

ABSTRACTS OF PRESENTATIONS AT THE ANNUAL MEETING

BOTANY SECTION

EDWARD W. CHESTER, *Presiding*

Fine Structure of Cleistothecia, ASCI, and Ascospores of Myxotrichum deflexum, W. C. ROSING, Middle Tennessee State University.

Cleistothecia of *Myxotrichum deflexum* are composed of a network of loosely woven peridial hyphae. Outer peridial hyphae (cleistothecial appendages) are branched, thick-walled, and smooth; peridial hyphae at the interior of the cleistothecium frequently terminate in spirals. Typical ascomycetous septa occur within the peridial hyphae, but septa within ascogenous tissues are provided with a dense pore coating. Ascospore delimitation occurs by invagination of a typical ascus vesicle. Initially, the navicular ascospores are unwallled and surrounded by a pair of spore-delimiting membranes. Wall material forms between these membranes and consists of an inner light primary layer and an outer dense secondary layer.

Establishment of Jojoba Callus Culture in MS Medium, TERESA M. ALL AND S. K. BALLAL, Tennessee Technological University.

Jojoba is a sclerophyllous shrub endemic to the Sonoran desert of the American southwest. This taxon is receiving increased attention because of the rich oil contained in the seeds. One method of propagation being studied for this plant is by tissue culture. The establishment of callus is a major step in the subsequent establishment of plantlets in culture. After 48 hrs of imbibition, the seeds were soaked in 5% sodium hypochlorite solution for thirty minutes. The seed coat was removed after washing in sterile distilled water. The cotyledons were sectioned and 5 mm pieces were aseptically transferred to tubes containing MS medium with various concentrations of 2,4-D and kinetin. The tubes containing the initial explants were placed in 12/12 hr light/dark cycle at 85° F in an environmental chamber that offered 7500 lux. A friable greenish callus begins to form in about two weeks. The ideal concentrations of 2,4-D and kinetin in the medium for callus growth were 10^{-7} M and 10^{-4} M respectively. The viability of the callus has been maintained for four months before transferring to a regeneration medium for plantlet formation.

Interaction of Auxins and Cytokinin on Callus Induction in Sweet Potato, MARY A. ELLIS AND PREM S. KAHN, Tennessee State University.

The effect of 2,4-Dichlorophenoxyacetic acid (2,4-D), 1-Naphthaleneacetic acid (NAA) and N6-benzyladenine (BA) on callus induction, growth and morphogenesis of *Ipomoea batatas* L. cv. Potojam, was studied. Callus was initiated from stem sections, cotyledonary nodes and shoot tip cultures on Murashige and Skoog's medium supplemented with various concentrations of NAA and BA. The highest frequency of callus initiation was obtained from shoot tips and stem sections on NAA and BA media. The growth rate of callus as measured in terms of fresh weight and dry weight showed an increase when media was supplemented with 2,4-D (0.1 and 0.5 mg/l) and BA (5.0 and 10.0 mg/l). It was interesting to note that callus cultures grown on media containing NAA and BA were slow growing, flat, compact, dark green in appearance and had 2-5 roots arising from their central portions. On the contrary, the calli on 2,4-D and BA media, were fast growing, soft and friable, pale yellow and did not have any roots differentiating from them. The data suggested, that the interaction of NAA and BA might trigger the morphogenetic potential of the callus cultures as compared to 2,4-D and BA modified media (Supported by USDA grant no. 7903-1-PS2).

Reversal of Gibberellin Acid Enhancement of Lettuce Seedling Hypocotyl Elongation, LISA A. STOKES AND B. P. STONE, Austin Peay State University.

Bacitracin, tunicamycin, monensin, glucosamine and vanadate reversed GA-enhanced elongation of lettuce hypocotyls. They all significantly inhibited root growth. Bacitracin was most effective in inhibiting root elongation and in reversing the GA stimulation of hypocotyl elongation. Dolichyl phosphate reversed the bacitracin regulation of gibberellin enhancement of lettuce hypocotyl growth and significantly inhibited root elongation.

The Vascular Flora of Fort Donelson National Military Park, EDWARD W. CHESTER, Austin Peay State University.

Fort Donelson National Military Park, a 240-ha historic site in Stewart County, Tennessee, preserves the site of a major Civil War battle and includes a National Cemetery. The park is mostly dissected upland but adjoins the impounded Cumberland River and is thus topographically diverse with a number of habitat and plant community types. A floristic study conducted during the 1982-1985 growing seasons showed that the

vascular flora consists of 645 species representing 356 genera and 104 families. Taxa of Asteraceae and Poaceae dominate and account for more than 26 percent of the species. About 23 percent of the flora is not indigenous and several of the introduced species are threats to native vegetation. No rare species of national significance were found but four taxa of concern in Tennessee were observed.

Photosynthetic Rates in Euryhaline Algae, MARGARET P. PREHN AND HOLLINGS T. ANDREWS, Tennessee Technological University.

Several members of the Chlorophyceae and Chrysophyceae were isolated from a saline marsh in the Quivira National Wildlife Refuge, Stafford County, Kansas. *Pseudendoclonium* (Chlorophyceae) and *Apistonema* (Chrysophyceae) have been cultivated in BBM supplemented with NaCl to obtain concentrations of 5, 10, 15, 20, 25, and 30 parts per thousand total salt. Photosynthetic rates have been determined with 15 day-old cultures in a Gilson Respirometer. Correlations have been made between asexual reproduction, vegetative reproduction, and rate of photosynthesis to determine the salt concentration optimum for vegetative growth.

CHEMISTRY SECTION

MARTIN V. STEWART, *Presiding*

The CPT Guidelines and the Teaching of Descriptive Inorganic Chemistry, GARY P. WULFSBERG, Middle Tennessee State University.

New methods of teaching descriptive inorganic chemistry developed by authors in response to the new A.C.S. CPT guidelines were reported at the Chicago A.C.S. meeting. The old method of presenting descriptive inorganic chemistry as a list of facts to be memorized is dead. Two new approaches will be used in new texts: (1) that of integrating the material with chemical principles; and (2) that of developing principles powerful enough to be used by students to predict reaction products and their properties. The latter approach has been used by organic chemists for decades; this author will describe how he uses this in a sophomore-level textbook, "Principles of Descriptive Inorganic Chemistry," to be published a year from now.

Computer-Assisted Instruction. II. Principles of NMR, D. J. WILSON, Vanderbilt University.

A set of demonstrations, simulations, and problem tutorials for use in teaching the principles of NMR will be shown. These menu-driven programs run on the IBM PC and similar MS-DOS computers. A list of topics covered includes the following: Larmor precession with and without rf field and relaxation, magnetization in rotating coordinates, relation between FID and frequency domain, ABC and ABCD spectra, adiabatic slow passage, signal phasing, spin echo simulation and problems, multiple pulse simulation, gated decoupling, lineshapes of systems with exchange, solvent peak suppression by WEFIT, T1 by inversion recovery, and precession on- and off-resonance.

Oxidation of Selected Primary Alcohols with N-Iodophthalimide, ROBERT G. ZIEGLER, Lincoln Memorial University, MICHAEL W. RIDENOUR, Campbell County High School and THOMAS BEEBE, Berea College.

N-iodosuccinimide has been used to oxidize primary alcohols, and because N-iodophthalimide has a similar structure, it should be able to oxidize primary alcohols in a similar manner. N-iodophthalimide was synthesized and then used to oxidize benzyl alcohol, 1-pentanol, and 2-methyl-1-propanol. The alcohols were mixed with the oxidant in an inert solvent and then irradiated with visible light from a tungsten lamp. Samples were withdrawn and analyzed with a gas chromatograph to identify the products. Benzyl alcohol yielded benzaldehyde; 1-pentanol yielded 2-methyl tetrahydrofuran; and 2-methyl-1-propanol yielded a mixture of 2-methylpropanal and 2-iodopropane. It was found that N-iodophthalimide oxidizes primary alcohols to the same products as does N-iodosuccinimide. There is sufficient evidence to support the proposal that the oxidations occur via a free radical pathway. Visible light homolytically cleaves the O-I bond of the intermediate alkyl hypodite. An alkoxy radical is formed which subsequently follows an available decomposition pathway to generate the oxidized product.

Thermal Denaturation Studies of Polyaromatic Hydrocarbon Interaction with Deoxyribonucleic Acids, JAMES C. HOWARD AND BARBARA GAYDOS, Middle Tennessee State University.

The interaction of a variety of aromatic hydrocarbons with DNA via intercalation may be one mechanism of carcinogenesis. During the screen-

ing of some porphyrins for their DNA binding affinity, it was discovered that meso tetra(4-N-methylpyridyl)porphine, T4MPyP, I, bound by intercalation. Thermal denaturation profiles (absorbance vs. temperature) were used to characterize this interaction. This report details the results for a "control" compound, namely, the classical intercalator proflavine, II, using calf thymus DNA and poly(dA-dT)-poly(dA-dT) as the nucleic acids.

Development of an Assay for Prostaglandins in Cell Culture Media, JUDITH M. BONICAMP, Middle Tennessee State University.

Prostaglandins, the major cyclooxygenase products of arachidonic acid, are potent mediators of cellular responses to challenge by chemicals and electromagnetic radiation, and to mechanical disturbance. The standard for identifying and quantitating prostaglandins is gas chromatography-mass spectrometry (GC-MS). Fragmentation with electron impact has been used in the past. Recently, GC-MS methods have been modified to increase sensitivity by use of negative ion chemical ionization (NICI) which reduces fragmentation, providing higher intensities of the high mass fragments. Sensitivity can be enhanced further by use of selective ion monitoring (SIM). A GC-MS method will be described for quantitating prostaglandins in cell culture media at the picomolar level, the concentration expected in the environment of cells reacting to chemical, electromagnetic, or mechanical stresses. This work was supported by the Department of the Army.

Removal of Antimony from Aqueous Systems by Coprecipitation, GERARD A. NYSSSEN, ERIC T. MILLER, TODD F. GLASS, AND CHARLES R. QUINN II, Trevecca Nazarene College.

The removal of antimony (III) from aqueous systems by coprecipitation with the flocculants ferric chloride, ferric nitrate, and aluminum nitrate was investigated. The effects of pH and added sodium nitrate were studied. At low ionic strengths residual antimony concentration in the range 0.1-0.2 mg/L were obtained at a pH of 8.5; added sodium nitrate at concentrations above about 0.2 M interfere. The method appears to yield lower residual Sb concentrations than do either lime precipitations or sulfide precipitation.

Removal of Refractory Organics by Aeration. VII. Solvent Sublation of Indene and Aldrin, L. K. FOLTZ, K. N. CARTER, JR., AND D. J. WILSON, Vanderbilt University.

The solvent sublation of indene and aldrin from aqueous systems into mineral oil was studied. With indene, the effects of Ni (II) and Zn (II) were investigated; the usual salting-out effect was observed, with no indication of complex formation between the olefin and the nickelous ion. The effects of a number of alcohols on the solvent sublation of indene were determined; very small concentrations of alcohol increase the rate of aldrin removal, while larger concentrations decrease it by roughly an order of magnitude at mole fractions of alcohol of the order of 0.01. Methanol is less effective than ethanol or n-propanol in decreasing the removal rate.

Elution of p-Dichlorobenzene and Endrin through Compacted Soil with Alcohol-Water Mixtures, G. A. NYSSSEN, D. D. CHU AND D. J. WILSON, Vanderbilt University.

p-Dichlorobenzene (p-DCB) was eluted through a compacted ferruginous clay with dilute aqueous solutions of methanol ethanol, n- and i-propanols, and n- and i-butanols. The presence of the alcohols results in very marked increases in the concentrations of p-DCB in the effluents from the clay-packed columns. Flux of p-DCB through the columns increases with increasing chain length of the alcohol, and normal alcohols increase the flux somewhat more than do the corresponding branched alcohols. Flux increases with increasing mole fraction of the alcohol. Flux enhancement is due almost exclusively to enhancement of the solubility of p-DCB. Endrin's elution rate through a compacted ferruginous Tennessee clay is markedly increased when ethanol is present along with water. High-humus clay, however, very markedly reduces the rate of endrin migration with similar water-ethanol mixtures.

Solubilities of Hydrophobic Compounds in Aqueous-Organic Solutions, G. A. NYSSSEN, E. T. MILLER, T. F. GLASS, AND C. R. QUINN II, Trevecca Nazarene College, and D. J. WILSON AND J. UNDERWOOD, Vanderbilt University.

The effects of several alcohols and ketones in enhancing the solubilities of several hydrophobic compounds in aqueous solution were investigated. Hydrophobic organics studied included endrin, p-dichlorobenzene, naphthalene, and dibutyl phthalate. Alcohols used were methanol, ethanol, n-propanol, i-propanol, n-butanol, i-butanol, t-butanol, and 1-octanol. Ketones used were acetone, methyl ethyl ketone, and methyl i-propyl ketone. Large non-linear enhancements of hydrophobic compound solubilities by the organic solvents were observed.

Sources of Error Affecting Isolated Yields of Organic Products Obtained from Aqueous Solution, MARTIN V. STEWART, ANTHONY C. UTLEY, AND WILLIAM L. JONES, JR., Department of Chemistry and Physics, Middle Tennessee State University.

We are presently employing Swain-Scott nucleophilic constants to predict yields of nucleophilic substitutions in cases where the product affording nucleophile is in competition with several other nucleophiles necessary to the total chemical system. Significant error can occur, however, if the isolated yield (obtained by weighing the product) is taken as a measure of true yield of the reaction as predicted by our model. These errors are exaggerated when a volatile product must be isolated from an aqueous reaction mixture and were investigated in detail for the 1,4-dimethoxybenzene obtained through methylation of 4-methoxyphenol with dimethyl sulfate in aqueous sodium hydroxide. The true reaction yield is obtained from the isolated yield only after a recovery study which included a Karl Fischer water determination of the residual water in the product. Acknowledgement is made to the donors of The Petroleum Research Fund, administered by the American Chemical Society, and the MTSU Subcommittee on Research for financial support.

The "Zero-Proton" and "Zero-Electron" Criteria for the Atomic-Scattering Factors of X-Ray Diffraction, THOMAS V. JEFFRIES, Campbellsville College, Campbellsville, Kentucky, and MARTIN V. STEWART AND GERRY D. THOMAS, Middle Tennessee State University.

Atomic-scattering factors of individual atoms and ions are essential parameters for single-crystal X-ray structure analysis. There is growing awareness that improper treatment of valence electrons in these calculations can introduce significant systematic error into a highly refined crystal-structure determination. The stabilizing influence of counter ions has been shown by Watson to be of fundamental importance in calculating the wave functions of ions in crystals and, hence, their X-ray scattering factors. The success of the Watson-sphere model can be graphically demonstrated in the form of plots of atomic-scattering factors versus atomic number for an iso-electronic series and versus formal charge for different oxidation states of a single element. The requirement of zero scattering of an extrapolated theoretical ion having no protons (*i.e.*, a "zero-proton ion") in the first case and for a "zero-electron" ion in the second is successfully met by the Watson-sphere model, but not by ordinary Hartree-Fock calculations. Thus, a practical criterion to critically compare different treatments of atomic scattering is provided.

Reactivity of Ruthenium Tetroxide Towards Coal-Like Functionalities in Simple Organic Compounds, W. H. ILSLEY, Middle Tennessee State University, and R. A. ZINGARO AND J. H. ZOELLER, JR., Texas A&M University.

The reactivity of Ruthenium Tetroxide towards coal-like organic functionalities was evaluated by oxidizing model substrates, containing aromatic and/or etheric functionalities, with $\text{RuO}_4 \cdot x\text{H}_2\text{O}$ in the presence of variable amounts of NaIO_4 cooxidant. Molar cooxidant/substrate ratios (*c/s*) of between 2 and 8 were employed. Most substrates gave low product yields under these conditions, but product distributions obtained at the various *c/s* ratios indicate that most functionalities are initially attacked at more than one site, and produce products which are themselves oxidized further. Benzene groups are rapidly oxidized to CO_2 , consuming several equivalents of cooxidant, when the ring is activated by electron donating substituents: slow or not at all when an electron withdrawing group is present. The alkylbenzyl ether group is oxidized rapidly and exclusively to the alkyl benzoate derivative with two equivalents of cooxidant, and the product ester is inert towards further oxidation at higher *c/s* ratios. Phenylpentadecane is oxidized at the aromatic ring and at the benzylic methylene, even at low *c/s* ratios, to form hexadecanoic acid, tetradecylphenone, and pentadecanoic acid. Higher *c/s* ratios produce significant amounts of shorter chain acids with no increase in the yield of phenone. Dihydroanthracene is oxidized rapidly to anthracene, but small amounts of anthrone and anthraquinone are also formed. Anthracene is sluggishly oxidized to the latter products.

Density Using Archimedes' Principle: A Microcomputer/Electronic Balance Interface Exercise, HARVEY BLANCK, Austin Peay State University.

Microcomputers interfaced to laboratory devices may sometimes be used to combine instructions, data collection and calculations into an efficient, unified package. An interface between an electronic toploading balance and a microcomputer was designed. It has been employed in an exercise to determine density using Archimedes' Principle. The interface hardware, interface software and experiment software are described.

ENGINEERING SECTION

JOHN T. MASON, III, *Presiding*

Beams Resting on an Idealized Soil Model, ABU K. SARWAR, Austin Peay State University.

Flexural behavior of beams resting on a homogeneous elastic soil medium is examined. The soil is idealized as a Winkler medium. It is assumed that

the deflection due to an external load at any point on the surface of the soil is proportional to the pressure at that point, and is completely independent of pressures or deflections occurring at other, immediately neighboring points along the length of the beam. Beams with free ends which are subjected to concentrated and uniformly distributed loads and concentrated moments are analyzed. The accuracy of the formulation is checked by comparing the numerical results with existing solutions. Numerical results are developed to illustrate the influence of the relative rigidity of a beam on its deflections, flexural moments and shear forces.

Measurement of the Thermal Conductivity of Concrete using a Radial-Heat-Flow Apparatus, ROBERT D. HAYNES AND DAVID W. YARBROUGH, Tennessee Technological University.

The thermal conductivities, k , of six concrete specimens containing perlite as a substitute aggregate have been measured in the range 298 to 322 K using a radial-heat-flow apparatus. Concrete cylinders having densities from 1148 kg/m³ to 1477.5 kg/m³ were found to have k from 0.549 W/m•K to 0.728 W/m•K. Computer simulations of the heat flow apparatus were used to confirm radial heat flow for a region of sufficient size for thermal measurements. The extent of moisture exchange between concrete specimens and the ambient was measured and the effect of moisture on k will be discussed.

Thermal Loading in Mass Concrete, GEORGE BUCHANAN, WADE GILBERT AND ED RYAN, Tennessee Technological University.

In this paper we describe our formulation of a theory that can be used to predict the propagation of thermal motion in an elastic half-space. Fourier's Law is the classical constitutive relation that relates temperature to heat flux. We will show that a modification of this classical statement will lead to a constitutive theory that predicts thermal motion with finite wave velocity. We will discuss our ideas for the analysis of structures, such as a reactor containment, that is subject to a sudden thermal loading.

Nuclear Waste Disposal and Management: Geotechnology Issues, NATH PARATE AND JOHN AWUJO*, Tennessee State University.

Disposal of nuclear wastes from various energy sources throughout the industrialized world is becoming a top priority for the safe and healthy environment for mankind. The paper deals with the ongoing efforts for safe disposal and management and the geotechnical-rock mechanics issues involved. Since two decades low and intermediate level nuclear waste are being disposed of as shallow land burial. Two methods, ground burial and ocean disposal, are practiced throughout the world (Holcomb, 1982). A third alternative disposal in space has been suggested but has not yet received serious attention. The ocean disposal favorites believe that the enormous dilution and dispersion capacity of oceans will prevent undesirable radionuclides concentrations in the ocean environment, if the wastes escape from containers. The others favor isolation and containment of the waste radioactivity until decay has essentially eliminated any hazard. The National Academy of Sciences recommended a mined deep geologic repository as a permanent safe disposal method. Efforts are going on to study the various rocks such as Rocksalt, Basalt, Tuff, Granite and more recently the "Shale" encouraged by the European researchers. The knowledge of rock-mechanics is very important in such efforts.

Removal of Bromacil in Wastewater by Dye-Sensitized Photooxidation, TALBERT N. EISENBERG*, E. JOE MIDDLEBROOKS AND V. DEAN ADAMS

Bench scale studies in 208 L (55 gal) drums were conducted to determine the degradation potential of dye sensitized photooxidation on the refractory herbicide bromacil. Herbicide concentrations of the wastewater were monitored over time under different operating conditions. The effects of mixing, dye concentration, pH, dissolved oxygen, initial bromacil concentration, suspended solids, light intensity, and detention time on bromacil degradation were determined. The rate of reaction was found to be dependent on the pH value (faster at alkaline pH), on MB concentration (optimum around 10 mg/L), and on settling characteristics of suspended solids. The rate of reaction did not appear to be affected by the sunlight intensities (294-879 W/m²) which occurred during the study.

Thermal Conductivity of Powders, VICTOR EBOLUM, Faber-Castell Corp., Lewisburg, Tennessee and D. W. YARBROUGH, Tennessee Technological University.

The apparent thermal conductivities (k_a) for fine perlite powder and two fumed silica powders have been measured in the range 300 to 873 K using a radial-heat-flow apparatus. The temperature dependent k_a for the three materials were described by

$$k_a = a + bT + cT^3$$

where the cubic temperature dependence is related to radiative transport. The k_a data were used to calculate extinction coefficients (E) for the three powders by equating the parameter c to the corresponding coefficient that

approximates radiative transport

$$c = 16 n^2 \sigma / 3E$$

with the refractive index (n) set equal to one. The E values were found to range from 460 m⁻¹ for perlite to 1614 m⁻¹ for the finer of the two silica products.

Locating Commercial Gasoline Storage Tanks in Putnam County, J. T. MASON III, Tennessee Technological University.

By May, 1986 owners of existing underground storage tanks must notify the state or local agency designated of their age, size, type, location, and use. If they were taken out of operation after January 1, 1974 the information must still be provided in addition to the date taken out of service. This research addresses those locations where the presence of tanks are no longer obvious and may be "forgotten". Previous research on locating environmental problems through old records revealed a valuable source of information on this. A review of lease records maintained at the County Registrar's Office was extremely helpful in locating past and present commercial gasoline storage tanks. This review was supplemented by on-site identification to develop a complete list of gasoline stations in Putnam County. Approximately 66% of all gasoline stations within the corporate limits of the four major population centers are listed in the lease records. Of those stations where there is no indication of past activity, 75% are in the lease records.

GEOLOGY—GEOGRAPHY SECTION

D.M.S. BHATIA, *Presiding*

Slope Failure Along Tennessee Highway 27 at Suck Creek in Marion County, ROBERT LAKE WILSON, University of Tennessee-Chattanooga.

For the past twelve years Tennessee Highway 27 along Suck Creek, near the Marion-Hamilton County line, has been subject to periodic subsidence as a result of slope failure. Overlays of asphalt were applied about every two years in order to repair the surface. At this particular location, the roadbed passed over the top of the Pennington Formation. The Pennington consists primarily of red and green shale with thin beds of sandstone, siltstone, limestone, and dolomite. The shale members of the formation are often found in areas where slope movement has occurred. During the week of August 5, 1985, heavy rains saturated the Chattanooga area and on Friday, August 9, a 400-foot section of the highway collapsed. Contributing to the collapse was the fact that the State Highway Department had begun work to relocate that portion of the highway and in the process had removed numerous rocks in the bed up Suck Creek. It was these rocks which were in part responsible for the stabilization of the slope and when the support was removed, the slope failure resulted.

Soil Erosion and Sedimentation Problems in Reelfoot Creek Watershed, HSIANG-TE KUNG, Memphis State University.

Reelfoot Lake in northwestern Tennessee is rapidly filling with sediments mainly supplied from its largest drainage basin—Reelfoot Creek Watershed. If measures are not taken to reduce the erosion and sedimentation problems of the soil in the basin, the lake will become a marsh or swamp within fifty years. A correlation or ratio between soil loss and sedimentation will be developed from this study to better understand the water quality problems in Reelfoot Lake and West Tennessee. Hence watershed characteristics of Reelfoot Creek Basin such as slope distribution, land use, erosional potential, critical erosion areas, conservation practices, and drainage network will be analyzed and the results will be used to correlate with collected stream water quality samples. The results shall facilitate better watershed management and help maintain Reelfoot Lake as one of the most scenic resort areas in West Tennessee.

Medium and Small Springs in Williamson County, KEITH E. OWENS AND D.M.S. BHATIA, Austin Peay State University.

Eighty-nine perennial springs were located and studied, of which ten were medium and seventy-nine were small in size. Their classification is based on an estimation of water flow. The use of the spring water varies from municipal water supply to domestic to agricultural use. In addition to being useful, some of the springs have colorful histories, such as: homesteads (Horn-tavern, Aunt Sally), hangings (Dixie), and stills (Blowing). Correlating the location of these springs with the geological maps, it appears that of the small springs forty-seven emanate from the Fort Payne Formation, and the rest in the Ordovician. Of the medium springs, five springs emanate from the Fort Payne Formation, and the remaining five in the Ordovician.

Influence of Isostatic Adjustment to Erosion on Structure of the Nashville Dome, A. L. REESMAN AND R.G. STEARNS, Vanderbilt University.

The structural Nashville Dome and the topographic Central Basin of Tennessee appear to be essentially cogenetic features. The basin is developing in response to different rates of denudation and the dome in response to

isostatic adjustment of the eroding terrain. The Chattanooga Shale, the most common datum used to show the structure of the dome, was adjusted theoretically by loading of missing pre-Chattanooga strata over the dome and unloading of post-Chattanooga rocks on the rims and assuming that isostasy responded to adjust the hypothetical Chattanooga surface. Adjustments, averaged within 4-mile blocks, showed a small anticlinal structure. All evidence for a pre-existing structure is removed using a 28-mile (7, 4-mile blocks) moving average of individual block adjustment. Applying the same technique, the present surface topography produces a curve that mimics the isostatically adjusted Chattanooga. Both curves resemble exponential growth with the low, flat section on the western rim and the steeper, higher section to the east. Higher denudation rates on the limestones of the Central Basin (> 40 m/my) compared to the post-Chattanooga Fort Payne Formation (around 10 m/my) suggest that both the basin and dome are young and are developing together. The dome will steepen, enlarge, and migrate eastward because both the present elevations and the potential for isostatic adjustments are greater to the east.

Some Taxonomic Problems Posed by Large Mississippian Cephalopods, C. RANDALL JACKSON AND JAMES X. CORGAN, Austin Peay State University.

Large Mississippian cephalopods, referable to the genus *Tylosidoceras* Miller and Collinson, 1950, have been reported from four localities in Kentucky and Tennessee. There are no other recorded occurrences of the genus. Each discovery of *Tylosidoceras* is a single certified individual found in soil developed from limestone beds that lie near the contact between the St. Genevieve and St. Louis formations. Two nominal species have been described, *Tylosidoceras unicum* Miller and Collinson, 1950, and *Tylosidoceras nosowi* Collinson, 1956. They differ in the prominence of major sculptural features, such as nodes and furrows. A fifth occurrence of *Tylosidoceras* is here reported. The site, in northwest Montgomery County, Tennessee, is in the same stratigraphic position as other finds. It is less than a mile from the type locality of *T. nosowi*. The new specimen shows a blend of characters once thought to distinguish *T. nosowi* from *T. unicum*. This suggests that the genus needs revision. Revision is made complex by legalistic problems, such as the apparent loss of the holotype of *T. unicum*. Currently, arrangements are being made to examine all described specimens of *Tylosidoceras*, revise the genus, and designate a lectotype for *T. unicum* if necessary.

Unique Mn Distribution in Deep Marine Dolomites, DAVID N. LUMSDEN AND ROGER V. LLOYD, Memphis State University.

Electron Spin Resonance investigations of the partitioning of trace quantities of Mn(II) into the Mg and Ca sites in dolomite ($\text{CaMg}(\text{CO}_3)_2$) suggests that the distribution is not random. Analysis of a suite of 30 Phanerozoic sedimentary dolostones, a suite of 30 metamorphic dolostones, and a suite of 30 deep marine dolomites, suggests that the deep marine dolomites have a unique Mn(II) partitioning. Specifically deep marine dolomite patterns commonly have broadened peaks and in the few cases where quantitative data can be obtained their Mn(II) partitioning ratios are less than one. This contrasts with spectra from crystalline dolostones where patterns are usually sharp and partitioning ratios range from 5 to 250.

Center Pivot Irrigation in Tennessee, BYRON J. WEBB, Austin Peay State University.

Irrigation of farmland in the United States, historically, has been practiced preponderantly in the arid West. In recent years, however, irrigation in the more humid eastern states has become increasingly important. The acreage irrigated in Tennessee has tripled during the past decade. Much of the latest expansion of irrigation in Tennessee has been provided by center pivot systems. The highly mechanized center pivot system has been utilized by adopting farmers within the state as a production tool for increasing yields over those which can be achieved under normal rainfall conditions, as well as insurance against yield declines in the event of drought. There are about fifty center pivot systems irrigating approximately one-fourth of all irrigated land in Tennessee. At least three-fourths of the total number of systems and acreage so irrigated is found in west Tennessee. Both wells and surface sources, primarily rivers, provide water. Corn, soybeans, and vegetables are the leading crops being watered by center pivot. The most important constraint presently on further expansion of the center pivot in Tennessee is the depressed farm economy. A long-term limiting factor on its expansion, however, could be inadequate water supplies.

MATHEMATICS AND COMPUTER SCIENCES SECTION

DAVID E. FIELDS, *Presiding*

Extension of a Mathematical Model of Radioiodine Dose to the Thyroid

to Age- and Sex-Dependent Data, GEORGE G. KILLOUGH AND KEITH F. ECKERMAN, Oak Ridge National Laboratory.

This paper describes the derivation of an age- and sex-dependent model of radioiodine dosimetry in the thyroid and the application of the model to estimating the thyroid dose for each of 4215 patients who were exposed to ^{131}I in diagnostic and therapeutic procedures. In most cases, the data available consisted of the patient's age at the time of administration, the patient's sex, the quantity of activity administered, the clinically-determined uptake of radioiodine by the thyroid, and the time after administration at which the uptake was determined. The model was made to conform to these data requirements by the use of age-specific estimates of the biological half-time of iodine in the thyroid and an age- and sex-dependent representation of the mass of the thyroid. Also, it was assumed that the thyroid burden was maximum at 24 hours after administration (the ^{131}I dose is not critically sensitive to this assumption). The metabolic model is of the form $A(t) = K[\exp(-\mu_1 t) - \exp(-\mu_2 t)] (\mu\text{Ci})$, where $\mu_i = \lambda_i + \lambda_i^b$, $i = 1, 2$, λ_i is the radiological decay-rate coefficient, and λ_i^b are biological removal rate coefficients. The values of λ_i^b are determined by solving a nonlinear equation that depends on assumptions about the time of maximum uptake and the eventual biological loss rate (through which age dependence enters). The value of K may then be calculated from knowledge of the uptake at a particular time. The dosimetric S-factor ($\text{rad}/\mu\text{Ci}\cdot\text{day}$) is based on specific absorbed fractions for photons of energy ranging from 0.01 to 4.0 MeV for thyroid masses from 1.29 to 19.6g; the functional form of the S-factor also involves the thyroid mass explicitly, through which the dependence on age and sex enters. An analysis of sensitivity of the model to uncertainties in the thyroid mass and the biological removal rate for several age groups is reported. This model could prove useful in the dosimetry of very short-lived radioiodines. Tables of age- and sex-dependent coefficients are provided to enable readers to make their own calculations. Research sponsored by the U.S. Food and Drug Administration under Interagency Agreement FDA 224-84-6014 under Martin Marietta Energy Systems, Inc, contract DE-AC05-84OR21400 with the U.S. Department of Energy.

Applications of Symbolic Mathematics on a Personal Computer, JONAS T. HOLDEMAN JR., Oak Ridge National Laboratory.

Microsoft markets a symbolic mathematics software product for personal computers called muMATH, which resembles Matlab and Macsyma available on computer mainframes. muMATH can manipulate algebraic expressions, perform differentiation, definite and indefinite integration of a limited class of mathematical functions, solve sets of linear equations, and solve ordinary differential equations, all in symbolic form. Use of muMATH can reduce a task which may involve several hours or days of tedious algebraic manipulations to a few minutes on a personal computer. Application of muMATH to the construction of a class of finite elements for fluid flow will be discussed.

Tutorial on Graphical Kernel System (GKS), ANTHONY Z. COLE, East Tennessee State University.

The design of the standard comes from a Workshop on Graphics Standards Methodology held in May 1976 in Seillac, France. The Graphical Kernel System (GKS) furnishes a set of subprograms for computer graphics programming. This standard provides a high level vocabulary for graphics. It also provides hardware independence and portability, even on an international scale. The GKS system is useful in the fields of science, engineering, business, and education. Concepts, Workstations, Graphical Output, Coordinate Systems, Segments, Styles of Interaction, Metafiles, and examples of some of these concepts were discussed in the presentation.

Computerized Recording of Joint Spatial and Radiological Data During Field Surveys, M. GUVEN YALCINTAS AND DAVID E. FIELDS, Oak Ridge National Laboratory.

Radiological survey activities are being handled routinely by the Radiological Survey Activities Group (RASA) at Oak Ridge National Laboratory (ORNL) for the Uranium Mill Tailings Remedial Action Program (UM-TRAP) and the Formerly Utilized Sites Remedial Action Program (FUSRAP). One of the major problems in conducting field surveys is the recording of the joint spatial and radiological data. A feasibility study has been completed to determine that information on the location of the surveyor can be obtained by means of ultrasound detectors and the radiological information for that location can be transmitted by radio to a sensing unit located in a nearby vehicle. The vehicle unit would receive the transmitted data and store this information in digital format. The mobile unit positioning and surveying systems, as well as the software to handle the data and the method of interface will be described. Application of the system and the benefits for the radiological survey procedures will be discussed. This Research was sponsored by the office of Nuclear Energy, U.S. Department of Energy, under Contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

Estimation of Sodium Aerosol Concentrations During Breeder Reactor Fires, D. E. FIELDS AND C. W. MILLER, Oak Ridge National Laboratory.

The authors devised and applied a methodology for estimating the concentration of aerosols released at building surfaces and monitored at other building surface points. A proprietary reactor design was obtained, and the site was parameterized using architectural blueprints. These site parameters serve as inputs to the methodology. Results of our calculations suggest that, in general, buildings can be designed so that aerosol concentrations will be below what is thought to be a level of concern. This methodology has been documented in report form, and has been extended to consider density-driven plume rise in the absence of an initial upward momentum. This extension is necessary to permit defensible consideration of the effects of releases through horizontal-emission exhaust ports and of the effects of different rain cap designs on aerosol concentrations at air intake ports. The extended approach permits estimates to be made of the height of a horizontally-emitted aerosol plume directed into winds of various velocities. The extended methodology also permits calculation of the elapsed time between emission of aerosols, either in a vertical or horizontal direction, and a change in aerosol concentration at a receptor point.

MEDICAL SCIENCES SECTION

R. DEAN BLEVINS, *Presiding*

The Size of Secreted Proteins in Cystic Fibrosis, D.H. WAGNER, AND J.K. HERD, East Tennessee State University.

Cystic Fibrosis (C.F.) is one of the most common inherited fatal diseases affecting caucasian children. Though first described as a separate disease in 1938, its fundamental biochemical lesion is not yet known. We postulate that the lesion is an abnormality in the cellular secretion mechanism, specifically a deficiency of signal peptidase activity. The primary consequence of such a deficiency would be the secretion of proteins with the amino terminal signal peptide (leader sequence) still covalently attached. We are examining this hypothesis by studying the size of a single protein α -L-Iduronidase, in secretions of C.F. fibroblasts. Iduronidase will be immunoprecipitated from medium conditioned by confluent C.F. fibroblasts labelled 1-3 days with ^3H -leucine. The size of ^3H -Iduronidase will then be determined by radiofluorography of SDS-polyacrylamide gels following electrophoresis. Molecular weight standards and ^3H -Iduronidase similarly immunoprecipitated from the medium of normal cells will be co-electrophoresed as controls.

Current Primitive Medicine in the Amazon Basin, D. I. PAV AND J. L. ROBERTSON, East Tennessee State University.

During a biological expedition to Ecuador in December 1984, visits were made to major tribes of the Ecuadorian Amazon basin, and their healing practices were recorded. Four groups, prominent in the healing arts and with at least part of their population still living in the jungle, were studied intensively: Jivaro, Quetchua, Colorado and Auca. Until recently, traditional Western medicine had little use for primitive healing practices. It was, therefore, noted with some surprise that there was an interchange of patients between the traditional and primitive physicians. White jungle settlers, Ecuador's city dwellers, North Americans and Europeans were among the patients of native healers, while some jungle tribes received vaccinations and malaria treatment in the regional medical centers. Slides of jungle habitat, jungle physicians and actual specific treatments are included in this presentation.

Fate of Mutagenic Chemicals in Laboratory Columns of Waveland Fine Sand Treated with Municipal Wastewater Sludge, R. D. BLEVINS, L. A. BRENNAN, AND O. C. PANCORBO, East Tennessee State University.

Several aerobically digested municipal wastewater sludges were Soxhlet extracted and the extracts examined for mutagenic potential using the Ames *Salmonella*/mammalian microsomal mutagenicity assay. The sludge from one wastewater treatment plant (Tennessee) was consistently mutagenic (i.e., dose-related response, with at least one dose producing a doubling in the number of revertants) using tester strain TA98 with metabolic activation. When a Soxhlet extract of this sludge in a hexane-acetone mixture was applied to laboratory columns (21 cm) of Waveland fine sand (Florida), and then leached with natural rainwater, mutagenic activity (all results obtained with TA98 with metabolic activation) was observed in the 5-6th pore volumes of column leachates extracted at acidic pH; weak mutagenic potential was also observed in the top 7 cm of soil following Soxhlet extraction. When the known mutagen, 2-aminoanthracene (2 μg), was spiked in the sludge extract, and subsequently applied to the columns and leached with rainwater, marked mutagenic activity was detected within the first 4 pore volumes of leachate and was found associated with soil in the 8 to 14-cm depth of the column. Finally, unfractionated sludge was applied to soil columns and then leached with 10 pore volumes of rainwater. Significant mutagenicity was observed in the first 2 pore volumes and was asso-

ciated with the top of 7 cm of soil. Although mutagens can be retained in sludge-treated soils, these results indicate significant migration of these chemicals following leaching with rainwater.

Mutagenic Activity Associated with an Isothiazolinone Biocide Used in Cooling Towers, G. M. WOODALL, O. C. PANCORBO, R. D. BLEVINS, AND K. FERSLEW, East Tennessee State University.

Cooling tower waters were screened for mutagenic potential using the Ames *Salmonella*/mammalian microsomal mutagenicity assay. Separation of organic compounds from cooling tower water samples was achieved using liquid-liquid extraction with methylene chloride at both basic and acidic pHs. Several doses of extract concentrates in dimethyl sulfoxide were screened for mutagenic activity in the Ames assay. Notable mutagenic activity was observed in water extracts from a hospital cooling tower following the treatment of the tower with an isothiazolinone biocide. The suspected mutagen, 5-chloro-2-methyl-4-isothiazolin-3-one, was quantified, using capillary gas chromatography-mass spectrometry, in extracts of subsequent water samples obtained from this tower shortly after treatment with this biocide. These water extracts, as well as the actual commercial formulation containing the isothiazolinones, were mutagenic with tester strains TA97 and TA100, without metabolic activation, but were not mutagenic with strain TA98. Tester strain TA97 was more sensitive than TA100 in detecting the mutagenic potential of this biocide, which is also used as a preservative in cosmetics and shampoos.

Lectins, J. HOWARD TRULL, Freed-Hardeman College.

Lectins are generally defined as plant extracts with the ability to agglutinate red blood cells. Though a few lectins have been isolated from animal tissues, the bulk of lectin research has been limited to the use of seed extracts. This work deals with lectin-like agglutination responses from tissue extracts other than from seeds. Since seeds contain embryonic tissue, it was assumed that perhaps other embryonic tissue extracts might give similar reactions. Insect galls on plants proved to be a fertile area of research in the isolation of lectins. The majority of insect galls tested proved to contain lectins. Purified biochemicals were also tested for lectin-like agglutination reactions. Dipeptides and histones both gave positive agglutination results with human erythrocytes.

SCIENCE AND MATH TEACHERS SECTION

JOHN R. FREEMAN, *Presiding*

The Effect of High School Science Background On Student Performance in a Required College Science Course, SARAH F. BARLOW, Middle Tennessee State University.

The purpose of this study was to determine the effect of high school science background on student performance in a university required general education science course (Biology 100). Students enrolled in Biology 100 were arbitrarily divided into three groups based on the number of high school science courses completed (one, two, three or more courses). A comparison of the mean numerical test averages (0-100) of the three treatment groups indicated differences which, through an analysis of variance, were demonstrated to be significant. It is concluded that for students in Biology 100, an increasing number of science courses completed in high school is significantly related to higher achievement in the college course.

Dolphins' Cognitive Abilities, L. DIANNA HOLCOMB, The University of Tennessee at Chattanooga.

The ability of two bottlenosed dolphins (*Tursiops truncatus*) to understand imperative sentences expressed in artificial languages was studied. One dolphin (Phoenix) was tutored in an acoustic language whose words were computer-generated sounds presented through an underwater speaker. The second dolphin (Akeakamai) was tutored in a visually-based language whose words were gestures of a trainer's arms and hands. The words represented agents, objects, object modifiers, and actions. These were recombinable, according to a set of syntactic rules, into hundreds of uniquely meaningful sentences from two to five words in length. The sentences instructed the dolphins to carry out named actions relative to named objects and named modifiers. Comprehension, at levels far above chance, was shown for all of the sentence forms and sentence meanings that could be generated by the lexicon and the set of syntactic rules. Dr. Louis M. Herman, University of Hawaii, is the founder of this research.

Environmental Analysis of Science Textbooks, A. P. WISHART, The University of Tennessee, Knoxville.

An environmental education textbook analysis has been made for the leading science textbooks used by Tennessee teachers since 1968. Comparisons have been tabulated for selected units and topics included in each of

the science texts. A textbook analysis scale has been developed by the author for the areas of biological science, earth science, chemistry and physics. All texts were examined for topics considered significant by the Environmental Protection Agency and by selected professional and environmental organizations. Changes in the "content" emphasis of selected topics have been described and tabulated for the science textbooks since the study was initiated.

The Pioneer Laserdisk as a Visual Aid, ROY W. CLARK, Middle Tennessee State University.

Laserdisks will someday replace the old clacking 35 mm slide projector and also the incredibly noisy film projector. Absolutely silent in operation, except for intended audio, the laserdisk player is every teacher's dream of a visual aid. The capabilities of a Pioneer Laserdisk will be demonstrated and some of the searching techniques discussed. There are disadvantages, too, and these will be given equal time. It seems probable that in the very near future recording will be possible as on VCRs.

ZOOLOGY SECTION

MARION R. WELLS, *Presiding*

Precocious Metamorphosis in Xenopus laevis: Mechanism of Action of Acetone, R. BELSER AND JAMES A. ADAMS, Tennessee State University.

Previous studies have shown that reagent grade acetone is a potent inducer of metamorphosis in amphibian larvae. This study specifically looks at the applicability of this phenomenon to the African clawed toad, *Xenopus laevis*, and the mechanism of action of acetone. Larvae were exposed to 50 mg l⁻¹ and 10 mg l⁻¹ acetone in artificial pond water (APW), 22 mg l⁻¹ dimethyl sulfoxide (DMSO) in APW, 600 mg l⁻¹ thiourea in APW, 600 mg l⁻¹ thiourea/50 mg l⁻¹ acetone in APW, and APW alone for controls. The investigation was conducted over a period of 125 days. As previously demonstrated with *Acris gryllus*, larvae exposed to 50 mg l⁻¹ acetone completed metamorphosis faster than those in other groups. However those larvae exposed to the small concentration of acetone always showed signs of metamorphosis sooner than those in the higher concentration. Unlike the results of earlier studies, those larvae exposed to DMSO completed metamorphosis before those exposed to 10 mg l⁻¹ acetone. Those exposed to thiourea and thiourea/acetone did not show early signs of metamorphosis. The control groups showed much faster metamorphosis than either of the thiourea exposed groups. This study supported by NIH - DRR Grant # S06 RR08092 - 12.

A New Species of Leiobunum C. L. Koch (Phalangida:Arachnida) from North Carolina, CHARLES R. MCGHEE, Middle Tennessee State University.

Through the courtesy of Dr. Richard L. Hoffman of Radford College and Dr. Perry C. Holt of Virginia Polytechnic Institute and State University I have received specimens of a new phalangid species belonging to the genus *Leiobunum* C. L. Koch. The male holotype and female allotype were collected in Macon County, North Carolina near the community of Highlands. Morphological characteristics place this species close to *Leiobunum calcar* (Wood) and several other taxa of the species group. Little has been reported on the phalangid fauna of southwestern North Carolina, but available data indicates that this species range may be limited to a small geographic area of the southern Appalachian mountains.

Sexual Dimorphism in Upper Canine Width of the Raccoon (Procyon lotor), MARK E. RITKE AND MICHAEL L. KENNEDY, Memphis State University.

Sexual dimorphism in width of the upper canine was assessed in the raccoon (*Procyon lotor*). Upper canine width and total skull length were recorded from 1,670 male and 1,474 female raccoons. Specimens were examined from throughout North and Central America. Skull length (a measure of skull size) explained 40.6% and 49.0% of the variation in canine width for males and females, respectively. Regression analysis indicated that males had wider canines than would be predicted from skull length using the female regression equation. Thus, selection for increased canine width could be stronger for males than for females. Possibly, selection for wider canine teeth in males is related to intrasexual combat.

Artificially Induced Metamorphosis in the Cricket Frog (Acris gryllus), S. POLLARD, JR. AND J. A. ADAMS, Tennessee State University.

The causative agents (hormones) involved in amphibian metamorphosis have been well established for decades, as well as the specific endocrine organs involved. Tri-iodothyronine and thyroxine, both secretions of the larval thyroid gland, are directly responsible for metamorphosis under physiological conditions. High amounts of the element iodine (approximately 300 times the amount found in equally effective levels of thyroxine) can also induce metamorphosis in amphibians. In our search for an appropriate

emulsifier to be employed in studying the effects of the hydrophobic polychlorinated biphenyls (PCB's) on metamorphosis, we found reagent grade acetone (a commonly used carrier molecule for PCB's) to be a potent inducer of metamorphosis in our test animal, *Acris gryllus*. The acetone was employed as a component of an artificial pond water (APW) medium. Other test conditions included exposure to thyroxin and dimethyl sulfoxide (DMSO) for comparison. Not only was metamorphosis significantly faster in acetone-treated animals, but the effect proved to be concentration dependent when acetone levels of 10 mg l⁻¹ and 50 mg l⁻¹ were compared. The 50 mg l⁻¹ acetone-treated group showed precocious metamorphosis at a rate not significantly different from that produced by thyroxin. DMSO exposure did not lead to significantly faster metamorphosis. This study supported by NIH-DRR Grant #S06 RR08092-10.

Evidence of Serotonin in the Abdominal Ganglia of the Horseshoe Crab, *J. KERR, B. WASHINGTON, AND R. F. NEWKIRK, Tennessee State University.

Serotonin (5-HT) plays an important role in the regulatory mechanisms of invertebrates. Its presence has been demonstrated in the nervous tissues of several arthropods. Serotonin has also been shown to have neuroregulatory effects. The authors demonstrated the presence of 5-HT in homogenates prepared from the abdominal ganglia of the horseshoe crab, and analyzed extracts of the homogenates using high performance liquid chromatography (HPLC). The data indicate the presence of serotonin. In addition techniques of immunohistochemistry were used to determine serotonin localization. Fixed abdominal ganglia were cryostat sectioned and reacted with an antiserum against serotonin. The antibody complex was visualized using an indirect method. The results showed specific antiserotonin-like immunoreactivity in each ganglion. Fiber-like structures were seen rather extensively in the neuropil, while only a few cell bodies were apparent in a ganglion. These results suggest the presence of 5-HT containing neurons in horseshoe crab central nervous system tissue and support the contention that it may be a neurotransmitter in this animal. (Supported by NIH Grant #S06 RR 08092-11)

Density Estimates of the Opossum, Didelphis virginiana, in Western Tennessee, FLOYD W. WECKERLY, PAUL L. LEBERG, AND MICHAEL L. KENNEDY Memphis State University.

Using trapping procedures, population density of the opossum (*Didelphis virginiana*) was studied at five sites in western Tennessee. Density estimates were assessed in relation to 16 habitat variables. Population densities ranged from one opossum per 11.9 ha to one per 111.7 ha. Distance to permanent water had the highest correlation ($r = -0.89$) with density and was statistically significant at $P = 0.02$. Other habitat variables studied were not significantly correlated with density values. Results of this study quantify associations of selected habitat variables with *D. virginiana* abundance. Additionally, they support previous studies that report higher opossum densities in wetter habitats and which, in general, indicate a wide range of ecologic tolerances for the species.

Influence of Environmental Factors on Activity Patterns of Fox Squirrels in North Dakota, JOHN P. NELSON JR., Memphis State University.

A study relating to the effect of environmental factors on the activity patterns of fox squirrels (*Sciurus niger*) was conducted at Sully's Hill National Game Preserve, Benson Co., North Dakota. A measurement of activity was obtained by counting the number of squirrels seen during a 30-minute period. Meteorological data were recorded for each period. Significant correlations were found between activity and temperature, wind direction, and hour after sunrise. Environmental factors influencing activity were consistent across all seasons. Activity patterns of fox squirrels in North Dakota were not found to differ greatly from those reported for other parts of the species' current range.

Field Identification of Coyotes and Domestic Dogs, DERRICK W. SUGG,* CHARLES LYDEARD,* AND MICHAEL L. KENNEDY, Memphis State University.

Field identification of coyotes (*Canis latrans*) and domestic dogs (*C. familiaris*) was assessed using two skull characters (greatest length of the upper molar tooththrow divided by the least distance between the alveoli of P1). These characters were found to differentiate the two taxa with a relatively high level of accuracy. If the molar tooththrow was 3.1 or more times the distance between the alveoli of P1, the specimen was a coyote. If this ratio was less than 2.7, it was a dog. External characters can be used to support identifications determined by cranial characters.

Population Characteristics of the Coyote (Canis latrans) in Tennessee, CHARLES LYDEARD,* ROBERT M. LEE, III,* AND MICHAEL L. KENNEDY, Memphis State University.

To determine selected population characteristics of the coyote (*Canis latrans*) in Tennessee, 425 specimens were examined from 38 counties.

Animals were collected primarily by hunters and trappers over a 10 year period (1975-1985). Results indicated that the species is statewide in distribution. Males had an average weight of 14.1 kg and females 11.4 kg. The sex ratio was 1:1, and the average litter size was 5.8 per female. Seventy-nine percent of the specimens examined were 1-3 years of age.

Movement and Habitat Usage of the Bobcat (Felis rufus) in Arkansas, RICHARD A. RUCKER,* Memphis State University.

The bobcat (*Felis rufus*) was studied in the Ouachita National Forest of western Arkansas from 1982 to 1984. Movement rates and habitat usage were assessed for eight animals using radio-telemetry techniques. A mean movement rate (based on 15 minute intervals) of 2.20 km/hr was recorded. Bobcats exhibited significant ($P < 0.005$) habitat selection with a preference for areas in regeneration.

A Survey of Gastrointestinal Helminth Parasites from White-Tailed Deer, Odocoileus virginianus, From Coffee County, Tennessee, M. KHALILI* AND M. C. DUNN, Middle Tennessee State University.

From January until June, 1985, a survey was taken of the gastrointestinal helminths infesting 50 white-tailed deer, *Odocoileus virginianus*, in Coffee County, Tennessee. Seven species of helminths and one immature nematode were found, including two new host records from Tennessee. These are:

Gongylonema pulchrum from the esophagus; *Ostertagia mossi*, *O. dikmansii*, *Haemonchus contortus*, and *Apteragia odocoilei* from the abomasum; *Moniezia spp.* and one immature nematode from the small intestine; and *Trichuris odocoileus* from the rectum. Helminths parasitized 92 percent of the deer.

The Breeding and Migratory Behavior of Two Species of Ambystoma, GEORGE M. MCGOVERN, Tennessee Technological University.

Breeding and migratory behavior of sympatric populations of *Ambystoma opacum* and *Ambystoma maculatum* was studied in Putnam County, TN. These salamanders were captured at various times using the drift fence method. Each individual was marked, measured, identified for sex, and released. Weather data, mark-recapture data, capture trap number, vertical and horizontal movement, length/weight relationship, and sex ratios were recorded. In the fall of 1983, *A. opacum* adults were abundant as they migrated toward a flooded forest breeding area. This trend was reversed in early spring of 1984 when large numbers of *A. maculatum* were captured moving toward the breeding area. Rain and daily minimum temperature appeared to be the major environmental stimuli that initiated migratory movement in both species. Daily maximum temperature played a less significant role.

JOURNAL OF THE TENNESSEE ACADEMY OF SCIENCE

VOLUME 61, NUMBER 2, APRIL, 1986

ADDITIONAL NOTES ON THE TAXONOMIC STATUS OF THE COYOTE (*CANIS LATRANS*) TENNESSEE

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ABSTRACT

In order to determine the taxonomic status of the coyote (*Canis latrans*) in Tennessee, 179 wild canid skulls of unknown taxonomic status were compared to known skulls of coyotes (*C. latrans*), dogs (*C. familiaris*), and red wolves (*C. rufus*). Twenty-one cranial measurements and four derived ratios were employed in a discriminant function analysis. Tennessee canids clustered distinctly with coyotes and were statistically separable from known dog and red wolf groups. Hybridization between canid taxa was found to be minimal. The wild canid presently occurring in Tennessee is best referred to as coyote, *C. latrans*.

INTRODUCTION

The coyote (*Canis latrans*) has been the subject of many investigations. Bekoff (1977) summarized much of the available literature concerning the species. Due to its recent expansion into the southeastern United States, *C. latrans* is an interesting model for ecological and systematic studies. The taxonomic status of this species in the southeastern United States has been somewhat uncertain. The coyote-like animals could represent coyotes or hybrids with other canids. Gipson et al. (1974), Elder and Hayden (1977), and Freeman (1976) have investigated the species taxonomically in Arkansas, Missouri, and Oklahoma, respectively. Additionally, Smith and Kennedy (1983) summarized the status of coyotes in Tennessee; however, new specimens have since become available for examination. These specimens are wild canids from counties which were not examined by Smith and Kennedy (1983) as well as additional specimens from counties included in their examination. Specimens from new counties represent animals from different habitats sampled by Smith and Kennedy (1983). Since only 61 canids from Tennessee were available

to Smith and Kennedy (1983), and since there is a growing interest in the coyote, there is a need for detailed study of the taxonomic status of *C. latrans* in the state. The purpose of this study was to further examine the taxonomic status of *C. latrans* in Tennessee.

MATERIALS AND METHODS

We recorded 21 skull measurements (Fig. 1) from adult canids as follows: 100 male, 79 female Tennessee canids (coyote-like); 88 male, 75 female known coyotes (knowns for all groups refer to individuals of verified taxonomic status); 78 male, 77 female known red wolves (*C. rufus*); 33 known dogs (*C. familiaris*)—since preliminary analysis showed no sexual dimorphism in this group, sexes were combined for the dogs in all analyses in order to increase sample sizes). Nowak (1979) considered the gray wolf (*C. lupus*) to have been extirpated south of the St. Lawrence River (northeastern United States and southern Canada) since the end of the 19th century. Thus, the gray wolf was not included in this study. Characters were chosen to include measurements that could be repeated with accuracy and those shown useful in previous canid studies (Nowak, 1979; Smith and Kennedy, 1983; and others). Measurements A, B, E, Q, R, S, and T (Fig. 1) were taken using an English dial height gauge to the nearest 0.01 inch. All other measurements were taken with dial calipers to the nearest 0.1 mm. Adult specimens (those over one year) were determined according to the criteria of Nellis et al. (1978). All known *C. latrans* (163 individuals), 154 *C. rufus*, seven *C. familiaris*, and three unknown Tennessee canids were examined at the United States Natural History Museum. The remainder of the unknown Tennessee canids (176) and *C. familiaris* (22) were examined at the Memphis State University Museum of Zoology. Four additional *C.*

familiaris and one *C. rufus* were examined at the University of Florida and Louisiana State University, respectively. Tennessee counties from which specimens were examined and sample sizes were as follows (males given first): Benton—6, 7; Carroll—1, 2; Chester—1, 0; Clay—1, 0; Crockett—0, 1; Davidson—1, 0; Dyer—1, 0; Fayette—9, 7; Franklin—1, 0; Gibson—2, 1; Hardeman—17, 16; Haywood—9, 2; Henderson—0, 1; Henry—2, 0; Lauderdale—6, 1; Lawrence—1, 0; Madison—2, 2; Maury—0, 1; McNairy—1, 4; Montgomery—1, 1; Obion—2, 2; Perry—1, 1; Robertson—1, 1; Shelby—18, 13; Stewart—1, 0; Tipton—8, 12; Weakley—1, 0; Williamson—0, 1; Wilson—1, 0. Five additional males and 3 additional females were western Tennessee specimens (counties unknown).

Linear discrimination function analysis was used to determine the taxonomic status of the unknown Tennessee canids. Step-wise discriminant function analysis was used in order to eliminate less useful characters. Biometric routines were carried out with the Statistical Package for the Social Sciences (SPSS) of Nie et al. (1975).

RESULTS

Using combined sexes for coyote, dog, and red wolf groups as knowns and Tennessee canids as unknowns (= Test 1) in a discriminant function analysis, 18 characters were found in combination to be useful discriminators (Table 1). For the first function, characters Q, R, A, and F had the highest discriminant function coefficients. Character J was found to have the highest correlation ($r = -0.78$), but it was excluded in the step-wise analysis. Characters H, E, and Y had the highest correlations for function 2 (Table 1). A plot of the discriminant scores for each animal is given as Figure 2. These results indicate that the known groups are different from each other (little overlap). Of the individuals in the three known groups, 98.6% were correctly classified (one specimen was classified as a red wolf). One-hundred fifty-two red wolves (98.1%) were correctly classified (three specimens were classified as coyotes). Ninety-seven percent of the dogs were correctly classified (one specimen was classified as a red wolf). Of the 179 unknown Tennessee canids, 86.6% (155) were classified as coyotes (22 specimens or 12.3% were classified as red wolves and two specimens or 1.1% as dogs). These two canonical functions accounted for 100.0% of the variability. Functions 1 and 2 had high canonical correlations ($r = 0.93$ and 0.89 , respectively) and were highly significant ($P < 0.001$).

When discriminant function analysis was applied using dogs, male coyotes, and male red wolves as knowns and male Tennessee canids as unknowns (= Test 2), 16 characters were found, in combination, to be useful discriminators (Table 1). For the first function, characters W, J, and E were the most heavily weighted characters based upon standardized discriminant function coefficients (Table 1). Characters Q, P, M, and S were the most heavily weighted for function 2. Character R was highly correlated ($r = -0.78$) but was excluded in the step-wise analysis. A plot for the discriminant scores for each animal is given in Figure 3A. Results showed distinct differences between groups. The percent of the grouped cases correctly classified was 97.5%. All the known male coyotes (88) were correctly classified. Seventy-four male red wolves (94.9%) were correctly classified (four specimens were classified as coyotes). Ninety-seven percent of the dogs were correctly classified

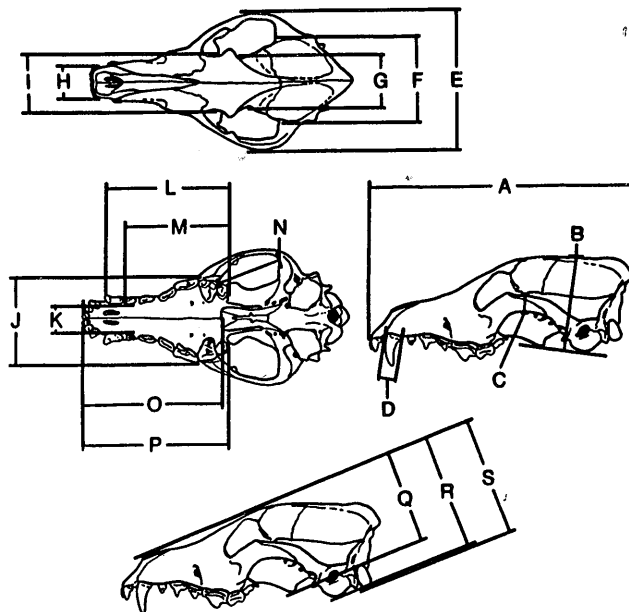


Fig. 1. Description of skull characters of *Canis latrans*. A, greatest skull length; B, cranial height; C, least zygomatic process-jugal height; D, canine diameter; E, zygomatic width; F, braincase width; G, posterior interorbital width; H, greatest width across I3 at alveoli; I, anterior interorbital width; J, width across P4s; K, width between alveoli of P1s; L, canine-M2 length; M, P1-M2 length; N, orbital length; O, premaxillary-palatine length; P, premaxillary-M2 length; Q, skull height at pterygoids; R, skull height at bullae; S, skull height at condyles; T (not shown), skull height at palatine (measurement obtained similar to Q-S and taken on the midline at the most posterior projection of the palatines); U (not shown), M2 width (greatest width upper molar two); V (not shown), width across P4s divided by least zygomatic process-jugal height; W (not shown), width across P4s divided by greatest width across I3 at alveoli; X (not shown), canine diameter divided by zygomatic width; Y (not shown), canine-M2 length divided by width across P4s.

(one specimen was classified as a coyote). Of the 100 unknown Tennessee male canids, 95.0% (95) were classified as coyotes, 3.0% (three) as red wolves, and 2.0% (two) as dogs. Functions 1 and 2 had high canonical correlations ($r = 0.94$ and 0.93 , respectively) and significant values ($P < 0.001$).

When discriminant function analysis was applied using dogs, female coyotes, and female red wolves as knowns and female Tennessee canids as unknowns (= Test 3), 15 characters were found in combination to be useful discriminators (Table 1). For the first function, characters S and Y were the most heavily weighted characters based upon standardized discriminant function coefficients (Table 1). Characters E, J, L, and P were the most heavily weighted for function 2. A plot for the discriminant scores for each animal is given as Figure 3B. Distinct differences were found between groups. The percent of the grouped cases correctly classified was 98.4%. All the known female coyotes (75) were correctly classified. Of the 77 known female red wolves, 98.7% (76) were correctly classified (one specimen was classified as a coyote). Thirty-one of the

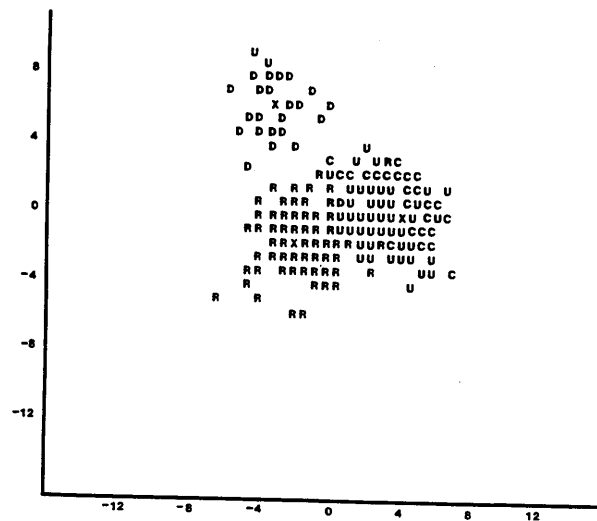


Fig. 2. A discriminant function analysis comparing dogs, coyotes, and red wolves as knowns, and Tennessee canids as unknowns. Both sexes combined. C = coyote; D = dog; R = red wolf; U = Unknown Tennessee canid.

dogs used (93.9%) were correctly classified (two individuals were classified as red wolves). Of the unknown Tennessee female canids, 94.9% (75) were classified as coyotes, and 5.1% (four) were classified as red wolves. Functions 1 and 2 had high canonical correlations ($r = 0.95$ and 0.94 , respectively) and significant values ($P < 0.001$). Thus, separating the sexes for the analyses increased the percent of unknown Tennessee canids into the coyote status from 86.6% (both sexes) to 95.0% (males) and 94.9% (females), respectively.

Using combined sexes of coyote and dog groups as knowns and Tennessee canids as unknowns in a discriminant function analysis (= Test 4), 16 characters were found in combination to be useful discriminators (Table 2). Characters S, P, O, and Q had the highest discriminant function coefficients (Table 2). A histogram of the discriminant scores for each animal is given as Figure 4A. These results indicate that the known groups are different from each other (little overlap). Of the individuals in the two known groups, 98.9% were correctly classified. Of the 163 known coyotes, 100.0% were correctly classified. Thirty-one dogs (93.9%) were correctly classified (two specimens were classified as coyotes). Of the 179 unknown Tennessee canids, 96.9% (173) were classified as coyotes, and 3.4% (six) were classified as dogs. There was a high canonical correlation ($r = 0.96$), and a high significant value ($P < 0.001$).

When discriminant function analysis was applied using dogs and male coyotes as knowns and Tennessee canids as unknowns (= Test 5), 13 characters were found in combination to be useful discriminators (Table 2). Characters H, A, M, and F were the most heavily weighted based upon standardized discriminant function coefficients (Table 2). A histogram for the discriminant scores for each animal is given in Figure 4B. Results showed distinct differences between known coyote and dog groups. The percent of grouped cases correctly classified was 99.2%. All the known male coyotes (88) were correctly classified. Ninety-seven percent of the dogs were correctly classified (one specimen was classified as a coyote). Of the 100 unknown Tennessee

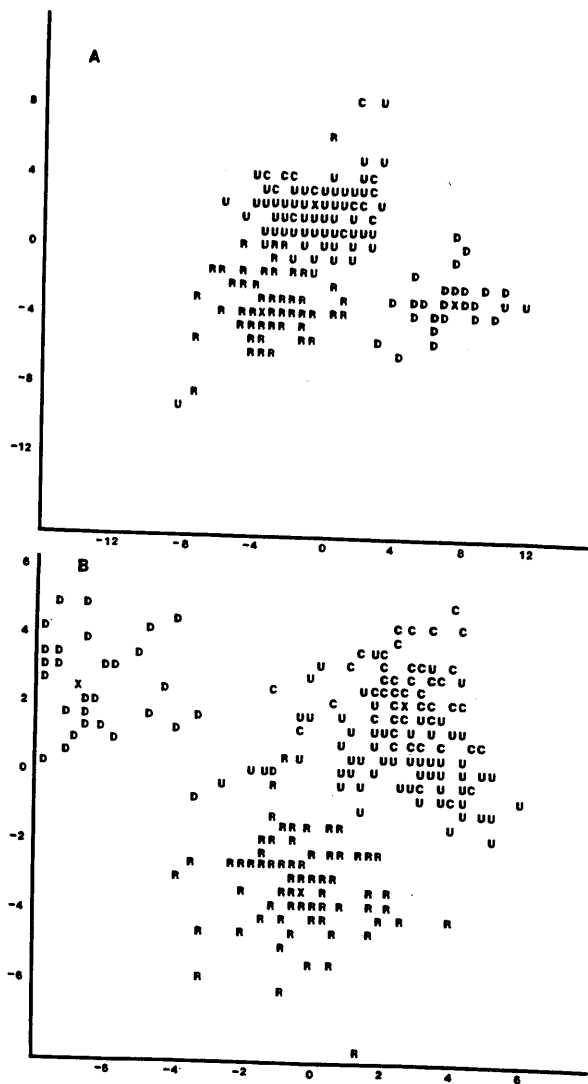


Fig. 3. (A) A discriminant function analysis comparing dogs, male coyotes, and male red wolves as knowns, and male Tennessee canids as unknowns. (B) A discriminant function analysis comparing dogs, female coyotes, and female red wolves as knowns, and female Tennessee canids as unknowns. C = coyote; D = dog; R = red wolf; U = Unknown Tennessee canid.

male canids, 98.0% (98) were classified as coyotes, and 2.0% were classified as dogs. There was a high canonical correlation ($r = 0.96$) and a significant value ($P < 0.001$).

When discriminant function analysis was applied using dogs and female coyotes as knowns and female Tennessee canids as unknowns (= Test 6), 14 characters were found in combination to be useful discriminators (Table 2). Characters K, F, O and B were the most heavily weighted characters based upon standardized discriminant coefficients (Table 2). A histogram for the discriminant scores for each animal is given in Figure 4C. Distinct differences were found between dog and known coyote groups. The percent of grouped cases correctly classified was 97.2%. All the known coyotes (75) were correctly classified. Thirty of the dogs used 90.9% were correctly classified (three individuals were classified as coyotes). Of the unknown Tennessee

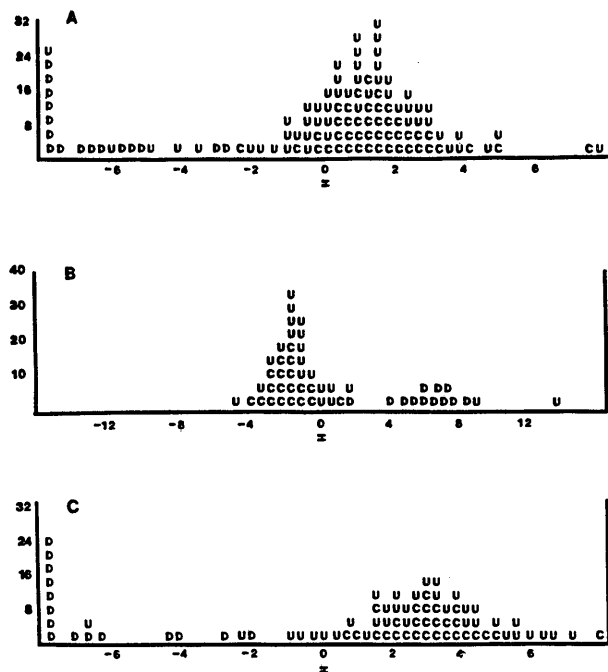


Fig. 4. A discriminant function analysis comparing dogs and coyotes as knowns, and Tennessee canids as unknowns. (A) Both sexes combined. (B) Known males (except the dogs, which were treated as one group, both sexes combined). (C) Known females (except the dogs, which were treated as one group, both sexes combined). C = coyote; D = dog; R = red wolf; U = Unknown Tennessee canid.

female canids, 97.5% (77) were classified as coyotes, and 2.5% (two) were classified as dogs. There was a high canonical correlation ($r = 0.98$) and a high significant value ($P < 0.001$).

DISCUSSION

Of the 21 measurements utilized in this study, 20 are known to be dimorphic (males larger than females for all characters) in the coyote (Kennedy et al., In press). Additionally, Polechla (1980) found male cranial measurements to be significantly larger than female in coyotes from New Mexico. Although our findings are comparable with similar studies that have grouped sexes (McCarley, 1962; Freeman, 1976; Elder and Hayden, 1977; Smith and Kennedy, 1983), it seems possible that pooling of sexes could lead to incorrect determinations of some individuals. Our results indicated an overall better separation of groups studied when sexes were treated separately.

In tests 1-6, several characters (J, K, L, M, Q, R, S, V, and Y) were shown to be useful discriminators. Characters K, Q, and S were found to be effective in the greatest number of test. Of these characters, J, K, L, and M were employed in similar studies (McCarley, 1962; Lawrence and Bossert, 1967; Gipson et al., 1974; Elder and Hayden, 1977; Mahan et al., 1978; Nowak, 1979; Smith and Kennedy, 1983).

Results of the present study show that Tennessee canids are statistically distinct from known dogs and red wolves but are not statistically distinct from coyotes. The wild canid presently occurring in Tennessee is best referred to as coyote (*C. latrans*). These findings agree with Smith and Kennedy (1983) for Tennessee and with previous studies (Gipson et al., 1974; Freeman, 1976; Elder and Hayden, 1977; Nowak, 1979) conducted in other southeastern states.

TABLE 1. Standardized canonical discriminant function coefficients with known *Canis latrans*, *C. familiaris*, and *C. rufus*, and Tennessee canids as unknowns.

Test 1 ^a			Test 2 ^b			Test 3 ^c		
Character	Function 1	Function 2	Character	Function 1	Function 2	Character	Function 1	Function 2
A	0.36797	-0.25877	A	-0.46946	0.22798	A	0.54981	0.27485
B	0.08512	-0.39481	B	-0.31407	0.00226	B	0.30966	-0.26995
E	0.14128	-0.64965	E	-0.72267	0.02299	D	-0.22021	0.09057
F	0.21861	-0.34914	F	-0.49526	0.12435	E	-0.47677	-0.70380
G	-0.03797	0.13869	G	0.31626	0.05160	F	0.42468	-0.21182
H	1.97140	0.86787	H	1.90726	3.47073	I	-0.32505	0.28112
I	0.14481	0.33269	J	-0.94670	3.01177	J	0.58676	2.79853
K	-0.13394	0.42934	K	0.44785	-0.18539	K	-0.32097	-0.45535
L	-2.45364	-1.17363	M	-0.50613	0.57657	L	-0.46133	-3.55823
M	0.41263	-0.16593	O	0.53267	0.00150	O	-0.62674	-0.19954
O	-0.10647	0.25152	P	-0.20502	-0.64983	P	0.47289	0.36649
Q	-0.39832	0.39481	Q	0.33979	-0.65422	Q	-0.58559	0.08898
R	-0.40460	-0.10052	S	0.33501	-0.34651	S	-0.73941	0.20654
S	-0.13301	0.59663	T	-0.35485	0.09096	U	0.44000	-0.11020
U	0.20215	-0.47898	U	-0.40841	0.08672	Y	0.87286	2.70292
W	1.43694	0.61573	V	-0.20112	0.01065			
X	0.04356	0.24733	W	0.95896	1.99366			
Y	2.00512	0.61916						

^aTest 1 Both sexes combined.

^bTest 2 Males (except *Canis familiaris*, which had both sexes combined).

^cTest 3 Females (except *Canis familiaris*, which had both sexes combined).

^dFor explanation of characters, see body of text.

TABLE 2. Standardized canonical discriminant function coefficients with known *Canis latrans*, *C. familiaris*, and Tennessee canids as unknowns.

Test 4 ^a		Test 5 ^b		Test 6 ^c	
Char-acter	Function 1	Char-acter	Function 1	Char-acter	Function 1
A	0.47689	A	-0.50709	A	0.46161
B	0.35687	B	-0.39805	B	0.52663
D	-3.12060	E	-0.41071	D	-4.21270
E	2.24953	F	-0.49919	E	2.61345
F	0.48288	G	0.22106	F	0.70599
G	-0.18879	H	0.69521	G	-0.33335
H	-0.43376	K	0.42343	I	-0.39437
I	-0.19714	M	-0.51287	K	-0.77544
K	-0.51937	O	0.33174	O	-0.63230
O	-0.61917	Q	0.39220	P	1.20726
P	0.90593	S	0.48533	S	-1.04461
Q	-0.54246	U	-0.24396	T	-0.53671
S	-0.60239	W	0.25975	U	0.54890
U	0.38363			X	3.34730

^aTest 4 Both sexes combined.

^bTest 5 Males (except *Canis familiaris*, which had both sexes combined).

^cTest 6 Females (except *Canis familiaris*, which had both sexes combined).

^dFor explanation of characters, see body of text.

Young and Jackson (1951) stated that coyotes readily breed with dogs. Similar studies have shown coyote x dog hybrids to group intermediately (Mengel, 1971; Gipson et al., 1974; Nowak, 1979). The presence of feral dogs in Tennessee would seem to provide an opportunity for hybridization with coyotes; however, Smith and Kennedy (1983) reported little evidence of dog x coyote hybridization. Our results support these findings. When only dog and coyote groups were analyzed in relation to Tennessee canids (Fig. 4), no individuals grouped as hybrids. These findings should not be interpreted to mean that no dog x coyote hybridization has occurred in Tennessee. However, indications are that hybridizations between the two groups has been minimal. Other studies in the Southeast have reported few coyote x dog hybrids (e.g., Gipson et al., 1974, Arkansas; 13.0%, Smith and Kennedy, 1983; 1.0%).

Gipson et al. (1975) examined the reproductive biology of wild canids in Arkansas and found that introgression of dog genes into a coyote population was possible. However, compared to other canids, a high proportion of coyote x dog hybrids examined failed to breed, and fewer pups were produced by such hybrids. Silver and Silver (1969), Mengel (1971), and Freeman (1976) observed that male coyote x dog hybrids, unlike male coyotes, did not provide any parental care; this would lessen the survival rate of the offspring. Gier (1957), Kennelly and Roberts (1969), Silver and Silver (1969), and Mengel (1971) found that there was a shifting of the coyote x dog hybrid breeding season from January through March (as in the coyote) to October through December. Mengel (1971) concluded that this shift in the breeding season of coy-dogs would prevent the development of hybrid swarms and block the introgression of dog genes into the coyote gene pool.

Smith and Kennedy (1983) found little evidence of the presence of *C. rufus* in the wild canid population of Tennessee. Our results collaborate this finding. Examination of the specimens in the present study, those possibly representing the influence of, *C. rufus*, indicated all specimens to best represent large *C. latrans* or *C. familiaris*. Additionally, other studies (Rhoads, 1896; Kellogg, 1939; Nowak, 1979) provide little evidence of recent red wolf occurrence in the state.

ACKNOWLEDGMENTS

This study was funded in part by Federal Aid to Wildlife restoration, Tennessee Wildlife Resources Agency, W-46R Pittman-Robertson. Computer time was provided by Memphis State University Computer Services. The following institutions are gratefully acknowledged for the opportunity to examine specimens in their care: Museum of Zoology, Louisiana State University, Baton Rouge; Museum of Zoology, Memphis State University, Memphis; Florida State Museum, University of Florida, Gainesville; United States Natural History Museum, Washington, D.C. We also thank M.L. Kennedy for his examination of an earlier draft of the manuscript and his many helpful suggestions.

LITERATURE CITED

- Bekoff, M. 1977. *Canis latrans*. Mammalian Species 79:1-9.
- Elder, W. H., and C. M. Hayden. 1977. Use of discriminant function in taxonomic determination of canids from Missouri. J. Mamm., 58:17-24.
- Freeman, R. C. 1976. Coyote x dog hybridization and red wolf influence in the wild *Canis* of Oklahoma. Unpubl. M.S. thesis, Oklahoma State Univ., Stillwater, 62 pp.
- Gier, H. T. 1957. Coyotes in Kansas. Kansas Agr. Exp. Sta. Bull. 393, Manhattan, 97 pp.
- Gipson, P. S., J. A. Sealander, and J. E. Dunn. 1974. The taxonomic status of wild *Canis* in Arkansas. Sys. Zool., 23:1-11.
- Gipson, P. S., I. K. Gipson, and J. A. Sealander. 1975. Reproductive biology of wild *Canis* (Canidae) in Arkansas. J. Mamm., 56:605-612.
- Kellogg, R. 1939. Annotated list of Tennessee mammals. Proc. U.S. Nat. Mus., 86:245-303.
- Kennedy, M. L., P. L. Leberg, and G.D. Baumgardner. In press. Morphologic variation in the coyote, *Canis latrans*, in the southern United States. Southwestern Nat.
- Kennelly, J. J., and J. D. Roberts. 1969. Fertility of coyote-dog hybrids. J. Mamm., 50:830-831.
- Lawrence, B., and W. H. Bossert. 1967. Multiple character analysis of *Canis lupus*, *latrans*, and *familiaris*, with a discussion of the relationships of *Canis niger*. Am. Zool., 7:223-232.
- Mahan, B. B., P. S. Gipson, and R. M. Case. 1978. Characteristics and distribution of coyote x dog hybrids collected in Nebraska. Am. Midl. Nat., 100:408-415.
- McCarley, H. 1962. The taxonomic status of wild *Canis* (Canidae) in the south central United States. Southwestern Nat., 7:227-235.
- Mengel, R. M. 1971. A study of dog x coyote hybrids and implications concerning hybridization in *Canis*. J. Mamm., 52:316-336.
- Nellis, C. H., S. P. Wetmore, and L. B. Keith. 1978. Age related characteristics of coyote canines. J. Wildl. Manage., 42:680-683.
- Nie, N. H., C. H. Hill, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1975. Statistical package for the social sciences. 2nd Edition, McGraw-Hill, New York, 675 pp.
- Nowak, R. M. 1979. North American quaternary *Canis*. Univ. Kansas Publ., Monogr. Mus. Nat. Hist., 6:1-154.
- Polechla, P. J., Jr. 1980. Food habits of the coyote (*Canis latrans* Say) in east-central New Mexico with special reference to size and sex differences. Unpubl. M.S. thesis, Eastern New Mexico Univ., Portales, 44 pp.
- Rhoads, S. 1896. Contributions to the zoology of Tennessee, No. 3: Mammals. Proc. Acad. Nat. Sci. Philadelphia, 48:175-205.
- Silver, H., and W. T. Silver. 1969. Growth and behavior of the coyote-like canid of northern New England with observations on canid hybrids. Wildl. Monogr., 17:1-41.
- Smith, R. A., and M. L. Kennedy. 1983. Taxonomic status of the coyote in Tennessee. Proc. Southeast. Assoc. Game and Fish Comm. Conf., 37:219-227.