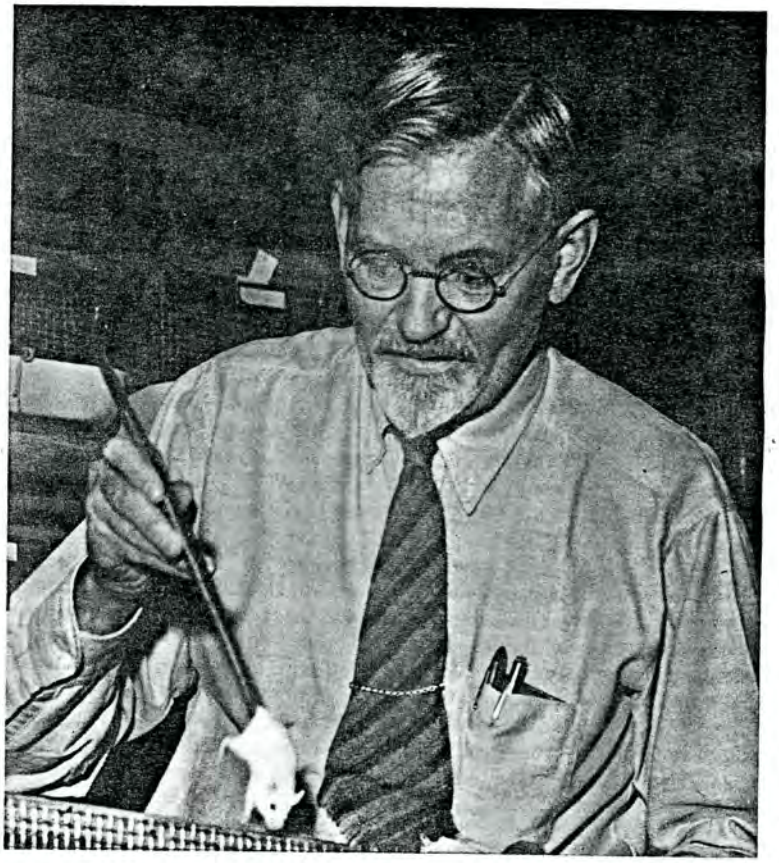
PEROMYSCUS NEWSLETTER

NUMBER FOUR



LEE R. DICE

SEPTEMBER 1987

Cover: LEE R. DICE
"Peromyscus Pioneer"
(See page 10)

This issue .....

... pays tribute to **Lee R. Dice** who exerted such a great influence on Peromyscus reseach during his thirty-eight year career at the University of Michigan. Dice is the subject of our "Peromyscus Pioneer" sketch in this issue and we have also attempted to generate a list of his graduafe students, many of whom had a major impact on Peromyscus research in their own right.

In gathering information about Dice we acknowledge many helpful sources. Elizabeth Horner, Van T. Harris and John A. King, all former Dice students, generously submitted names of other Dice proteges and provided background. Dr. Francis Evans, Dice's successor as Director of the Laboratory of Vertebrate Biology, made helpful suggestions in locating sources. We relied heavily upon the lengthy 1978 obituary prepared by Evans for the **Journal of Mammalogy** (59:635-644). It was greatly appreciated. We also gleaned considerable information from the annual reports prepared by the Laboratory. The personnel at the historical archives of the University of Michigan confirmed key dates and facts. The personal reminiscences of many individuals who were associated with Dice were recalled from over the years. We want to particularly thank Lee Dice's daughter Dr. Dorothy Foster, of the University of Oklahoma at Norman, and his son, Dr. John R. Dice of Brunswick, Maine, for their assistance.

Also in this issue we are featuring a comparative "Peromyscus-on-Mus" linkage map prepared by Joe Nadeau and A.H. Reiner. This map periodically will be updated as new data becomes available.

On pages 16 - 19 are several Peromyscus dendrograms published in recent years. The idea is to stimulate discussion resulting in a "consensus" tree which we can feature on the cover of a future issue.

Gene lists of naturally occuring genetic variants of enzymes and other proteins (see previous issues of **PN**) are supplemented with three additional lists representing P. californicus, P. eremicus and closely related forms, and P. floridanus. These, as well as those presented in earlier issues, will be periodically updated.

Please continue to send us reports of your ongoing research and other Peromyscus-related news. Number Five is scheduled for March 1988. Please let us have your entries by January 31st.

wdd.

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Wallace D. Dawson, Editor
Peromyscus Stock Center
Department of Biology
University of South Carolina
Columbia SC 29208
(803) 777-3107

Oscar G. Ward, Co-editor
Department of Ecology and
Evolutionary Biology
University of Arizona
Tucson AZ 85721
(602) 621-7520

Janet Crossland, Staff Assistant
and Colony Manager
Peromyscus Stock Center
University of South Carolina
Columbia SC 29208

C O N T E N T S

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NEWS AND COMMENT.

Bruce Buttler has completed PEROMYSCUS (RODENTIA) AS ENVIRONMENTAL MONITORS: A BIBLIOGRAPHY. More than 300 references are listed following a ten page overview of research in this area. This is his second bibliography on the genus supplementing his earlier one on genetics. Both bibliographies are available from Bruce. Write % Biology Department, Canadian Union College, College Heights, Alberta, Canada TOC OZO.

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The Stock Center has received additional materials relating to Peromyscus which will be added to the permanent reference collection of books, reprints, photographs and preserved materials. We are very grateful for these additions and believe that they will enhance the Stock Center as a research resource.

Van T. Harris kindly contributed numerous back issues of the Univeristy of Michigan **Contributions from the Laboratory of Vertebrate Genetics** (later **Biology**) including papers by Dice, Blair, Barto, Harris, Howard and others who worked with Peromyscus at Ann Arbor.

John A. King also gave us back issues of the **Contributions** and as well as other deer mouse references. Jack has also provided us with correspondence pertaining to the Peromyscus stocks he maintained at Michigan State. King has now retired.

B. Elizabeth Horner donated a motion picture sequence of climbing behavior in various species and subspecies of Peromyscus made while she was working with Dice at Michigan, and also a group of flat skins for reference.

These items are being catalogued. Materials from the Stock Center reference collection will be made available to researchers. Copies of historical reprints will be provided at cost. Other materials will be made available on loan. We are still seeking an original copy of McCabe and Blanchard's 1950 classic "**Three Species of Peromyscus**". If anyone is aware of where a copy can be located for our collection, please let us know.

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Kimberly Nelson, a graduate student in Rodney Honeycutt's laboratory at Harvard Museum, was this year's recipient of the prestigious Albert and Alma Shadle Fellowship awarded by the American Society of Mammalogists. Kim is analyzing mitochrondrial DNA variants in populations of two cytotypes of P. leucopus in Oklahoma. **Jack Hayes**, who is working with Mark Chappell (U.C. Riverside) on physiological adaptation of P. maniculatus to high altitude, also received a research award from the mammal society.

Peromyscus **has made it on a U.S. postage stamp!** The deer mouse was one of fifty subjects on a sheet of 22 cent stamps featuring mammals, birds and other animals of the United States. The stamps were issued in commemoration of the 50th annivarsary of the National Wildlife Federation. Unfortunately, the commentary on the deer mouse in the accompanying special booklet sold by the Postal Service was not particularly complimentary to our little rodent.

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MOUSE AND TIM is a book for children which features a deer mouse named "Mouse" raised by Tim, a young boy. Faith McNulty is the author and it is published by Harper and Row. It is nicely illustrated by Marc Simont and is ideal for 4 to 8 year olds.

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LUMPS AND BUMPS: Scott Wright is interested in tumors of Peromyscus mice. He needs tumor masses from wild and colony mice. Anyone who sees a suspicious mass is asked to please remove it and fix it in 10% formalin. If it is larger than a pea, please cut it in half and fix both halves. Fix the tissues in a large container full of formalin, then transfer the tissues and a little formalin to a sandwich size ziplock bag for mailing. Please include species, sex,age and tumor description (e.g., soft gray mass immediately below the sternum eaqual in size to the heart). Send tissues and information to: Dr. Scott Wright, Department of Infectious Diseases, Box J-137, JHMHC, University of Florida, Gainesville FL 32610.

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FREE Peromyscus californicus! Susan Hoffman needs to reduce the size of a breeding colony of P. californicus from southern California. Both wild caught and lab bred mice are available for the cost of shipping (while supplies last). Contact S. Hoffman, Division of Mammals, Museum of Zoology, University of Michigan, Ann Arbor MI 48109.

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Twenty-nine presentations concerning some aspect of Peromyscus biology were given at the 1987 Annual Meeting of the American Society of Mammalogists at Albuquerque NM.

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~~ Ira Greenbaum and Scott Gunn have proposed a revised standard karyotype and chromosomal nomenclature system for Peromyscus. The system includes identifying subregions on each chromosome. An ad hoc standardization committee is considering this and other matters related to Peromyscus cytogenetics. Those with an interest in this matter should contact Oscar Ward at the University of Arizona. ~~

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Dr. K. **Moriwaki** of the National Institute of Genetics, Misima, Japan, has informed us of the death of Dr. **T.H. Yosida**, the prominent rodent cytogeneticist known for his work with Rattus. However, Dr. Yosida for a time also maintained a stock of Peromyscus. This was one of the very few kept outside North America. Dr. Moriwaki, Professor of Cell Genetics, spent two years (1963-65) at the Mammalian Genetics Center in Ann Arbor when the Peromyscus group there was still active.

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Iron-on patches for clothing featuring a Peromyscus are available from Susan Smith, 1430 N. Shalanwood Lane, Placentia, CA 92670-3632

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Joseph Nadeau of the Jackson Laboratory has reviewed the genetic symbols and nomenclature for P. maniculatus and has made it consistent with that of the laboratory mouse. This revision will be reflected in the gene tables for the deer mouse in the March 1988 PEROMYSCUS NEWSLETTER, The gene lists for P. maniculatus are updated annually in the March issue.

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Ramone Baccus has accepted a position at Berry College at Rome, Georgia.

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Donald Dewsbury, Department of Psychology, University of Florida, has written a draft of a husbandry protocol for **Peromyscus** used in captivity. This is part of a program underway by the American Society of Mammalogists to develop standard and humane procedures for maintaining native species in the laboratory. It is anticipated that these procedures will meet the requirements of the Animal Welfare Act and other regulations. Norman Negus, at the University of Utah, is coordinating this program.

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PEROMYSCUS STOCK CENTER

What is the Stock Center? The deer mouse colony at the University of South Carolina has been designated a genetic stock center under a grant from the Biological Resources Program of the National Science Foundation. The major function of the Stock Center is to provide genetically characterized types of **Peromyscus** in limited quantities to scientific investigators. Continuation of the center is dependent upon significant external utilization, therefore potential **users are encouraged to take advantage of this resource.** Sufficient animals of the mutant types generally can be provided to initiate a breeding stock. Somewhat larger numbers, up to about 50 animals, can be provided from the wild-type stocks. A user fee of $5 per animal is charged and the user assumes the cost of air shipment. Animals lost in transit are replaced without charge. Tissues, blood, skins, etc. can also be supplied at a modest charge.

Stocks Available in the Center:

WILD TYPES	ORIGIN
P. maniculatus bairdii (BW Stock)	Closed colony bred in captivity since 1948. Descended from 40 ancestors wild-caught near Ann Arbor MI
P. polionotus subgriseus (PO Stock)	Closed colony since 1952. Derived from 21 ancestors wild-caught in Ocala Nat'l. Forest FL. High inbreeding coefficient.
P. leucopus (LL Stock)	Derived from 38 wild ancestors captured between 1982 and 85 near Linville NC. Third to fifth generations in captivity.
P. maniculatus X P. polionotus F_1 Hybrids	Sometimes available.

MUTATIONS IN THE SOUTH CAROLINA STOCK CENTER:

Coat Colors	ORIGINAL SOURCE
Albino **c/c**	Sumner's albino deer mice (Sumner, 1922)
Black (Non-agouti) **a/a**	Horner's black mutant (Horner et al., 1980)
Blonde **bl/bl**	Mich. State colony (Pratt and Robbins, 1982)
Brown **b/b**	Huestis stocks (Huestis and Barto, 1934)
Dominant spotting **S/-**	Wild caught in Illinois (Feldman, 1936)
Gray **g/g**	Natural polymorphism. From Dice stocks (Dice, 1933)
Ivory **i/i**	Wild caught in Oregon. (Huestis, 1938)
Pink-eyed dilution **p/p**	Sumner's "pallid" deer mice. (Sumner, 1917)
Platinum **pt/pt**	Barto stock at U. Mich. (Dodson et al., 1987)
Silver **si/si**	Huestis stock. (Huestis and Barto, 1934)
White-belly non-agouti **a^w/a^w**	Egoscue's "non-agouti" (Egoscue, 1971)
Wide-band agouti **$A^{WB}/-$**	Natural polymorphism. Univ. Michigan stock (McIntosh, 1954)
Yellow **y/y**	Sumner's original mutant. (Sumner, 1917)

Note: Some of the coat color mutations are immediately available only in combination with others. For example, silver and brown are maintained as a single "silver-brown" double recessive stock. Write the Stock Center or call (803) 777-3107 for details.

Other Mutants and Variants	ORIGIN
Alcohol dehydrogenase negative **Adh^o/Adh^o**	South Carolina BW stock. (Felder, 1975)
Alcohol dehydrogenase positive **Adh^f/Adh^f**	South Carolina BW stock. (Felder, '1975)
Epilepsy **ep/ep**	U. Michigan **artemisiae** stock. (Dice, 1935)
Flexed-tail* **f/f**	Probably derived from Huestis flexed-tail (Huestis and Barto, 1936)
Hairless-2 **hre/hre**	Egoscue's hairless (Egoscue, 1962)
Juvenile ataxia **ja/ja**	U. Michigan stock. (VanOoteghem, 1983)

Enzyme variants. Wild type stocks given above provide a reservoir for several enzyme and other protein variants. See Dawson, et al. (1983).

*Available only on pink-eye dilution background.

Limited numbers of other stocks, species, mutants and variants are on hand, or under development, but are not currently available for distribution. For additional information or details about any of these mutants or stocks contact:

W. D. Dawson
Peromyscus Stock Center
Department of Biology
University of South Carolina
Columbia SC 29208
(803) 777-3107

The Advisory Committee for the Peromyscus Stock Center:

John C. Avise (University of Georgia)
Ira F. Greenbaum (Texas A and M University)
Clement L. Markert (North Carolina State University)
Joseph H. Nadeau (Jackson Laboratory)
Suellen Van Ooteghem (Wright State University)
Wallace D. Dawson (University of South Carolina)

Peromyscus Pioneer

LEE R. DICE

1887 - 1977

No individual created a greater impact on the study of Peromyscus than did Lee Raymond Dice. During the decades from 1930 through 1960 Dice and his group at the University of Michigan profoundly affected the subsequent course of Peromyscus biology. Through his many graduate students and other associates he exercised an influence which persists to the present time. His numerous studies on variation in deer mice added immensely to our understanding of the nature of mammalian subspecies, and his Peromyscus hybridization experiments helped define the limits of reproductive isolation among species. He was a significant figure in the development of neodarwinism and was among the first to examine mammalian variation in the light of the modern evolutionary synthesis.

Lee Dice was born on July 15, 1887, in Savannah, Georgia, and spent his infancy in Pennsylvania. When he was two years old his family emigrated to Washington state and settled near Prescott, where his father purchased a share of a large wheat farm. Dice spent his boyhood there and developed an enthusiasm for natural history. In 1908 he enrolled at the Washington State Agricultural College at Pullman, but a year later he transferred to the University of Chicago from which he previously had taken a correspondence course in ornithology with R.M. Strong. While at Chicago he took courses in botany, zoology and paleontology, and there Professor V.E. Shelford introduced Dice to ecology. From that point on in his life Dice considered himself an ecologist. After a year at Chicago he was unable for financial reasons to continue and, at the urging of his friend W. M. Mann, who later became director of the National Zoo, Dice transferred once again, this time to Stanford University. Here he enrolled in a course in evolution under David Starr Jordan and Vernon Kellogg. During this time he was also involved in fisheries research with J.O. Snyder of the U.S. Fish Commission and worked briefly at the Marine Laboratory at Pacific Grove.

In 1911 Dice finished an A.B. degree at Stanford and assumed a position as Deputy Fur Warden for the Alaska Fisheries Service. During the next year he travelled extensively in the Alaskan backcountry, often enduring hardships and spending extended periods completely alone. In late 1912 he returned to the states and resided a short time in Washington, D.C., completing his reports, then resigned the fur warden position in the spring of 1913. About this time he had an offer of a scholarship to work with Thomas Hunt Morgan, the Drosophila geneticist, at Columbia University. However, because of an eye strain condition he had developed, Dice bypassed this opportunity and instead went to work in the summer of 1913 at the University of Montana Biological Station at Flathead Lake. That autumn he entered graduate school at the University of California working with S.J. Holmes on vertical movements of the water flea Daphnia, and finished his master's degree the following spring. During the summer of 1914 he returned to Washington to gather data on distribution of vertebrates in the southeastern region of the state. These data, supplemented by his earlier records collected over several years, formed the basis of his doctoral dissertation which was directed by the Joseph Grinnell, the noted mammalogist and ornithologist, at the Museum of Vertebrate Zoology at Berkeley. Dice completed his Ph.D. in the spring of 1915. It is noteworthy that Dice received both the master's and doctoral degree in a span of less than two years.

In the four years following receipt of the Ph.D. Dice moved through a rapid series of positions: Instructor in Zooloogy, Kansas State Agricultural College (1916); Assistant Professor of Zoology, University of Montana (1917); Field Assistant, U.S. Biological Survey (1918); Laboratory Technician, as a World War I draftee, at Yale Unversity and Camp Greene, N.C., (1918-19); Assistant in Zoology, University of Illinois (1919). It was also during this period, in 1918, that he married Dora Lemon, who had been a fellow graduate student at Berkeley. In the autumn of 1919 Dice accepted a position as Curator of Mammals in the Museum of Zoology and Instructor in Zoology at the University of Michigan. He remained at Michigan for the remaining 38 years of his active career.

Dice's work with Peromyscus dates from 1922. In that year he published **"Some factors affecting the distribution of the prairie vole, forest deer mouse and prairie deer mouse"** (Ecology, 3:29), the first of his many papers on these mice. It was also that year he began keeping Peromyscus of several species in captivity. During the 1920's Dice's research activities were still largely devoted to ecology and distributional surveys, and his deer mouse laboratory work was conducted on a small scale. However, by 1930 several events had occurred which re-oriented the course of Dice's subsequent work and led him into the research for which he became best known. In 1925 Clarence C. Little, who had trained with W.E. Castle the eminent mammalian geneticist, became president of the University of Michigan and established the Laboratory of Mammalian Genetics to investigate mouse genetics. Since Dice was working with deer mice, he was appointed an associate of the laboratory and became involved for the first time in genetic research. In 1930 F.B. Sumner was coerced by Scripps Institution to abandon his deer mouse stocks, including several mutant lines (See sketch on Sumner in PN #2). Dice acquired Sumner's animals, adding a significant increment to the Michigan colony and further involving Dice in genetics of Peromyscus. Two years previously Dice had been promoted to assistant professor and his faculty position had become secure. At this point his career began to advance rapidly.

In 1931 Dice reported (J. Mamm., 12:210) examples in Peromyscus of two subspecies of the same species occurring in the same geographic area, but residing in ecologically different habitats. The ranges of P. maniculatus gracilis and P. m. bairdii overlap in southern Michigan. Dice proposed that this represented the extremes of a circle of subspecies connected to the north of the Great Lakes via several other races. This case is frequently cited as a classic example of a "Rassenkreise". Dice's 1933 paper, **"Fertility relationships between some species and subspecies of mice in the genus Peromyscus"** (J. Mamm.,14:298) was the first of several papers in which he demonstrated in the laboratory that species classified in different subgenera or species groups were invariably intersterile and subspecies within a species were interfertile, but species within a species group exhibited limited ability to hybridize, suggesting that at this taxonomic level reproductive isolation was only partially established.

Together with Harold Leraas (Contr. Lab. Vert. Genet., 3) in 1936 Dice reported a convenient method of graphically comparing means, standard errors and ranges. Dice-Leraas diagrams are still widely employed. Dice's 1937 volume, **"Studies of mammalian ecology in southwestern North America, with special attention to the colors of desert mammals"** co-authored with Philip Blossom (Publ. Carnegie Inst. Wash., 485) was a landmark documentation of protective coloration in Peromyscus and other small mammals. Dice also reported several new single factor mutations (gray, dilute, epilepsy) in the deer mouse during this period.

Dice described many examples of intergradation between subspecies. His documentation with measurements of deer mice collected along transects through North Dakota (Contr. Lab. Vert. Genet., 13) and Nebraska (ibid., 14) provided convincing evidence of the often arbitrary nature of subspecific boundaries. He convincingly demonstrated that clines of morphometric characters do not necessarily coincide with coat color variations. He also showed that taxonomic subspecies sometimes had diphyletic origins with separate ancestral populations having undergone parallel evolution (Ibid., 12). Dice's major evolutionary conclusions were summarized in two 1940 review papers published in The American Naturalist, "Ecologic and genetic variability within species of Peromyscus" (74:212) and "Speciation in Peromyscus" (74:289).

By the late 1930's Dice had garnered a productive group of graduate students and other associates. Elizabeth Barto arrived in 1937 after having worked with Ralph Huestis at the University of Oregon. Barto remained at Michigan until her retirement in 1972. W. Frank Blair began working with Dice as a graduate student in the mid 1930's and continued as a research associate until after World War II. Adolph Murie and Paul A Moody were also among Dice's early graduate students. Margaret Liebe Watson, Don W. Hayne, B. Elizabeth Horner, Van T. Harris, Walter E. Howard, Robert G. Lindeborg, Philip Clark, T. T. Liu and William B. McIntosh were among the graduate students who worked on some aspect of Peromyscus biology. John A. King was one of Dice's last graduate students, and although the subject of his dissertation was prairie dog social behavior, he subsequently adopted Peromyscus as an experimental subject. Dice was a man of broad interests and he did not insist that all of his students research on Peromyscus, thus, some of his students employed other species in their research. A list of graduate students who trained under Dice is given on p. 14.

During the 1940's Dice became increasingly interested in human heredity. The Laboratory of Vertebrate Biology, which he directed, devoted a portion of its effort to human studies and was funded, in part, by the Medical School. James V. Neel joined the staff in 1946 and, with Dice, established the Institute of Human Biology, which eventually, under Neel, became one of the foremost laboratories for human genetic research. Dice's enthusiasm for human genetics continued until after his retirement in 1957, and his work with Peromyscus accordingly diminished. Although, he published 21 papers after 1955, only four of these involved Peromyscus, and three of these were co-authored. However, his final published effort, the chapter on "Speciation" in Biology of Peromyscus (1968. J. A. King, ed.), a review of the subject on which Dice established his reputation, constituted a fitting conclusion to his career.

Dice was highly respected by his contemporaries, as reflected by his election to office in several learned societies. He was president of the Ecological Society of America (1952-53), the Society of Systematic Zoology (1949-50), the Ecological Union [now the Nature Conservancy] (1948), and the American Society of Human Genetics (1950-51); and vice president of the American Society of Mammalogists (1947-51) and the Society for the Study of Evolution (1947-48, 1953-54). (It is difficult to imagine an individual who today would have the breadth of interest to hold the presidency of both the Ecological Society and the Human Genetics Society). Dice also held numerous other offices and committee responsibilities in several organizations including the Animal Welfare Institute, the American Eugenics Society and the Michigan Academy of Science, Arts and Letters. For many years he was involved with the Cranbrook Institute of Science which was locally active in the Ann Arbor area. His work was amply supported by a

variety of public and private sources. He was the beneficiary of funds from the National Science Foundation, the Carnegie Institute, the Cranbrook Institute and certain affluent individual benefactors. Dice's bibliography consists of 138 publications, excluding abstracts and book reviews. Of these about 55 dealt principally with Peromyscus. He authored a number of book length works including **Natural Communities** (1952. Univ. Mich. Press, 547 pp.) and **Man's Nature and Nature's Man: The Ecology of Human Communities** (1955. Univ. Mich. Press, 329 pp.).

In spite of his considerable contributions, Dice had his detractors. Certain of his colleagues, possibly envious of his "empire" of active associates and graduate students, considered him aloof. Others felt that his late career shift into human genetics was a mistake, and that he should have continued his evolutionary studies with Peromyscus. Speculation has arisen as to why Dice never attained the stature of Dobzhansky, Mayr, Simpson and other leaders among the neodarwinians when he obviously was equipped intellectually and possessed the experimental organisms and resources to achieve this rank. Instead Dice chose to publish many of his most exciting findings in the relative obscurity of his in-house publication, Contributions of the Laboratory of Vertebrate Biology. Indeed Dice authored or co-authored 22 of the 76 contributions in this series, and some forty other papers appeared in various local and intra-mural publications. This is not to suggest that Dice's work could not withstand the scrutiny of external review. Indeed his insistence upon including massive tables of data and graphical interpretation no doubt was a factor in his reluctance to submit to the space limitations imposed by journal editors. Dice was also a particularly systematic and persistent individual. His customary analytical procedure was to rear a first generation in the laboratory from wild-caught animals, and measure about fifteen characters in 50 - 150 progeny as representative of each wild population. In this way he could control for age and environmental variation. This procedure was repeated for each of 130 populations of Peromyscus species and subspecies reported in 14 extensive articles in his "**Variation ...**" series. To some of his critics these studies seemed tedious and redundant, and after awhile failed to yield returns in terms of new insights. Nevertheless, these studies still represent some of the best available documentation of genetic variation in small mammal populations.

After his retirement in 1957, Lee Dice continued to write, attend scientific meetings and participate in research projects. But he also was able to devote more time to his other interests, including gardening and classical music. His vast knowledge of the mammalian and human genetic literature remained a source of amazement to his associates, and his stimulating discussions provided inspiration to a younger generation of "peromyscologists". There are many aspects of Dice's life and accomplishments which, because of space limitations, can not be addressed here, but those who study Peromyscus will always be indebted to this man and will find continued enlightenment in his work. Lee R. Dice passed away in Ann Arbor, Michigan, on January 30, 1977 at the age of 89. He was survived by his wife and three children, Betty, John and Dorothy.

References:

Evans, Francis C. 1978. Obituary. Lee Raymond Dice (1887-1977). J. Mamm., 59:635-644.

Annual Reports. (1944 through 1949). Laboratory of Vertebrate Biology. University of Michigan. Ann Arbor.

GRADUATE STUDENTS WHO WORKED UNDER THE DIRECTION OF LEE. R. DICE:

Name	Approximate dates	Comment. Later position
Adolph Murie	1925 - 29	(May have been the first) National Park Service
Paul Moody	1925 - 27	("His second student"-Moody). University of Vermont
W. Frank Blair	1935 - 38	Res. Assoc. U. Mich. until 47. University of Texas
Harold J. Leraas	1932 - 35	Practiced dentistry.
Margaret Liebe Watson	Late 1930's	
Elizabeth Barto	1937 - 52	Received Ph.D. about '52. Remained at Univ. Michigan
Adolph Stebler	1933 - 35; 50-51	(Worked with wolves). Oklahoma Wildlife Research Unit
B. Elizabeth Horner	1944 - 47	Smith College
Walter E. Howard.	1945 - 47	Univ. California - Davis
Don W. Hayne	1945 - 47	Michigan State Univ.; North Carolina State Univ.
Van T. Harris	1945 - 49	U.S. Fish and Wildlife Service
Robert G. Lindeborg	1946 - 48	Highland Univ. (N.M.)
Burton T. Ostenson	1946 - 48	Pacific Lutheran College
Earl J. Larrison	1946 - 49	Univ. Idaho. [Ecology, ornithology]
Bernard P. Leonard	1946	
Maurice T. Fliegelman	1946	[Had an MD degree]
George T. Baxter	1946	
Arliss Denyes	1946 - 49	Florida State University
John A. King	1947 - 51	Jackson Laboratory; Michigan State Univ.
T. T. Liu	1947 - 50	Fudan University
William B. McIntosh	1947 - 51	Ohio State University; U.S. Army
Philip Clark	1948 - 53	Died in accident

There may have been others who were overlooked.

21 July 1987

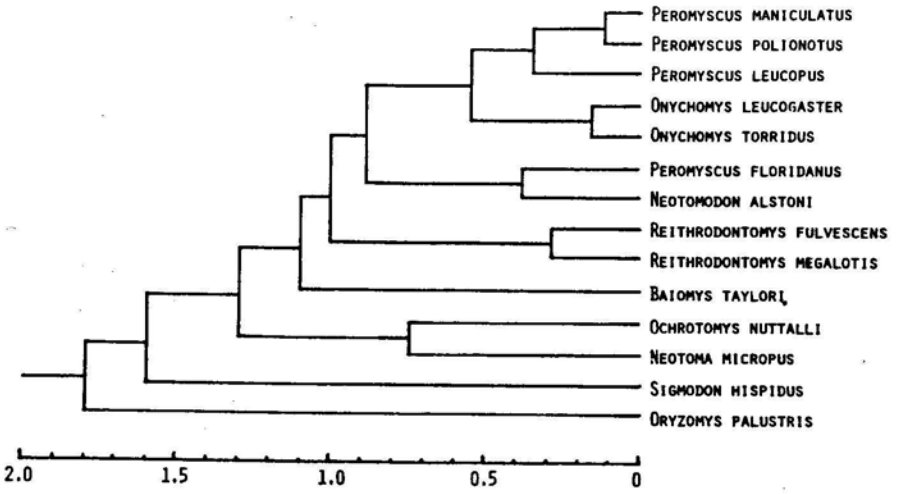
Lee R. Dice: His Chief Characteristic

In a world of subjectivity, characterized by fads, fashions, personalities, cults, bandwagons, many people turn to science for a refuge in objectivity only to find that science is like other human enterprises: religion, athletics, music, art, business, politics, militia. However, we learn from these subjective experiences and personalities, often in ways that are not immediately apparent. Lee R. Dice did not believe in the exaltation of scientific personalities. He would be disturbed if he believed that his scientific discoveries were remembered less than his personal attributes. Still, it is his personality that contributed to the progress of science in so many different ways.

The one personal attribute that best characterized Lee Dice was his willingness, even eagerness, to enter new areas. The study of *Peromyscus* did not originate with him, but he pushed its study further and into more areas than his predecessors. His interest in the ecology and evolution of the genus led him to study its genetics at the level of geographical populations. He readily adopted the emerging new discipline of statistics to his studies and contributed a few statistical techniques of his own. He early recognized the relevance of behavior to population genetics and spent many of his later years devising and constructing new electrical apparatus to measure and record the behavior of elusive deermice. By combining his knowledge of the ecology, behavior and genetics of *Peromyscus* he recognized the applicability of this combination for the study of human genetics. This led to the establishment of the first clinic of human genetics and a population study of human assortative mating. One of his retirement projects was to write a book "of mice and men" to illustrate their genetic, ecological, and behavioral parallels. Although this was never completed, he quickly accepted the latest developments in high fidelity recording and spent hours listening and converting classical music to tapes, which he sent to his children. He liked the manipulation of advanced equipment as well as progressive scientific concepts.

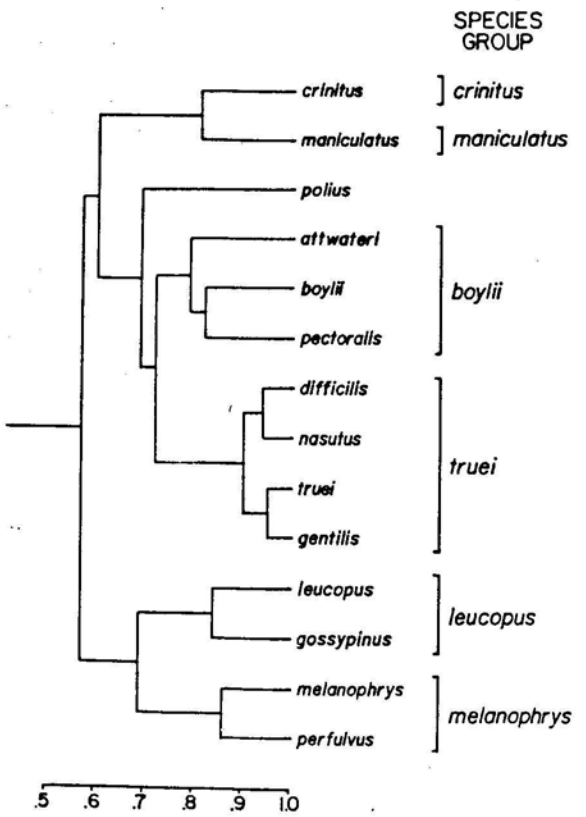
Perhaps the ultimate evidence for Dice's acceptance of innovations are the diversity of his students. His comprehensive view of biology led him to accept and train students with unusual backgrounds and interests. Those students whom I recall would probably accept as their first labels: mammalian geneticist, human geneticist , statistician, community ecologist, physiologist, wildlife manager and conservationist, systematist, behaviorist, and evolutionist. The remarkable thing about Dice is that he could comfortably wear any of those labels.--John A. King (student: 1948-51).

PEROMYSCUS DENDROGRAMS



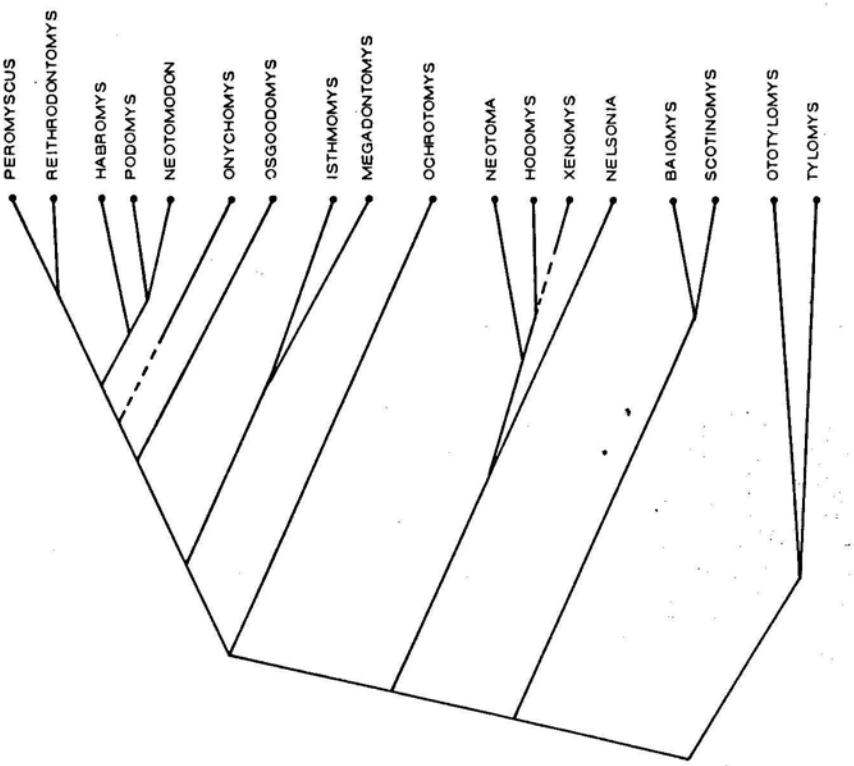
Unweighted Pair Group Method of Analysis (UPGMA) dendrogram depicting possible relationships within the cricetine rodents based on genetic distances at 13-15 protein loci.

(From Patton et al., 1981)

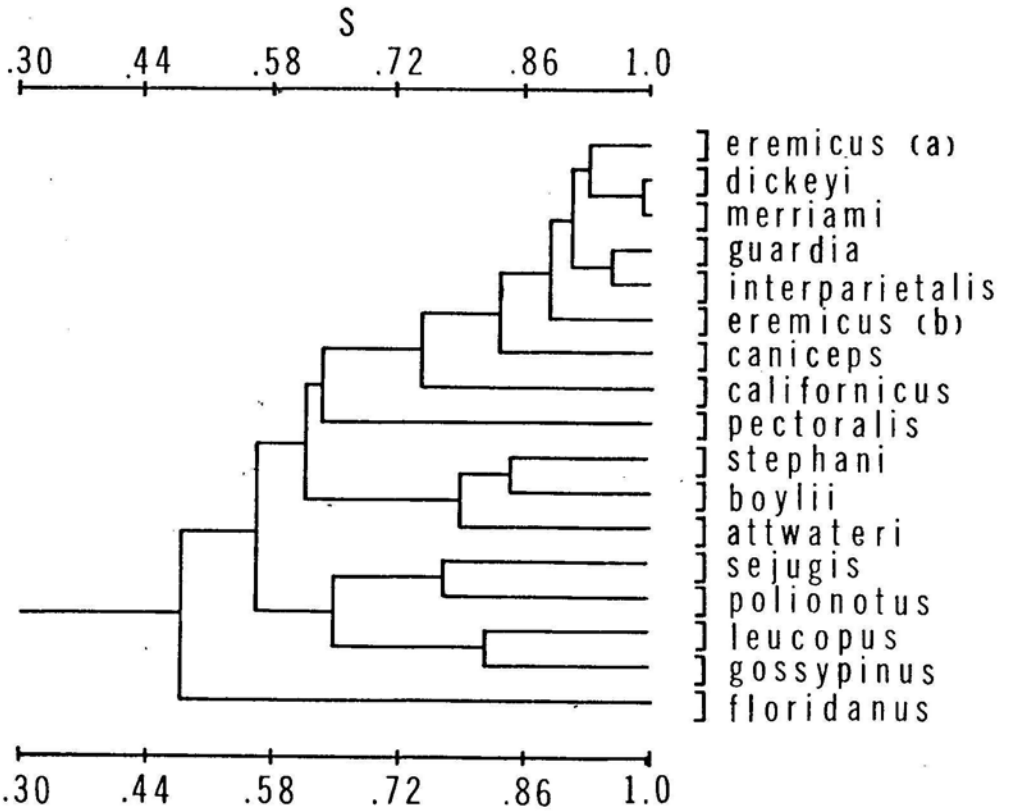


Biochemical similarity dendrogram based on genic identity, *I*, for 14 species of the subgenus *Peromyscus*.

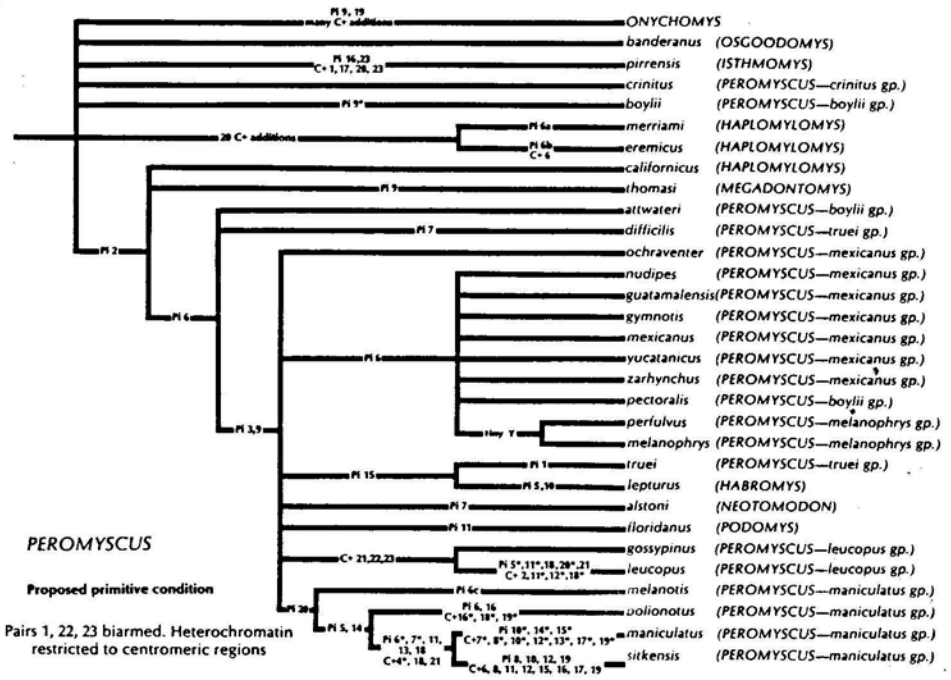
(From Zimmerman et al., 1978)



The phylogeny of neotomine-peromyscine rodents proposed herein; compare with that formulated by Hooper and Musser, 1964 (Fig. 4). (From Carleton, 1980)

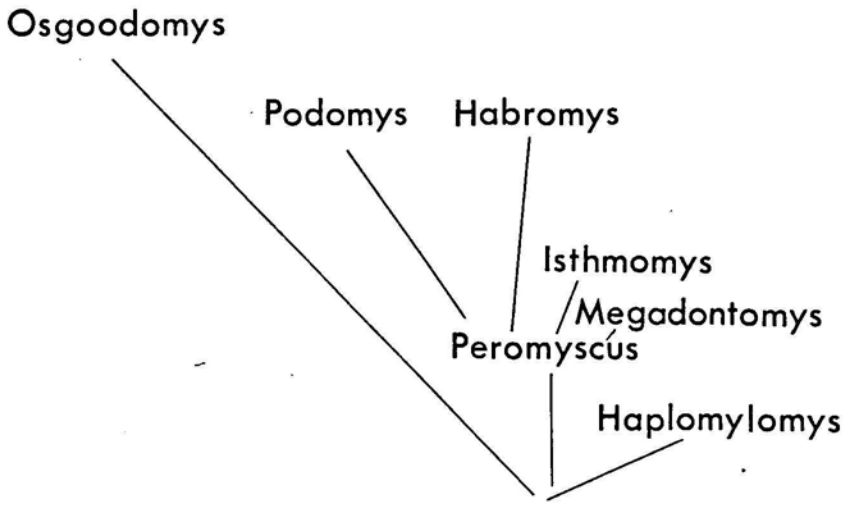


—Biochemical similarity dendrogram of *Peromyscus* species. From Avise *et al.*, 1974b. The placement of species in the allozyme based dendrogram agrees closely with the formal classification of *Peromyscus* (Table 5). (From Avise, 1974)



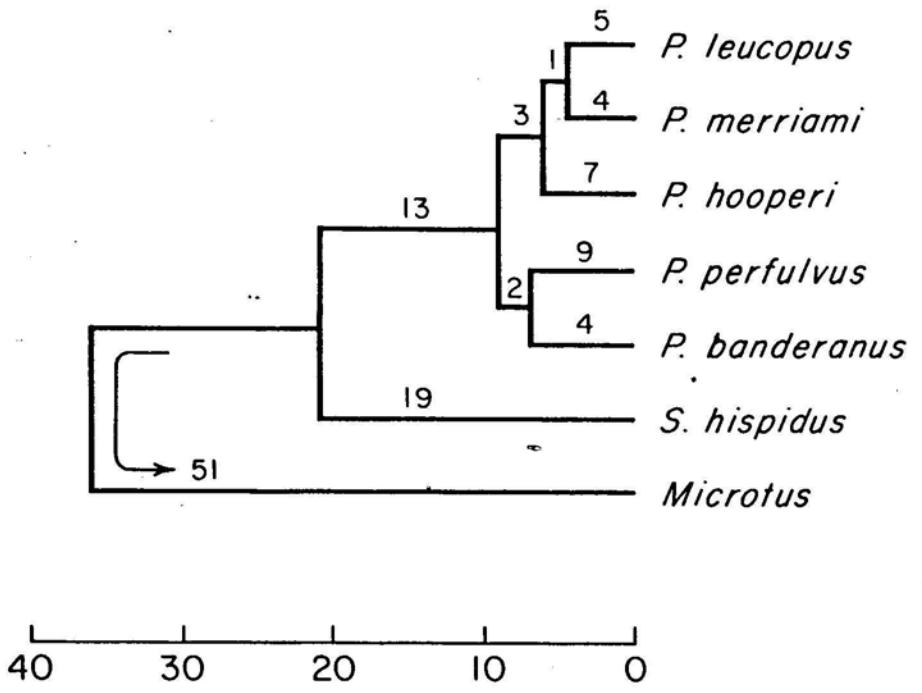
.—Arrangement of 30 species of *Peromyscus* and the genus *Onychomys*, derived from a cladistical analysis of chromosomal homology based on G- and C-banded chromosomes. Pi indicates a pericentric inversion, and C+ indicates addition of heterochromatin. Numbers identify chromosomes to a standard (Committee, 1977), and letters following indicate a unique event. Polymorphic rearrangements are indicated by an asterisk (*). Species are grouped based on the assumptions that shared chromosomal rearrangements became established in a common ancestor, and that the most parsimonious positioning of rearrangements would provide the most probable evolutionary tree for the 30 species. Subgenera of species of *Peromyscus*, and species groups where appropriate, follow the specific designation in parentheses. The primitive condition follows Greenbaum and Baker (1978) and Yates et al. (1979).

(From Stangl and Baker, 1984)



Possible relationships of the subgeneric groups of *Peromyscus* as suggested by the morphology of the male genital tract.

(From Linzey and Layne, 1969)



—Phylogenetic relationships among selected cricetine rodents based on average albumin immunological distance. Methods of construction are described in the text. The numbers on the branches represent albumin change estimated to have occurred along each branch. The average amount of albumin change that has occurred since each branch point is indicated by the immunological distance scale at the bottom.
(From Fuller et al. 1984)

Acknowlegements

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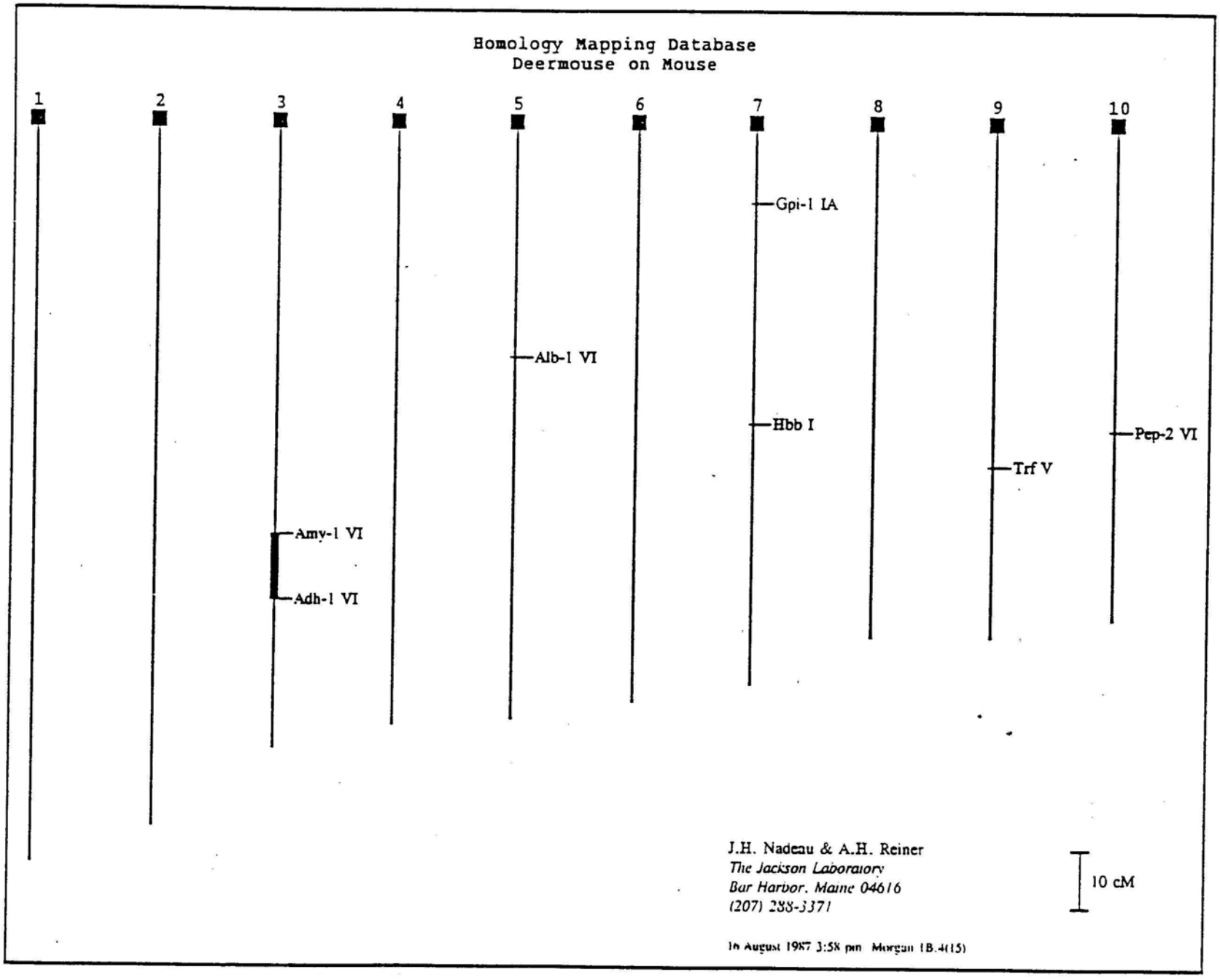
Homology Mapping Database
Deermouse on Mouse
1
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9
10
Gpi-1 IA
Alb-1 VI
Hbb I
Trf V
Pep-2 VI
Amy-1 VI
Adh-1 VI
J.H. Nadeau & A.H. Reiner
The Jackson Laboratory
Bar Harbor, Maine 04616
(207) 288-3371
10 cM
16 August 1987 3:58 pm Morgan 1B.4(15)

Chromosomal location of genes that have been mapped in both deer mouse and house mouse.

Deer mouse gene	Chr	Reference	Mouse gene	Chr	Reference
Adh-1	VI	4	Adh-1	3	1, 10
Alb-1	VI	4	Alb-1	5	7, 12
Amy-1	VI	4	Amy-1	3	1, 9, 13
Gpi-1	IA	15	Gpi-1	7	6, 11
Hbb	I	15	Hbb	7	11, 14
Pep-2	VI	4	Pep-2	10	8, 16
Trf	V	5	Trf	9	2, 3

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Table 1. VARIANT PROTEIN LOCI REPORTED FROM NATURAL POPULATIONS OF PEROMYSCUS CALIFORNICUS.

Protein	Locus Symbol	Reference
ALBUMIN	Alb-1	Avise et al. (1974)
ESTERASE	Es-3 Es-4 Es-4+ Es-5	Smith (1979)
alpha-GLYCEROPHOSPHATE DEHYDROGENASE	Gpd-1	Avise et al. (1974) Smith (1979)
ISOCITRATE DEHYDROGENASE	Idh-1 Idh-2	Avise et al. (1974) Smith (1979)
MALATE DEHYDROGENASE	Mdh-1	Avise et al. (1974) Smith (1979)
MALIC ENZYME	Mod-1 Mod-2	Smith (1979)
PEPTIDASE	Pep-1	Smith (1979)
6-PHOSPHOGLUCONATE DEHYDROGENASE	Pgd-1	Avise et al. (1974) Smith (1979)
PHOSPHOGLUCOSE ISOMERASE	Pgi-1	Smith (1979)
PHOSPHOGLUCOMUTASE	Pgm-1 Pgm-3	Avise et al. (1974) Smith (1979)
POSTALBUMIN	Palb	Smith (1979)
SORBITOL DEHYDROGENASE	Sdh-1	Avise et al. (1974) Smith (1979)
TRANSFERRIN	Trf	Avise et al. (1974)

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Table 2. VARIANT PROTEIN LOCI REPORTED FROM NATURAL POPULATIONS OF PEROMYSCUS EREMICUS AND RELATED SPECIES.

Protein	Locus Symbol	Species	References
ALCOHOL DEHYDROGENASE	Adh-1	P. eremicus	Avise et al. (1974)
ESTERASE	Es-1	P. eremicus	Rasmussen and Jensen (1971) Avise et al. (1974)
GLUTAMATE OXALOACETATE TRANSAMINASE	Got-1	P. eremicus	Avise et al. (1974)
alpha-GLYCEROPHOSPHATE DEHYDROGENASE	Gpd-1	P. eremicus	Avise et al. (1974)
ISOCITRATE DEHYDROGENASE	Idh-1 Idh-2	P. eremicus P. guardia P. interparietalis	Avise et al. (1974)
LACTATE DEHYDROGENASE	Ldh-1	P. eremicus P. caniceps	Avise et al. (1974)
PHOSPHOGLUCONATE DEHYDROGENASE	Pgd-1	P. eremicus P. caniceps	Avise et al. (1974)
PHOSPHOGLUCOMUTASE	Pgm-1	P. eremicus	Avise et al. (1974)
PLASMA PROTEIN B (MACROGLOBULIN)	Ppb	P. eremicus P. caniceps	Avise et al. (1974)
TRANSFERRIN	Trf	P. eremicus P. merriami P. caniceps	Rasmussen and Koehn (1966) Avise et al. (1974)

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Table 3. VARIANT PROTEIN LOCI REPORTED FROM NATURAL POPULATIONS OF PEROMYSCUS FLORIDANUS.

Protein	Locus Symbol	Reference
ESTERASE	Es-1 ES-2 Es-4	Smith et al. (1973)
GLUTAMATE OXALOACETATE TRANSAMINASE	Got-1	Smith et al. (1973)
HEXOSE-6-PHOSPHATE DEHYDROGENASE	Gpd-1	Smith et al. (1973)
HEMOGLOBIN	Hb-1	Smith et al. (1973)
ISOCITRATE DEHYDROGENASE	Idh-1	Smith et al. (1973)
LACTATE DEHYDROGENASE	Ldh-1 Ldh-2 Ldh-3	Smith at al. (1973)
MALIC ENZYME	Mod-1	Smith et al. (1973)
PHOSPHOGLUCOMUTASE	Pgm-1 Pgm-3	Smith et al. (1973)
PRE-ALBUMIN	Pra	Smith et al. (1973)
TRANSFERRIN	Trf	Smith et al. (1973)

Smith, M.H., R.K. Selander and W.E. Johnson. 1973. J. Mamm., 54:1-13.

Sequences reported:

I. INDIVIDUAL COPY STRUCTURAL GENES.

Hbb. Beta globin complex. Partial sequences of structural adult beta globin genes in P. **maniculatus** (Padgett et al., 1987):

Twelve lambda clones represent a total of 80'kb in three sections with gaps of undetermined length. Clones isolated using three Mus **Hbb** probes. Sequences given for three regions ([a]110, [b]110 and [c]219 bp, respectively) from each **Hbb-b1** and **Hbb-b2**, and for two regions ([a]110 and [c]219 bp) from **Hbb-b3** adult beta globin genes. The second of the three beta globin coding blocks is located (except for initial two codons) in the third sequenced region for each of the three genes. No termination codons are present in the coding sequences. **Hbb-b1** and **b2** have identical coding sequences and match for all but two non-coding bases in regions sequenced. **Hbb-b3** varies from **b1** and **b2** at ten sites in the third region, which contains the second coding block, and at numerous sites in the non-coding first region. Region two was not sequenced for **Hbb-b3**. Homologies with Mus and other mammals are discussed together with molecular evolution of the beta globin gene.

II. REPEAT ELEMENTS.

Mys-1 element in P. **leucopus** (Wichman et al. 1985):

Features: 2843 bp. 343 bp terminal repeats (1-343) and (2501-2843). Open reading frame [1] 489 bp (595-1083) and ORF [2] 642 bp (1552-2193) with a single interrupt codon at 1795. ORF [1] translated reveals homologies with other known reverse transcriptase proteins. 20 bp pyrimidine tract (344-364); internal direct repeats 1243-1280, 1281-1318; T A sequences beginning at 1516 and at 2240. Lys tRNA binding site at 2487-2498. **Mys** elements 2 - 8 share restriction sites in common. **Mys** probe hybridizes with P. **gossypinus** and other cricetid, but not murid, genomic digests. **Mys** elements probably occur in 500 to 1000 copies per haploid genome in both P. **leucopus** and P. **gossypinus**.

.....

L1 long interspersed repeat family in P. **maniculatus**.

Features: Sequence not reported in **Peromyscus**. Homology with **Mus** and other mammalian L1 sequences shown by Burton et al. (1986).

DNA Libraries:

P. **leucopus**. Constructed from P. l. **leucopus** from Georgia. Dr. H. A. Wichman, School of Basic Life Sciences, Univ. Missouri- Kansas City, Kansas City MO 64110. (Wichman et al. 1985).

P. **maniculatus**. Constructed from P. **m. sonoriensis** from California, using lambda phage Charon 4A vector. (Dr. M. Edgell and associates, Dept. of Bacteriology and Immunology, Univ. North Carolina, Chapel Hill NC 27514). Several separate libraries from individual animals. Univ. South Caroina (M. Felder) also has one of these libraries.

Mitochondrial DNA:

RESTRICTION ENZYME ANALYSIS.

P. polionotus, P. maniculatus and P. leucopus. Digest with EcoRI, HindIII, BstEI, BstEII, HaeIII and PstI. 25 combinational types from 23 populations indicated. (Avise et al., 1979)

P. maniculatus, P. polionotus, and **P. leucopus.** Digest with HincII, BglII, HindIII, BstEII, EcoRI, BamHI, Xba and HpaII. 61 combinational types in **P. maniculatus,** 22 combinational types in **P.polionotus,** and 12 combinational types in **P. leucopus.** (Lansman et al., 1983; Avise et al. 1983)

P. maniculatus. Digest with EcoRI, HindIII, BstEII, PstI, BglII, AvaI, Ava II, MboI and HinfI. 26 combinational types from 26 populations from California Channel Islands and southern California mainland. (Ashley and Wills, 1987)

P. leucopus. Digest with BamHI, BglII, BstEII, EcoRI, HincII, HindIII, HpaII and XbaI. 7 combinational types from six populations representing two cytotypes and a hybrid zone in Oklahoma. (Nelson et al., 1987)

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C O N T R I B U T I O N S

Ann Eileen Miller BAKER
Zoology Department
Colorado State University
Fort Collins, CO 80523
(303) 491-5307

MICE COLONIZING HOMES: Progress Report:

Colonization is important in speciation, wildlife conservation, and pest control. Colonization attempts can be quantified by frequent monitoring of potential colonization sites. Colonization attempts were quantified in the following report with the help of cooperators that trapped rodents entering their homes. Requests for cooperators were published in professional society newsletters or journals, including **Peromyscus Newsletter**.

House mice (N = 32, **Mus domesticus** = Md) and deer mice (N = 19, **Peromyscus maniculatus** = Pm) colonized homes (table 1). Mice entered homes through holes or open garage doors. Most colonization attempts occurred in the summer and fall (29 of 33 between June and November), where a colonization attempt is defined as all mice entering a home on a given date. No colonizations occurred in January, February, March, and June, which may reflect more small sample size than reality. Most colonizations of the same home occurred within a 2-wk period, though two homes (AB, BB) were recolonized over 8-11 mo. More homes were colonized by Md than Pm (11 vs 3), which may reflect the predominance of cooperators living in the suburbs and on farms. One home (V:HB) was colonized by both species (3 Md, 1 Pm). Species showed sexual differences in colonization attempts: 16 female, 14 male Md colonizers; 17 female, 2 male Pm colonizers. 5 Md and 3 Pm were pregnant, which implies populations could be founded by a pregnant female. Most colonizers were adults and subadults, which may be an artifact of trapping because <5 g mice may be less likely to trip the trap mechanism (minimum weight of trapped mouse, 7 g).

These 33 colonization attempts imply these mice found new populations in most months of the year, with the exception of late winter. 27 of these 33 colonization attempts could have led to successful colonization because colonizers included both sexes or pregnant females. Though the highest densitites of mice occur in the fall, when most farmers report an influx of mice, other causes could force Md to colonize at different times. No habitat disturbances were reported by most cooperators, though RL mentioned a nearby field was plowed before he caught 2 Pm. Late summer and fall are the main periods of colonization reproted in other studies of mice entering homes (Jensen 1966; Vlasak and Porkert 1982). Spring and fall dispersal periods have been documented for Pm (Fairbairn 1972). Sheppe (1967) also trapped Pm and Md at the same site.

One advantage of continuous removal trapping by cooperators is that large data sets of rare events can be collected. Two potential disadvantages follow. First, there is no way to distinguish true colonizers from transients. Second, colonizers may choose sites based on optimal population density (Gilbert and Singer 1972). Continuous removal may keep density below this optimum.

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Table 1. House colonizers

Date	Species	Sex	Wght (g)	Habitat <1 km	Attracted by	Coop.
Nv2385	Pm	F	14	fields	dog food infested	RL
	Pm	F	22			
Dc23	Mm	F	13	suburb	bird seed infested	AB
	Mm	F	12			
	Mm	M	14			
	Mm	F	17			
	Mm	F	22			
	Mm	F	14			
Ag2986	Md	F	13	suburb	dog food infested	NK
Sp18	Md	M	10			
Sp	Md	Fp		chickens		LF
Sp29	Md	A		chickens	cat caught in house	KE
Oc01	Md	M	16	suburb	bird seed attracts	DH
Oc19	Md	M	16	fields		JC
	Md	M	19			
Oc20	Md	F	18			
Oc21	Md	M	19			
	Md	M	18			
Oc25	Md	M	15	farm		KB
Nv24	Md	F	14	suburb	bird seed infested	AB

Md= *Mus domesticus*; Pm= *Peromyscus maniculatus*; A = adult of unknown sex; Fp= pregnant female. All cooperators are gratefully acknowledged. Anyone wishing to cooperate please write: Ann Baker, Zoology Dept, Colorado State University, Fort Collins 80523 (303) 491 5307

Wallace D. DAWSON
Department of Biology
University of South Carolina
Columbia SC 20208

Co-workers:
Renee Bradshaw
Janet Crossland
David Kass

One of the projects underway in our laboratory is formal genetic analysis and description of several previously unreported coat color traits in the deer mouse. These traits have been tentatively designated "white", "ashy" and "California blonde". White is attributed to a dominant gene, **W**. Animals with this gene have extensive areas of white on the coat, but have dark eyes. The trait is variably expressed with some animals being nearly all white, while others have extensive pigmented areas, particularly in the mid-dormal area. The trait spontaneously appeared in the laboratory colony at Michigan State University and was isolated there by Gale Haigh, Bob Robbins and Bruce Cushing. The ashy trait, originally called "dunes ashy" was identified about 1960 by R.R. Huestis in mice collected near Humbolt Bay, California. The trait is inherited as a recessive (**ash**). Animals have normal pigmentation until about six months of age then, beginning on the rostrum and rump, become progressively grayer, until some of the animals age 2 - 3 years become almost entirely white except for a few scattered guard hairs. The California blonde color was identified by Louise Roth from P. **m. santacruzei** collected on the Channel Islands of California. The trait is recessive (**cfb**). This trait is non-allelic with the brown (**b**), blonde (**bl**) and platinum (**pt**) loci. (W. Dawson, J. Crossland and Kelley Teed)

Further characterization of the hairless-2 (**hre**) mutant is being conducted using scanning electron and light microscopy. The hairless deer mouse will be used in parallel studies with the hairless house mouse (**hr**) as a model of human atrichosis. (Joanne Hoppenhauer, Loren Knapp and Roger Sawyer)

* * *

Mary Fleming FINLAY
Biology Department
Benedict College
Columbia, SC 29204
(803) 256-4220

Associates:
Patricia Marsteller
Alonzo Harris
Cheryl Harper

We maintain stocks of **Peromyscus polionotus** and P. **maniculatus bairdii**, both derived from Dr. W. D. Dawson's colony at the University of South Carolina.

Our current research has been : comparing DPG (2,3-diphosphoglycerate) among **Peromyscus** and inbred mice. DPG is a red blood cell intermediate, affecting the affinity of the rbc for oxygen. In rats a major locus regulating the level of DPG has been found to be linked to beta hemoglobin. We have investigated variation of DPG among **Peromyscus** and lab mice.

For **maniculatus** the mean level of DPG was 3.31µ mol/ml blood (standard deviation 0.75, n = 29), for **polionotus** 3.13µ mol/ml (sd - 0.95, n = 27) and the **Peromyscus** mean 3.26µ mol/ml (sd = 0.89, n = 57). Fourteen strains of mice also were investigated and for the mice the mean DPG was 3.20µ mol/ml (sd = 0.83, n = 216), indicating no significant variation for the level of this intermediate among lab mice and the **Peromyscus** studied.

Body mass and hemoglobin also were recorded. For **Peromyscus** the mean hemoglobin was 10.10 g/dl (sd = 1.85, n = 37) and for lab mice it was 13.90 g/dl (sd = 1.87, n = 44). The ratio of hemoglobin/DPG was 0.33 in **Peromyscus** (sd = 0.04), while the ratio was 0.27 (sd = 0.05) in the lab mice. In **Peromyscus** the ratio of DPG/body mass was 0.19 (sd = 0.05) with no significant variation in the ratio between species, while in lab mice it was 0.12 (sd = 0.04).

The P. **maniculatus** and **polionotus** each derive from a single founder population, the **bairdii** from Wisconsin, the **polionotus** from Ocala, FL. It would be interesting to ascertain if **Peromyscus** populations from other geographic locations, and particularly from higher elevations, have different levels of DPG. We would appreciate information concerning stocks from higher altitudes that might be available.

* * *

John GLENDINNING
Department of Zoology
University of Florida
Gainesville, FL 32611
(904) 392-1107

I am studying the response of a rodent community (**Peromyscus melanotis, P. aztecus hylocetes, Neotomodon alstoni, Reithrodontomys sumichrasti,** and **Microtus mexicanus**) to overwintering colonies of monarch butterflies that form annually at several high-elevation sites in Michoacan, Mexico. These monarch colonies range between 0.5 and 5.0 ha in size, attain densities of ca. 10 million butterflies per ha, and remain in the same place for 3-4 months. Only **P. melanotis** capitalizes on this super-abundant and lipid-rich food resource: they recruit extensively into the colonies, reaching densities of 75-105 per ha (sex-ratio skewed towards females ca. 2:1); they feed extensively on the butterflies; and they initiate high levels of reproduction. Populations of **P. melanotis** and the other mouse species that live outside the monarch colonies do not breed at this time.

Presently, I am testing several hypotheses to determine why **P. melanotis** in the only species that utilizes the monarchs. **P. melanotis**: 1) competitiveley excludes all other mouse species; 2) is the only species tolerant of the microhabitat characteristics (i.e. understory vegetation) found in monarch colonies; 3) is the only species that can feed selectively on low-cardenolide and low-pyrrolizidine alkaloid (the concentration of these toxins varies among monarchs) monarchs, and thus avoid toxicosis; and 4) is more tolerant of the "bitter" or aversive taste of the monarch's toxins (assumes all species equally insensitive to the toxins). Results to date are most consistent with hypothesis 4.

* * *

David J. GUBERNICK
Indiana University
Department of Psychology
Psychology Building
Bloomington, IN 47405
(812) 335-3309

Co-workers:
Jeffrey Alberts
William Timberlake

We have been investigating the causes and consequences of male parental care in the biparental California mouse, **Peromyscus californicus**. Fathers and mothers provide extensive and virtually equivalent amounts of parental care. Fathers exhibit all the parental care activities displayed by mothers, except nursing. We are currently exploring the proximate mechanisms underlying the onset and maintenance of parental behavior and the effects of the father's presence on growth, sexual maturation and reproduction of his offspring. Our colony numbers between 500-600 adults and are descended from mice originally trapped near Los Angeles and Laguna Hills, California. I would like to hear from anyone who is conducting field or laboratory studies of the California mouse.

* * *

Timothy D. JOHNSTON
Department of Psychology
University of North Carolina at Greensboro
Greesboro, NC 27412-5001
(919) 334-5013

Co-workers:
Randy Fulk
Barbara Turpin
Thom Tomlinson

The focus of our research is the development of foraging behavior in two rodent species, **Mesocricetus auratus** and **Peromyscus leucopus**. With P. leucopus we are investigating the effect of early experience with various foraging techniques on preference for using those techniques in adulthood. In particular, we are interested in how early experience with unpredictable access to various foraging tasks affects the diversity of adult preferences for those tasks. This study, which is being carried out by Randy Fulk as his dissertation research, is an attempt to mimic foraging experience in a fluctuating environment, which may lead to the development of generalist food habits. The study also examines the relationship between efficiency on a foraging task and preference for that task, as well as the effect of early experience on foraging efficiency.

* * *

Laura J. MCLELLAN
Division of Biology
Kansas State University
Manhattan, KA 66506
(913) 532-5865

My dissertation research has focused on microgeographic variation in the phenotype of **Peromyscus maniculatus bairdi** in northcentral Kansas. This is the most abundant small mammal in native prairie and adjacent cultivated areas. Following harvest and during fallow phases cultivated areas support higher densities of P. **maniculatus**, and individuals weigh more and have longer breeding seasons than those form the surrounding native prairie. The food supply and population dynamics of P. **maniculatus** clearly differ between these two habitat types, but it is not clear how these factors are reflected in the phenotype of P. **maniculatus**.

The primary objectives of my research are to 1) describe and quantify phenotypic variation for P. **maniculatus** within and among local populations with respect to age, sex and habitat, in order to 2) determine environmental influences on phenotype, and 3) estimate the relative contribution of genetic and environmental factors to phenotypic variation among populations. Morphometric data, non-metric data, and quantitative genetic data, are being studied, using wild caught and lab-reared individuals, to estimate ecogeographic and lineage effects on the phenotype of P. **maniculatus**.

A total of 520 wild-caught P. **maniculatus**, collected during May 1985, have been examined using morphometric techniques. External and skeletal (cranial and postcranial) dimensions vary with age, sex habitat and collecting location, producing a complex pattern of variation within and among local populations. Both sexes are larger in clutivated areas than they are in native prairie, and measurable morphological differences occur among populations a few miles apart. The non-metric data are currently being analyzed, and the laboratory study will be completed this fall.

* * *

Duke S. ROGERS
Department of Veterinary Pathology
Veterinary Medicine
Texas A & M University
College Station, TX 77843
(409) 845-0589

Co-worker:
Mark Engstrom

In an effort to evaluate phylogenetic relationships among members of the **mexicanus** species group, myself and Dr. Mark D. Engstrom have examined 30 presumptive genetic loci from populations representing nine species within the group. Unlike other **Peromyscus**, members of the **mexicanus** group are karyotypically uniform. Aside from **P. furvus** which possesses a different FN and some variation in the Y chromosome among other species within the group, all **mexicanus** group species examined to date have apparently identical C- and G-banded karyotypes. Because karyotypic data are relatively uninformative, we are undertaking an analysis of allozymes in order to assess phylogenetic relationships.

The species we are examining include **Peromyscus gymnotis**, **P. guatemalensis**. **P. megalops**, **P. melanocarpus**, **P. ochraventer**, **P. mexicanus**, **P. nudipes**, **P. yucatanicus**, and **P. zarhynchus**. In addition, we include representatives of other species groups within the subgenus **Peromyscus**, as well as **P. (Podomys) floridanus** and **P. (Megadontomys) thomasi** as outgroup taxa. Results of our genetic analyses indicate that **P. mexicanus** is composite. Some samples of the nominate species are more closely allied to other species (e.g. **P. gymnotis**) than to other **P. mexicanus**. In addition, our results suggest that the **mexicanus** group as currently defined is polyphyletic. **Peromyscus megalops**, **P. melanocarpus**, and **P. ochraventer** speciated prior to the branching events separating the remaining **mexicanus** group members from the **truei** and **boylii** groups.

* * *

George S. SMITH, M.D.
Department of Pathology
University of California
Los Angeles, CA 90024
(213) 825-8006

Efforts continue to develop inbred lines of **Peromyscus leucopus** (Pele) and **maniculatus** (Pema). A status report and some observations are submitted. **Peromyscus leucopus** (Pele) was obtained in late 1981 from the random bred colony at Argonne Laboratories in Illinois.

The folowing table illustrates how our inbreeding is progressing at this time for the most advanced two lines and a cross of them (10, 13, 130). I have other separate lines at lesser development.

--- Remaining divisions of line at each generation ---

Line	F1	F2	F3	F4	F5	F6	F7	F8	F9
Pele 10 *11/81	1	1	2	3	9	[24]	40	10	2
Pele 13 11/81	1	1	2	4	6	[8]	7	4	0
Pele 130**	2	5	14	[35]	60	26	1st lit		

[ ] = Breeding continues at this and subsequent generations

* Date line started

** Cross of $13f_4$ female and $10f_4$ male

Sample populations for lifespan are continuing at 30% or less survival. These show that Pele (males) have about 35% longer lifespan at survival than the two different groups of Pema. Almost one third of the Pele males are still alive at the age when the longest survivor among Pema males died (63 months). Half a dozem male Pele were productive breeders at 54 months of age. We have now repeatedly seen that breeding deteriorates noticeably by F_5, F_6. We have so far been unsuccessful in getting beyond F_6 inbreeding with the Pema obtained from random bred colonies at University of California Irvine.

A critical issue in the inbreeding is the mating productivity of the lines. In spite of impressions, data show productivity to be relatively stable in successful sublines. The Pele 130 have been superior in this regard from the beginning of the cross. We usually wean between 21 and 30 days and mate at 8 to 10 weeks. It is common that the first litter is one or two pups with larger subsequent litters.

Line	Generated Mated	Number of Productive Matings	Litters Per Mating **	Pups Per Litter
Pele 10	F_{6*}	15	1.7	3.0
	F_7	13	2.7	2.7
Pele 13	F_{6*}	3	4.1	2.7
	F_7	3	1.7	2.9
Pele 130	F_{4*}	29	2.6	3.7
	F_5	23	2.0	3.9

* The later generation is actively mating while the earlier is in mid to late phase of mating.

** It must be noted that we do not continue breeding after adequate pups are mated and produce the subsequent generation. Commonly this is after about three to four litters.

I would consider some selective requests from experienced investigators for a few animals to perform genetic marker or immunologic work. Note that the spleen is half the size of the **Mus** spleen.

* * *

Holly A. WICHMAN
Division of Molecular Biology & Biochemistry
School of Basic Life Sciences
University of Missouri - Kansas City
Kansas City, MO 64110
(816) 276-2243

Co-workers:
Thomas Payne
Tod Reeder

We are continuing our characterization of **mys**, a retrovirus-like family of transposable elements originally isolated from the genome of the white-footed mouse, **P. leucopus**. Previous work (Nature 317:77-81, 1985) has shown that the majority of **mys** elements in the **Peromyscus** genome have a total length of about 2.8 kb, including 343 bp direct long terminal repeats, and that, in addition to these structurally conserved elements, there are other elements present in the genome which share sequence homology with **mys**. There are between 500 and 1000 copies of the 2.8 kb **mys** element in the **P. leucopus** genome. Sequence analysis has confirmed the retrovirus-like structure of these elements and has suggested that **mys** elements may have an A-T rich target site.

Our ongoing analysis of the **mys** family indicates that the size and general structure of these elements are conserved throughout the genus **Peromyscus**, but that there are numerous restriction fragment length polymorphisms (RFLPs) within the

elements themselves. RFLP distribution patterns are examined by digesting genomic DNA from each species of interest with a restriction endonuclease, separating the resulting fragments by gel electrophoresis, blotting to a nylon filter, and hybridizing to an internal **mys** probe. To date we have looked at 7 RFLPs in 10 species of **Peromyscus** (**P. crinitus, boylii, eremicus, melanophrys, truei, gossypinus, leucopus, melanotis, maniculatus, and oreas**) and in **Onychomys**. The results of these studies are shown below. Each RFLP is given a letter designation; capital letters indicate that the variable restriction sites are in the LTR of the element; lower case letters indicate that at least one of the sites is within the body of the element. An asterisk indicates the presence of a particular RFLP.

	A	B	c	D	e	f	g
Onychomys	*	*					
P. crinitus	*	*					*
boylii	*	*					*
eremicus	*	*	*				
melanophrys	*	*	*				
truei	*	*	*	*			?
gossypinus	*	*	*	*	*	*	
leucopus	*	*	*	*	*	*	
melanotis	*	*	*	*	*	*	*
maniculatus	*	*	*	*	*	*	
oreas	*	*	*	*	*	*	

The distribution of the RFLPs within this group is generally consistent with the known karyotypic relationships between species. We are interested in looking at additional species of **Peromyscus** so that eventually we can construct a phylogenetic tree based on RFLP data and compare it to trees generated from other data sets. We are also planning to use sequence analysis of the LTRs to determine whether there are age differences between **mys** RFLP types. Since the LTR are identical at the time of insertion of an element into a chromosome, difference between LTRs of a given element will act as a molecular clock approximating the amount of time that element has been accumulating mutations.

Mys-homologous elements are also present in the genomes of other rodents. To date, hybridizations have been made to DNA from 7 other genera: **Reithrodontomys, Onychomys, Ochrotomys, Neotoma, Sigmodon, Phodopus,** and **Mus**. **Mys** homologs have been seen in all the cricetid rodents, but not in **Mus**. The size of the elements is only conserved in **Onychomys** and hybridization is detectable in the more distant genera only at reduced stringency, which suggests that this element has undergone quite rapid evolution.

Finally, we are just beginning a project to examine the distribution of **mys** elements in the genome. We are interested in learning whether **mys** elements are preferentially located in the AT-rich components of the genome, as is suggested by their AT-rich target sites.

We wish to thank the numerous investigators who have provided us with tissues for DNA isolation.

* * *

David A. ZEGERS
Department of Biology
Millersville University
Millersville, PA 17551
(717) 872-3409

Joseph F. Merritt
Resident Director
Powdermill Nature Reserve
Carnegie Museum of Natural History
Star Route South
Rector, PA 15677

Joe Merritt and I are collaborating on several projects at Powdermill, the biological field station of the Carnegie Museum of Natural History. These studies focus on winter survival strategies of **Peromyscus leucopus** and **P. maniculatus**. Recently, we've submitted manuscripts documenting seasonal changes in capacity for nonshivering thermogenesis (NST) in both species and the efficacy of environmental factors to cue changes in NST of **P. maniculatus**. Joe has studied the energetics of huddling and used radiotelementry to track **Peromyscus**.

In addition we've been analyzing tree use by these species, and Joe has been monitoring population levels of both species on a grid twice monthly since 1979. Andy Antipas, a former student of mine, and I are finishing a manuscript dealing with our research into the seed preferences of **P. leucopus**.

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