead>
<tr>
<th>Group No.</th>
<th>Treatment (0.2 ml, i.p.)</th>
<th>Day of Death After Challenge*</th>
<th>Dead Total</th>
<th>Mean Survival Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Undiluted Mouse Antisera</td>
<td>1, 1, 4, 20, 28, 28</td>
<td>6/6</td>
<td>13.6</td>
</tr>
<tr>
<td>II</td>
<td>Normal Mouse Sera</td>
<td>1, 1, 1, 1, 2, 2</td>
<td>6/6</td>
<td>1.6</td>
</tr>
</tbody>
</table>

*Challenged with 0.2 ml of approximately \(4.4 \times 10^8\) organisms i.p., 30 minutes after treatment.

Results are shown in Table I. It can be seen that in terms of survival time a mean of 13.6 days for those receiving immune sera was obtained compared to a survival time mean of 1.6 days for those mice receiving nonimmune sera. Thus the sera from immunized mice conferred protection.
Phagocytosis of Salmonella enteritidis

Separate standard agglutination tests were then performed on sera from ten different immunized mice. No agglutinins were observed in any of them at a titer of 1:20 or more. It was concluded that routine procedures were inadequate for demonstrating agglutinating antibodies, if present.

A series of agglutination tests was then performed to test specifically for "H" and "O" agglutinins. Antigens were prepared as follows according to procedures described by Kolmer et al (7). The "O" antigen was prepared by adding 2-3 ml of 95% alcohol to 50 ml of a 24-hour tryptose broth culture of S. enteritidis and subsequently incubated at 37°C for 12 hours. The organisms were washed twice in normal saline and resuspended in fresh saline to a turbidity equal to the No. 2 tube of the McFarland nephelometer. The "H" antigen was prepared by adding 1 ml of 0.5% formalin to 50 ml of a 24-hour tryptose broth culture of the organism which was washed in normal saline twice and resuspended in fresh saline in amount to produce turbidity equal to the No. 2 tube of the McFarland nephelometer. The tube agglutination tests were conducted on pooled mouse antisera using routine procedures as above. The "O" antigen series were incubated in a water bath at 50°C overnight before reading. The "H" antigen series were incubated in a 50°C water bath for 2 hours after which time they were placed in the refrigerator overnight. An antiserum from a rabbit was also tested for comparison. The results of the tests (Table II) revealed that the "H" antigen produced a titer of 1:160, whereas the "O" antigen gave a titer of only 1:40 in the mice.

Table II.
Agglutination Tests on Mouse and Rabbit Antisera Against "O" and "H" Antigens of Salmonella enteritidis

| Anti- | Control | Reciprocal of Titer |
| Anti- | 20 | 40 | 80 | 160 | 320 | 640 | 1280 |
| sera | O | H | O | H |
| Mouse | | | | | | | |
| | +++ | ++ | + | +++ | + | -- | -- |
| | | | | | | | |
| Rabbit | | | | | | | |
| | ++++ | ++++ | ++++ | ++++ | +++ | ++ | -- |
| | +++++ | +++++ | +++++ | +++++ | +++++ | +++ | ++ |

-= No reaction
+ = Degree of agglutination

"H" Antigen Agglutination Test Using Special Conditions: — Further agglutination tests under various conditions were conducted using the "H" antigen: it did produce the more sensitive agglutinating antibody reaction above. The conditions consisted of three different temperatures,
pH ranges, and levels of salt concentration. The temperatures were 22°C, 37°C, and 50°C. The pH ranges were 4.8, 6.8, and 7.8. The salt concentrations were 0.70%, 0.85%, and 1.0%. The "H" antigen was prepared from 50 ml of a 24-hour tryptose broth culture of the organism to which 1 ml of 0.5% formalin was added and incubated at 37°C for 12 hours. The tests were incubated for 2 hours at the temperatures indicated, followed by standing in the refrigerator overnight. Again, rabbit antiserum was also tested. The results are presented in Table III. It can be seen from the Table that the best agglutination in mouse antisera was obtained at an optimal condition of a temperature of 50°C, a pH of 6.8, and a salt concentration of 0.85%, i.e., the standard conditions routinely used in such tests.

Table III.
"H" Agglutination Tests Against Mouse Antisera Under Varying Conditions

<table>
<thead>
<tr>
<th>Test Sera</th>
<th>Condition variable</th>
<th>Conditions</th>
<th>Titer of Sera&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouse Antisera</td>
<td>pH</td>
<td>pH 4.8</td>
<td>50°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.8</td>
<td>50°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.8</td>
<td>50°C</td>
</tr>
<tr>
<td></td>
<td>%NaCl</td>
<td>6.8</td>
<td>50°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.8</td>
<td>50°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.8</td>
<td>50°C</td>
</tr>
<tr>
<td></td>
<td>Temp.</td>
<td>6.8</td>
<td>22°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.8</td>
<td>37°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.8</td>
<td>50°C</td>
</tr>
<tr>
<td>Normal Mouse Sera</td>
<td></td>
<td>6.8</td>
<td>50°C</td>
</tr>
<tr>
<td>Normal Rabbit Serum</td>
<td></td>
<td>6.8</td>
<td>50°C</td>
</tr>
<tr>
<td>Rabbit Antiserum</td>
<td></td>
<td>6.8</td>
<td>50°C</td>
</tr>
</tbody>
</table>

Readings were made after two hour incubation at the respective conditions and left to set at room temperature for 15 minutes.

<sup>1</sup>Reading of ++ or more.
Phagocytosis of Salmonella enteritidis

Blocking Test, "Incomplete Antibodies": — So-called incomplete antibodies fail to agglutinate saline suspensions of homologous cells, but their presence can be detected by one or more methods. One kind of incomplete antibody can be demonstrated by the following type of "blocking test". S. enteritidis in saline suspension when mixed with the mouse antisera should fail to be agglutinated when subsequently exposed to homologous rabbit antisera. If blocking antibodies were present in the mouse antisera they would expectedly combine with the corresponding agglutinogen(s) of the bacteria and specifically prevent later reaction with the rabbit agglutinin.

The procedure for the "Blocking Test" performed is as follows. Beginning with a 1:10 dilution, serial dilutions of the mouse antisera were made and a routine agglutination test was conducted. The tubes were incubated for 12 hours in a 50° water bath; following the incubation period a reading was made to determine the amount of agglutination. The readings were recorded (Table IV) and 0.5 ml of a 1:160 dilution of rabbit antiserum added to each tube. The tubes were again incubated overnight in a 50°C water bath. The agglutination results are given in Table IV. The 4-plus reading in each tube indicates that incomplete "blocking" antibodies were lacking in the mouse sera.

Another method used to detect incomplete antibodies was the conglutination test. The procedure consists of a routine agglutination test except that Specific Bovine Albumin (Dade) was used in preparing the serial dilution instead of the usual normal saline. The negative readings (Table IV) indicate that no incomplete antibodies were present in the immune sera of the mice.

Phagocytosis: — It has been shown that unless certain types of Gram-negative bacteria are mixed with immune sera they are not readily phagocytosed by mouse macrophages (11). With this in mind it was decided to determine whether mouse antisera would affect the phagocytosis of S. enteritidis by mouse polymorphonuclear leukocytes.

The production and collection of the phagocytes from the mouse peritoneal cavity was patterned after the method described by Fishman and Shechmeister (1). Mice were injected intraperitoneally with 1 ml of an Aleuronat suspension and sacrificed by severing the cervical vertebrae. The mice were dipped in 1:500 Roccal solution then the skin was reflected over the abdomen. Five-tenths ml of sterile 0.85% saline was introduced into the peritoneal cavity, mixed, and as much of the fluid removed as possible. The fluid containing the cells was immediately placed in heparinized capillary tubes and incubated at 37°C until used. Counts on the cell population showed from 3.5 x 10^6 to 4 x 10^6 cells per ml.

Using a modification of the technique described by Huddleson et al (5), 0.2 ml of bacteria was added to 0.2 ml of the test sera in serological tubes and placed in a 37°C incubator for 45 minutes. To this suspension 0.2 ml of the heparinized phagocytes was added and the mixture incubated at 37°C for one hour. With a Pasteur pipet a portion of the
Table IV.
Tests For Incomplete Antibodies In Mouse Antisera
Against *Salmonella enteritidis*

<table>
<thead>
<tr>
<th>Anti-sera</th>
<th>Titer of Sera¹</th>
<th>Blocking Test</th>
<th>Conglutination Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>Mouse</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Rabbit</td>
<td>+++</td>
<td>++++</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50°C incubation overnight</td>
<td></td>
</tr>
<tr>
<td>Mouse</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rabbit</td>
<td>+++</td>
<td>++++</td>
<td>+++</td>
</tr>
</tbody>
</table>

¹Reciprocal of the dilution
— = No reaction
+ = Degree of agglutination
Phagocytosis of *Salmonella enteritidis*

Sediment was drawn off and smears were made. The smears were passed through an open flame 3 times to promote quick drying which minimizes shrinkage of the phagocytes.

The phagocytic index was calculated for the sera tested. For each test sera 25 polymorphonuclear leukocytes containing bacteria were counted on each of 4 different smears for a total of 100 cells. The index was obtained by dividing the total number of bacteria phagocytosed by the total number of phagocytes counted. The results are presented in Table V. Also the per cent of phagocytes containing bacteria was calculated (Table VI). From the above Tables it can readily be seen that the phagocytic index for both the mouse and the rabbit antisera is significantly higher than that of the normal mouse sera.

Table V.

**Phagocytic Indexes of Mouse and Rabbit Antisera**

Against *Salmonella enteritidis*

<table>
<thead>
<tr>
<th>Treatment of Bacteria with</th>
<th>Slide No.</th>
<th>Number of Phagocytes Counted</th>
<th>Number of Bacteria</th>
<th>Phagocytic Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouse Antisera</td>
<td>1</td>
<td>25</td>
<td>357</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>25</td>
<td>393</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>25</td>
<td>345</td>
<td>14.8</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>25</td>
<td>386</td>
<td></td>
</tr>
<tr>
<td>Rabbit Antiserum</td>
<td>1</td>
<td>25</td>
<td>314</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>25</td>
<td>322</td>
<td>12.3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>25</td>
<td>296</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>25</td>
<td>301</td>
<td></td>
</tr>
<tr>
<td>Normal Mouse Sera</td>
<td>1</td>
<td>25</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>25</td>
<td>102</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>25</td>
<td>101</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>25</td>
<td>96</td>
<td></td>
</tr>
</tbody>
</table>
**Table VI.**

Number of Mouse Peritoneal Phagocytes Showing Phagocytosis

<table>
<thead>
<tr>
<th>Sera</th>
<th>Total Number of phagocytes counted</th>
<th>Number Showing Phagocytosis</th>
<th>Per Cent Showing Phagocytosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouse antisera</td>
<td>158</td>
<td>100</td>
<td>63.2</td>
</tr>
<tr>
<td>Rabbit antisera</td>
<td>172</td>
<td>100</td>
<td>58.2</td>
</tr>
<tr>
<td>Normal Mouse Sera</td>
<td>262</td>
<td>100</td>
<td>38.2</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The present studies have shown that there is something present in the antisera of immunized mice that can protect mice by prolonging the mean time to death from 1.6 days to 13.6 days (Table I). These results to some extent support Paulissen’s hypothesis (9) that humoral elements play an important role in resistance of actively immunized, irradiated mice.

The agglutinating antibody is sometimes associated with resistance (10). This is especially true of the anti-"O" antibody (10). The present studies failed to show conclusively that an agglutinating antibody in the immune sera (Table II) is important. A titer of 1:40 was obtained against the "O" antigen and a titer of 1:160 was obtained against the "H" antigen. Ordinarily titers of this magnitude are not considered to be sufficient to produce protection. On the other hand, if one takes into consideration the size of the mouse as compared to the size of the rabbit or human, it seems feasible that these low titers may confer protection to the mouse. The studies on agglutination using various conditions failed to give an increase in titer over that of standard conditions.

The series of tests on the immune sera for incomplete antibodies failed to produce evidence of such an antibody (Table IV). Agglutination of the bacteria by the rabbit antisera after no agglutination by the mouse antisera, indicates the organisms were not tied up by incomplete antibodies in the mouse antisera. The 3-plus reading in the first tube (Table IV) may be due to the slight agglutination (2-plus) by the mouse antisera. The absence of incomplete antibodies was also supported by the conglutination test performed (Table IV).
An in vitro experiment using mouse polymorphonuclear (PMN) leukocytes was conducted in this study. The results in Table V clearly show that the immune sera from both the mouse and the rabbit greatly enhance the phagocytosis of bacteria in vitro by the PMN leukocytes. Also it is shown (Table VI) that a greater number of PMN leukocytes phagocytose the bacteria in the presence of immune sera than normal sera. These findings are in agreement with others (6, 11) who have found that specific antibody enhances phagocytosis. Of some note is that the rabbit antisem containing agglutinins to a titer of 1:1280 showed less ability to enhance phagocytosis by mouse leukocytes than the mouse antiserum with virtually no agglutinin titer. This suggests either that rabbit agglutinating antibodies are considerably less effective in aiding mouse leukocytes than the meager mouse agglutinating antibodies, possibly resulting from complications due to species differences, or that agglutinating antibodies and those which enhance phagocytosis are of two different kinds in the mouse. It is tempting to consider the latter to be the more likely.

It is interesting to note in connection with the presence of anti-"H" antibodies (Table II) that Gorer and Schütze (3) found in a strain of mice resistant to Salmonella typhimurium that the specific antibody response to the "H" antigen was better than in a susceptible strain, but this relation did not hold for the "O" antigen. This appears strange since anti-"O" agglutinins are considered more important in resistance to Salmonellae than are anti-"H" agglutinins (10). The findings of Gorer and Schütze of a protective anti-"H" anti-body when considered together with results of Ralston and Paulissen (8) in which mouse antisera were found to inhibit motility of S. enteritidis, and the results herein showing enhancement of phagocytosis, suggest that inhibition of motility of S. enteritidis by mouse (anti-"H") antisera, that is, slowing the organisms down and/or immobilizing them, may well aid in their ingestion by the phagocytes and may be an important factor of immunity observed by Gorer and Schütze. This point was noted by William Champlin.*

REFERENCES


GROUNDWATER AQUIFER PATTERNS AND VALLEY ALLUVIATION ALONG MOUNTAIN FORK CREEK, CRAWFORD COUNTY, ARKANSAS

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INTRODUCTION

An alluvial valley fill study was undertaken in the summer of 1965 in the Boston Mountains of northern Arkansas. It was an attempt to discern the pattern (if any) of alluviation and aquifer development, using electrical resistivity and auger boring techniques. Alluvial deposits in the valley of Mountain Fork Creek, Crawford County, Arkansas, selected for study are representative of similar accumulations throughout the region on several counts. (1) Rocks of Mississippian and early Pennsylvanian age comprise the valley floor and walls; (2) local bedrock includes shale, sandstone, siltstone, and limestone with siliceous, ferruginous, and calcareous facies of essentially all of these plus minor chert; (3) strata are generally flat-lying or gently inclined to the south (1/2° to 1°) and are only locally and slightly disturbed by minor faults and gentle folds; (4) general inclination of strata is only slightly less than the similar southerly gradient of Mountain Fork Creek so that reaches of the valley floor and lower walls 1 to 3 miles long comprise essentially one formation and lithology and are replaced to the south by similar reaches of successively younger, lithically distinct units.

The valley of Mountain Fork Creek was also selected for study because of one unique feature. In the headward reaches of the stream [Map, Fig. 1] there is an inlier of chert and cherty limestone strata referable to the Boone Formation of Mississippian age. This inlier is the only bedrock source of fragmental white chert within the Mountain
Fork Creek drainage basin. The main channel of the creek has incised the cherty strata some 40-50 feet and one can conclude that chert clasts have been available to down-valley areas for an extended period of time. In addition, because said chert has not been utilized locally for construction purposes, chert clasts associated with Mountain Fork Creek valley alluvium may be inferred to have come from said inlier. The Boone chert is unlike any other bedrock exposed in the valley and the chert clasts are readily distinguished in alluvial deposits even where present in only trace amounts.

The presence of the above-discussed chert inlier led the writer to direct a graduate student at the University of Arkansas (Medina, 1962) in a sedimentological thesis study of the Mountain Fork Creek alluvial deposits. The principal purpose of that thesis study was to determine how the alluvium had been deposited. If emplaced by a laterally corroding and depositing stream, essentially the entire alluvial fill should contain scattered chert clasts. But if the alluvium had been latterally introduced by valley wall erosion and scarp retreat only those parts of the alluvium later reworked by the stream would contain chert.

In brief summary, Medina (1962) concluded that chert was limited to gravels along the present stream channel and further that these stream channel gravels exhibited sedimentological parameters distinct from the remainder of the valley alluvium, being better rounded and better sorted, showing rapid size reduction in a down-valley direction, and rarely containing appreciable sub-sand-size material or metastable rock fragments. According to the same study the remaining valley alluvium contains metastable limestone clasts, is everywhere poorly sorted with large amounts of sub-sand-size material, and only shows appreciable clast size reduction away from the valley sides toward the main drainage line with some rounding in the same direction, both at a much slower rate per unit distance than for similar clasts in the stream channel gravels. Medina (1962) concluded that the great bulk of the Mountain Fork Creek valley alluvium was introduced laterally by a high-density transport medium which moved only short distances (presumably sheet floods and mud flows operating in a rigorous, non-vegetated and probably arid environment).

This writer concluded from Medina's study (1962) that drastically different groundwater aquifer characteristics and depositional patterns should be associated with each of the two principal components of the valley alluvium to the extent that they exist. The present report represents an attempt to test this idea. To this end, an earth resistivity apparatus constructed to federal specifications by the Arkansas Highway Department was obtained on a loan by the Arkansas Geological Commission. The latter commission later drilled some 12 auger holes to test alluvial thickness indicated by resistivity data.

The writer is indebted to the Arkansas Geological Commission and particularly to Mr. Norman F. Williams its director for financing field work and supplying instruments and boring equipment. The Office of
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Water Resources Research of the University of Arkansas made the completion of this report financially possible.

INSTRUMENT TECHNIQUES

A total of six cross-valley resistivity traverses were completed along Mountain Fork Creek with an average of one sounding station per 100 feet of traverse length. Spacing was somewhat closer where the location of stations was keyed to subtile changes in alluvial topography believed to be tied to lithologic variations. In all, there were 68 separate resistivity sounding stations. The number of sounding readings per station averaged four, was at a minimum two, at a maximum nine and in each case was extended to include some bedrock.

The resistivity sounding technique used relied upon a four-electrode system (two steel stakes and two porcelain pots filled with copper sulphate) with an initial ("a") spacing of three feet. Depth calculations were made by the Barnes Layer Method and these satisfactorily showed individual layer resistivities. In all, data from ten instrument stations was checked by drilling to bedrock and in all ten sites data from the four-electrode setup pinpointed the alluvial-bedrock contact within a specific 3-foot interval.

Apparently depending somewhat on water content (which in surface layers varied with short-term precipitation) there appear several lithologic-resistivity relations of considerable constancy.  (1) A near-surface layer frequently encountered is a dark-brown, silty — probably loessal — loam with resistivities of 0.52 million ohm centimeters where high in clay and moist, to 4.1 million ohm centimeters where very dry, sandy, pebbly and/or clay lean.  (2) Coarse alluvial gravel layers show resistivities from 4.0 to 6.5 million ohm centimeters without consistent regard to apparent water content — the lower readings occurring where much silt and/or clay is present in the matrix and some of the higher values occurring in water-saturated layers that were clay lean.  The adhered moisture on the clay minerals may be more conductive.

With regard to bedrock, silty shale beds of the upper Fayetteville Formation and younger Morrowan silty shale beds had resistivity values of 8 to 11 million ohm centimeters.  Siliceous siltstones, calcareous sandstones and limestones show resistivities from 13 to 150-plus million ohm centimeters.  Clay shale of the lower Fayetteville Formation consistently reads 1.8 — 2.1 million ohm centimeters.

From the foregoing discussion it is readily apparent that the only bedrock resistivity values in the area that might consistently compare with values in overlying alluvium are those found in the lower Fayetteville Formation.  On the basis of magnitude alone, bedrock-alluvium contacts could not be picked in a traverse across that formation.  However, it was there observed that alluvial-resistivity values fluctuated, presumably because of variations in compactness, gravel, clay, and moisture content, whereas shale-resistivity values were consistently of a single value over considerable depth intervals.
A total of six resistivity sounding traverses were completed along the valley of Mountain Fork Creek and their locations are shown (Fig. 1). Traverse 1, a mile downstream from the chert inlier, crossed a pediment slope and valley flat developed on shale of the Mississippian Fayetteville Formation. The cross-profile illustrated (Fig. 2,a) shows a bedrock alluvium contact with distinct valley flat and side wall cloaked with an average thickness of some 5 feet of detritus which observation indicated was essentially chert free and largely shale debris from subjacent bedrock. Remnants of a cherty alluvial terrace were noted some 10 feet above the present channel along the valley margins. Alluvium in the present stream channel carries a chert admixture as does a gravelly depression (flood overflow line) extending down valley from a bend in the stream channel upstream from the resistivity traverse.

Traverses 2 and 3 are a pair spaced some 300 feet apart, trending across a generally straight and symmetrical portion of the valley some five miles downstream from the chert inlier. As illustrated (Figs. 1; 2, b-c) an average of only some 2-3 feet of alluvium coats the pediment crossed by the traverses and the bulk of the clasts in the coarse, angular gravels observed were similar to siliceous siltstone and ferruginous sandstone exposed in the subjacent Pennsylvanian strata. All of the alluvium in the valley appeared to be chert free except that in immediate association with the present stream channel and a thin veneer in a dry slough (flood overflow route) fringed on the valley-wall side by an abrupt rockcut terrace some 5 feet high. Probably the outstanding disclosure of a study of the resistivity data along traverses 2 and 3 was the fact that two portions of the bedrock valley floor were on a level with or lower than bedrock in the present stream channel. Further, it is important that a topographic high with a bedrock core separates the abandoned slough and the present channel. The absence of chert from most of the alluvial fill and the presence of bedrock obstructions
between flow routes clearly demonstrates that the stream did not attain its present position by means of any system of lateral corrosion or cut-fill migration. No remnant of a chert-bearing, high level alluvial terrace was observed.

Traverse 4 extends across a pediment slope and valley flat just below a sharp bend in the creek channel 6 miles down-valley from the chert inlier. As illustrated (Figs. 1; 3,a) the resistivity data showed a 2-3-foot-thick alluvial veneer across the pediment and adjacent valley flat. Excepting flood overflow swales with minor cherty gravel fills and along the main channel the alluvium in the valley is chert free, generally argillaceous and impervious. Several swales developed in bedrock below thin alluvial covers have elevations lower than bedrock in the adjacent open creek channel and this relation plus the chert free character of much of the valley gravel precludes alluviation by lateral channel sinuosity oscillation through cut and fill.

Traverses 5 and 6 represent a second pair spaced some 300 feet apart and generally bisecting a valley flat on the concave side of a large "meander" bend in the channel of Mountain Fork Creek (Figs. 1; 3,b-c). Twelve of the resistivity stations were auger-drilled to bedrock. A greater alluvial thickness (average 6-8 feet) was encountered in this river bend on the valley than on traverses 1-4 and several aquifer relationships were indicated. Water saturated cherty gravels occupy two bedrock swales that are expressed on the alluvial surface by flood overflow routes. The bedrock bottoms of these swales are 6-8 feet below the bedrock under the present stream channel and are separated from that channel by bedrock rises. The alluvium across the valley flat is generally chert free though alluvial gravels in flood overflow swales contain local patches of chert and chert is mixed with other lithologies in gravels in the main channel.

The chert-free character of much of the alluvium in the vicinity of traverses 5 and 6 shows that the stream did not attain its present chan-
nel position by cut and fill shifts from a slip-off slope. Cherty gravel patches along the bottoms of bedrock swales show earlier occupation of these swales by channeled runoff and account for the aquifer character of the gravels in these swales. Saturation of these gravels in this instance is believed to reflect the local natural impoundment of water in the present channel of the creek above the formation known as Natural Dam. A hillside seepage appeared to have saturated a patch of gravel in a small alluvial fan near traverse 3 but other gravels observed in the valley of Mountain Fork Creek appeared unsaturated during the dry months of the survey (July, August, 1965). Furthermore, only the cherty gravels that have been handled by throughflowing channeled runoff appear to be sufficiently well sorted to act as aquifers. These generally seem to give up contained water to the stream as water levels fall in the latter.

ALLUVIAL PATTERNS

A study of the alluvium along Mountain Fork Creek by resistivity, auger boring and observation has disclosed several existing relations. In general the detritus which sheaths the pediment slopes is thin (3.5 feet thick), chert free and appears generally impervious and poorly suited for aquifer purposes. It tends to closely reflect subjacent bedrock in lithic content but is in any case a more or less intimately mixed association of sand, silt, clay and gravel including some boulders. In many places this non-sorted, closely packed mixture forms a type of "hardpan" that sheds water like cement and appears dry only a few minutes after a heavy rain. The larger clasts are an assortment of sandstone, siltstone, shale plus occasional limestone fragments, all more or less angular in shape.

The valley flats along Mountain Fork Creek combine the alluvial debris described above with two other types of material. The bulk of the valley flats seem to be buried with essentially the same type of angular, poorly sorted, chert-free detritus. Where the present stream channel has incised and reworked this valley fill it contains an admixture of white, angular chert clasts, includes many well-rounded pebbles and cobbles and very little silt or clay. It seems pervious and of probable aquifer caliber although most of this debris is close to the main channel and drains immediately back into the stream as water levels fall after rains.

Cherty material has additionally been incorporated into the valley fill where flood overflow sweeps across it down-valley from sharp channel bends. Such overflow lines (Fig. 4) usually follow the most direct down-valley routes and have steeper slopes than the main stream channel. Many are expressed as shallow swales in the surface micro-topography of the valley-flat alluvium. Not all swales show surface gravel material but auger borings into several disclosed rather thick cherty gravel fills. Three swales which seemed to extend downslope to an area of natural impoundment contained water saturated cherty gravel apparently of aquifer quality.
These cherty, valley-floor deposits are actually in flood distributaries, consequent on a pre-existing, non-cherty alluvial fill. The swales diverge, converge and generally anastomose across the older alluvium and locally exhibit patches of coarse, cherty surface gravel (high-water point-bar deposits). The patterns are reminiscent of drainage patterns developed elsewhere on a larger scale and described by the writer (1966). Some of the cherty gravel in the swales actually rests on bedrock and may date back to a time of early valley incision and/or to some prior incision of the alluvium to bedrock. In any event, the gravely composition of the alluvium under the swales as shown by auger boring makes it clear that the swales are not of compactional origin. They appear to be swales because erosion and deposition both occur within them and the most recent events in many were erosional.

The third sedimentary increment recorded across many valley flats along Mountain Fork Creek is a tan-brown silty interval underlying the surface of many alluvial swells. At least some of this material is probably loess, for it is mainly silt and wind-deposited materials are widespread across the region. Some may have been waterlaid in areas of temporary impoundment such as that just above Natural Dam (Fig. 4).

RECENT FLUVIAL HISTORY

The recent history of fluvial events in the valley of Mountain Fork Creek would include several distinct stages of development. (1) Erosion of a relatively narrow, v-shaped valley 200-300 feet deep and exposure of the Boone chert inlier—the through-flowing stream that accomplished this presumably reflects humid conditions and left thin patches of chert pebble gravel along its channel 1/2-1 foot thick, presumably when runoff decreased and it ceased to erode. (2) Localized fluvial activity subsequently coincided with the development of valley flats and pediments which appear to have been simultaneously alluviated, the former to depths of 10-15 feet. The agents that deposited the poorly sorted debris were probably arid sheet floods and mudflows.
which dried up and held, the principal bedrock types (chert, sandstone and shale) close to their respective outcrop areas and short reaches (1-2 miles) downvalley from these. More than two miles below the Boone inlier, the bulk of this alluvium is chert free. (3) Through-flowing running water then swept the alluviated surface (probably with increasing rainfall) removing 5-10 feet of material near the valley mid-line, re-exposing the Boone inlier and ultimately scouring multiple channels, some to bedrock. (4) Through-flowing channel-confined runoff subsequently lost transporting power, (probably as rainfall diminished) alluviated the multiple channel system with relatively cherty, well-sorted gravel to a level somewhat lower than that of the principal alluvial fill, and created a swell-swale alluvial topography. (5) Subsequent incision continuing to the present reflects humid conditions and the through-flowing runoff has deepened a new channel, locally to bedrock (probably along an old swale route) which is currently incapable of containing high-volume runoff—overflows across adjacent alluvial flats are most pronounced downvalley from sharp bends which appear to back-up flow and valley flats appear to be currently undergoing more erosion than deposition. Admittedly, some floods have left gravel banks in overflow swales but such deposition must be regarded as temporary.

Swells on Mountain Fork Creek valley flats presently exhibit rather thick caps of silty loam in most places and only rarely a few scattered clasts of sandstone and siltstone. Related studies of the general area indicate that much of this silty material is loess, blown in from arid areas to the west. And though some dust is undoubtedly accumulating at present, the valley alluvium probably had such a surficial layer prior to present incisional processes. Locally the surficial silt has been washed into depressions and includes pebbles.

One aspect of present findings is particularly interesting and important. The floods (here defined as over-bank flow) that periodically inundate the valley floor of Mountain Fork Creek are of a climatic origin. No single channel capable of containing present runoff maxima exists and none has been recently permitted to form and deepen without aggradational interruption. The consequent runoff forms primary drainage networks during floods and the stream closely resembles those discussed by the writer (1958, 1959, 1966) from other regions repeatedly subject to arid-humid climate changes. A geomorphic history for the Ozark Dome involving such climate changes has been proposed by Quinn (e.g., 1965).

ALLUVIAL GROUNDWATER EVALUATION

The present study delineates several alluvium-aquifer relations for Boston Mountain drainage systems. Specifically with regard to Mountain Fork Creek, the bulk of the valley is too thinly alluviated to provide extensive alluvial groundwater along long reaches. Also, many of the thicker alluvial sections are composed of poorly sorted colluvium in the form of small valley-side alluvial fans. Only where these accumula-
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tions have been subject to valley-side runoff from springs and tributaries have fine clastic fractions been flushed away and in some cases such gravels are a potential source of groundwater. Elsewhere in the valley, only the alluvium that has been subjected to through-flowing runoff exhibits a degree of sorting approaching aquifer caliber. The bulk of such material is found in direct association with the present main stream channel and in thick channel-fill sections on the valley flat where alluvial depths carry below the water level in the main stream. Bore holes encountered water under such relationships. It should be emphasized that channel fills of aquifer caliber are close to and essentially parallel to the main stream channel except directly downvalley from sharp bends in the channel or on the concave side of large bends where overflow has affected large portions of the valley flat. Also, in the latter areas alluvial thickness seems greatest, and water-well locations in such sites appear to have the greatest potential.

Alluvial aquifer development along the valley of Mountain Fork Creek may or may not typify that in other valleys of the Boston Mountain region. The matter requires additional study in streams of different magnitudes and in areas where there are other bedrock types and channel patterns.

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THE INTELLECTUALS: A CRITIQUE

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In recent years several self-conscious studies about intellectuals have been published. To name but a few:1 Lewis Coser's Men of ideas: a sociologist's view; Christopher Lasch’s New radicalism in America: the intellectual as a social type; Lewis Feuer's The scientific intellectual; Richard Hofstadter's Anti-intellectualism in American life; Jacques Barzun’s The house of intellect; and George Huszar’s The intellectuals.

In general these studies either avoid the knotty question, "what is an intellectual?" or they give us flabby answers. Coser, for example, said that "intellectuals are gatekeepers of ideas and fountainheads of ideologies."2 Whatever is meant, the definition is broad and vague. Barzun, although more precise, had a similar failing. He said that intellectuals are men who carry brief cases.3 Many writers have criticized Barzun’s statement. Hofstadter, for example, wrote: "Few of us believe that a member of a profession, even a learned profession, is necessarily an intellectual in any discriminatory or demanding sense of the word."4 He went on to say — and quite rightly — that "we know, for instance, that all academic men are not intellectuals."5 However, he proposed a definition which, while narrower, was vaguer. An intellectual, he implied, is a creative person: "We do not think of him as being an intellectual if certain qualities are missing from his work — disinterested intelligence, generalizing power, free speculation, fresh observation, creative novelty, radical criticism."6 (Most of us will admit that whatever a creative person is, he is rare.) Feuer focused on "men of science," those who insist on testing and on rejecting everything that does not correspond with the so-called 'facts of experience.'7 In a curiously dialectic way, he dealt with a tradition which denies the validity of tradition as such. As for Huszar, he simply dodged the problem of definition. After saying that he was using the word in


2Coser, Men of ideas, p. x.

3Barzun, House of intellect, introduction.


5Ibid.

6Ibid., p. 27.

7Feuer, The scientific intellectual, introduction, and passim.
"a relatively broad sense," he never quite explained in which "relatively broad sense."

Confusion? Worse confounded! Paul Valéry, a contemporary literary critic, expressed his confused reaction in this way:

So, I was in my own abyss, unable to explain to a child, to a savage, to an archangel—to myself, this word intellectual, which gives nobody else any difficulty at all.

It wasn't that images failed me. On the contrary, every time this terrible word consulted my mind, the oracle responded with a different image. All were naive. Not one of them precisely annulled the sensation of not understanding.

Tatters of dream came to me.

I formed figures which I called 'Intellectuals.' Men almost motionless, who caused great movement in the world. Or very animated men, by the lively action of whose hands and mouths, imperceptible objects were made manifest... Pardon me for telling you the truth. I saw what I saw.

Men of thought, Men of letters, Men of science, Artists—Causes, living causes,.. minimal causes, causes within causes and inexplicable to themselves—and causes whose effects were as vain, but at the same time as prodigiously important, as I wished. The universe of these causes and their effects existed and did not exist. This system of strange acts, productions, and prodigies had the all powerful and vacant reality of a game of cards. Inspirations, meditations, works, glory, talents, it took no more than a certain look to make these things nearly everything, and a certain other look to reduce them to nearly nothing...9

Despite their weakness, these studies are not without keen insight nor without considerable interest, especially Hofstadter's. For example, he suggested that we may identify intellectuals by their pious and playful attitudes toward ideas.10 (Perhaps he meant that we can tell an intellectual by his split personality or, better still, by his tendency toward manic-depressive moods.) When, however, we consider piety and playfulness separately, they seem more meaningful. By stressing piety, Hofstadter meant that the intellectual lives for ideas, that he has a sense of dedication to the life of the mind, somewhat like a religious commitment; that he is engage—he is pledged, committed, and enlisted. What most people are willing to admit, namely that ideas and

8Huszar (ed.), The intellectuals, p. 5.
10Hofstadter, Anti-intellectualism, p. 27.
abstractions are of major importance in human affairs, he conclusively feels.\textsuperscript{11}

By piety Hofstadter probably meant to connote as well the idea that the role of an intellectual is, in good measure, inherited from the cleric. The clerical heritage is quite evident. Consider the tradition of personal discipline — the Germans call it Sitzfleisch. Consider, too, the traditional role of the cleric as caretaker of values, related to his own search for truth. Moreover, the professional thinker’s involvement with symbols was said to have originated with the magical role of the priest. Ed Shils, a University of Chicago sociologist, summed up the tie between man of religion and man of ideas: "[Intellectuals exhibit] an unusual sensitivity to the sacred, an uncommon reflectiveness about the nature of their universe, and the rules which govern their society... [They] elicit, guide, and form the expressive dispositions within a society."\textsuperscript{12}

By piety, finally, Hofstadter meant to recall that intellectuals not only are the upholders of the clerical tradition, they are also descendants of the biblical prophets — "inspired madmen."\textsuperscript{13} Coser calls them — who attacked men of power, who, in short, represent the millenial, the apocalyptic, the radical tradition. (More will be said about the intellectual and radicalism elsewhere in this paper. Suffice to say, meanwhile, that at best public opinion tends to think of him often as a radical, as an "inspired madman.")

Hofstadter used the idea of play as a counterpoise to piety. That is play checks the tendency of the committed intellectual to fanaticism. Moreover, the intellectual, more than any other person, is aware of the sheer delight in mental activity. We often speak of the play of the mind, do we not? Little doubt, then, but that an intellectual relished the play of the mind for its own sake. It very well might be, too, that this element of playfulness is an important factor in creative discovery, in the sense, at least, that an intellectual who enjoys playing with ideas is apt to turn answers into questions.

The element of play has held a significant role in the history of culture. Huizinga, a Dutch social historian, discussed this relationship in his celebrated study, \textit{Homo ludens}\.\textsuperscript{14} Likewise the role of professional jokesters is historically tied to intellectuals. Take the medieval court jester, for instance. His chief social function was to play none of the expected roles but to say and do only the unexpected. Outside

\textsuperscript{11}Ibid., p. 28.


\textsuperscript{13}Coser, \textit{Men of ideas}, p. viii.

\textsuperscript{14}(Boston, Beacon Press, 1955).
The Intellectuals: A Critique

of the social hierarchy, he could easily smile at, mimic, the usual social proprieties. Classified among the lowly and uprooted, he was nevertheless permitted to criticize, to ridicule the high and the mighty. Under the thin guise of laughter he satirized society's sacred cows. Surely the court jester has relevance for our understanding of intellectuals. Their experience suggests that one is not free to prick the public's conscience unless one is outside of the social establishment, unless one is free, unless one is alienated. It suggests, too, the ambivalent relationship that jesters and intellectuals alike have often shared with society. Tolerated most of the time, occasionally even rewarded by society, they were, at the same time, scapegoats of society. It is a part of the intellectual's tragedy that the things he most values about himself and his work are quite unlike those society values in him. Society values him—and never more than today—because he can in fact be used for a variety of purposes, from popular entertainment to the design of weapons. But his playfulness is apt to seem a perverse luxury; his piety to seem nettlesome, if not actually dangerous. And neither quality is considered to contribute very much to the practical business of life.

Lasch came closest to defining with precision the term intellectual. An intellectual, he said simply, is a critic of society. This definition has many advantages. First, it is quite consistent with the original use of the term, apparently first coined during the Dreyfus Affair. During the Affair the term acquired special meaning. It meant someone who was anti-clerical, anti-militaristic, anti-aristocratic, yet largely opposed to the values of a bourgeois society. He was identified with the revolutionary tradition. In short, a Dreyfusard—and hence an intellectual—was said to be a radical, an upholder of the Revolution, a critic of society.

This definition tends to incorporate most of the descriptive ideas about intellectuals. It incorporates the idea of the intellectual as cleric, as philosopher, as moralist, as skeptic, as satirist. It embraces, as well, the idea of alienation, which results often from a critic's clash with society. It includes the romantic tradition, with its emphasis upon individualism, and the populist tradition. (By populism I mean the belief in the creativity and the superior moral worth of the ordinary people.)

Lasch's definition would be considerably improved if he made two ideas more emphatic: first, the idea that the intellectual turns social critic largely because of the contradiction which he, in his role as custodian of morality, senses between what ought to be and what appears to be; second, that the intellectual, bent on making human existence appear rational and right, communicates his ideas to society which often finds them threatening. An intellectual, therefore, is a

social critic who persists on finding rational and empirical norms for what should be and who insists on communicating his critical thoughts.

Admittedly, this definition has at least two significant weaknesses: 1) It tends to exclude the thinker that shares all or some of the following values: authoritarianism, elitism, irrationalism, a tendency toward orthodoxy in religion, and, above all, fears change and prefers social stability. The suggested definition, in other words, eliminates those thinkers who are anti-intellectual. (They are anti-intellectual, it is emphasized, for many reasons, the most important being because they oppose the skeptical tradition, believing that excessive intellectual analysis or discussion can disrupt the foundation of order which they prize above all.) This deficiency can be handled easily enough — by calling such thinkers as Edmund Burke “anti-intellectual intellectuals,” or, if one finds this combination of words objectionable, call them “anti-intellectualist intellectuals.” Whatever we call them, the history of intellectuals, sadly enough, has been dominated by the anti-intellectual intellectuals, by those who fear and oppose social critics, and not by intellectuals who see their historical role as being social critics.

2) Most academicians reject this definition. There very rejection, however, attests more to the decline of radicalism in America than to any essential shortcoming which the proposed definition may have. Several factors account for the decline of radicalism.

1) Social legislation and state intervention in economic life, the two central policies of the government from the New Deal to the Great Society, aroused the enthusiasm as it dulled the criticism of many intellectuals and near intellectuals. For their essential political and social expectations were being realized.

2) Liberalism, not radicalism, emerged with enhanced prestige after World War II. It went from one triumph to another, saved by the unexpected success of the capitalist order in sustaining a decent standard of living; saved, in the last analysis by the contemporary thirty years’ war, hot and cold, which made that feat possible. Similarly, liberals point to their continued success at the polls which proves, they maintain, that unlike the radicals, they, at least, could be elected to power.

3) The ranks of liberals were increased and those of the radicals diminished by defectors from the revolutionary camp, and these recruits brought to liberalism the same polemical gifts, the same sense of commitment, and the same intolerance of opposition which they had learned as Bolsheviks.

17Morton White uses this definition. See his “Reflections as Anti-intellectualism,” Daedalus (Summer, 1962), pp. 457-68. White makes a distinction between the anti-intellectual, who is hostile to intellectuals, and the anti-intellectualist, who is critical of the claims of Rational intellect in knowledge and in life.
4) Liberalism thrived after the war and radicalism declined because the idea of ideology, itself, became increasingly suspect; pragmatism now dominates the intellectual scene, to the point where it itself has become somewhat of an ideology. A recent critic analyzed this rise of political pragmatism: "Pragmatism has been wrongly called the philosophy of the practical man. It represents the anti-intellectualism of the American intellectual, who is overawed by the practical sweep of American life." He observed that "in no country of the world is there such a tremendous gap between the values recognized by intellectuals and the values that actually govern political and economic realities." Despite the deplorable circumstance, he continued to say, "in no country is the intellectual so preoccupied with affecting the course of politics to the exclusion of his intellectual interests. The less power he has of determining conditions, the more passionate, it would seem, is his will-o’the wisp quest of political influence." It is here that the philosophy of pragmatism is most revealing.

5) The current liberal theory of pluralism is passionately opposed to the radical tradition. Consider, for example, the attacks of liberals upon the Berkeley Free Speech Movement. They denounced the FSM as a threat to law and order and upheld stability as a morality unto itself. In effect, the "pluralists" said that no matter what the circumstances were, the students committed some kind of crime in bypassing normal processes of change, i.e., in not operating through the so-called channels.

The "pluralists" emphasis on stability should not be taken to mean that they are opposed to political conflict. But conflict, they argue, should take place between contending leaders and political elites, as Seymour Lipset calls them. Conflict is healthy when it is between groups with different interests, so long as they do not seek to transform the political structure. So long as the demands of these groups are limited, the more conflicting groups the better.

"Equilibrium" is the metaphor commonly used by the "pluralists" to describe their social ideal. Equilibrium means balancing: the pairing-off of opposing forces and attitudes that negate each other and thus preserve the existing institutional structure, with only marginal changes. This kind of balancing means limited popular participation in politics, limited commitment of individuals or groups to principles and a "polity" which gives the widest latitude in decision-making to

19Ibid.
20Ibid.
those already in decision-making positions. The values which the "pluralists' called democratic in actuality are a threat to the vision of an open society, for they actually describe the means to preserve an elitist, a bureaucratic society. To this extent, they are anti-intellectual intellectuals.

6) The complex society which emerged after World War II has likewise contributed to the decline of radicalism in America. For one thing, it increased the demand for an educated class. Many new jobs at relatively high salaries suddenly became available in the academy, in government, and in industry. The prices which professional thinkers paid for their rise in status is high — by joining the establishment they have given up much of their freedom. Whereas, in the past, young scholars faced an unfriendly world alone, or together in their bohematics, they now sink into middle class suburbs, country homes, country clubs, and college towns. Far more insidious is that slow attrition which has removed the challenge, the whole idea of the intellectual vocation — the idea of a life dedicated to values that cannot be realized by a commercial, capitalistic civilization.

7) The rise of a so-called 'mass culture' has reinforced the liberal community’s fears of democratic movement. They prefer a cultural elitism.

8) Finally, old radicals and liberals alike view the cultural expressions of the new radicals with hostility, calling them beatniks, or hipsters, or dropouts. In at least one important cultural sense the new radicals are dropouts — dropouts from history. The withdrawal from school, so typical of their generation, and so inscrutable to ours, is best understood as an existential symbol of their rejection of the notion of cultural continuity and progress, which our graded education system represents in institutional form. Lester Fiedler has described the new radicals with understanding:

It is not merely a matter of their rejecting what happens to have happened just before them, as the young do, after all, in every age; but of their attempting to disavow the very idea of the past, of their seeking to avoid recapitulating it step by step — up to the point of graduation into the present.

Specifically, the tradition from which they strive to disengage is the tradition of the human, as the West has defined it, Humanism itself, and more especially, the cult of reason. . .22

The new radicals, in short, are manifesting, in an exaggerated but significant way, the same tendencies as the liberals. Yet liberals are equally firm in using the new radicals to justify their disillusionment, or plain opposition to radicalism.

THE INVIOLABILITY CONTROVERSY IN THE TRIAL OF LOUIS XVI

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The attempt at constitutional monarchy during the French Revolution ended abruptly on August 10, 1792, with the dethronement of Louis XVI in what has been termed the Second French Revolution.\(^1\) One major problem that the new National Convention faced when it convened in mid-September was the determination of the fate of the ci-devant roi. The solution of this dilemma, generally designated by historians as Louis XVI's trial, falls between November 6, 1792, the date of the first full-scale report to the Convention on evidence against Louis, and January 21, 1793, the date of his execution.

The thesis of this paper is that much of the debate at the tribune of the Convention during Louis XVI's trial revolved around the issue of royal inviolability—that is, whether or not the king was inviolable and therefore not subject to trial—but that arguments in support of inviolability were in fact academic and dilatory: academic because they were largely theoretical and advanced without expectation of practical results, dilatory because they formed a part of the efforts of some Girondin deputies to delay the trial and save the king.

With few exceptions the royal inviolability controversy centered on the provisions on royalty in the Constitution of 1791. It is therefore appropriate to cite the pertinent articles of Section I: "Of the Royalty and the King":

Article 2: The person of the king is inviolable and sacred: his only title is King of the French.

Article 5: If, one month after the invitation of the legislative body, the King shall not have taken this oath [given in article 4], or if, after having taken it, he retracts it, he shall be considered to have abdicated the throne.

Article 6: If the King puts himself at the head of an army and directs the forces thereof against the nation, or if he does not by a formal instrument place himself in opposition to any such enterprise which may be conducted in his name, he shall be considered to have abdicated the throne.

Article 7: If the King, having left the kingdom, should not return after the invitation which shall be made to him for that purpose by the legislative body and within the period which shall be fixed

by the proclamation, which shall not be less than two months, he shall be considered to have abdicated the throne.

Article 8: After the express or legal abdication, the king shall be in the class of citizens and can be tried like them for acts subsequent to his abdication.\(^2\)

Discussion on these articles by the National Assembly aroused no heated arguments; none of the approximately eighty Constituents, subsequently deputies to the Convention, apparently raised a voice against them.\(^3\) But a vigorous challenge of royal inviolability followed the king's flight to Varennes in June, 1791. Several future conventionnels, among them Jerome Pétion de Villeneuve, Maximilien Robespierre, and François Buzot, attacked the dogma and demanded that Louis be tried by the legislative body or a specially-convened Convention.\(^4\)

Inviolability became an official issue in Louis's trial with the presentation of a report by the Convention's Legislative Committee on November 7, 1792. In the first section the reporter Jean-Baptiste Mailhe listed as the first of several questions discussed by the committee: "Is Louis XVI jugeable for the crimes he is imputed to have committed on the constitutional throne?" The committee, in effect, had concluded in the affirmative. The Legislative Assembly suspended Louis and returned to the nation all the powers formerly confided in the monarch. The nation had in turn elected the Convention as the organ of its sovereign will, thereby effecting the negation of royal inviolability. In essence, continued Mailhe, "royal inviolability is as if it had never existed." The report further stated that the penal code, which stipulated death for treasonable activity, furnished the law whereby Louis could be judged. The committee report ended with a fourteen-article projet for consideration by the Convention, the first article of which read: "Louis XVI can be tried."\(^5\) The Convention rejected a Jacobin proposal to add "and ought to be tried," but it postponed discussion of the committee's report.\(^6\)


\(^3\)J. Mavidal and E. Laurent (eds.) Archives Parlementaires de 1787 à 1860: Recueil complet des débats législatifs et politiques des Chambres françaises; Première série (1787 à 1799) (Paris, 1867-1913), IX, 24-25; cited hereafter as Archives.


\(^6\)Archives, LIII, 282.
The decision to concentrate attention only on the first article of the committee’s projet came on November 13, as the result of a motion by Péron, a former Jacobin now associated with the Right in the Convention. In the course of his brief comments he clearly attacked "the stupid dogma of inviolability," and cited his long-standing opposition to it. But, he concluded, it was important to prove, with the law in hand, that Louis could not invoke the law.\(^7\)

In the course of the next two weeks ten deputies read prepared speeches on royal inviolability. Not all of those either for or against the dogma developed the same arguments respectively. Among the predominantly Girondin conventionnels supporting it, for example, Charles Morisson said that the death penalty prescribed for treason in the penal code was not applicable to Louis, since his crimes were committed while he was under the Constitution; also, there was no other pre-existant laws by which Louis could be tried. Therefore, the Legislative Assembly had applied the maximum penalty when it dethroned this "enemy of the French."\(^8\) Claude Fauchet put emphasis primarily on the need of a pre-existant law;\(^9\) Jean-Marie Rouzet admitted that Louis was probably jugeable in the sense of the committee’s report, but argued that it was not in the interest of the nation to try him;\(^10\) and Pierre-Joseph Faure decried the existence of inviolability, that "loi barbare, loi absurde," but insisted that it did exist and had to be respected.\(^11\)

But if diversity existed among the speakers defending inviolability it was equally evident in opposition speeches. Antoine Saint-Just attacked as false not only Morisson’s defense of the dogma, but the Legislative Committee’s view that Louis could be tried as a citizen. The ex-king, he declared, should be tried as an enemy of France.\(^12\) Taking another approach, Pierre François Robert cited the Declaration of the Rights of Man to the effect the law should be the same for all, whether it protected or punished. The nation, incensed at the grant of inviolability to the king, became a "living law" on August 10 and proclaimed by its action that Louis would be judged.\(^13\) But on December 3, in what is sometimes referred to as the "Montagnard thesis"

\(^7\)Ibid., LIII, 385.
\(^8\)Ibid., LIII, 387-389.
\(^9\)Ibid., LIII, 393-394.
\(^10\)Ibid., LIII, 421-422.
\(^11\)Ibid., LIII, 638.
\(^12\)Ibid., LIII, 390.
\(^13\)Ibid., LIII, 395-396.
on this subject,\textsuperscript{14} Maximilien Robespierre attacked not so much the validity of royal inviolability as its relevance to the case at hand. Louis XVI, he argued, was not an accused, the conventionnels were not judges. No trial was necessary since the king had already been tried by the people in the August 10 insurrection: "Louis cannot therefore be judged; he has already been condemned."\textsuperscript{15}

Parenthetically, the inviolability issue was by no means confined to debate at the tribune of the Convention. A number of contemporary pamphlets supported the king's inviolability, two of which are particularly noteworthy. Jacques Necker, the former finance minister of Louis XVI, argued that the king could not be tried as a particular, and that furthermore he had not violated any constitutional laws. He buttressed royal inviolability with historical references, noted that kings could not be tried by their peers and certainly not by partial men, and declared the doctrine both just and necessary.\textsuperscript{16} In response to Necker's published views, an anonymous pamphleteer claimed for Louis not only constitutional inviolability, but furnished an apparent rarity for this trial: an impassioned argument for inviolability on the basis of divine-right. Scolding Necker for avoiding this approach, the writer declared boldly: "Louis is both the most live image of and the minister of God. By virtue of this double title he is due a religious homage; to refuse to render it to him is to commit a sacrilege."\textsuperscript{17}

The controversy seemed at an end on December 3 when the National Convention decreed not only that Louis could be tried, but that in effect the Convention itself would serve as both judge and jury. But the issue of royal inviolability reappeared in subsequent phases of the trial, particularly in arguments by Louis's counsel, and in some of the orations by conventionnels in the week that followed the formal defense.

\textsuperscript{14}This phrase is used by G. Pariset, \textit{La Revolution (1792-1799)} (Paris, 1920- ), p. 18. The "Montagnard view" is the phrase used by M. J. Sydenham, \textit{The Girondins} (London, 1961), pp. 135-136. Both refer to Robespierre's thesis that no trial was necessary since Louis had already been condemned. But François Robert, see above p. 4, a Paris Jacobin, insisted that Louis could be tried; and Jean-Paul Marat, also a Jacobin, concluded that Louis "soit promptement juge" in his paper, \textit{Journal de la République française}, December 4-5, 1792.

\textsuperscript{15}Archives, LIV, 74-75. Robespierre reiterated these views in a letter to his constituents on December 14, 1792; see \textit{Oeuvres complètes de Robespierre} (Paris, 1912-1958), V, 135-136.


\textsuperscript{17}M. M.***, \textit{Reponse aux reflexions de M. Necker, sur le proces intentée à Louis XVI} . . . (Paris, 1792), pp. 26, 31-32.
Inviolability Controversy in Trial of Louis XVI

II

Louis XVI appeared at the bar of the Convention for the first time on December 11, where he heard the act of accusation and was asked to examine and respond to certain documents which had been submitted in evidence against him. Though the Convention voted after this first confrontation that the ex-king might choose one lawyer or defender, in the end he had a total of three: François-Denis Tronchet, who accepted Louis's bid after the refusal of the king's first choice; Lamoignon de Malesherbes, whose volunteered services Louis accepted; and Raymond Desèze, whom Louis and the Convention accepted at the request of the two other members of the defense counsel.

But the defense was handicapped from the outset by the king's decision to respond to the Convention's charges on December 11. Had he followed the example of the English King Charles I he would have refused to recognize the competency of the Convention to try him. His counsel, despite this handicap, attempted to exploit every possibility to save the king. The first section of the formal defense, read by Desèze on the occasion of Louis's second and final appearance before the Convention on December 26, claimed inviolability (thereby reopening what seemed a closed issue), the second part reiterated in detail Louis's responses of December 11 to the specific charges brought against him.

Desèze opened this impressive defense at the obvious point: he denied that the Convention's decision to try Louis had closed the issue of royal inviolability. He then proceeded to examine the constitutional articles which dealt specifically with royalty,¹⁸ and to build his conclusions around them. In the first place, he reasoned, a sovereign nation delegated the exercise of its sovereignty to its monarch (if, as in the case of France, it decided to give itself a king), which meant that the monarchical form of government itself presupposed that the king was inviolable. Second, there were no limits to that inviolability, no conditions which altered it. Third, even if the king should commit the crimes foreseen in the Constitution, that document contained nothing about the subsequent creation of a tribunal to try the king, nothing of a trial of any sort, but only of dethronement. Finally, if the king abdicated or was dethroned, he could be tried thereafter only for crimes committed after his downfall.¹⁹

These defense arguments apparently made little impression on the deputies, though some of the attention given to inviolability after December 26 was in part a reaction to the formal defense. But in the twenty-nine speeches given after Louis's second and final appearance, new issues crowded out the old; that is, inviolability took a back seat to the "appeal to the people" movement. Despite its secondary role, however, inviolability remained, on the surface at least, an issue in

¹⁸See above, p. 2.
¹⁹Raymond Desèze, Defense de Louis, prononcée à la barre de la Convention nationale. . . (Paris, 1792), pp. 4-13; Archives, LV, 618-621.
many of the speeches delivered between December 27, 1792, and January 4, 1793. So frequently did mention of it occur, in fact, that one deputy suggested that the order of appearance at the tribune be based on defense or attack of inviolability.

That the issue had indeed taken on a less important role was evident in the decreasing number of deputies who mentioned it. The fact that only two Jacobins said anything on the subject would suggest that the Left considered the issue closed, though these deputies did spend considerable time in their attack. All seven of the deputies who supported royal inviolability after December 26 were Girondins, including Pierre Vergniaud; but such prominent Girondin leaders as Charles Barbaroux, Buzot, and Pétion spoke against the dogma.

But even among the speeches of the Girondins who supported the dogma there is evidence of an increasing loss of enthusiasm; their arguments showed no refinement and were much the same as those presented from November 15 to December 3. None incorporated any of the clear logic provided by the formal defense, though the Girondins could hardly afford to do so since their support of inviolability had already exposed them to charges of royalism. The academic nature of their arguments was again evident. For example, Rouzet, on December 27, termed the dogma "a monster in the social order," but declared it a reality nonetheless.20 Hardly less original, Vergniaud called the dogma absurd but maintained that only the people could withdraw it since they had granted it initially.21 Petit, not to be outdone in this parade of cliches, pointed to the necessity of a pre-existant law, a law established prior to the crime, by which Louis could legally be tried.22

The two Jacobins who attacked inviolability, on the other hand, at least made an effort to bring new arguments to bear. Jean-Bon Saint-André quizzed the supporters of inviolability as to their reasons for invoking it for the former king. Why claim inviolability for Louis if he was now only a common citizen? Further, he argued, the inviolability granted to the monarch had been destroyed when the king was dethroned and imprisoned; in short, the "general will" had released the citizens from what he termed an immoral oath.23 In a more reasoned approach, Bertrand Barère put the capstone on the anti-inviolability case. Suppose for the sake of argument that royal inviolability did exist. Even then it would not be necessary to consult the people to deprive Louis of this constitutional shield, for the following reasons: 1) the Paris-sponsored August 10 insurrection had destroyed inviolability, the departments had applauded this action, therefore the entire French nation had spoken; 2) the Legislative Assembly had

20Archives, LV, 711.
21Ibid., LVI, 91.
22Ibid., LVI, 122.
23Ibid., LVI, 117, 120.
suspended and imprisoned the ex-king, and the nation had approved; hence, the people had sanctioned a second time the end of royal inviolability; 3) the nation had given the Convention no mandate to respect or reestablish inviolability; and 4) even if it were admitted that those granting inviolability should revoke it, the decision should not go to the primary assemblies since they had not been convoked to ratify the Constitution of 1791 in the first place.24

III

The fate of the inviolability issue, a controversy present throughout the trial of Louis XVI, is easily told. On January 15-17, 1793, the Convention voted on three questions, the first of which is of immediate concern: "Is Louis guilty of criminal acts against the French nation?" The results show that 683 deputies voted for the king's guilt, none voted against.25 The Convention then rejected the appeal to the primary assemblies, voted death for Louis XVI, and defeated a move for reprieve. On January 21, 1793, the blade of the guillotine fell on Louis le dernier, as he was so often called during his trial. The tyrant, as one conventionnel put it, was no longer.

If one considers the royal inviolability issue only as seen in the course of the trial within the Convention, a few basic conclusions seem inescapable. First, the controversy illustrates that no disciplined parties existed in the Convention during the period of the trial. Lack of uniformity in presentation of arguments and emphasis, most noticeable among Girondins, excludes consideration of group opinion as that of organized political parties in the modern sense. Second, the declining homogeneity among Girondins on this issue, plus the lack of originality and ingenuity on the part of die-hard supporters of royal inviolability, would suggest that the initial Girondin leadership of the Convention was on the wane as the trial progressed. Third, the introduction of the issue by the Girondin Péition, and the lip-service given by several other Girondin deputies, may be taken as part of the Right's poorly-structured attempt to delay the trial. Finally, despite all the attention to inviolability, its supporters did not carry their declarations to the logical conclusion in the final determination of Louis's fate. In short, it would appear to this writer that the dozen or so deputies who invoked inviolability for Louis XVI, if they had actually been serious in their defense of it, would either have voted against Louis's guilt — since in the legal sense he could hardly be considered guilty if truly inviolable — or else they would have refused to vote. None, however, took either action. These items do not provide conclusive proof that arguments in support of royal inviolability were merely academic and dilatory, but they leave this writer with something more than a strong suspicion that they were.

24Ibid., LVI, 203-204.

REPORT OF SCIENCES TEACHING IMPROVEMENT COMMITTEE

Roy C. Rom
University of Arkansas

This committee was organized in June for the following specific purposes: (1) to investigating curriculum and curriculum improvement, (2) to consider teaching and teacher improvement, (3) to publicize information concerning our first objectives and where possible, to offer constructive criticism in the form of recommendations.

As a committee we have no authority or jurisdiction. What may be said of us, is that we are the summation of many small voices crying in the wilderness. The wilderness of science education. Yet, these apparent disadvantages are our strength, for we stand in a juxtaposition between science teachers, the State Department of Education, and the school superintendents. We aspire to serve as liaison between such groups while being stand-offish enough to look at each objectively, to let each see himself as others see him, to be a genuine gadfly, if you please.

Committee Members:

Mrs. Alice Brooks, Ozark
Mrs. Gladys Giles, Fort Smith
Miss Aileen McWilliams, Mena
Mr. Freeman Thomas, Jacksonville
Mr. Curtis Love, State Department of Education, Little Rock
Dr. Jim Fribourgh, Little Rock
Dr. Roy C. Rom, Fayetteville

The word curriculum is derived from the Latin word currere, to run; it refers to the race course. Since we are racing to new goals today and since the old race course is worn and possibly leading in the wrong direction, many teachers, educators, and scientists recognize the need for curriculum improvement or change.

Whereas traditional science teaching may have had as its basis the accumulation of unrelated facts, new programs should concentrate on the development of concepts, principles, generalizations and issues of science. Teaching should draw lesson applications from the student's environment and experience.

In recent years some challenging proposals for updating scientific concepts and for redirecting learning, which leads to an understanding and an appreciation of science, have been built into the new science courses. Some of these programs have had extensive classroom testing. These programs suffer from lack of adequately trained personnel to teach them and poor classroom facilities to execute them. This is particularly true in the K-6 situation. To eliminate the difficulty of inadequate teacher preparation, colleges and universities that are train-
ing teachers must be challenged to update their own curriculum and to offer post-graduate orientation, retraining, and training opportunities to workers in the field.

To gain some background information on teacher training and experience, particularly as related to Arkansas schools, this committee conducted a survey in September. Considering the "average" Arkansas science teacher, 70.98% hold a BS degree, and 29.02% an MS degree. A look at the undergraduate major field of the science teachers reveals some disturbing information. Only 40% of our teachers meet the state certification requirements for science teaching which have as their basis only 24 semester hours of subject matter.

Our committee considers this unfortunate. This is not a criticism of the individual as much as an indication of the exercise of expediency on the part of school boards or their relegation of science to the category of unimportant in their total school program.

The survey indicated that a substantial number of teachers never attended in-service training or institute type courses. Only 2% were negative in their attitude; however, 40% were in the "it would depend on conditions" category. Sub-committees were organized to ferret out facts on three fronts, aimed particularly at meeting the conditions of this 40% group as well as all science teachers, such as: (1) teacher attitude on curriculums and type of workshops or institute sessions, (2) factors concerning teacher interest in such programs, and (3) current programs in Arkansas.

The cumulative opinions of teachers could lead to bold suggestions in curriculums which would deal equally with method and subject matter.

These should center on giving the teacher an understanding of concepts built on principals, which are the binding ingredients of science study and are useful in extending knowledge into new fields and which will not become outmoded with the passage of time.

As to method, teachers need and want instruction in the integration of text, lecture, recitation, and demonstration of their subject or the seminar approach. Special reference is made to the vital need of making all science learning relevent to the pupil by first making it relevent to the teacher. Teachers also require specific instruction in the use and application of the equipment, tools, and materials used as learning aids.

Initiation of such programs could come from regional science teacher associations who would propose a program and submit it to a college or university for activation. The State Department of Education should participate in terms of certification credit. Perhaps N.S.F. sponsorship for such programs might be obtained.

Many teachers would like to increase their professional competence but do not know how to go about it. At the same time they overlook information and opportunities available. There is a strong indication
that much information for science teachers is stalled in the principals office.

Some teachers are not particularly interested in any opportunity for growth primarily because their major teaching interest is not science even though they have some science teaching responsibility.

Salary increases for workshop participation would be a strong incentive, however, such a plan does not fit into most school board and administrative policies.

If workshops paid stipends of sufficient size to compensate for teachers having to forego other employment, teachers interest in education programs would be enhanced.

While regional workshops would still be inaccessible to some teachers, they would be very desirable in most instances and they would be a sound accommodation to teachers with family responsibilities.

A survey of 27 institutions of higher learning in Arkansas was made to learn about current programs in the state and to relate them to teacher requirements.

Only 5 schools are planning programs. One institution has programs for graduate credit, 2 others for undergraduate credit. Little scholarship money is available; where it is not, teacher registration for the course is low. The opportunities available for teacher improvement are thus very limited.

It appears that for financial reasons numerous teachers cannot avail themselves of the few available opportunities for self-improvement; for others the motivation for personal sacrifice for future gain is faint primarily because there is not much reality to future gain. Present opportunities in terms of current offerings by institutions in the state lack the luster to excite enthusiasm among working teachers.

The immediate challenge to this committee is to communicate these current ideas to teachers, school boards, faculties, and institutions of learning. Our hope is that in the future more opportunities will be available for improvement of the science teacher, that school boards will encourage improvement through incentive programs and rewards for excellence, and that teachers will use the opportunities to advantage. We recommend that:

1. There should be established in the school systems in the state of Arkansas a recognized program of science instruction in each of the elementary grades.
   a. This program should be science instruction and known as such by parent, pupil, teacher, and administrator.
   b. This program should be characterized by: A study of science through its principles, a study of science through pupil experience, a study of science through its relationship to the work and environment in which the student lives, a study
of science through a progressive learning process culminat-
ing in the 8th grade with an emphasis on earth and physical
sciences.

2. The teaching of science in the secondary school should be an
expansion of previously attained knowledge with emphasis on
concepts of chemistry and physics. Its purpose would be such
that it could be terminal in nature yet act as a spring board
for those going on to higher science learning.

3. A committee on curriculum construction work with the Arkansas
Advisory Council on Secondary Education, Arkansas Academy
of Science, Elementary Education Council, Arkansas Science
Teachers Association, State Department of Education and any
other interested or qualified group.

4. School administrators and superintendents recognize that a
satisfactory science teaching program requires a specific science
department in the school, equipped with audiovisual facilities,
laboratory desks and equipment, and a library containing
journals; magazines, keys, charts, manuals, and reference
books.

5. School boards and administrators accept the State Board of
Education's certification as a minimum requirement for employ-
ment and that added emphasis be placed on candidates having
a university or college degree with a major and a minor in
science.

6. Teachers continually examine all opportunities for furthering
their science teaching skills through pursuit of science orientated
in-service or institute programs.

7. Colleges and universities review and expand their current offer-
ings for science teachers and see that they are answering the
needs of teachers in the elementary and secondary schools.
Where possible, these courses should have the incentive of
graduate credit, and should have sufficient scholarship money
or stipends available.

8. Science teachers be permitted to participate in the establish-
ment of curriculums for in-service training programs.

9. In-service programs, where possible, be established on a
regional basis and at a time when participation would be
most convenient for the teacher.
THE UNDERGRADUATE CURRICULUM IN CHEMISTRY

Lester C. Howick
University of Arkansas

Until very recently the undergraduate curriculum in sciences was quite uniform from college to college and was quite stable with respect to time. Currently these curricula are receiving a great deal of attention. This interest is stimulated not only by the rapidly growing enrollment but also by a variety of other factors. One of these is the rapid developments being made in the sciences today. The amount of time, energy and money being spent on scientific research is greater than ever before in the history of man and new knowledge is being developed at an unprecedented rate. Another factor is the recent improvement in high school training in the sciences and mathematics. Within the past decade there has been a tremendous effort by the high schools in Arkansas to improve and update their science offerings with the result that the colleges now bear the responsibility for providing the students with a challenging and rewarding program which utilizes this preparation. Finally, graduate schools and employers have come to expect a much higher level of training than was previously possessed by the graduating senior.

We who are engaged in college level teaching in Arkansas are particularly affected by the changes made elsewhere in Chemistry curriculum. It is no longer true, if it ever was, that our students must meet the educational level of the surrounding geographical area. In this age of increased citizen mobility our students must be prepared to compete with graduates from any state in the union. When they apply for a job or a graduate position they are compared with all possible candidates regardless of geographical areas of origin. If we fail to prepare these young people for this competition then we have failed in our primary responsibilities as teachers.

Thus, our goal is before us but it is a goal that is rapidly moving forward. In a recent article (1) Professor Robert I. Walker reports that over sixty percent of the institutions in the United States which grant Bachelor's degrees with a major in chemistry have revised their course sequences with accompanying changes in course content during the past five years. A series of articles (2-4) in the March issue of the Journal of Chemical Education reports on a special symposium held at the American Chemical Society national meeting in Atlantic City entitled "The Changing Chemistry Curriculum." From these articles and from other publications and papers presented at meetings one is led to the conclusion that any curriculum which has not undergone significant modification since 1960 is probably out of touch with modern advances in chemical knowledge and that students passing through these programs will probably be greatly handicapped at the end of their undergraduate training.

In an attempt to better prepare our students for this competition, the University of Arkansas instituted in the fall of 1965 a new curriculum
leading to the B.S. degree in chemistry. This program is specifically designed for the well qualified entering student. It recognizes his background by encouraging him to complete the elementary material through physical chemistry as rapidly as possible so as to proceed to courses of greater content. The science and mathematics portions of this program and the semester hours credit for each are shown in the following table.

University of Arkansas
B. S. Chemistry Curriculum

<table>
<thead>
<tr>
<th>Fall Semester</th>
<th>Spring Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1st Year</strong></td>
<td></td>
</tr>
<tr>
<td>5 General Chemistry</td>
<td>4 Analytical Chemistry I</td>
</tr>
<tr>
<td>5 Calculus I</td>
<td>5 Calculus II</td>
</tr>
<tr>
<td>4 Biology</td>
<td>4 Biology</td>
</tr>
<tr>
<td><strong>2nd Year</strong></td>
<td></td>
</tr>
<tr>
<td>4 Organic Chemistry</td>
<td>5 Organic Chemistry</td>
</tr>
<tr>
<td>4 Physics</td>
<td>4 Physics</td>
</tr>
<tr>
<td>3 Calculus III</td>
<td></td>
</tr>
<tr>
<td><strong>3rd Year</strong></td>
<td></td>
</tr>
<tr>
<td>4 Physical Chemistry</td>
<td>6 Physical Chemistry</td>
</tr>
<tr>
<td>2 Modern Organic Analysis</td>
<td>4 Analytical Chemistry II</td>
</tr>
<tr>
<td>3 Advanced Inorganic</td>
<td></td>
</tr>
<tr>
<td>3 Elective Advanced Chemistry</td>
<td></td>
</tr>
<tr>
<td>Lecture</td>
<td>Research</td>
</tr>
<tr>
<td>Minimum Total Hours:</td>
<td></td>
</tr>
<tr>
<td>40 Chemistry</td>
<td></td>
</tr>
<tr>
<td>136 All courses.</td>
<td></td>
</tr>
</tbody>
</table>

While strongly believing that this course sequence is well designed to prepare the qualified student for graduate work or industrial employment we also recognize that not all of the high schools are giving this level of preparation and alternative sequences are available which begin at a lower level but sacrifice flexibility in the final year to still achieve the same coverage.

Finally, it should be strongly emphasized that a simple list of such courses does not adequately reflect the greatest changes which are taking place. These are changes in the content of the individual courses. In many cases while the titles employed are the classical titles, the courses themselves bear little resemblance to those taught only ten years ago. In this respect even the most current of textbooks are too old for they are outdated before they see print and a great responsibility resolves upon the teaching faculty for the rapid and effective incorporation of current developments into the ever changing undergraduate curriculum.
Arkansas Academy of Science Proceedings

LITERATURE CITED
