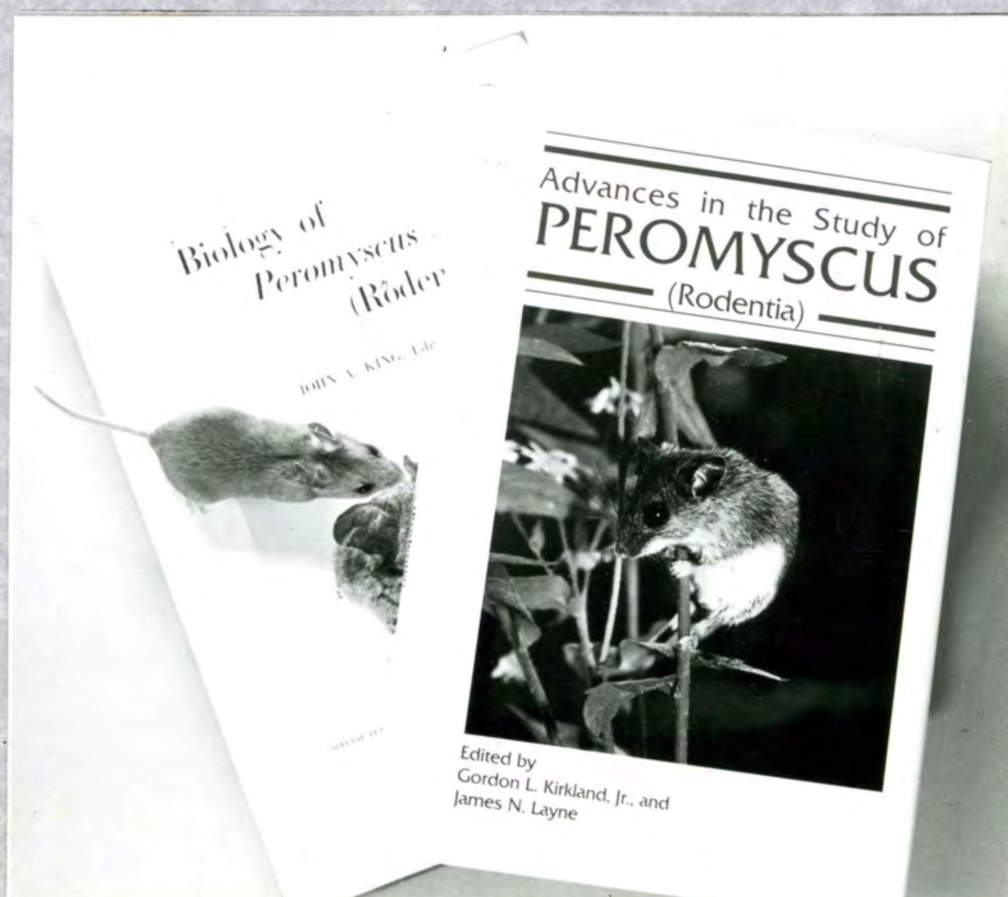
PEROMYSCUS NEWSLETTER

NUMBER NINE



MARCH 1990

Cover: *Peromyscus polionotus* perusing the literature.
(Photo by Clint Cook)

PN Issue Number Nine highlights:

* An Overview of *Advances in the Study of Peromyscus (Rodentia)*

* Paul Moody, Peromyscus Pioneer - by William Kilpatrick

* Update on *Peromyscus* Molecular Biology

* Gene Lists for *P. maniculatus*

-- Deadline for Issue Number Ten is **August 30, 1990** --

PEROMYSCUS NEWSLETTER is produced by the

Peromyscus Stock Center
South Carolina Institute of Biological Research and Technology
University of South Carolina
Columbia SC 29208

with support in part from
National Science Foundation Grant # BSR-8419860.

Wallace D. Dawson, Editor
Peromyscus Stock Center
Department of Biological Sciences
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

* * *

ANNNOUNCEMENTS, NEWS AND COMMENT

Our thanks to **Fred Elder** of the University of Texas Medical School at Houston for preparing Ray Lee's obituary for this issue of PN. Lee made some of the best ever *Peromyscus* chromosome preparations. Elder had been one of Ray Lee's graduate students.

We also want to thank **Bill Kilpatrick,** University of Vermont, for writing an excellent biographical sketch on Paul Moody, our "Peromyscus Pioneer" for this issue. Paul Moody was the first to apply immunological methodology to systematic problems in *Peromyscus.*

****

A N N O U N C E M E N T

The American Society of Mammalogists will hold a symposium, **"Biological Monitoring with Mammals"** as part of their 1990 Annual Meeting to be held in Frostburg, MD. For additional information contact: Karen McBee, Department of Zoology, Oklahoma State University, LSW 430, Stillwater OK 74078 or Greg Linder, NSI Technology Services, 200 S.W. 35th Street, Environmental Research Laboratory, Corvallis OR 97333.

****

Nationally syndicated columnist **James Kilpatrick** recently devoted a column to his encounter with a deer mouse in his Virginia Blue Ridge Mountain cottage office. Kilpatrick relates that the rodent stashed hundreds of Orkin poison pellets into his typewriter, having transported them individually over sixty feet from the kitchen all during one night - a total distance, he estimated, of more than a mile! Two weeks later the culprit succumbed to a snap trap baited with a gum drop, rather than poison. "On postmortem examination," he writes, "the misguided athlete proved to be a deer mouse, *Peromyscus maniculatus,* just under 3 inches long, not counting a 2-inch tail. Color, cinnamon-brown on top, dirty-white below; ears, large; tatoos, none." *[We had a similar experience with an escaped pack-* P. polionotus *a few years ago. Our mouse stashed capillets, small test tubes, tube caps, etc. in secret and not-so- secret places in the lab, including the automated timing mechanism of an autoclave. Repairing the autoclave cost us a several-hundred dollar service call from Atlanta. WDD]*

\+ + + + + + +

Ann Baker, Department of Biology, Colorado State University, writes that she is continuing to obtain records on *Peromyscus* and *Mus* birthrates.

><><><><><

John Glendinning, Florida State University, has found lowering the pH of drinking water to 2 or 3 with HCl to be useful in controlling *Pseudomonas* infections in his *Peromyscus melanotis* colony.

-----X-----

Kazuhiro Koyasu, School of Dentistry, Aichi-Gakuin, Nagoya, Japan, is breeding *Apodemus*. He is examining chromosomal dimorphism in a hybrid zone in central Honshu.

****

M. RAYMOND LEE

March 21, 1928 - July 4, 1989

M. Raymond Lee was born in Hoytsville, Utah on March 21, 1928. He served in the U.S. Army from 1946 to 1948 stationed in Panama in, as he liked to call it, "the occupation army of Panama." Upon his return from military service, he entered Weber College in Ogden, Utah where he studied until 1950. He and his wife, Shirley, married in 1949. Ray completed his undergraduate education in 1952 at the University of Utah, Salt Lake City, with a major in Zoology and graduating with honors. He continued postgraduate studies at the University of Utah where he received his M.S. in 1954 and his Ph.D. in Vertebrate Zoology in 1960 working with Dr. Stephan D. Durrant. In 1960-61 he worked as a Field Representative for the University of Kansas spending most of that time in Mexico. He began work as a Research Associate at the University of Illinois, Urbana, with Dr. Donald F. Hoffmeister in 1961, and in 1963 he was appointed to the faculty of the University of Illinois. From 1964 until 1967 Ray served as the editor of the Journal of Mammalogy.

Those of us who pursued advanced degrees with Ray, taught with him, ventured in the field with him, and collaborated with him, became aware of the love he had for mammalogy, and for the life sciences in general. To learn from Ray was a joyful experience because to teach was a joyful experience for Ray. He served on nearly 50 doctoral committees during his years at the University of Illinois, and chaired five others.

My personal remembrances of Ray center on his scientific integrity and his insistence for exactness of observation, documentation and expression. A particularly noteworthy examply of this to me was the effort that he, along with David Schmidly of Texas A&M University, devoted to the description of what is now *Peromyscus hooperi*. While Ray had determined that he had been sent several live specimens of an undescribed species of *Peromyscus* in 1970, the locality of their capture was in doubt. Rather than publish an incomplete or ambiguous description of this species, over the next six years he and David organized numerous field expeditions and extensively searched existing museum collections to confirm and extend the information available on this mouse. Not until Ray was convinced of the accuracy of their data, and not until the geographic range of this new species could be more precisely defined, was he willing to publish.

The message which Ray unfailingly conveyed to his students was that scientific investigation should be uncompromisingly accurate, unbiased, and in the process, it should also be fun. To Ray, I think that the investigation, and the knowledge gained through the investigation were not only their own reward, they were the ultimate reward.

To Ray, the process of education was as important as the knowledge obtained. He was always available to students for discussions of a variety of topics in biology, and he had the special ability to get students to work through their own questions seeking their own answers. In doing so, he imparted his love of scientific investigation, of learning, and of life in each student with whom he worked. In doing so he imparted a little of himself in all of us who were fortunate enough to have known him.

Ray was a teacher, a scientist, a mentor and a friend. He will be greatly missed.

Frederick F. B. Elder, Department of Pediatrics, The University of Texas Health Science Center - Houston, P.O. Box 20708, Houston, Texas 77225.

****

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 Research 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 fee. Write or call for details.

Stocks Available in the Peromyscus Stock 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. polionotus leucocephalus (LS Stock)	Derived from mice wild-caught on Santa Rosa I., FL. Bred by R. Lacy. 3rd to 5th generation in captivity
P. leucopus (LL Stock)	Derived from 38 wild ancestors captured between 1982 and 85 near Linville NC. Fifth to seventh generations in captivity.
P. maniculatus X *P. polionotus* F_1 Hybrids	Sometimes available.

MUTATIONS AVAILABLE FROM THE STOCK CENTER

Coat Colors	**ORIGINAL SOURCE**
Albino *c/c*	Sumner's albino deer mice (Sumner, 1922)
Ashy *ahy/ahy*	Wild-caught in Oregon ~ 1960 (Teed *et al.*, 1990)
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 $A^{Nb/-}$	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.

MUTATIONS AVAILABLE FROM THE STOCK CENTER (continued)

Other Mutations 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
Institute of Biological Research and Technology
University of South Carolina
Columbia SC 29208
(803) 777-3107

The Advisory Committee for the Stock Center:

Ira F. Greenbaum (Texas A&M University)
Rodney C. Honeycutt (Texas A&M University)
Clement L. Markert (North Carolina State University)
Joseph H. Nadeau (Jackson Laboratory)
Suellen Van Ooteghem (Westinghouse Corporation)
Wallace D. Dawson (University of South Carolina)
Oscar G. Ward *ex officio* (University of Arizona)

PAUL A. MOODY

1903 - 1986

Although Paul Moody published only a few papers concerning *Peromyscus*, he was the first investigator to use biochemical methodology to examine the evolutionary relationships of mice of this genus. During the decades from 1930 to 1960 Moody and his students at the University of Vermont contributed to the development of the field of systematic serology. He engaged in the study of evolutionary relationships of mammals using a variety of serological tests: hemagglutination, Schultz-Dale anaphylactic test, and the precipitin test, both in the form of the interfacial test and a turbidity test measured photoelectrically with a Libby Photronreflectometer. This work included examination of the evolutionary relationships among rodents, lagomorphs, and artiodactyls.

Paul Amos Moody was born on January 13, 1903, in Randolph Center, Vermont. Although some of his childhood was spent in Vermont, he moved with his family to Moville, Iowa, where he attended high school. In 1924 Moody finished an A.B. degree from Morningside College in Sioux City, Iowa, and entered a Ph.D. program at the University of Michigan. Here, under the supervision of Lee R. Dice, and with the aid and encouragement of Alexander G. Ruthven of the Department of Zoology and John F. Shepard of the Department of Psychology, Moody examined the brightness vision of deer mice. Paul Moody was the second graduate student of Lee R. Dice, completing his Ph.D. in the spring of 1927.

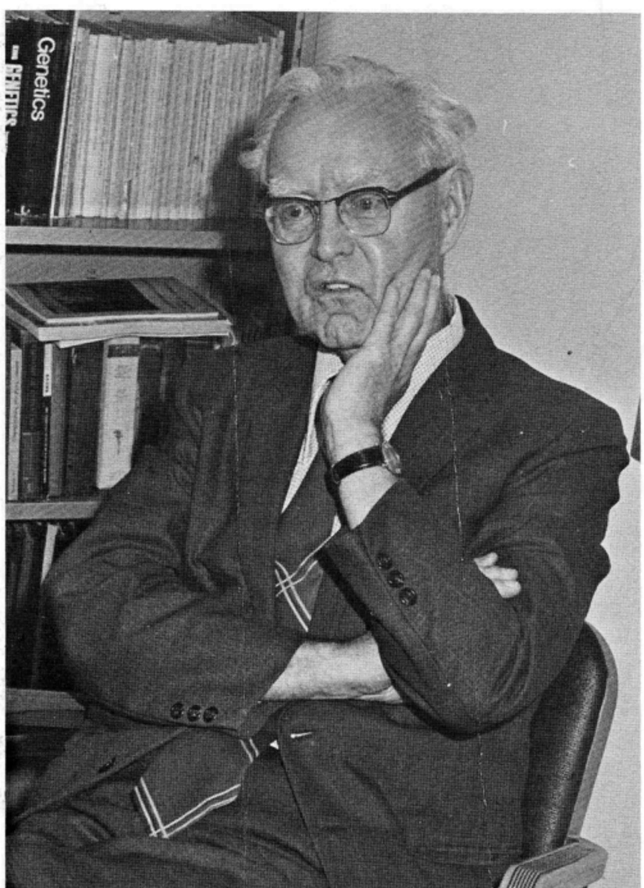
In July of 1927 he married Helen Judith Inlay, who had been a student at Morningside College. Moody joined the zoology faculty of the University of Vermont as an Assistant Professor of Zoology in the fall of 1927. He was promoted to Associate Professor in 1931 and to Howard Professor of Natural History and Zoology in 1945. Although his first love was teaching and research, he served as the first Director of Graduate Study of the University of Vermont from 1942 through 1949 and was chairman of the Department of Zoology from 1945 through 1963. In 1968 he retired from the University of Vermont but continued teaching on a part-time basis until 1974. In May of 1988 he received an Honorary Doctor of Science degree from the institution to which he had given 47 years of his professional career.

Moody's work with *Peromyscus* dates from his doctoral dissertation "Brightness vision in the deer mouse, *Peromyscus maniculatus gracilis*" which was published in 1929 (J. Exp. Zool., 52:367-405). During the mid-1930's, Moody's research interest turned to the developing field of serology and the use of immunological techniques to examine the evolutionary relationships among mammals. In 1939 in collaboration with one of his first graduate (M.S.) students, Harry P. Levine, Paul Moody published the results of an application of the precipitin test to examine the evolutionary relationships of a series of rodents: woodchuck, gray squirrel, pocket gopher, white-footed mouse, cotton rat, wood rat, muskrat, roof rat, and porcupines (Physiol. Zool., 12:400-411). The precipitin test, however, did not provide the sensitivity needed to differentiate between species of *Peromyscus*. In 1940 Moody published a modification of the Schultz-Dale test which, at least in some cases, provided the sensitivity to differentiate between the serum proteins of *Peromyscus maniculatus* and *Peromyscus gossypinus* (J. Immunol., 39:113-123). Greater sensitivity was reported by Moody in 1941 with the use of red blood cell proteins (J. Mamm., 22:40-47) where he used an agglutination test of red blood cells to differentiate individuals of *Peromyscus maniculatus* from individuals of *Peromyscus leucopus* among a series of mice collected on Mt. Mansfield, Vermont. In 1948 Moody published his final paper concerning *Peromyscus* (Contrib. Lab. Vert. Biol., Univ. Michigan, 39:1-16) in which he attempted to use the red blood cell agglutination test to examine the relationships of three stocks of *Peromyscus maniculatus* collected by Lee Dice from the Columbia River valley. Although this work was unable to provide much insight into the relationships of these three stocks, it did demonstrate considerable variation among individuals of local populations and the fundamental genetic cohesion among conspecific populations.

Moody published three additional paper utilizing immunological techniques to examine the evolutionary relationships of mammals. The first of these was published in 1949 and reported no support for a relationship between lagomorphs and rodents (Evolution, 3:25-33). Some of the immunological tests in this paper, however, indicated an affinity between lagomorphs and artiodactyls. A second paper, published in 1956 with David E. Donner, his last graduate (M.S.) student, examined the serological relationships of Old and New World porcupines. They found that these two groups were not very closely related and that each was about equally related to the guinea pig and agouti (Evolution, 10:47-55). Moody published his last serological investigation in 1958 in which he examined the evolutionary affinities of the musk ox and concluded that it was a Caprinae and not a Bovinae (J. Mamm., 39:554-559).

Paul Moody wrote two major text books, **Introduction to Evolution** (1950, 1953, 1962 Harper and Brothers, N. Y.) and **Genetics of Man** (1967, 1975 W. W. Norton, N. Y.), both of which received wide acceptance. He was a warm and carring teacher who continued to teach evolution and human genetics at the University of Vermont until he reached the mandatory retirement age of 70.

Paul Moody was one of the pioneers in the utilization of immunological techniques to examine evolutionary relationships. He was well ahead of his time in utilizing biochemical techniques in his studies of evolutionary relationships before these methods were refined and sophisticated electronic equipment became available. He not only envisioned how these techniques could be used for species identification and examination of evolutionary relationships but also speculated on how such biochemical characterizations of gene products (antigens) could be used to examine gene flow among populations. Paul A. Moody passed away in Burlington, Vermont, in the fall of 1986 following a brief illness. He was survived by his wife, who died in February of 1990, and two daughters, Marilyn and Dorothy.



[Prepared by C. W. Kilpatrick, Dept. Biology, University of Vermont]

An Overview

ADVANCES IN THE STUDY OF PEROMYSCUS
Gordon L. Kirkland, Jr. and James N. Layne, Editors. Texas Tech University Press.

The long-anticipated volume **Advances in the Study of Peromyscus (Rodentia)** is now available in both paperback ($ 22) and hardcover ($ 35) editions. This work will be an essential in the library of *Peromyscus* researchers, particularly those with an ecological bent. Since the PN readership will be the primary beneficiaries of this new book, we present here an overview of its contents.

The volume is based on six symposium papers presented at the Fourth International Theriological Congress in Edmonton in 1985. The contributors have amplifed and updated their presentations in the interval since. The intent of both the symposium and the book was to describe the advances in *Peromyscus* research since publication of **Biology of Peromyscus (Rodentia)** [John A. King, Editor] in 1968. The new volume is considerably less comprehensive than the earlier work, therefore will not satisfy all needs. There is also considerable variation in the length and depth of the individual reviews. **Advances in the Study of Peromyscus (Rodentia)** in reality consists of a detailed taxonomic generic conspectus by Michael Carleton, four relatively concise reviews of largely field-oriented studies, and an engrossing analytical comparison of *Peromyscus* and *Apodemus*.

The 135 page "Systematics and Evolution" review of peromyscines by Carleton is impressive. He obviously devoted a great deal of effort to the task and the finished product will serve as a standard reference for many years to come. The book is easily worth obtaining for this section alone. Carleton briefly traces the taxonomic history of *Peromyscus*, particularly emphasizing the contributions of Wilfred Osgood and Emmet Hooper. Throughout Carleton notes the strengths and weaknesses of the earlier classification schemes, but builds his current classification without radical departures from these antecedents. No doubt, some will argue with his decision to elevate several subgenera (*Habromys, Podomys, Neotomodon, Megadontomys, Osgoodomys* and *Isthmomys*) to generic status, per his 1980 classification of New World murids. He views *Onychomys* as a sister genus to these, but, in contrast to his 1980 view, removes *Reithrodontomys* from the immediate assemblage of peromyscines. He also abandons, for present, the subgeneric category within *Peromyscus* proper, no longer recognizing subgenus *Haplomylomys*. Carleton reviews in some detail each of his thirteen species groups, indicating where future changes are likely to occur. He notes the state of taxonomic flux within the *boylii* group as a result of active field work. The *mexicanus* group is also in need of more study, in Carelton's view. A formal taxonomic summary of the genera of peromyscines concludes the treatment. Current *Peromyscus* systematics and taxonomy of *Peromyscus* as outlined by Carleton is morphology-based, but enhanced with protein electrophoretic and karyotypic information. Application of modern taxonomic philosophy, *a la* Hennig, has also played a role. Techniques of molecular biology will undoubtedly clarify the relationships among some of these species groups in the future. Carleton cites the need to apply more diversified types of information to systematics of the genus. Seventeen range maps are another major plus. Ranges of the 53 species of *Peromyscus* (*sensu strictu*) are clearly defined in distinctive shadings. Overall, although some may quibble over details, it is an excellent accomplishment and Mike is to be commended.

The systematics chapter is followed by four shorter reviews. Each of these concentrates on information which has become available in the past two decades. The subjects included are those primarily of concern to field mammalogists and ecologists, which, of course, reflects where much of the interest in *Peromyscus* lies. Richard MacMillian and Theodore Garland update the more extensive 1983 reviews of Hill (J. Mamm. 64:19ff) and MacMillan (J. Mamm. 64:38ff) on "Adaptive Physiology", strongly concentrating on basal metabolic rate (BMR) and evaporative water loss (EWL). The literature is dealt with principally in a four page table which lists values obtained by various workers for metabolic chararteristics. Relationships among these parameters are illustrated in a series of graphs. The authors stress that *Peromyscus* are physiological generalists, *i.e.* tend to have intermediate BMR, EWL and water regulatory efficiency compared with heteromyids and other rodents. The role of torpor in energy and water conservation is also a distinctive feature of *Peromyscus*.

John S. Millar faces the formidable task of reviewing the extensive topic of "Reproduction and Development", which he does admirably. Such a topic deserves several chapters. Millar has thus been constrained to summarizing numerous published studies in tabular form. This remedy will prove useful, since specific information, *e.g.,* litter size relationship to parity for a given species, can readily be obtained directly from his tables. The works cited by Millar are virtually all of an observational, rather than experimental, nature. For example, studies on experimental embryology and hormonal manipulation of reproduction are not covered.

Donald and Glennis Kaufman are charged with the equally challenging task of summarizing the advances in "Population Biology". A major development since King's 1968 book has been the widespread use of protein electrophetic surveys to assess levels of population polymorphism (P) and individual heterozygosity (H). The Kaufmans have collected data from numerous such studies and arranged them into convenient tables which will be useful for reference. It is clear that the relationship of heterozygosity to life history traits, *i.e.* fitness, is still not clear. The authors deal somewhat more superficially with population dynamics and organization, sex ratios, microhabitat, predator-prey relationship, interspecific competition and habitat partitioning, and foraging. Since population studies are frequently inconclusive, or even contradictory, the results are difficult to generalize. Don and Glennis raise some interesting questions which should entice *Peromyscus* field biologists far into the future.

Jerry Wolff addresses "Social Behavior" in a brief review, concentrating primarily on *P. maniculatus* and *P. leucopus*. Nevertheless, it is a concisely written interesting chapter which addresses home range and territory, mating systems, adult-juvenile interactions and nesting behavior. The importance of population density in territorial defense behavior is stressed. Mating systems in *Peromyscus* range from monogamous in *P. polionotus* to promiscuous in some *P. maniculatus* and *P. leucopus*. Nesting patterns also vary. Like other topics in this volume, few generalizations emerge which apply to *Peromyscus* overall.

The final chapter "*Peromyscus* and *Apodemus*: Patterns of Similarity in Ecological Equivalents" by W. I. Montgomery (Queens University, Belfast, N. Ireland) is an innovative approach to the question of convergent evolution. These two genera representing distantly related muroids have long been regarded as ecological counterparts in Eurasia and North America. They are superficially similar in size, coat color pattern, dietary habits and habitat requirements. Montgomery has gathered an immense amount of data for a more detailed comparison. He concludes that the two genera are broadly similar in many respects, but there are also significant differences. For example, *Peromyscus*, but not *Apodemus*, often employ torpor as a physiological stress-reducing mechanism. Therefore, caution should be exercised when applying the ecological equivalence theme. The chapter is considerably more instructive than the original presentation at the Edmonton symposium.

In summary, *Advances in the Study of Peromyscus* contains much useful information. However, the title is misleading in that some significant areas of *Peromyscus* research are totally omitted. These tend to be laboratory-based experimental and biomedical subjects. As one example, more than 30 articles have been published since 1976 in the biomedical and pharmacological literature on the alcohol dehydrogenase (ADH) negative deer mouse, which is the only known mammalian model of this condition. Multimillion dollar research involving four major U.S. and one foreign institution has substantialy furthered knowledge of metabolism of small organic molecules. Yet, there is no mention of any of this exciting work on *Peromyscus.* Noteworthy advances in *Peromyscus* cytogenetics by T.C. Hsu, Ira Greenbaum, Robert Baker and many others were only discussed with reference to systematics. New insights have emerged from experimental reproductive work of Don Dewsbury, J. Mal Whitsett, Irving Zucker, E.L. Bradley and many others; and also from an enoromous amount of melatonin and neuroamine research on regulation of metabolism, reproduction and behavior in *Peromyscus*. These advances and others have received little or no notice in this volume. Nevertheless. these deficiences do not lessen the book's usefulness to the *Peromyscus* enthusiast, who should by all means obtain a copy.

Finally, plaudits are due for the fine cover photo, which we understand was made by Jerry Wolff.

WDD

GENETIC LOCI IN THE DEER MOUSE

(*Peromyscus maniculatus*)

Tables 1A, 1B, 1C and 1D list recognized genetic loci described in *Peromyscus maniculatus* and other species of the *maniculatus*-group. This list is limited to loci for which formal genetic analysis of crosses has been conducted and appropriately reported in the published scientific literature. Additional genetic traits are known and some have been mentioned in abstracts, casual reports, newsletters, grant proposals, papers presented at meetings, etc. The latter are not included, since the descriptions and genetics generally are not complete enough to formally define the loci.

Table 2 lists presumptive variant protein loci described from natural populations of *P. maniculatus* and other members of the *maniculatus*-species group. These loci have not necessarily been formally demonstrated by mendelian crosses. Monomorphic (invariant) protein loci are not listed, but variants among potentially interbreeding species are included. For example, one allozyme may occur in one species, *e.g. P. polionotus*, and another in a different species, *e.g. P. maniculatus*. Only published reports are included.

Although the genetic nomenclature of *Peromyscus* is not yet completely standardized, the conventions used for the house mouse (*Mus*) are employed wherever possible. In designating genetic loci we adopted the symbols given by the original investigator, unless there is clear homology with *Mus* loci for which standarized symbols are assigned; or in cases where the original symbols have been superceded by subsequent usage, in which case we have used the most recent revision. However, identity of locus symbols used for *Peromyscus* with those used in other taxa of mammals does not necessarily imply homology. As a case in point, *ja* in *Mus* is the "jaundiced" locus, while in *Peromyscus ja* represents "juvenile ataxia". If a variant is shown to be allelic with a previously reported gene, the locus symbol is reduced to an allelic symbol. Where two authors have used the identical symbol for different loci in *Peromyscus* we have given priority to the first reported, and devised an alternate designation for the other.

Table 3 lists current linkage group assignments for established loci.

References cited in the tables are available in a list of *Peromyscus* genetic literature compiled by Dr. Bruce Buttler, Biology Department, Canadian Union College, College Heights, Alberta, Canada, TOC OZO.

Table 1A

Genetic Loci Formally Described in the *Peromyscus maniculatus* Species Group:

Coat and Eye Pigmentation and Pattern Variants.

Name of locus and allelic variants	Symbol	Mode of inheritance[f]	Linkage group	Definitive description and analysis	Collateral descriptions, interactions and recurrences	Recombination reported
AGOUTI			III			
Wide-band agouti	A^{Nb}	dominant		McIntosh (1956a)	Blair (1947) as "buff"	Clark (1938) as "buff"
White-belly non-agouti	a^{w}	recessive		Egoscue (1971)		
Non-agouti (Black)	*a*	recessive		Horner *et al.* (1980)		
BROWN	*b*	recessive	II	Huestis and Barto (1934)	Blair (1947), McIntosh (1956a), Dawson *et al.* (1969)	Huestis and Barto (1934), Blair (1947), Barto (1955, 1956), McIntosh (1956a)
Orange-tan	b^{ot}	recessive		Egoscue and Day (1958)		
BLOND	*bl*	recessive		Pratt and Robbins (1982)		
ALBINO	*c*	recessive	I	Sumner (1922)	Clark (1938)	Sumner (1922), Clark (1936, 1938), Feldman (1937), Barto (1942a), Huestis and Lindstedt (1946), Huestis (1946)
COLORLESS HAIRTIP*	*ctp*	recessive		Bowen and Dawson (1969)	Bowen (1968)	
DILUTE*	*d*	recessive	II	Dice (1933)		Clark (1938), Barto (1942a, 1956), McIntosh (1956a)
GRAY	*g*	recessive		Dice (1933)	Clark (1938), Blair (1947), McIntosh (1956a)	Blair (1944, 1947)
IVORY	*i*	recessive		Huestis (1938) McIntosh (1956a)	Clark (1938)	Barto (1942a, 1956),
PINK-EYED DILUTION	*p*	recessive	I	Sumner (1917) as "pallid"	Clark (1938), Barto (1942b)	Sumner (1922), Clark (1936, 1938), Feldman (1937), Snyder (1980a)
PLATINUM	*pt*	recessive		Dodson *et al.* (1987)		Dodson *et al.* (1987)
RED EYE (Heterochromia)	*r*	recessive		Huestis and Willoughby (1950)		
DOMINANT SPOT (Whiteface)	*S*	dominant		Feldman (1936)	Maddock (1966)	Feldman (1937)

(Table Continued)

Table 1A. Coat and Eye Color Variants (Continued)

Name of locus and allelic variants	Symbol	Mode of inheritance[1]	Linkage group	Definitive description and analysis	Collateral descriptions, interactions and recurrences	Recombination reported
SILVER	*si*	recessive	I	Huestis and Barto (1934)		Huestis and Barto (1934), Huestis and Piestrak (1942), Huestis and Lindstedt (1946), Barto (1956)
WHITE CHEEK*	*Wc*	dominant		Blair (1944)	Bowen and Dawson (1977)	Blair (1944)
WHITESIDE	*wh*	recessive		McIntosh (1956b)		
YELLOW	*y*	recessive		Sumner (1917)	Sumner and Collins (1922), Clark (1938), McIntosh (1956a)	Sumner (1922), Feldman (1937), Barto (1956), McIntosh (1956a)
COMPLEXLY INHERITED TRAITS:						
Minor white spotting (star, splash, etc.)	*p-1, p-2*	recessive incompletely penetrant		Feldman (1936)	Sumner (1932), Barto and Huestis (1933)	
Grizzled	"G"	"complex dominant"		Sumner (1928, 1932)		
Coat pattern in *P. polionotus*				Bowen and Dawson (1977)	Bowen (1968)	Bowen and Dawson (1977)
Pointed A	P_a	dominant	VII			
Pointed B	P_b	dominant	VII			
Tapered	*Tp*	dominant				
Coat pattern modifiers				Bowen and Dawson (1977)		
Squared modifier	*Rs*	incompletely dominant				
Tapered modifier	*Rt*	dominant				

[1]Autosomal unless other wise stated.

*No longer known to be in existence

Table 1B

Genetic Loci Formally Described in the *Peromyscus maniculatus* Species Group:

Integumentary, Skeletal and Pathological Variants.

Name of locus	Symbol	Mode of Inheritance[1]	Linkage group	Definitive description and analysis	Collateral descriptions, interactions and recurrences	Recombination reported
CATARACT-WEBBED (Syndactyly)	*cw*	recessive		Anderson and Burns (1979)		
FLEXED TAIL	*f*	recessive	I	Huestis and Barto (1936)		Huestis and Barto (1936a), Huestis and Piestrak (1942), Huestis and Lindstedt (1946), Huestis *et al.* (1956), Barto (1956)
HAIRLESS-1	*hr-1*	recessive		Sumner (1924)		Sumner (1924, 1932), Feldman (1937), Clark (1938), Barto (1942a, 1955, 1956), McIntosh (1956a)
HAIRLESS-2	*hr-2*	recessive		Egoscue (1962)		
NUDE*	*n*	recessive		Clark (1938)	Barto (1942a)	
SPHEROCYTOSIS (Inherited jaundice)	*sph*	recessive		Huestis and Anderson (1954)	Huestis *et al.* (1956) Motulsky *et al.* (1956)	Huestis *et al.* (1956)

[1]Autosomal unless otherwise stated.

*No longer known to be in existence.

Table 1C

Genetic Loci Formally Described in the *Peromyscus maniculatus* Species Group:

Behavior and Neurological Variants.

Name of locus	Symbol	Mode of Inheritance[1]	Linkage group	Definitive description and analysis	Collateral descriptions, interactions and recurrences	Recombination reported
BOGGLER	*bg*	recessive		Barto (1955)	Vandermere and Barto (1969)	Barto (1955)
EPILEPSY (EP; waltzing in *artemisiae*)	*ep* ("*e*", v_2)	recessive		Dice (1935)	Clark (1938), Watson (1939), Chance and Yaxley (1950), Barto (1954, 1956)	Watson (1939) Barto (1956)
JUVENILE ATAXIA	*ja*	recessive		VanOoteghem (1983)		
SPINNER* (Waltzing in *rhoadsi*)	*sp* (v_3)	recessive		Watson (1939)	Barto (1954)	
TREMOR*	*tr*	recessive		Huestis and Barto (1936b)		
WALTZER* (Waltzing in *bairdii*)	*v* (*w*)	recessive	III	Dice (1935)	Clark (1938), Watson (1939)	Barto (1942a, 1954, 1956), McIntosh (1956a)

[1]Autosomal unless otherwise stated.

*No longer known to be in existence

Table 1D

Genetic Loci Formally Described in the *Peromyscus maniculatus* Species Group:

Biochemical and Immunological Variants.

Name of locus	Allelic designation	Linkage group	Definitive description and formal analysis	Recombination reported
ALCOHOL DEHYDROGENASE (liver)	Adh^{f} Adh^{s} Adh^{o}	VI	Felder (1975), Burnett and Felder (1978a, 1978b)	Dawson *et al.* (1983)
ALBUMIN (serum)	Alb^{100} Alb^{96} Alb^{86}	VI	Brown and Welser (1968) Jensen and Rasmussen (1971)	Dawson (1982), Dawson *et al.* (1983)
AMYLASE (salivary)	$Amy\text{-}1^{a}$ $Amy\text{-}1^{b}$ $Amy\text{-}1^{c}$	VI	Evans *et al.* (1977)	Dawson *et al.* (1983)
ERYTHROCYTIC ANTIGEN	$Ea^{A} = (Pm^{A})$ $Ea^{B} = (Pm^{B})$ $Ea^{C} = (Pm^{C})$	IV	Rasmussen (1961), Savage and Cameron (1971)	Randerson (1973)
ESTERASE (erythrocytic)	$Es\text{-}1^{o}$ $Es\text{-}1^{a}$ $Es\text{-}1^{b}$	IV	Randerson (1965), Van Deusen and Kaufman (1978)	Randerson (1973)
ESTERASES (tissue and serum)	*Es-2* through *Es-7* (Symbols not standardized)		Rasmussen and Jensen (1971), Dawson (1982), Gill (1976), Baccus *et al.* (1980)	Dawson (1982)
GLUTAMATE OXALOACETATE TRANSAMINASE (soluble) (ASPARTATE AMINO TRANSFERASE)	$Got\text{-}1^{a}$ $Got\text{-}1^{b}$ $Got\text{-}1^{c}$		Gill (1976)	Dawson *et al.* (1983)
GLUCOSE-6-PHOSPHATE (AUTOSOMAL HEXOSE-6-P) DEHYDROGENASE) (soluble)	$G6pd\text{-}1^{a}$ $G6pd\text{-}1^{b}$		Shaw and Barto (1965) Shaw (1966)	
α-GLYCEROPHOSPHATE DEHYDROGENASE (tissue)	$Gpd\text{-}1^{a}$ $Gpd\text{-}1^{b}$		Gill (1976)	
HEMOGLOBIN - ALPHA TYPE GLOBINS (Duplicated locus)	$Hba^{1} = (Hb^{s}) = (HbI^{o})$ Hba^{2} $Hbc^{o} = (Hb^{o}) = (HbI^{o})$ Hbc^{1} $Hbc^{2} = (Hb^{f})$		Thompson *et al.* (1966), Rasmussen *et al.* (1968), Jensen *et al.* (1976), Maybank and Dawson (1976), Snyder (1978, 1980b)	
HEMOGLOBIN - BETA TYPE GLOBINS (Triplicated locus)	Hbb^{1} Hbd^{o} *Hbb-b1* Hbd^{1} or *Hbb-b2* Hbe^{o} *Hbb-b3* Hbe^{1}	I	Snyder (1978, 1980b), Padgett *et al.* (1987)	Snyder (1980a)
HAPTOGLOBIN (serum)	Hpt^{1} Hpt^{2}		Rasmussen (1968) Griswold and Dawson (1971)	

(Table continued)

Table 1D. Biochemical and Immunological Variants (Continued)

Name of locus	Allelic designation	Linkage group	Definitive description and formal analysis	Recombination reported
IMMUNOGLOBIN ($7Sy_1$)	Ig^f Ig^s		Coe (1972)	
LACTATE DEHYDROGENASE A SUBUNIT (tissue)	$Ldh\text{-}A^a$ $Ldh\text{-}A^b$		Cattanach and Perz (1969)	
LACTATE DEHYDROGENASE B SUBUNIT (tissue)	$Ldh\text{-}B^f$ $Ldh\text{-}B^s$		Shaw and Barto (1963)	
LEUCINE AMINOPEPTIDASE (serum)	$Lap\text{-}1^a$ $Lap\text{-}1^b$	V	Dawson (1982)	Dawson (1982), Dawson *et al.* (1983)
6-PHOSPHOGLUCONATE DEHYDROGENASE (tissue)	$Pgd\text{-}1^a$ $Pgd\text{-}1^b$		Gill (1976)	Dawson *et al.* (1983)
PHOSPHOGLUCOMUTASE-1 (tissue)	$Pgm\text{-}1^a$ $Pgm\text{-}1^b$		Gill (1976)	
PHOSPHOGLUCOMUTASE-4 (tissue)	$Pgm\text{-}4^a$ $Pgm\text{-}4^b$ $Pgm\text{-}4^c$		Gill (1976)	
SUPEROXIDE DISMUTASE	$Sod\text{-}1^J$ = (Ng^J) $Sod\text{-}1^P$ = (Ng^P) $Sod\text{-}1^M$ = (Ng^M)		Birdsall *et al.* (1970)	
TRANSFERRIN (serum)	Trf^a = (Trf^J) Trf^b Trf^c Trf^e Trf^M	V	Rasmussen and Koehn (1966), Biggers and Dawson (1971), Griswold and Dawson (1971) Canham *et al.* (1970)	Dawson (1982) Dawson *et al.* (1983)

[1] Autosomal unless otherwise stated.

Table 2. VARIANT PROTEIN LOCI REPORTED FROM NATURAL POPULATIONS OF THE *PEROMYSCUS MANICULATUS* SPECIES GROUP

Protein	Locus	Species[1]	Reference
Acid phosphatase	*Acp-1*	*P. maniculatus*	Baccus and Wolff (1989)
Adenosine deaminase	*Ada-1*	*P. maniculatus*	Baccus and Wolff (1989)
Alcohol dehydrogenase	*Adh-1*	*P. maniculatus* *P. melanotis*	Avise *et al.* (1979) Baccus *et al.* (1980) Massey and Joule (1981) Calhoun *et al.* (1988) Baccus and Wolff (1989)
Albumin	*Alb*	*P. maniculatus* *P. polionotus*	Rasmussen (1970) Jensen and Rasmussen (1971) Selander *et al.* (1971) Avise *et al.* (1974) Biggers and Dawson (1971) Loudenslager (1978) Baccus *et al.* (1980) Calhoun *et al.* (1988)
Aldolase	*Aldo-1*	*P. maniculatus*	Baccus and Wolff (1989)
Amylase	*Amy-1*	*P. maniculatus*	Aquadro and Patton (1980)
Carbonic anhydrase	*Ca-1*	*P. maniculatus*	Baccus and Wolff (1989)
Catalase	*Cat-1*	*P. maniculatus*	Baccus and Wolff (1989)
Esterase	*Es-1* *Es-2* *Es-3* *Es-4* *Es-5* *Es-6* *Es-7* *Es-8*	*P. maniculatus* *P. polionotus*	Rasmussen and Jensen (1971) Selander *et al.* (1971) Peck and Biggers (1975) Gill (1976) Loudenslager (1978) Massey and Joule (1981) Foltz (1981) Aquadro and Kilpatrick (1981) Baccus and Wolff (1989)
Gluconate dehydrogenase	*Gdh-1*	*P. maniculatus*	Baccus and Wolff (1989)

(Continued)

Table 2. Variant protein loci from *P. maniculatus* group populations (Continued).

Protein	Locus	Species[1]	Reference
Glutamate oxaloacetate transaminase	*Got-1* *Got-2*	*P. maniculatus* *P. polionotus* *P. melanotis*	Selander *et al.* (1971) Gill (1976) Loudenslager (1978) Avise *et al.* (1979) Baccus *et al.* (1980) Massey and Joule (1981) Aquadro and Kilpatrick (1981) Calhoun *et al.* (1988) Baccus and Wolff (1989)
Glucose-6-phosphate dehydrogenase	*G6pd-1* (*H6pd-1*)	*P. maniculatus*	Shaw and Barto (1965) Loudenslager (1978) Aquadro and Kilpatrick (1981)
α-Glycerophosphate dehydrogenase	*Gpd-1*	*P. maniculatus* *P. polionotus* *P. oreas*	Selander *et al.* (1971) Mascarello and Shaw (1973) Gill (1976) Avise *et al.* (1979) Calhoun *et al.* (1988) Baccus and Wolff (1989)
Glucose phosphate isomerase	*Gpi-1* (*Pgi-1*)	*P. polionotus* *P. melanotis* *P. maniculatus*	Selander *et al.* (1971) Avise *et al.* (1974) Avise *et al.* (1979) Massey and Joule (1981) Foltz (1981) Baccus and Wolff (1989)
Glutamate pyruvate transaminase	*Gpt-1*	*P. maniculatus*	Baccus and Wolff (1989)
Hemoglobin	*Hba* *Hbb*	*P. maniculatus* *P. polionotus* *P. melanotis*	Thompson *et al.* (1966) Ahl (1968) Foreman (1968) Rasmussen *et al.* (1968) Rasmussen (1970) Selander *et al.* (1971) Snyder (1978, 1980) Loudenslager (1978) Avise *et al.* (1979) Massey and Joule (1981) Aquadro and Kilpatrick (1981) Chappell and Snyder (1984)
Haptoglobin	*Hpt*	*P. polionotus*	Peck and Biggers (1975)
Immunoglobin (7Sγ)	*IgG*	*P. maniculatus*	Coe (1972)

(Continued)

Table 2. Variant protein loci from *P. maniculatus* group populations (Continued).

Protein	Locus	Species[1]	Reference
Isocitrate dehydrogenase	*Idh-1*	*P. maniculatus*	Mascarello and Shaw (1973)
	(Icd-1)	*P. oreas*	Baccus *et al.* (1980)
	Idh-2	*P. polionotus*	Avise *et al.* (1974)
		P. sejugis	Massey and Joule (1981)
			Aquadro and Kilpatrick (1981)
			Calhoun *et al.* (1988)
			Baccus and Wolff (1989)
Lactate dehydrogenase	*Ldh-1*	*P. maniculatus*	Selander *et al.* (1971)
	Ldh-2	*P. polionotus*	Avise *et al.* (1979)
		P. melanotis	Massey and Joule (1981)
			Calhoun *et al.* (1988)
Malate dehydrogenase	*Mdh-1*	*P. maniculatus*	Selander *et al.* (1971)
	Mdh-2	*P. polionotus*	Massey and Joule (1981)
Malic enzyme	*Me-1*	*P. maniculatus*	Baccus and Wolff (1989)
Nucleoside phosphorylase	*Np-1*	*P. maniculatus*	Baccus and Wolff (1989)
Peptidase	*Pep-1*	*P. maniculatus*	Avise *et al.* (1979)
	(Pep-B)	*P. melanotis*	Baccus *et al.* (1980)
	Pep-2		Massey and Joule (1981)
			Calhoun *et al.* (1988)
			Baccus and Wolff (1989)
6-Phosphogluconate dehydrogenase	*Pgd-1*	*P. maniculatus*	Selander *et al.* (1971)
		P. polionotus	Mascarello and Shaw (1973)
		P. oreas	Gill (1976)
			Avise *et al.* (1979)
			Baccus *et al.* (1980)
			Massey and Joule (1981)
			Foltz (1981)
			Baccus and Wolff (1989)
Phosphoglucomutase	*Pgm-1*	*P. maniculatus*	Selander *et al.* (1971)
	Pgm-2	*P. polionotus*	Mascarello and Shaw (1973)
	Pgm-3	*P. melanotis*	Gill (1976)
	Pgm-4		Avise *et al.* (1979)
			Massey and Joule (1981)
			Aquadro and Kilpatrick (1981)
			Baccus and Wolff (1989)
Sorbitol dehydrogenase	*Sdh-1*	*P. maniculatus*	Baccus *et al.* (1980)
			Massey and Joule (1981)
			Baccus and Wolff (1989)

(Continued)

Table 2. Variant protein loci from *P. maniculatus* group populations (Continued).

Protein	Locus	Species[1]	Reference
Superoxide dismutase	*Sod-1*	*P. maniculatus*	Baccus and Wolff (1989)
Transferrin	*Trf*	*P. maniculatus* *P. polionotus*	Rasmussen (1970) Biggers and Dawson (1971) Selander *et al.* (1971) Avise *et al.* (1974) Gill (1976) Redfield (1976) Loudenslager (1978) Avise *et al.* (1979) Baccus *et al.* (1980) Massey and Joule (1981) Foltz (1981)
Miscellaneous non-specific proteins (pre- and postalbumins *etc.*)		*P. maniculatus*	Mascarello and Shaw (1973) Gill (1976) Baccus and Wolff (1989)

[1]Species from which protein variants were obtained.

References:

Ahl, A.S. 1968. Comp. Physiol. Biochem. 24:427-435.

Aquadro, C.F. and J.C. Patton. 1980. J. Mamm., 61:703-707.

Aquadro, C.F. and C.W. Kilpatrick. 1981. In: Smith, M.H. and J. Joule.(Eds) Mammalian Population Genetics. 214-230.

Avise, J.C., M.H. Smith and R.K. Selander. 1979. J. Mamm., 60:177-192.

Baccus, R. and J.O. Wolff. 1989. J. Mamm., 70:592-602.

Baccus, R., J. Joule and W.J. Kimberling. J. Mamm., 61:423-435.

Biggers, C.J. and W.D. Dawson. 1971. J. Mamm., 52:376-385.

Calhoun, S.W., I.F. Greenbaum and K.P. Fuxa. 1988. 69:34-45.

Chappell, M.A. and L.R.G. Snyder. 1984. Proc. Nat. Acad Sci., 81:5484-5488.

Coe, J.E. 1972. J. Immunol., 108:907-912.

Foltz, D.W. 1981. Am. Nat.,117:665-675.

Foreman, C.W. 1968. Comp. Biochem. Physiol.,25:727-731.

Gill, A.E. 1976. Bichem. Genet., 14:835-848.

Jensen, J.N. and D.I. Rasmussen. 1971. J. Mamm., 52:508-514.

Loudenslager, E.J. 1978. Biochem. Genet., 16:1165-1179.

Mascarello, J.T. and C.R. Shaw. 1973. Texas Rep. Biol. Med., 31:507-518.

Massey, D.R. and J.J. Joule. 1981. In: Smith, M.H. and J. Joule (Eds.) Mammalian Population Genetics. 180-201.

Peck, C.T. and C.J. Biggers. 1975. J. Hered., 66:237-241.

Rasmussen, D.I. 1970. Symp. Zool. Soc. Lond., 26:335-349.

Rasmussen, D.I., J.N. Jensen and R.K. Koehn. 1968. Biochem. Genet., 2:87-92.

Redfield, J.A. 1976. Can. J. Zool., 54:463-474.

Selander, R.K., M.H. Smith, S.Y. Yang, W.J. Johnson and J.B. Gentry.Univ. Texas. Studies in Genetics. 6:49-90.

Shaw, C.R. and E. Barto. 1965. Science, 148:1099-1100.

Snyder, L.R.G. 1978. Genetics, 89:531-550.

Snyder, L.R.G. 1980. Evolution, 34:1077-1098.

Thompson, R.B., H.B. Hewett, S.S. Kilgore, A.P. Shepherd and W.N. Bell. Nature, 210:1063-1064.

Table 3

MAPPED GENE LOCI IN *PEROMYSCUS MANICULATUS*

Gene Symbol	Name of Locus	Linkage Group	Reference
A^{Nb}	Agouti	III	13.
Adh-1	Alcohol dehydrogenase (liver)	VI	9.
Alb	Albumin (serum)	VI	9.
Amy-1	Amylase (salivary)	VI	9.
b	Brown	II	13.
c	Albino	I	4, 5, 11, 18.
d	Dilute	II	13.
Ea-1	Pm erythrocytic antigen	IV	14.
Es-1	Esterase-1 (erythrocytic)	IV	14.
Es-5	Esterase-5 (kidney)	IVa	8.
Es-6	Esterase-6 (kidney)	IVa	8.
f	Flexed tail	I	10, 11.
Gpi-1	Glucose phosphate isomerase	I	17.
Hbb	Beta globin (hemoglobin)	I	17.
Lap-1	Leucine aminopeptidase (serum)	V	8.
p	Pink-eyed dilution	I	4, 5, 17, 18.
P_A	Pointed rump pattern A	VII	3.
P_B	Pointed rump pattern B	VII	3.
Pep-2	Tripeptidase (erythrocytic)	VI ?	8.
sb	Snub nose	I	16.
si	Silver	I	10, 11.
Trf	Transferrin (serum)	V	8.
v	Waltzer	III	13.

References:

1. Baccus, R., J. Joule and W.J. Kimberling. (1980). J. Mamm., 61:423-435.
2. Barto, E. (1942). Papers Mich. Acad. Sci., Arts. Lets. 27:195-213
3. Bowen, W.W. and W. D. Dawson. (1977). J. Mamm., 58:521-530.
4. Clark, F.H. (1936). J. Hered., 27:259-260.
5. Clark, F.H. (1938). Contrib. Lab. Vert. Genet., 7:1-11.
6. Committee. (1977). Cytogenetics, 19:38-43.
7. Cramer, D.V. (1988). Rat News Letter, 20:15-20
8. Dawson, W.D. (1982). Acta Theriol., 27:213-230.
9. Dawson, W.D., L.L. Huang, M.R. Felder and J.B. Shaffer (1983). Biocehm. Genet., 21:1101-1114.
10. Huestis, R.R. and V. Piestrak (1942). J. Hered.,33:289-291.
11. Huestis, R.R. and G. Lindstedt (1946). Am. Nat., 80:85-91.
12. Koop, B.F., R.J. Baker, M.W. Haiduk and M.D. Engstrom. (1984) Genetica, 64:199-208.
13. McIntosh, W.B. (1956). Contrib. Lab. Vert. Biol., 73:1-27.
14. Randerson, S. (1973). J. Hered., 64:371-372.
15. Robinson, R. (1964). Heredity, 19:701-709.
16. Robinson, R. (1972). Gene Mapping in Laboratory Mammals, pp.431-441.
17. Snyder, L.R.G. (1980). Biochem. Genet., 18:209-220.
18. Sumner, F.B. (1922). Am. Nat., 56:412-417.

---------------PEROMYSCUS MOLECULAR GENETICS---------------

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 the 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; Pine *et al.*, 1988):

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 common restriction sites. *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 (=*LINE-1*) long interspersed repeat family in *P. maniculatus:*

Features: No sequences published for *Peromyscus*. Three clones sequenced by D. Kass, University of South Carolina (PN #7). Homology with *Mus* and other mammalian *L1* elements shown by Southern blotting (Burton *et al.*, 1986).

DNA Libraries:

I. GENOMIC LIBRARIES.

P. leucopus. Constructed from *P. l. leucopus* from Georgia. Dr. H. A. Wichman, University of Idaho (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 Carolina (M. Felder) also has one of these libraries

II. cDNA LIBRARIES.

P. maniculatus. Two constructed from liver mRNA by M.R. Felder, University of South Carolina (See PN # 6)

Mitochondrial DNA:

RESTRICTION ENZYME ANALYSIS.

P. polionotus, P. maniculatus and *P. leucopus.* Digest with EcoRI, HindIII, BstEI, BstEII, HaeIII and PstI. 25 combinational types (haplotypes) 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, BstII, PstI, BglII, AvaI, AvaII, MboI and HinfI. 26 combinational types from 26 populations from California Channel Islands and southern California mainland. (Ashley and Wills, 1987, 1989)

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)

Transgenics:

Four *P. leucopus mys* repeat element (retroposon) clones (1, 2, 4, 7) microinjected into *Mus domesticus* male pronuclei. Three transgenic *Mus* recorded. *Mys* transcripts produced. Consensus target sequence recognized by *mys* element 3' deduced: > **ATCC........T(T/G)AAGTT**. (Pine *et al.,* 1988)

....

References

Ashley, M. and C. Wills. 1987. Analysis of mitochondrial DNA polymorphisms among Channel Island deer mice. *Evolution*, 41:854-863.

Ashley, M. and C. Wills. 1989. Mitochondrial-DNA and allozyme divergence patterns are correlated among island deer mice. *Evolution*, 43:646-650.

Avise, J.C., R.A. Lansman and R.O. Shade. 1979. The use of restriction endonucleases to measure mitochondrial DNA sequence relatedness in natural populations. I. Population structure and evolution in the genus *Peromyscus*. *Genetics*, 92:279-295.

Avise, J.C., J.F. Shapira, S.W. Daniel, C.F. Aquadro and R.A. Lansman. 1983. Mitochondrial DNA differentiation during the speciation process in *Peromyscus*. *Mol. Biol. Evol.*, 1:38-56.

Burton, F.H., D.D. Loeb, C.F. Voliva, S.L. Martin, M.H. Edgell and C.A. Hutchison. 1986. Conservation throughout Mammalia and extensive protein-coding capacity of the highly repeated DNA long interspersed sequence one. *J. Mol. Biol.*, 187:291-304.

Lansman, R.A., J.C. Avise, C.F. Aquadro, J.F. Shapiro and S.W. Daniel. 1983. Extensive genetic variation in mitochondrial DNA's among geographic populations of the deer mouse, *Peromyscus maniculatus*. *Evolution*, 37:1-16.

Nelson, K., R.J. Baker and R.L. Honeycutt. 1987. Mitochondrial DNA and protein differentiation between hybridizing cytotypes of the white-footed mouse, *Peromyscus leucopus*. *Evolution*, 40:169-181.

Padgett, R.W., D.D. Loeb, L.R.G. Snyder, M.H. Edgell and C.A. Hutchison. 1987. The molecular organization of the beta-globin complex of the deer mouse, *Peromyscus maniculatus*. *Mol. Biol. Evol.*, 4:30-45.

Pine, D.S., E.C. Bourekas and S.S. Potter. 1988. *Mys* retrotransposons in *Peromyscus leucopus* and transgenic *Mus musculus*. *Nucleic Acids Res.*, 16:3359-3373.

Wichman, H.A., S.S. Potter and D.S. Pine. 1985. *Mys*, a family of mammalian transposable elements isolated by phylogenetic screening. *Nature*, 31:77-81.

Rodney Honeycutt, Corresponding Editor
Department of Wildlife and Fisheries
Texas A & M University
College Station TX 77843

<><><><><><><><><><>

NOTICE

PEROMYSCUS NEWSLETTER IS NOT A FORMAL SCIENTIFIC PUBLICATION.

Therefore ...

INFORMATION AND DATA IN THE "CONTRIBUTIONS" SECTION
SHOULD NOT BE CITED OR USED
WITHOUT PERMISSION OF THE CONTRIBUTOR.

THANK YOU !

<><><><><><><><><><>

CONTRIBUTIONS

Blair U. BRADFORD
Laboratory of Hepatobiology and Toxicology
Department of Pharmacology
University of North Carolina
Chapel Hill NC 27599-7365

Coworkers:
Barbara J. Keller
Ronald G. Thurman

THE EFFECT OF SHORT-TERM EXPOSURE TO ETHYLHEXANOL IN ALCOHOL DEHYDROGENASE DEFICIENT DEERMICE.

Previous work has shown that infusion of ethylhexanol (EH) in the isolated perfused rat liver inhibits 02 uptake markedly, causes release of enzymes and damages periportal regions of the liver lobule. Further, active state 3 rates of respiration in isolated mitochondria were inhibited by EH. Since EH is metabolized by alcohol dehydrogenase (ADH), the purpose of these studies was to develop methods to determine rates of EH metabolism in ADH-positive (ADH+) and negative (ADH-) deermice (*Peromyscus maniculatus*) and to evaluate the effect of short-term treatment with EH in vivo and in vitro. Breath EH was determined by allowing deermice to breathe into a closed chamber at 37°C. Samples were collected every 10-20 min. and EH was determined by gas chromatography. Rates of EH metabolism were calculated from the linear decline in breath concentration over time. Rates of elimination were 2 to 3-fold higher in ADH+ than in ADH- deermice; however, EH concentrations remained unchanged in the whole body for up to 2 hours after treatment. These data suggest that disappearance of EH from the breath does not reflect rates of elimination in vivo most likely because of its lipophilicity. Subsequently, livers from ADH- deermice were perfused with 1.7 to 2.0 mM EH. Large decreases in hepatic respiration were observed in perfused livers of both ADH- and ADH+ deermice. Rates of EH uptake and LDH release by the perfused liver were significantly greater in the ADH- than ADH+ deermouse. Short-term treatment with EH in vivo had no effect on basal rates of respiration in the perfused liver. These data suggest that hepatotoxicity of EH is due to parent EH and not one of its metabolites (ES-04325).

* * *

Richard J. DOUGLASS
Biology Department
Montana Tech University
Butte MT 59701
(406) 496-4101

THE USE OF RADIO-TELEMETRY TO EVALUATE MICROHABITAT SELECTION BY DEER MICE

The determination of habitat selection of small mammals traditionally has been based on live trapping. The basic assumption (usually unstated) is that a capture in a trap under certain habitat conditions indicates that the animal selected that trap because of those habitat conditions. This assumption ignores the fact that we have attempted to attract animals with bait and the trap may emit con or contraspecific odors from previous captures. In this paper I simply tested the assumption that a capture represents habitat selection.

Not surprisingly, given the various attractants and repellents offered to a deer mouse by a trap, deer mice seem to be captured randomly in respect to microhabitats in which traps are placed. Free roaming deer mice (radio-collared), however are very selective of microhabitats. I consider this to indicate that trapping does not indicate true microhabitat selection. If this is true for other species, then we should seriously re-evaluate models of microhabitat selection, mammal community structure and niche segregation based on live-trapping.

Other aspects of potential interest not reported in this paper include divergent intersexual habitat selection, rapid movement rates and some pointers on telemetry.

Trapping data indicated both sexes to be randomly distributed in respect to microhabitat but telemetry data showed deer mice to be very selective. Additionally females selected forested microhabitats. Females were frequently found in burrows under roots in these areas and up to 4 m above ground on branches of trees. Males tended to pass through these areas but rarely stayed long. Without quantification, it appears that the two sexes get together on the brushy side of the brush-forest ectone. Both sexes use that area (and are trapped there) but for much of the time, females remain in the forest.

While we were tracking deer mice, we found some of them to move incredibly rapidly (perhaps any speed is incredibly when you are stumbling through brush and trees in the dark). During one episode a male traversed 130 m downhill across the tracking grid in less than three minutes. He returned to his orginal location in about the same amount of time. At one point I was able to get ahead of him. He seemed not to care because he ran within 0.5 m of me on his way back up the hill. I think it would be interesting and feasible to compare movement rates among sexes, weather conditions, lighting conditions, seasons etc. using telemetry. We also need to devise some means of determining how much the collars inhibit the animals movements. My opinion is that collars have little effect on mobility but I have only observed collared animals.

To attach radios, we simply glued (with dental acrylic) an AVM SM1 transmitter to a plastic wire tie and placed it on the mouse (the collar and transmitters weighed 1.8 gm). We cut the excess plastic off of the tie and turned the mouse loose. This operation takes about the same time that it does to ear-tag the mouse. It requires only one person, no anesthetic and only detains the mouse for the time it is in the live trap. To recover radios (batteries only last 14 days), we simply set 5 to 10 traps around the animals burrow just before sunset. Without exception, radio-collared animals entered one of these traps within 30 minutes after sunset. Alternately we simply waited by the burrow and captured the deer mouse by hand when he came out. Collars were removed by cutting the tie with a pair of scissors. Some animals were recollared up to four times. The collar did abrade neck hair on the mice and one developed a slight eye infection from alternately manipulaitng the collar and rubbing her eyes. The infection was gone one week after removing the collar.

I highly recommend the use of telemetry with small mammals but it can be very labor intensive. If you are going to use telemetry, select a level study sight. We used a steep hill which resulted in tracking animals being similar to training for a triathelon. Also if you want to be able to locate animals with precision (< 0.5 m^2) and not disturb them, be sure to use a receiver with an atenuator.

Ref. J. Mamm. 70:648-652.

* * *

Harold J. EGOSCUE
PO Box 787
Grantsville UT

Studies on the ecology of *Peromyscus* fleas in the Great Basin continue. Field trips to the Alvord Desert and environs of southeastern Oregon and the Ruby Mountains of northeastern Nevada were among the most interesting places where I collected in 1989. I still look for areas where two or more kinds of *Peromyscus* occur sympatrically to see if certain fleas have preferences.

A new species of flea in the genus *Traubella* from canyon mice in southwestern Utah was described. This flea is apparently quite host-specific to *Peromyscus crinitus stephensi*. Special efforts to find it on other small mammals, even as a stray, were unsuccessful.

* * *

Patricia A. FAIL
Head, Laboratory of Reproductive
Endocrinology & Toxicology
Research Triangle Institute
Post Office Box 12194
Research Triangle Park NC 27709

A colony of *Peromyscus maniculatus bardii* is located at Research Triangle Institute. The ancestors of this stock were caught originally near Rose Lake in Lansing, Michigan, probably in the late 1950s. Since 1980, they have been in captivity in North Carolina under the care of Dr. Patricia Fail.

This colony, used for reproductive and toxicology studies, has tested viral antibody free for one year. Recently, a study of fertility during and after withdrawal of boric acid was reported below for an abstract from Adv. Contra. Delivery Systems, V:323-333. 1989.

Boric acid (Bora) exists in nature as the mineral eassolite or can be produced from boras or from other boratos which are native to California and other western states. BORA is best known for its use as an insecticide. It is also used in manufacturing processes for a variety of products used by the general public and medicinally for antiseptic and astringent applications in humans and animals and for antibacterial and antifungal applications in plants. Because of its high production and potential for human exposure, we have utilized both Swiss (CD-1) and wild deer mice (*Peromyscus maniculatus*) to characterize the reproductive toxicity and to compare species sensitivity to BORA. Adult CD-1 Swiss mice were exposed to O, 1000, 4500, or 9000 ppm BORA in feed for 18 weeks (n=20/sex/group). Fertility, at the final mating, was suppressed at 9000 ppm (0%) and impaired at 4500 ppm BORA (5.3%) compared to controls (74%). Among the litters at 4500 ppm, during the 18-week cohabitation period, live litter size and body weight were significantly reduced compared to controls. This decreased fertility was shown to be specific for the male. At necropsy, the males in the 4500 and 9000 ppm groups had decreased testis and epididymis weights, sperm counts, and sperm motility. For male Swiss mice treated with 9000 ppm BORA for eight weeks, body weight, total accessory sex organs, and testicular index were significantly decreased from controls, but the testes were not as small as in animals after 27 weeks of BORA treatment. Adult deer mice were exposed to 0, 4500, or 9000 ppm BORA in food for nine weeks (n=60 per group). Fertility was suppressed at 9000 ppm (0%) and impaired at 4500 ppm (54%), compared to 62% in controls. Nine weeks after the last exposure to BORA, a subset of deer mice males in all three groups siree an equal number of offspring. While the fertility at 9000 ppm was similar (0%) in both species, both gross and microscopic analysis of the testis indicated more severe pathology in the Swiss mouse treated for 27 weeks. The return of fertility in the wild deer mice suggests the possibility of rodent control by BORA with or without causing sterilization. These results clearly indicate that BORA is a reproductive toxicant in mice, primarily through an effect on the testes.

* * *

Alicia V. LINZEY
Department of Biology
Indiana University of Pennsylvania
Indiana PA 15705
(412) 357-7958

Coworkers:
Michael H. Kesner
Carl S. Luciano
Mark Feil

Studies on population ecology and genetics of *Peromyscus leucopus* continue to be a focus of our research. A long-term population study of mice inhabiting bluebird boxes has entered its' 6th year, with weekly monitoring taking place on a year-round basis. The first 4 years of data, considered in the context of population regulation in suboptimal habitats, are described in a manuscript currently in press. A preliminary study of population ecology of mice inhabiting a PCBs-contaminated woodland has recently been completed and data are currently being analyzed. Thus far, the analysis has provided some interesting insights into the difficulties of attributing deviant demographic patterns to contaminant effects. Finally, DNA studies of mice inhabiting adjoining optimal and suboptimal habitats are in progress. The latter studies are an outgrowth of previous field research indicating that mice living in a woodland and adjoining clearcutting form relatively distinct subpopulations, with segregation maintained by behavioral interactions at the transition between habitats (Linzey, 1989. Can. J. Zool., 67).

Michael A. STEELE
Department of Biology
Wilkes University
Wilkes-Barre PA 18766

Coworker:
Robert Browne

Population Genetics of Small Mammals in Habitat Islands of the Southern Appalachians

We are currently assessing genetic variation in populations of *Peromyscus maniculatus* and *Clethrionomys gapperri* in island habitats of the southern Appalachians.

The small mammal communities of the southern Appalachians represent some of the most diverse assemblages of mammalian fauna in eastern North America. Most of the mammals comprising these communities are northern species which reach the southernmost limit of their ranges in the Great Smoky Mountains. Because of their affinity for northern boreal habitats, many of these ahimals exhibit very specific elevation and vegetation requirements. As a result, they tend to be restricted to isolated "islands" of spruce-fir and adjacent plant communities. Since many of these species are represented by small, disjunct and relict populations on the periphery of their range, they may be particularly susceptible to local extinction.

The primary goal of this investigation is to characterize the gene pools of two species of small mammals residing in spruce-fir islands in the mountains of North Carolina. A study of the genetic differentiation among such populations would serve as an initial step in understanding the degree of habitat isolation that may occur in these spruce-fir forests. In addition, it would allow us to identify those specific island habitats where dispersal barriers have resulted in the greatest genetic isolation, as well as those corridors that still serve as links between such islands.

To address these questions we are quantifying the degree of genetic variation and differentiation within and among populations of deer mice (*Peromyscus maniculatus*) and red-backed voles (*Clethrionomys gapperi*) in all major mountain peaks in North Carolina. Quantification of evolutionary distances by allozymic and mtDNA will allow independent assessment of this differentiation. Because these two species are relatively common, but generally restricted to higher elevations, they represent ideal subjects for tracing such patterns. Any differences observed for these species should represent conservative estimates for rarer species.

Electrophoretic studies were begun in October, 1989. Preliminary results suggests that allelic fixation has occurred in both the deer mice and vole populations inhabiting the one island-type habitat examined to date (Richland Balsalms). Allelic fixation has been especially severe for the vole population, with no variation found among the individuals sampled at that site.

We will be continuing this study over the next year, and welcome any comments or suggestions form the "*Peromyscus* community".

* * *

Jerry O. WOLFF
Savannah River Ecology Laboratory
Drawer E
Aiken SC 29802

Coworker:
Donna M. Cicirello
Kellogg Biological Station
Hickory Corners MI 49060

We have completed two years of field and laboratory studies on infanticide in *P. leucopus*, the results of which are published or are in press (Animal Behaviour and Behavioral Ecology and Sociobiology). We are now conducting a complimentary study with *P. maniculatus* and *P. polionotus* using the same lab and field procedures. Preliminary results suggest that like *P. leucopus*, neither males nor females of either species discriminates between their own and strange pups. In fact we have exposed nursing dams of all three species to pups of all three species and the dams behaved maternally toward all of them. Consequently, there is no indication that females can even discriminate between their own and another species' pups. In the field, lactating females discriminate between familiar and unfamiliar pups based on location (the maternal nest site) but not scent or relatedness. We did find, however that *P. maniculatus* males are more paternal (actually retrieving and huddling with pups) than either *P. leucopus or P. polionotus* males. This is unexpected, because field and laboratory evidence suggests that *P. polionotus* is monogamous, whereas *P. maniculatus* is reported to be more promicuous like *P. leucopus*. We are documenting the social behavior of *P. maniculatus* very carefully, because this particular subspecies (*P. m. nubiterrae*) does not seem to behave like other *P. maniculatus* subspecies, especially as it relates to paternal behavior.

We have had considerable success getting mice to use wooden nest boxes placed 1 to 2 m in trees. One interesting observation that we have made is that *P. maniculatus* males nest with females during late pregnancy, during and shortly after parturition, and during successive pregnancies. These events rarely occur in *P. leucopus*. *Peromyscus leucopus* males will nest with a dam and her older pups, but not when the pups are less than 9 or 10 days old. These results may be related to a closer bond between *P. maniculatus* males and females or a higher confidence of paternity of *P. maniculatus* males than that of *P. leucopus* males.

The 1989-90 winter is the fourth time in the last 10 years that mice have bred throughout the winter. Each time winter breeding followed high mast production in autumn. These years included 1985-86, 1988-89, and very likely 1980-81. All of the nest boxes this winter that contained breeding pairs were also full of acorns. In all cases, winter breeding preceded a peak in population density the following summer. Thus, population fluctuations may be related to good and bad years of mast production .

We would like to hear from anyone who has published, unpublished, or anecdotal information on any of the above topics.

* * *

RECENT PUBLICATIONS

Alderman, J., S. Kato, and C. S. Lieber. 1989. The microsomal ethanol oxidizing system mediates metabolic tolerance to ethanol in deermice lacking alcohol dehydrogenase. Arch. Biochem. Biophys., 271:33-39.

Alderman, J. A., S. Kato, and C. S. Lieber. 1989. Characteristics of butanol metabolism in alcohol dehydrogenase-deficient deermice. Biochem. J., 257:615-617.

Ashley, M. V. and C. Wills. 1989. Mitochondrial-DNA and allozyme divergence patterns are correlated among island deer mice. Evolution, 43:646-650.

August, P. V., S. G. Ayvazian, and J. G. T. Anderson. 1989. Magnetic orientation in a small mammal, *Peromyscus leucopus*. J. Mamm., 70:1-9.

Baccus, R. and J. O. Wolff. 1989. Genetic composition of fluctuating populations of *Peromyscus leucopus* and *Peromyscus maniculatus*. J. Mamm., 70:592-602.

Barry, R. E., Jr., A. A. Fressola, and J. A. Bruseo. 1989. Determining the time of capture for small mammals. J. Mamm., 70:660-662.

Batty, J., R. A. Leavitt, N. Biondo, D. Polin. 1990. An ecotoxicological study of a population of the white footed mouse (*Peromyscus leucopus*) inhabiting a polychlorinated biphenyls-contaminated area. Arch. Environ. Contam. Toxicol., 19:283-290.

Bradley, R. D., D. J. Schmidly, and R. D. Owen. 1989. Variation in the glans penes and bacula among Latin American populations of the *Peromyscus boylii* species complex. J. Mamm., 70:712-725.

Briggs, J. M. and K. G. Smith. 1989. Influence of habitat on acorn selection by *Peromyscus leucopus*. J. Mamm., 70:35-43.

Burgess, E. C., J. B. French, Jr., and A. Gendron-Fitzpatrick. 1990. Systemic disease in *Peromyscus leucopus* associated with *Borrelia burgdorferi* infection. Am. J. Trop. Med. Hygiene, 42:254-259.

Calhoun, S. W., M. D. Engstrom, and I. F. Greenbaum. 1989. Biochemical variation in pygmy mice (*Baiomys*). J. Mamm., 70:374-381.

Callister, S. M., W. A. Agger, R. F. Schell, and K. M. Brand. 1989. Efficacy of the urinary bladder for isolation of *Borrelia burgdorferi* from naturally infected, wild *Peromyscus leucopus*. J. Clin. Microbiol., 27:773-774.

Carleton, M. D. 1989. Systematics and evolution. In: Kirkland, Jr. G. L. and J. N. Layne (Eds.). *Advances In The Study Of Peromyscus (Rodentia)*. Texas Tech Univ. Press. pp. 7-141.

Carlson, L. L., A. Zimmermann, and G. R. Lynch. 1989. Geographic differences for delay of sexual maturation in *Peromyscus leucopus*: Effects of photoperiod, pinealectomy, and melatonin. Biol. of Reprod., 41:1004=1013.

Carroll, J. F., E. T. Schmidtmann, and R. M. Rice. 1989. White-footed mice: Tick burdens and role in the epizootiology of Potomac horse fever in Maryland. J. Wildl. Dis., 25:397-400.

Clark, B. K., D. W. Kaufman, E. J. Finck, and G. A. Kaufman. 1989. Small mammals in tall-grass prairie: Patterns associated with grazing and burning. Prairie Nat., 21:177-184.

Clover, J. R., T. D. Hofstra, B. G. Kuluris, M. T. Schroeder, B. C. Nelson, A. M. Barnes, and R. G. Botzler. 1989. Serologic evidence of *Yersinia pestis* infection in small mammals and bears from a temperate rainforest of north coastal California. J. Wildlife Dis., 25:52-60.

Cork, S. J. and G. J. Kenagy. 1989. Rates of gut passage and retention of hypogeous fungal spores in two forest-dwelling rodents. J. Mamm., 70:512-519.

Dalquest, W. W. and R. M. Carpenter. 1988. Early pleistocene (Irvingtonian) mammals from the Seymour Formation, Knox and Baylor Counties, Texas, exclusive of Camelidae. Occ. Papers The Museum Texas Tech Univ., 124:1-28.

Dalquest, W. W. and F. B. Stangl, Jr. 1989. Late pleistocene mammals form the northwestern corner of the Oklahoma panhandle. Texas J. Sci., 41:35-47.

Dawson, W. D. 1990. Genetic linkage map of deer mouse (*Peromyscus maniculatus*). In: O'Brien, S. J., Ed. *Genetic Maps*. Cold Spring Harbor Lab. Press, 5:4.96-4.99.

Derting, T. L. and J. A. Cranford. 1989. Physical and behavioral correlates of prey vulnerability to barn owl (*Tyto alba*) predation. Am. Midl. Nat., 121:11-20.

Dewsbury, D. A. 1989. Deer mice as a case study in the operation of natural selection via differential reproductive reproductive success. In D. A. Dewsbury (Ed.) *Contemporary Issues in Comparative Psychology*. Sinauer, Sunderland, MA. pp 129-148.

Dewsbury, D. A. 1990. Fathers and sons: Genetic factors and social dominance in deer mice, *Peromyscus maniculatus*. Anim. Behav., 39:284-289.

Douglass, R. J. 1989. The use of radio-telemetry to evaluate microhabitat selection by deer mice. J. Mamm., 70:648-652.

Douglass, R. J. 1989. Assessment of the of selected rodents in ecological monitoring. Environ. Manage., 13:355-363.

Earle, M. and D. M. Lavigne. 1990. Intraspecific variation in body size, metabolic rate, and reproduction of deer mice (*Peromyscus maniculatus*). Can. J. Zool., 68:381-388.

Egoscue, H. J. 1989. A new species of the genus *Traubella* (Siphonaptera: Ceratophyllidae). Bull. S. Calif. Acad. Sci., 88:131-134.

Etheredge, D. R., M. D. Engstrom, and R. C. Stone, Jr. 1989. Habitat discrimination between sympatric populations of *Peromyscus attwateri* and *Peromyscus pectoralis* in west-central Texas. J. Mamm., 70:300-307.

Fail, P. A., J. D. George, H. R. Sauls, S. W. Dennis, and J. C. Seely. 1989. Effect of boric acid on reproduction and fertility of rodents. Adv. Contra. Deliv. Syst., 5:323-333.

Falco, R. C. and D. Fish. 1989. The use of carbon dioxide-baited tick traps for sampling *Ixodes dammini* (*Acari: Ixodidae*). Acarologia, 30:29-34.

Fendick, E. A., G. L. Stevens, R. J. Brown and W. P. Jordan. 1989. Element content in tissues of four rodent species sampled in the geysers geothermal steamfield. Environ. Pollut., 58:155-178.

Ginsberg, H. S. and C. P. Erving. 1989. Habitat distribution of *Ixodes dammini* and Lyme disease spirochetes on Fire Island, New York. J. Med. Entomol., 26:183-189.

Gubernick, D. J. and J. R. Alberts. 1989. Postpartum maintenance of paternal behaviour in the biparental California mouse, *Peromyscus californicus*. Anim. Behav., 37:656-664.

Gubernick, D. J. and R. J. Nelson. 1989. Prolactin and paternal behavior in the biparental California mouse, *Peromyscus californicus*. Horm. and Behav., 23:203-210.

Hale, D. W. 1989. A reevaluation of chromosomal variation in populations of *Peromyscus maniculatus* along an elevational gradient. Evolution, 43:226-228.

Hayes, J. P. 1989. Altitudinal and seasonal effects on aerobic metabolism of deer mice. J. Comp. Physiol. B Biochem. Syst. Environ. Physiol., 159:453-459.

Hayes, J. P. 1989. Field and maximal metabolic rates of deer mice (*Peromyscus maniculatus*) at low and high altitudes. Physiol. Zool., 62:732-744.

Hegstrom, L. J. and S. D. West. 1989. Heavy metal accumulation in small mammals following sewage sludge application to forests. J. Environ. Qual., 18:345-349.

Holler, N. R., D. W. Mason, R. M. Dawson, T. Simons, and M. C. Wooten. 1989. Reestablishment of the Perdido Key Beach mouse (*Peromyscus polionotus trissyllepsis*) on Gulf Islands National Seashore. Conserv. Biol., 3:397-404.

Inatomi, N., D. Ito, and C. S. Leiber. 1990. Ethanol oxidation by deermice mitochondria under physiologic conditions. Alcoholism, 14:130.

Iskjaer, C., N. A. Slade, J. E. Childs, G. E. Glass, and G. W. Korch. 1989. Body mass as a measure of body size in small mammals. J. Mamm., 70:662-667.

Kaufman, D. W. and G. A. Kaufman. 1989. Nongame wildlife management in central Kansas: Implications of small mammal use of fencerows, fields, and prairie. Trans. Kans. Acad. Sci., 92:198-205.

Kaufman, D. W. and G. A. Kaufman. 1989. Population biology. In: Kirkland, Jr. G. L. and J. N. Layne (Eds.). *Advances In The Study Of Peromyscus (Rodentia)*. Texas Tech Univ. Press. pp.233-270.

Kaufman, G. A. 1989. Use of fluorescent pigments to study social interactions in a small nocturnal rodent, *Peromyscus maniculatus*. J. Mamm., 70:171-174.

Kaufman, G. A. and D. W. Kaufman. 1989. An artificial burrow for the study of natural populations of small mammals. J. Mamm., 70:656-659.

Kavaliers, M. and D. G. L. Innes. 1989. Population differences in benzodiazepine sensitive male scent-induced analgesia in the deer mouse, *Peromyscus maniculatus*. Pharmacol. Biochem. & Behav., 32:613-619.

Keane, B. 1990. The effect of relatedness on reproductive success and mate choice in the white-footed mouse *Peromyscus leucopus*. Anim. Behav., 39:264-273.

Kirkland, Jr. G. L. and J. N. Layne (Eds.). 1989. *Advances In The Study Of Peromyscus (Rodentia)*. Texas Tech Univ. Press.

Knapp, R. 1989. The effect of red light on reproduction in *Peromyscus maniculatus*. J. Mamm., 70:341-346.

Korn, H. 1989. A feeding experiment with 6-methoxybenzoxazolinone and a wild population of the deer mouse (*Peromyscus maniculatus*). Can. J. Zool., 67:2220-2224.

Kotler, B. P., M. S. Gaines, and B. J. Danielson. 1988. The effects of vegetative cover on the community structure of prairie rodents. Acta Theriol., 33:379-391.

Krohne, D. T. 1989. Demographic characteristics of *Peromyscus leucopus* inhabiting a natural dispersal sink. Can. J. Zool., 67:2321-2325.

Lawson, K. F., R. Hertler, K. M. Charlton, J. B. Campbell, and A. J. Rhodes. 1989. Safety and immunogenicity of ERA strain of rabies virus propagated in a BHK-21 cell line. Can. J. Vet. Res., 53:438-444.

Lin, L. and E. B. Pivorun. 1989. Analysis of serotonin, dopamine and their metabolites in the caudate putamen, the suprachiasmatic nucleus and the median raphe nucleus of euthermic and torpid deermice, *Peromyscus maniculatus*. Pharmacol. Biochem. Behav., 33:309-314.

Lin, L. H. and E. B. Pivorun. 1989. Analysis of monoamines and their metabolites in the hypothalamus, suprachiasmatic nucleus and the pineal gland of euthermic and torpid deermice, *Peormyscus maniculatus*. In: Malan, A. and B. Canguilhem, Eds. *Living In The Cold*, 2:63-74.

Linzey, A. V. 1989. Response of the white-footed mouse (*Peromyscus leucopus*) to the transition between disturbed and undisturbed habitats. Can. J. Zool., 67:505-512.

Lomolino, M. V. 1989. Bioenergectics of cross-ice movements by *Microtus pennsylvanicus*, *Peromyscus leucopus*, and *Blarina brevicauda*.

Lusk, S. J. G. and J. S. Millar. 1989. Reproductive inhibition in a short-season population of *Peromyscus maniculatus*. J. Anim. Ecol., 58:329-341.

Marinelli, L. and J. S. Millar. 1989. The ecology of beach-dwelling *Peromyscus maniculatus* on the Pacific Coast. Can. J. Zool., 67:412-417.

Mastrota, F. N., R. H. Yahner, and G. L. Storm. 1989. Small mammal communities in a mixed-oak forest irrigated with wastewater. Am. Midl. Nat., 122:388-393.

Mather, T. N., S. R. Telford III, A. B. MacLachlan, and A. Spielman. 1989. Incompetence of catbirds as reservoirs for the Lyme disease spirochete (*Borrelia burgdorferi*). J. Parasitol., 75:66-69.

Mather, T. N., M. L. Wilson, S. I. Moore, J. M. C. Ribeiro, and A. Spielman. 1989. Comparing the relative potential of rodents as reservoirs of the Lyme disease spirochete (*Borrelia burgdorferi*). Am. J. Epidemiol., 130:143-150.

Mathiere-Costello, O. 1989. Muscle capillary tortuosity in high altitude mice depends on sarcomere length. Respir. Physiol., 76:289-302.

Merriam, G., M. Kozakiewicy, E. Tsuchiya, and K. Hawley. 1989. Barriers as boundries for metapopulations and demes of *Peromyscus leucopus* in farm landscapes. Landscape Ecol., 2:227-237.

Millar, J. S. 1989. Reproduction and development. In: Kirkland, Jr. G. L. and J. N. Layne (Eds.). *Advances In The Study Of Peromyscus (Rodentia)*. Texas Tech Univ. Press. pp.169-232.

Millar, J. S. and W. D. Millar. 1989. Effects of gestation on growth and development in *Peromyscus maniculatus*. J. Mamm., 70:208-211.

Minchella, D. J., B. A. Branstetter, and K. R. Kayacos. 1989. Molecular characterization of sylvatia isolates of *Trichinella spiralis*. J. Parasitol., 75:388-392.

Montgomery, W. I. 1989. *Peromyscus* and *Apodemus*: Patterns of similarity in ecological equivalents. In: Kirkland, Jr. G. L. and J. N. Layne (Eds.). *Advances In The Study Of Peromyscus (Rodentia)*. Texas Tech Univ. Press. pp. 293-366.

Morris, D. W. 1989. Density-dependent habitat selection: Testing the theory with fitness data. Evol. Ecol., 3:80-94.

Morrison, M. L. and R. G. Anthony. 1989. Habitat use by small mammals on early-growth clear-cuttings in western Oregon. Can. J. Zool., 67:805-811.

Munger, J. C. and W. H. Karasov. 1989. Sublethal parasites and host energy budgets: Tapeworm infection in white-footed mice. Ecology, 70:904-921.

Munger, J. C., W. H. Karasov, and D. Chang. 1989. Host genetics as a cause of overdispersion of parasites among hosts: How general a phenomenon? J. Parasitol., 75:707-710.

MacMillen, R. E. and T. Garland, Jr. 1989. Adaptive Physiology. In: Kirkland, Jr. G. L. and J. N. Layne. (Eds.) 1989. *Advances In The Study Of Peromyscus (Rodentia)*. Texas Tech Univ. Press. pp. 143-168.

McCallister, C. T. and S. J. Upton. 1989. *Isospora peromysci*, new record Davis, 1967 (*Apicomplexa : Eimeriidae*) in *Peromyscus leucopus* and *Peromyscus maniculatus* (*Rodentia : Cricetidae*) from Texas. J. Protozool., 36:175-176.

Nagorsen, D. W., K. F. Morrison, and J. E. Forsberg. 1989. Winter diet of Vancouver Island marten (*Martes americana*). Can. J. Zool., 67:1394-1400.

Nestler, J. R. 1990. Intracellular pH during daily torpor in *Peromyscus maniculatus*. J. Comp. Physiol. B, 159:661-666.

Norsten, C., T. Cronholm, G. Ekstrom, J. A. Handler, R. G. Thurman, and M. Ingelman-Sundberg. 1989. Dehydrogenase-dependent ethanol metabolism in deer mice (*Peromyscus maniculatus*) lacking cytosolic alcohol dehydrogenase: Reversibility and isotope effects in vivo and in subcellular fractions. J. Biol. Chem., 264:5593-5597.

Owen, J. G. 1989. Population and geographic variation of *Peromyscus leucopus* in relation to climatic factors. J. Mamm., 70:98-109.

Pasitschiniak-Arts, M. and J. Gibson. 1989. Distribution and abundance of small mammals in Lake Superior Provencial Park, Ontario. Can. Field-Nat., 103:70-74.

Pellis, S. M., V. C. Pellis, and D. A. Dewsbury. 1989. Different levels of complexity in the playfighting by muroid rodents appear to result from different levels of intensity of attack and defense. Aggressive Behav., 15:297-310.

Ports, M. A. and L. K. Ports. 1989. Associations of small mammals occurring in a pluvial lake basin, Ruby Lake, Nevada. Great Basin Nat., 49:123-130.

Pulsifer, M. D., and T. B. Herman. 1989. Comparative arboreal behaviors of wild-caught and captive-born deer mice, *Peromyscus maniculatus* Wagner, from Isle Haute and mainland Novia Scotia. Can. J. Zool., 67:789-794.

Ribble, D. O. and M. Salvioni. 1990. Social organization and rest co-occupancy in *Peromyscus californicus*, a monogamous rodent. Behav. Ecol. Sociobiol., 26:9-16.

Rose, R. K. 1989. Autumnal densities of small mammals in Douglas County, Kansas. Trans. Kan. Acad. Sci., 92:6-11.

Schwab, R. G. and J. H. Theis. 1989. Annual cyclicity of gall stone prevalence in deer mice (*Peromyscus maniculatus gambelii*). J. Wildlife Dis., 25:462-468.

Schwan, T. G., K. K. Kime, M. E. Schrumpf, J. E. Coe, and W. J. Simpson. 1989. Antibody response in white-footed mice (*Peromyscus leucopus*) experimentally infected with the Lyme disease spirochete (*Borrelia burgdorferi*). Infect. Immun., 57:3445-3451.

Sinsky, R. J. and J. Piesman. 1989. Ear punch biopsy method for detection and isolation of *Borrelia burgdorferi* from rodents. J. Clin. Microbiol., 27:1723-1727.

Smith, S. A., I. F. Greenbaum, D. J. Schmidly, K. M. Davis, and T. W. Houseal. 1989. Additional notes on karyotypic variation in the *Peromyscus boylii* species group. J. Mamm., 70:603-608.

Stangl, F. B., Jr. and R. J. Baker. 1989. Polymorphisms in chromosome 5 of the white-footed mouse, *Peromyscus leucopus* (Rodentia: Cricetidae). Texas J. Sci., 41:327-330.

Sudman, P. D. and I. F. Greenbaum. 1989. Visualization of kinetochores in mammalian meiotic preparations and observations of argentophilic differences between mitotic and meiotic kinetochores. Genome, 32:380-382.

Sudman, P. D., I. F. Greenbaum, D. W. Hale, and S. A. Smith. 1989. Synaptic adjustment in *Peromyscus beatae* (**Rodentia: Cricetidae**) heterozygous for interstitial heterochromatin. Cytogenet. Cell Genet., 50:1-5.

Sullivan, R. M., S. W. Calhoun, and I. F. Greenbaum. 1990. Geographic variation in genital morphology among insular and mainland populations of *Peromyscus maniculatus* and *Peromyscus oreas*. J. Mamm., 71:48-58.

Tannenbaum, M. G., G. R. Haigh, M. K. Vaughn, and R. J. Reiter. 1990. Effects of acute cold exposure at night on pineal *N*-acelyltransferase activity and melatonin content in white-footed mice, *Peromyscus leucopus*. Comp. Biochem. Physiol., 95:363-366.

Tannenbaum, M. G. and E. B. Pivorun. 1989. Summer torpor in montane *Peromyscus maniculatus*. Am. Midl. Nat., 121:194-197.

Timberlake, W. and D. L. Washburne. 1989. Feeding ecology and laboratory predatory behavior toward live and artificial moving prey in seven rodent species. Anim. Learn. and Behav., 17:2-11.

Weaver, D. R., L. L. Carlson, and S. M. Reppert. 1990. Melatonin receptors and signal transduction in melatonin-sensitive and melatonin-insensitive populations of white-footed mice (*P. leucopus*). Brain Res., 506:353-357.

Wolfe, J. L. and C. T. Summerlin. 1989. The influence of lunar light on nocturnal activity of the old-field mouse. Anim. Behav., 37:410-414.

Wolff, J. O. 1989. Social behavior. In: Kirkland, Jr. G. L. and J. N. Layne (Eds.). *Advances In The Study Of Peromyscus (Rodentia)*. Texas Tech Univ. Press. pp. 271-291.

Wolff, J. O. and D. M. Circirello. 1989. Field evidence for sexual selection and resource competition infanticide in white-footed mice. Anim. Behav., 38:637-642.

Xia, X. and J. S. Millar. 1989. Dispersion of adult male *Peromyscus leucopus* in relation to female reproductive status. Can. J. Zool., 67:1047-1052.

Yahner, R. H. 1989. Small mammals associated with even-aged aspen and mixed-oak forest stands in central Pennsylvania. J. PA Acad. Sci., 62:122-126.

Zou, J., J. T. Flinders, H. L. Black, and S. G. Whisenant. 1989. Influence of experimental habitat manipulations on a desert rodent population in southern Utah. Great Basin Nat., 49:435-448.