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PROCEEDINGS OF THE TENTH ANNUAL MEETING

SOCIETY FOR THE STUDY OF AMPHIBIANS AND REPTILES

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The Ohio State University, Columbus
Chairman James C. List, *presiding*

MEETING COMMITTEE

Barry D. Valentine and John M. Condit, *Co-Chairmen*
David H. Stansbery, Norton M. Rubenstein
Kraig Adler, *Program Chairman*

ABSTRACTS OF PAPERS PRESENTED AT THE MEETING

Symposium
THE BIOLOGY OF SALAMANDERS
Robert E. Gordon, *Moderator*

1. The Biology of Salamanders: Introductory Remarks. Robert E. Gordon, Associate Dean of Science, University of Notre Dame, Notre Dame, Indiana 46556.

Throughout the past decade there has been a growing awareness of the totality of meaning of the word *systematics* among American herpetologists. In its simplest form, the word connotes a wedding between taxonomy and the total biology of the particular group studied.

For those whose interest is directed toward the caudate amphibians, the realization, that taxonomic and evolutionary alignments based solely on the external morphology of adult organisms take us down a limited road, has led to a diversification of studies utilizing techniques developed in functional fields of biology (*i.e.*, modern comparative anatomy, behavioral biology, biodemography, ecology and physiology, to mention only a few such areas); in short, the approach has been that of systematics and not morphological taxonomy.

When one then considers the state of scientific communication today -- the multitude of meetings and publications -- it becomes apparent that progress in any one field, or the state of our knowledge concerning any one group, may be concealed by the dispersement of the individual contributions in the vast sea of contributed papers and oral reports.

With these thoughts in mind, and with the celebration of the tenth anniversary of a society that has stimulated many individuals in the field, it seemed appropriate to pause and consider in one place, at one time, the status of salamander biology -- to see where we are, what the problems are, and what we should do tomorrow.

In formulating the inventory, we attempted to pick the adaptive peaks in continuum of studies with full knowledge that time prevented coverage of all facets.

Preliminary discussions with the invited speakers, and other interested individuals*, led to the conclusion that while we should talk about the problems now, it would be premature to attempt a published synthesis. It was and is our hope that this activity will stimulate further work thus bringing the field to a state at which publication of a synthesis would represent a lasting, and not ephemeral, contribution to herpetology and general systematics. Lest this stimulus be lost, we did agree that a record in the form of the following abstracts should be preserved.

*I am indebted to Joseph A. Tihen and Kraig Adler for valuable suggestions toward the organization of the symposium.

2. Aspects of the Physiological Ecology of Salamanders. Victor H. Hutchinson, Institute of Environmental Biology, University of Rhode Island, Kingston, Rhode Island 02881.

Physiological ecology is more than the study of the interface between organisms and their ecosystems; it must include the organismic biologists' realization that both organisms and ecosystems are more than the sum of their individual components. The development of physiological ecology may be compared to the *alpha, beta,* and *gamma* stages of development of taxonomy and systematics, with the *gamma* stage - the one with the most integration of diverse fields of knowledge - still far in the future.

A review of past and present investigations on the physiological ecology of salamanders in the areas of temperature relations, gas exchange, salt and water balance, circulation, food utilization and growth, circadian and other periodicities, and reproduction clearly shows our lack of knowledge. This review indicates many problem areas, from *alpha* through *gamma* levels, deserving of attention by investigators. Much of the published work is valuable mainly for its heuristic value.

The salamanders, occupying the vertebrate evolutionary position of transition from aquatic to terrestrial existence, offer one of the most fruitful animal groups for study and eventual understanding of the evolution of physiological systems in diverse environments.

3. Aspects of Salamander Behavior: Orientation. Denzel E. Ferguson, Department of Zoology, Mississippi State University, State College, Mississippi 39762.

Salamanders perform local movements on home areas, presumably with reference to familiar cues. The spectacular migrations and homing movements of pond-breeding salamanders of the families Ambystomatidae and Salamandridae require more complex orientational mechanisms. Although several investigations have suggested the use of various visual and olfactory cues in salamander orientation, it appears that much of the research has involved inadequate experimental procedures and/or erroneous assumptions.

Recent laboratory experiments by Landreth and Ferguson show that *Taricha granulosa* employs a sun-compass for direction finding but uses olfaction for goal recognition. Our field studies demonstrate that newts follow a compass course to breeding sites, are able to compensate for displacements made in view of the sky, and continue to employ a sun-compass even when deprived of vision and displaced over 17 miles. Orientation fails under complete cloud cover. Preliminary findings of Byrd and Ferguson demonstrate that certain *Ambystoma* also exhibit sun-compass capabilities.

Investigations of orientation should be based on the assumption that an animal uses whatever directional information is available and employs alternative cues when deprived of normally used information. Normal intact animals best demonstrate normal orientational behavior. In homing studies, salamanders must be displaced in darkness.

The existence of sun-compass orientation in five families of anurans and two families of salamanders suggests that the sun-compass is the primary orientational mechanism in Amphibia.

4. The Reproductive Biology of Salamanders. Stanley N. Salthe, Department of Biology, Brooklyn College of the City University of New York, Brooklyn, New York 11210.

There are three major modes of development in the salamanders. They are associated with sites of development I, in static waters; II, in running waters; and III, on land. Each of these modes has its own characteristics, such as numbers, sizes, and disposition of the ova; stage at hatching; parental behavior. These characteristics run across taxonomic grouping. This suggests parallel evolutionary trends.

Attention is focused on the relationships between numbers and sizes of ova and the adult body sizes of the females. These factors are found to be interrelated in both simple and complex ways, and in turn influence both the size at hatching and the size at metamorphosis.

It is possible in only a few cases, where much detailed information exists, to suggest which of the correlated factors have been the primary objectives of selection. The number and closeness of some of the correlations suggest that at least some of the characteristics involved have been evolving in an allometric fashion, being simply not selected against.

5. The Population Dynamics of Salamanders. James A. Organ, Department of Biology, City College of the City University of New York, New York City 10031.

To determine the density of a local population one may count the entire population, annihilate it and count the bodies, use a "unit-area" census, or use a capture-marking-release-recapture system. All of these methods have been applied to salamander populations with mixed success.

To determine the structure or life table of a population one may take a group of individuals born or hatched at the same time and follow them through time until the last member of the original group is dead or one may take a census and determine the age of each individual at the time of the census. The first method yields a "horizontal" life table and the second yields a "vertical" life table. Of the two approaches, the second has been the more successful in salamander studies.

Taxonomic stability, diversity in habitat, and high local density give salamanders an excellent potential as subjects for population analysis but many technical difficulties have yet to be resolved. Among these are sampling methods that yield comparable data for aquatic and terrestrial portions of a population, sampling methods that yield a true representation of the juvenile portion of a population, simple and accurate methods of age determination, and reliable methods of marking individuals.

The approach of investigators to salamander populations has been overly restrictive. Density studies are rarely combined with age structure analysis and *vice versa*. Intensive "single species" studies are the rule rather than the more rewarding "comparative" approach. Long term studies of the dynamics of natural populations of salamanders comparable to those available for some fishes, birds, and mammals are virtually nonexistent. The necessary tools of analysis are available at present but the raw data on which to use these tools are still rare for salamander populations.

6. A Synopsis of Salamander Classification. Arden H. Brame, Jr., Department of Biological Sciences, University of Southern California, Los Angeles, California 90007.

I follow the classification of recent salamanders proposed by Wake (1966) and of fossil salamanders used by Estes (1965) which I incorporated in *A List of the World's Recent and Fossil Salamanders* (Brame, 1967).

Classification of Brame, 1967
(with numbers of genera, species, and species plus subspecies)

ORDER CAUDATA	Genera	Species	Species plus Subspecies
SUBORDER CRYPTOBRANCHOIDEA			
Family Hynobiidae	5	30	31
Family Cryptobranchidae	2	3	4
SUBORDER SIRENOIDEA			
Family Sirenidae	2	3	9
SUBORDER SALAMANDROIDEA			
Family Salamandridae	15	42	91
Family Proteidae	2	6	9
Family Amphiumidae	1	3	3
SUBORDER AMBYSTOMATOIDEA			
Family Ambystomatidae	4	32	47
Subfamily Dicamptodontinae	(1)	(1)	(1)
Subfamily Rhyacotritoninae	(1)	(1)	(2)
Subfamily Ambystomatinae	(2)	(30)	(44)
Family Plethodontidae	23	185*	249*
Subfamily Desmognathinae	(3)	(9)	(17)
Subfamily Plethodontinae	(20)	(176)*	(232)*
Tribe Hemidactylini	(8)	(20)	(38)
Tribe Plethodontini	(3)	(24)	(48)
Tribe Bolitoglossini	(9)	(132)*	(146)*
Supergenus *Batrachoseps*	(1)	(3)	(4)
Supergenus *Hydromantes*	(1)	(5)	(9)*
Supergenus *Bolitoglossa*	(7)	(124)*	(133)
TOTAL	54	304	441

*These figures represent corrections or additions to Brame (1967).

Summary of Numbers of Genera and Species of Recent Species

Author	Date	Number of Genera	Number of Species
Linnaeus	1758	1	3
Laurenti	1768	3	19
Gray	1850	34	64
Duméril, Bibron & Duméril	1854	22	58
Boulenger	1882	28	98
Cope	1889	38	113 or 114
Noble	1931	40	
Brame	1957	60	284 (414)**
Brame	1967	54	304* (441)**

*Corrections of Brame (1967) **Species plus subspecies

CLASSIFICATORY PROBLEMS

SUPRAORDINAL OR SUBCLASS PLACEMENT OF SALAMANDERS.

As indicated from the previous discussion, in order to know the true relationships of the salamanders to their relatives the caecilians and frogs and in order to trace back their origins, we need much more critical fossil material from the late Paleozoic and early and mid-Mesozoic. The problem is best summarized by Romer (1966) "The temnospondyls show the greatest number of skull characters in common with the Lissamphibians; on the other hand, the lissamphibian vertebral construction suggests descent from Paleozoic lepospondyls. But the peculiar dentition and other specializations of the Lissamphibia are not seen in any Paleozoic group. We need to know much more about the smaller amphibian life of late Paleozoic and Triassic times before we can bridge the gap between modern and ancient amphibian groups."

STATUS OF SIRENS.

Goin and Goin (1962) suggested that numerous peculiarities of skull and vertebrae of sirenids justifies placing them in a separate Order Trachystomata as classified by Cope (1889). Estes (1965) and Wake (1966) show that there are no compelling reasons to separate the sirens from other salamanders.

RELATIONSHIPS OF *PROTEUS* AND *NECTURUS*.

Some workers consider the olm and mudpuppies closely related and place them in a single family, the Proteidae. Others consider these Old-World and New-World perennibranch salamanders to be only distantly related and place them in separate families, the Proteidae and the Necturidae. Hecht (1957) pointed out that the resemblances of *Necturus* and *Proteus* are common to larval forms and they are not necessarily closely related. Seto, Pomerat, and Kezer (1964) showed that the two genera have the same chromosome number of 19 and suggested this may indicate a close relationship. Salthe (1967) after analyzing salamander courtship patterns stated that "*Proteus* may be more distantly related to *Necturus* than is usually suggested. On the other hand, it may be a salamandrid related to the *Triturus* group of newts."

STATUS OF THE AMPHIUMOIDEA.

Regal (1966) proposed the removal of *Amphiuma* from the suborder Salamandroidea and resurrected a separate suborder, the Amphiumoidea as Cope (1889) had done earlier. Salthe and Kaplan (1966), however, in their paper on immunology and rates of enzyme evolution in the Amphibia, concluded that *Amphiuma* is more closely related to the plethodontids than to any other group of salamanders. Perhaps Estes' description of the Paleocene amphiumid from Wyoming will help solve the relationship problem here.

7. The Fossil Record of Salamanders. Joseph A. Tihen, Department of Biology, University of Notre Dame, Notre Dame, Indiana 46556.

The fossil record gives virtually no direct information concerning the ancestry of the salamanders, nor of the phylogenetic relationships among the major taxa. But it does place some limitations on speculation concerning these matters, particularly with respect to details of time and place, and it also provides some bases for additional speculation.

The earliest known salamander fossil is a femur from the upper Jurassic of Wyoming. As the name, *Comonecturoides*, implies, this femur bears a strong resemblance to that of *Necturus*, but the material is completely inadequate for any firm conclusion concerning its relationships. Cretaceous fossils include: rather abundant sirenids, probably through most of the Cretaceous, all from

North America; *Hylaeobatrachus*, a possible proteid from the lower Cretaceous of Belgium; a tiny unnamed thing from the lower to middle Cretaceous of Israel that appears to be a salamandrid; desmognathines from the upper Cretaceous of North America; and scapherpetonids, also from the upper Cretaceous of North America. This latter group shows some resemblances to cryptobranchids, and perhaps should not be placed in a separate family, but they also differ in certain characters that have been considered important (possession of bicipital ribs; fusion of angular and prearticular).

A major problem with these late Mesozoic and most early Tertiary fossils is that the deposits from which they come represent broad flood plains, lakes, or extensive swamps. As a result, the fossils are usually aquatic forms, and likely partially neotenic, thus not demonstrating the typical "adult" characteristics that might be expected in their more terrestrial relatives, some of whom were presumably living at that time.

The early appearance of sirenids, and the fact that these early representatives are already "good" sirenids, strongly divergent from other salamanders, suggest that the sirenids constitute a very early branch from the major urodelan stock, and do not have close relatives among any of the extant groups.

In the Paleocene and Eocene, a number of forms appear that are referred without question to extant families. These include the salamandrids in Europe and the cryptobranchids, ambystomatids and amphiumids in North America. In addition a member of the extinct family Batrachosauroididae is also found in North America. Certain vertebrae from the Paleocene of Europe are considered to represent ambystomatids by some; in my opinion they may equally well be hynobiids, but firm familial reference must await additional material. Much of the Tertiary material consists only of vertebrae, and it is difficult to be certain that all vertebral characteristics were correlated with other generic and familial characteristics in identically the same way at that time as they are at present. Specifically, I remain unconvinced that bicipital as opposed to unicipital rib-bearers, and anterior as opposed to posterior position of the basapophyses, are adequate of themselves to establish the familial relationships of specimens.

In any event, the appearance of all of these families in the late Mesozoic and early Tertiary establishes without doubt that most of the evolutionary differentiation at the familial level had occurred no later than the earliest Tertiary, and probably before the end of the Mesozoic. The "advanced" groups - the salamandrids and plethodontids - both are known from the Cretaceous.

The fossil salamanders of the Oligocene and the much more numerous ones from the Miocene are more similar to the modern forms. This is in part certainly due to evolutionary activity between the early and the later Tertiary, but probably also due in part to the fact that we are finding fossiliferous "upland" (at least not broad lowland flood plain) stream deposits, and so are recovering the more terrestrial representatives of the various groups for the first time, even though they may have been in existence much earlier. Before or during the Miocene, the following extant genera appear: *Siren, Andrias, Ambystoma, Salamandra, Tylototriton, Triturus, Notophthalmus*, and probably *Plethodon*. A number of presumably extinct genera currently recognized have been proposed for specimens that probably should actually be referred to extant genera (particularly in the Salamandridae). Although some Miocene specimens do undoubtedly represent extinct genera (*e.g., Batrachosauroides*), it is likely that the great majority of Miocene forms represent extant genera. Although this does not of itself necessarily imply the converse, *i.e.*, that most modern genera were already in existence during the Miocene. I think that this also is likely to prove true. In other words, most evolutionary differentiation at the generic level was probably completed before or during the Miocene.

We may tabulate the earliest known occurrences of the various salamander families, and whether this is in Eurasia or in North America, as shown in Table 1.

Table 1. Earliest known occurrence of the various salamander families. A "?" indicates familial affinity of the specimen(s) involved is questionable; an "X" indicates that it is fairly well established. Eur = Eurasia; N Am = North America.

		Sirenidae	Scapherpetonidae	Batrachosauroididae	Necturidae	Proteidae	Amphiumidae	Cryptobranchidae	Hynobiidae	Ambystomatidae	Plethodontidae	Salamandridae
Jurassic	Eur											
	N Am				?							
Cretaceous	Eur					?						X
	N Am	X	X								X	
Paleocene	Eur								?	?		
	N Am						X			?		
Eocene	Eur					X						
	N Am			X				X		X		
Miocene	Eur											
	N Am											
Recent	Eur								X			
	N Am				X							

The earliest known salamander occurs in North America; the early-diverging sirenids occur only in North America; the majority of families first appear there. All of these facts suggest that the group originated in North America, and that this continent is the site of primary differentiation and center of primary dispersal.

The southernmost localities where any fossil salamanders have been found are at approximately 30° N. latitude. The order seems to have been largely limited to the northern part of the globe throughout its history. No major geographic barriers to southward movement existed during the time of primary dispersal; the almost universal limitation of the distribution of this group southward must have been primarily ecological. But the climates, landforms, and biotas of the salamander-inhabited areas of that time were quite different than those of the same geographic areas today. Present information allows only a fragmentary knowledge of past distributions, but it appears that throughout most of their history, salamanders have occupied much of the same geographic areas that they do today. Some of the early salamanders, perhaps particularly in the early Tertiary, were at least broadly associated with a biota and a climate that is considered subtropical to tropical. Many of the reptiles such as boids, aniliids, varanids, and the like (as well as other organisms), associated with early Tertiary salamanders are now largely restricted to tropical and subtropical regions. It would thus seem that the ecological factors preventing the early southward spread of salamanders were microenvironmental rather than broad general climatic and biotic ones, or that the environmental tolerances of the group as a whole have changed during the course of their evolution.

Incidentally, this strictly northern origin and distribution of salamanders is in direct contrast to the pattern in anurans. The evidence is continually increasing that frogs originated in, and underwent their major differentiation in and dispersal through, the southern hemisphere, with only stragglers entering the Holarctic. This is a factor that must be taken into account in theorizing about a common ancestor for all "Lissamphibia."

8. Adaptation and Larval Morphology of Salamanders. Barry D. Valentine, Department of Zoology and Entomology, The Ohio State University, Columbus, Ohio 43210.

The central theme concerns the morphology of larval salamanders and its contribution to our knowledge of adaptation and taxonomy. This is reviewed in terms of past, present, and future studies. The future is particularly promising because studies of larvae eliminate such sources of variation as sexual dimorphism and ontogenetic changes, and greatly reduce geographic variation. Larval morphology is very diverse and the four major kinds (pond, stream, torrent, and terrestrial) are distinguished by adaptive structural combinations of gills, gular folds, fins, and balancers; these are discussed and illustrated. The four larval types cut across taxonomic lines and are probably the result of parallel adaptation in distantly related species. In the discussion of larval morphology, special attention is given to gills, gill slits, gill rakers, balancers, jaws, and teeth, while less detailed data are provided for fins, gular folds, labial folds, and skin. All of these features and many others are lost, modified, or replaced during transformation.

9. The Evolutionary Morphology of Salamanders. David B. Wake, Department of Anatomy, The University of Chicago, Chicago, Illinois 60637.

Salamanders offer many opportunities for fruitful investigations of evolutionary morphology. This evolutionarily conservative group is ideal for such studies because of the survival of many primitive and intermediate forms which facilitates meaningful interpretation of the direction of change and adaptive significance of morphological features. A small but useful fossil record, advances in genetics, development, and ecology, and progress in studies of salamander systematics provide a solid background for morphological investigations.

A major role of evolutionary morphological studies is the evaluation and interpretation of characters used in systematics. Examples are chosen from the author's recent work on feeding mechanisms in salamandrids and plethodontids, salamander vertebral morphology, and morphological modes of evolution, such as paedomorphosis. A critique of recent classifications of terrestrial salamanders is presented, with emphasis on character analysis and rigorous objectivity. The philosophical basis of deducing phylogenies is briefly discussed.

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CONTRIBUTED PAPERS: *Session I*

Arnold G. Kluge, *presiding*

Museum of Zoology, The University of Michigan, Ann Arbor, Michigan 48104.

10. Distribution and Variation in the Florida Worm Lizard, *Rhineura floridana*. George R. Zug, Museum of Zoology, The University of Michigan, Ann Arbor, Michigan 48104.

The range of *R. floridana* is entirely restricted to the northern two-thirds of Florida with the exception of an unconfirmed Georgia locality. Within this area, it occupies both xeric and mesic habitats (scrub, longleaf pine-turkey oak, hammocks).

Six characters (total number of lateral head scales, number of supralabials, number of infralabials, number of body annuli, number of caudal annuli bearing dorsal granular segments, and number of segments around midbody) showed a similar pattern of geographic variation, indicating the presence of two distinct populations. The population on the Lake Wales Ridge typically has lower counts in all six characteristics in comparison to the condition in the north-central Florida population.

Aside from *R. floridana*, both *Eumeces egregius* and *Tantilla relicta* have distinct populations on the Lake Wales Ridge. This suggests a previous separation of these populations, and it is suggested that the separation was insular.

A hypothetical history of *Rhineura* is constructed to explain the present pattern of variation. The history rests on two main assumptions: the Lake Wales Ridge population was initially isolated by high sea levels of the first interglacial epoch of the Pleistocene; the island was predominantly scrub and the insular population became restricted to this habitat by adaptation.

11. Status of the salamander genus *Desmognathus* in Alabama. Norton M. Rubenstein, Department of Zoology and Entomology, The Ohio State University, Columbus, Ohio 43210.

There is at present only one known endemic desmognathine salamander in the state of Alabama: *Phaeognathus hubrichti*. The number of other desmognathine species reported from the state is five: *Desmognathus ocoee*, *D. auriculatus*, *D. aeneus chermocki*, *D. f. fuscus*, and *D. m. monticola*. These species are relatively easily discernible on the basis of meristic data, although absolute identification in the field is frequently difficult.

To this list of the Alabama species is added another known race, *D. fuscus conanti*, which has been collected by the author in Marion and Franklin counties. Along with this addition, two new Alabama species are in manuscript (including the salamander from Mount Cheaha, previously referred to *D. monticola*), and a third possible desmognathine species is being investigated.

12. Cliff-dwelling Populations of *Desmognathus* in North Carolina. James E. Huheey, Department of Chemistry, University of Maryland, College Park, Maryland 20740, and Ronald A. Brandon, Department of Zoology, University of Southern Illinois, Carbondale, Illinois 62903.

A study of the ecology and life history of populations of *Desmognathus ochrophaeus carolinensis* inhabiting wet cliff habitats at higher elevations has been initiated. Populations investigated include those from Webb Overlook and Pauls Gap in the Great Smoky Mountains and Scaly Mountain and Bridal Veil Falls in the Blue Ridge Mountains. Comparative non-cliff-face populations were studied at Rabun Bald, Scaly Mountain, and Blue Valley in the Blue Ridge Mountains.

Cliff-face populations tend to contain individuals which are smaller and darker than comparable forest populations. They mature at a smaller size and large individuals are uncommon.

Two populations were chosen for more intensive study. At both sites animals were active during the day. At one of the sites day-time activity appeared to be as extensive as night-time activity.

Capture and release experiments indicated that populations on cliff-faces were rather dense. Recapture data were interpreted in terms of distribution of individuals, natural movements, and return from displacement.

13. Food Selection and Age-class Competition in *Cnemidophorus tigris*. C. J. McCoy, Section of Reptiles and Amphibians, Carnegie Museum, Pittsburgh, Pennsylvania 15213.

The diet of *Cnemidophorus tigris septentrionalis* in western Colorado was studied by examination of the stomach contents of approximately 300 animals collected during 1962 and 1963. Adult lizards eat a great variety of arthropods, and occasionally small lizards or lizard eggs. The most important foods, in order of frequency, are caterpillars, beetles, grasshopper nymphs, and spiders. Seasonal variation in the relative importance of these groups results from changes in the availability and acceptability of the various prey groups. Caterpillars and grasshopper nymphs are abundant in the habitat in early summer, but much less available later in the season. This difference is reflected in the diet of the lizards, where it is partially compensated by increased utilization of ants and termites. Beetles and spiders are staples of the diet which show little seasonal fluctuation.

Prey size class and species selection by adult and sub-adult segments of the lizard population were compared. Adult and sub-adult lizards depend on significantly different parts of the local prey population. The resulting reduction in food competition permits the maintenance of a relatively large annual class of sub-adult lizards, which provides for a more resilient population response to short-term environmental fluctuations.

CONTRIBUTED PAPERS: *Session II*
Ronald A. Brandon, *presiding*
Department of Zoology, University of Southern Illinois, Carbondale, Illinois 62903.

14. Premating Behavior in the Fence Lizard, *Sceloporus undulatus*. J. P. Kennedy, Department of Anatomy, The University of Texas at Houston, Dental Branch, Houston, Texas 77025.

Premating behavior is usually initiated by the sexually active male. Approach of the male to a nearby female is made in short runs and momentary stops during which the male elevates and then abruptly lowers the body on the forelegs with a rhythmic vertical bobbing of the head. The trunk is laterally compressed; the gular region is extended. This clearly male behavior may function in sex recognition. The breeding system is promiscuous in this population and not all premating behavior results in mating. The non-receptive female responds to the presentation of a male intent on mating by elevating her body on all four legs and hopping in short jerky movements. The trunk is notably arched; the gular region is extended, the tail is elevated. These sequences and the lack of heterospecific antagonistic behavior between fence lizards and several coexisting lizards in the Big Thicket of Texas are illustrated.

15. Variation in the Dorsal Pattern of Southern Populations of *Desmognathus ochrophaeus*. Stephen G. Tilley, Museum of Zoology, The University of Michigan, Ann Arbor, Michigan 48104.

The plethodontid salamander *Desmognathus ochrophaeus* exhibits considerable variation in its dorsal pattern, particularly in the southern portions of its range. This variability is best dealt with, and trends within it best discerned, by dividing the dorsal pattern into components. Those used in the present study were: the dorso-lateral melanophore pattern, the mid-dorsal melanophore pattern, the general dorsal melanophore density, the larval spots, and the dorsal chromatophore pattern. Each of these is influenced by various combinations of ontogenetic, genetic, sexual, and possibly ecotypic variation. The unusually high degree of variability observable in the dorsal pattern of *D. ochrophaeus* results from the superposition of each of these components, each variable within itself. The degree to which variation within a given component correlates with variation within others is presently under study.

The only important broad geographic trend in the dorsal pattern is the replacement, in progressively more southern populations, of straight dorso-lateral stripes by zigzag ones. Populations as far south as the Great Smoky Mountains contain both individuals with straight stripes and those with zigzag stripes. This variation appears to be continuous rather than discontinuous, there being various degrees of "zigzagedness." On this basis, and from studies of variation within single broods, the hypothesis that more than one species is involved is rejected.

16. Some Features of the Caecilian Cardiovascular System. Ronald Lawson, Department of Biology, The University of Salford, Salford 5, Lancs., England.

The ventricle of the caecilian heart contains one or more longitudinal muscular ridges (central trabeculae) which may represent the remnant of an interventricular septum and suggest that the heart in modern amphibians might have evolved from an essentially four chambered structure (two atria and two ventricles). The myocardium consists of an elaborate series of muscle fibres separated by large spaces. The intra-myocardial spaces communicate with a complex series of cardiac veins which open into the sinus venosus. During each ventricular systole some blood is forced into the cardiac veins.

Considerable variation in the form of the major arterial vessels is found in this group. A symmetrical arrangement is found in *Ichthyophis* whereas other genera such as *Hypogeophis* show considerable asymmetry.

The cephalic circulation in caecilians shows considerable resemblance to that of *Salamandra* and other urodeles, but has several major differences from that of *Rana* and other anurans. Recent literature, especially that of Bertmar, indicates the importance of the cephalic circulation in establishing relationships. However, it is difficult to decide if the similarities in the pattern of the head circulation in the caecilians and the urodeles are really indicative of close affinities.

17. Movements of Subadult Greenfrogs, *Rana clamitans*. Eugene E. Schroeder, Department of Biology, Eastern Kentucky University, Richmond, Kentucky 40475.

Subadult greenfrogs were studied near the campus of the University of Virginia Mountain Lake Biological Station to determine their movements for the first season following transformation. A total of 471 greenfrogs were captured and individually toe-clipped at Sylvatica Pond. An additional 59 subadults were released at the study site. Many of these frogs were recaptured one or more times. All frogs (except 2) had dispersed from the pond by late August.

Subadult greenfrogs occupied a limited shore area before permanently leaving the pond. Night foraging was confined to within 3 to 4 feet of the water's edge. In general, activity of the frogs increased with precipitation and decreasing light. Sampling indicated that frogs moved from 205 yards to three miles during the summer. Movement patterns varied among frogs. Immigration and the establishment of a home range were evident at a new water impoundment. Translocation experiments revealed no homing tendencies for subadult greenfrogs.

18. Egg Laying Situations and Early Larval Behavior in *Eurycea lucifuga*. N. Bayard Green, Department of Biological Sciences, Marshall University, Huntington, West Virginia 25701.

Eggs of the cave salamander were collected in the twilight and the dark zones of three West Virginia caves in Greenbrier and Monroe counties. The eggs were attached by short pedicels to the sides of rimstone pools or lay in the mud on the bottom. The eggs, each with two envelopes, measured 4.1-4.4 mm in total diameter and were deposited during fall and early winter. Hatching occurs from

11.1-12.4 mm; newly-hatched larvae were unpigmented.

Rapid larval growth follows hatching until absorption of the yolk at 15-17 mm. In early spring the larvae migrate through water from overflowing rimstone pools to streams where development is completed after twelve to fifteen months when the larvae transform at approximately 55 mm total length.

19. The Recent Herpetofauna of the Northern Wet Mountains, South-Central Colorado. Benjamin H. Banta, Department of Natural Science, University College, Michigan State University, East Lansing, Michigan 48823.

Sampling small animals by use of buried cans and jars was first employed by this investigator in southern and western Nevada in 1955. This method was again employed on a longer term basis in Saline Valley, Inyo Co., California, in 1959-1960. It has been used for extensive sampling in the Pike's Peak region of Colorado during 1963-1965.

Seventy-two buried can/jar pitfall sampling stations beginning near Silver Cliff, Custer Co., and ending near the southern outskirts of Cannon City, Freemont Co., were established on June 26, 1963 and pulled up or otherwise deactivated on October 24, 1964. The altitudinal range for the sampling stations was from about 5800 to 8200 feet. A check list of the amphibians and reptiles obtained during this period follows:

Species	Altitudinal Range	Number 1963	Number 1964
AMPHIBIA			
Ambystoma tigrinum mavortium	5600-8000	22	9
Bufo woodhousei woodhousei	6200-7900	2	4
Scaphiopus bombifrons	5800-6200	1	1
REPTILIA			
Crotaphytus collaris collaris	6000-6200	5	3
Holbrookia maculata maculata	5620-5800	2	6
Phrynosoma douglassi brevirostre	7900-8013	5	1
Sceloporus undulatus erythrocheilus	5580-8200	281	320
Eumeces multivirgatus gaigei	7590	1	1
Eumeces obsoletus	6000-6200	5	2
Cnemidophorus sexlineatus	5580-7500	25	21
Cnemidophorus tessellatus	5580-6800	18	29
Masticophis flagellum testaceus	7700	1	0
Pituophis melanoleucus sayi	6900-8000	2	2
Thamnophis elegans vagrans	7100-7900	3	1
Crotalus viridis viridis	6050-8013	2	5
	Totals	375	405

No additional species were obtained in 1964 that were not obtained in 1963 and one species obtained in 1963 was not obtained in 1964. Generally more specimens per species were obtained in 1964 than in 1963. The 1964 samples provided additional evidence as to the actual extent of altitudinal distribution of several species.

20. The Central Basin Physiographic Province and its Influence upon the Distribution of Tennessee Reptiles and Amphibians. Ralph M. Sinclair, 1197 Holz Avenue, Cincinnati, Ohio 45230.

The Central Basin (Bluegrass) of Tennessee is a well defined physiographic province which has received attention of both geologists and botanists. The Basin is approximately 60 miles wide and 120 miles long. The boundaries of the Outer Basin have been interpreted from both a restricted and broad sense. The Basin is a result of the erosion of the Cincinnati Arch, an anticline, and is composed of Ordovician limestone. A subclimax forest of red cedar occurs over much of the area.

There are 71 species of reptiles and amphibians occurring in the general area. Although there are no endemics, the fauna is striking. Forms such as *Lygosoma laterale* and *Eurycea longicauda* skirt the Inner Basin, while others such as *Eurycea lucifuga, Plethodon dorsalis,* and *Cnemidophorus sexlineatus* develop greater population densities than observed in peripheral areas. Parallels between the Bluegrass Basins of both Kentucky and Tennessee are both physiographic and ecologic. The most conspicuous elements of the herpetological fauna are *Haldea valeriae, Tantilla coronata, Eumeces inexpectatus, Cnemidophorus sexlineatus, Eurycea lucifuga,* and *Plethodon dorsalis.*

21. Some Osteological Observations on the Genus *Rana.* Charles J. Chantell, Department of Biology, University of Dayton, Dayton, Ohio 45409.

Osteologically the differences among species of temperate North American *Rana* are less than those among *Bufo* and *Hyla.* Even so, certain skeletal characters and/or skeletal ratios serve to define some species and or species-groups of *Rana.* To date 170 skeletons, the majority of which are completely disarticulated, from 17 species of *Rana* have been examined. Skeletal elements possessing structures and/or ratios deemed useful in characterizing certain species or species-groups include the ethmoid, parasphenoid, foramen magnum, atlas, coracoid, scapula, humerus, sacrum and ilium. Species found to have adequate diagnostic skeletal characters include *R. catesbeiana, R. sylvatica, R. grylio, R. capito, R. clamitans,* and *R. boylei.* Although the taxonomic make-up of the species-groups varies somewhat with the skeletal element being examined, the two most consistent groups are *R. catesbeiana, R. sylvatica, R. clamitans, R. heckscheri, R. grylio* and *R. capito*; and *R. boylei, R. aurora, R. mucosa* and *R. cascadae.* Characters on the humerus of *R. sylvatica, R. septentrionalis* and *R. pretiosa* suggest affinities with the latter group. Certain of the skeletal characters and ratios examined (*e.g.,* numbeus, ilium, sacrum) are found to vary significantly intraspecifically with regard to sex and size or age.

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