# KENTUCKY SALAMANDERS OF THE GENUS *DESMOGNATHUS*: THEIR IDENTIFICATION, DISTRIBUTION, AND MORPHOMETRIC VARIATION

A Thesis

Presented to

the Faculty of the College of Science and Technology

Morehead State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Biology

by

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July 24, 2000

Accepted by the Faculty of the College of Science and Technology, Morehead State University, in partial fulfillment of the requirements for the Master of Science Degree.

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7-24-2000
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**Kentucky Salamanders of the Genus *Desmognathus*: Their Identification, Distribution, and Morphometric Variation**

Leslie S. Meade, M.S.
Morehead State University, 2000

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The objectives of this study were to (1) summarize the taxonomic and natural history data for *Desmognathus* in Kentucky, (2) compare Kentucky species and subspecies of *Desmognathus* with regard to sexual dimorphism, (3) analyze interspecific variation in morphology of Kentucky *Desmognathus*, and (4) compile current range maps for *Desmognathus* in Kentucky. Species and subspecies examined included *D. ochrophaeus* Cope (Allegheny Mountain Dusky Salamander), *D. fuscus fuscus* (Green) (Northern Dusky Salamander), *D. fuscus conanti* Rossman (Spotted Dusky Salamander), *D. monticola* Dunn (Seal Salamander), and *D. welteri* Barbour (Black Mountain Dusky Salamander). Salamanders were collected in the field or borrowed from museum collections. Taxonomic and natural history data for Kentucky *Desmognathus* were compiled from literature, preserved specimens, and direct observations. Morphometric characters examined included total length, snout-vent length, tail length, head length, head width, snout length, vent length, tail length/total length, snout-vent length/total length, and snout length/head length. Results of t-tests for sexual dimorphism indicated that snout length, vent length, and snout length/head length were significantly different between the sexes ($p<0.05$) in all species, with males being larger in all cases. Total length, snout-vent length, tail length, head length, head width, snout length, vent length, and snout length/head length were

significantly different for *D. f. fuscus* ($p<0.05$). Only three characters, snout length, vent length, and snout length/head length, were significantly different between the sexes ($p<0.05$) in *D. ochrophaeus*. A comparison of interspecific variation was also completed with regard to all characters by using Bonferroni t-tests. *Desmognathus welteri* was significantly different from *D. monticola* in snout-vent length, head length, head width, and snout length. The subspecies of *D. fuscus* were not significantly different from each other in any character examined. *Desmognathus ochrophaeus* was significantly different ($p<0.05$) from all other *Desmognathus* in total length, snout-vent length, tail length, head length, head width, snout length, and vent length. The ranges of Kentucky *Desmognathus* were compiled to show individual county records, and not just a broad continuous range. *Desmognathus ochrophaeus*, *D. monticola*, and *D. welteri* occur primarily on the Cumberland Plateau of eastern Kentucky. *Desmognathus f. conanti* is a coastal plain species found only in the Jackson Purchase region of Kentucky. *Desmognathus f. fuscus* occurs on the Mississippian Plateau and ranges eastward to the Cumberland Mountains and Cumberland Plateau.

Accepted by: Leslie E. Meade, Chairman

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## ACKNOWLEDGMENTS

I wish to thank the following people and organizations for their respective contribution to my thesis project, of whom without, this project would not have been possible.

Faculty Committee Members:

Dr. Leslie E. Meade: advice and support.

Dr. David Eisenhour: statistical guidance, advice, and support.

Dr. Gerald DeMoss: advice and support.

Faculty (Noncommittee Members):

Dr. Geoffrey Gearner: equipment, advice and support.

Dr. Brian Reeder: equipment, advice and support.

Dr. Joe Winstead: advice and support.

Dr. Lloyd Jaisingh: statistical advice.

United States Forest Service Personnel:

John MacGregor: distributional records.

Dan Dourson: distributional records and collection sites.

Museums, Universities, and Associated Personnel:

Dr. Leslie E. Meade, Morehead State University.

Dr. Floyd Scott and Dr. Dave Snyder, Austin Peay State University.

Dr. Ron Brandon and Jeffrey Stewart, Southern Illinois University at Carbondale.

**ACKNOWLEDGMENTS (cont.)**

Dr. James Petranka, University of Kentucky.

I would like to thank Robert Fischer, Steve Gotti, and James Poindexter of the National Museum of Natural History for their generous hospitality during our scientific visit to examine the Smithsonian's Desmognathine collection. However, none of the specimens examined in Washington, D.C. were used in this study.

Graduate Students:

John Cox and Mehrunissa Lambat for assistance at the National Museum of Natural History, Murray State, and at Austin Peay; and for advice and support.

Chris Goshorn, Mike Spencer, and Mike Fultz for assistance with collecting specimens at Cawood Branch, Leslie Co., and Black Mountain, Harlan Co., Kentucky.

Ryan McCall and Todd Jacobs for advice and support.

Mike Garrett and Mike Kenewell for assistance with collecting specimens in Livingston Co., Kentucky.

Family:

I would like to especially thank my family for encouragement, patience, financial assistance, advice, and support throughout the duration of my project.

## TABLE OF CONTENTS

PAGE

## LIST OF TABLES

**TABLE** **PAGE**

## LIST OF FIGURES

# INTRODUCTION

The family Plethodontidae contains 27 genera and over 240 species of salamanders. Two subfamilies are recognized: the subfamily Desmognathinae, which includes the genera *Desmognathus* and *Phaeognathus*, and the subfamily Plethodontinae, which includes all of the remaining genera (Larson, 1984; Petranka, 1998). The differences in these two subfamilies is based on head musculature and skeletal features. Salamanders of the genus *Desmognathus* are commonly called dusky salamanders, with the word "dusky" used in reference to their brownish color. The name *Desmognathus* is derived from the Greek *desmos* (=band) and *gnathos* (=jaw). Dusky salamanders are lungless salamanders and probably originated in mountain streams of the appalachian region where oxygen is available in high concentrations and lungs were not required for survival (Dunn, 1926). Reduction and loss of lungs makes a salamander negatively buoyant, thus keeping the body on the bottom in fast moving water (Zug, 1993). Respiration in these salamanders occurs by means of the skin (cutaneous), or mouth and throat (buccopharyngeal) (Goin et al., 1978). Other characteristics they share with members of the family Plethodontidae include small body size (2-8 inches), a nasolabial groove, costal grooves, internal fertilization and no ypsiloid cartilage to support lungs. Nasolabial grooves connect the nostrils to the upper lip and allow olfactory information to reach the Jacobson's Organs (Brown, 1968; Goin et al., 1978; Dawley and Bass, 1989; Dawley, 1992). Costal grooves are important because they allow water to move upward to the sides

and backs of salamanders, thus keeping their skin moist for respiration (Lopez and Brodie, 1977).

Dusky salamanders are placed in the subfamily Desmognathinae based on their unique jaw structure. In these amphibians, the mouth is opened by raising the upper jaw and skull with a prominent gularis muscle (Figure 1); this muscle forms a noticeable swelling on each side of the throat (Goin et al., 1978). They also differ from other salamanders in having enlarged hindlimbs and a distinct postocular line from their eye to the angle of the jaw. Fifteen species of salamanders in the genus *Desmognathus* are currently recognized and four of these are currently found in Kentucky (Petranka, 1998). Kentucky species and subspecies include *D. ochrophaeus* Cope (Allegheny Mountain Dusky Salamander), *D. fuscus fuscus* (Green) (Northern Dusky Salamander), *D. fuscus conanti* Rossman (Spotted Dusky Salamander), *D. monticola* Dunn (Seal Salamander), and *D. welteri* Barbour (Black Mountain Dusky Salamander). Range maps for these salamanders are available in Conant and Collins (1991, 1998) and Petranka (1998).

Edward D. Cope described *Desmognathus ochrophaea* (=*D. ochrophaeus*) in 1859. The type locality was listed as "Susquehanna County, Pennsylvania." Kentucky authors have referred to this salamander as *D. f. ochrophaeus* (Dury and Williams, 1933); *D. o. ochrophaeus* (Barbour, 1953; Bush 1957, 1959; Barbour, 1971); and *D. ochrophaeus* (Conant, 1975; Conant and Collins, 1991). Tilley and Mahoney (1996) have recently divided *D. ochrophaeus* into four species arranged north to south as *D. ochrophaeus*, *D. orestes*, *D. carolinensis* and *D. ocoee*. Only *D.*

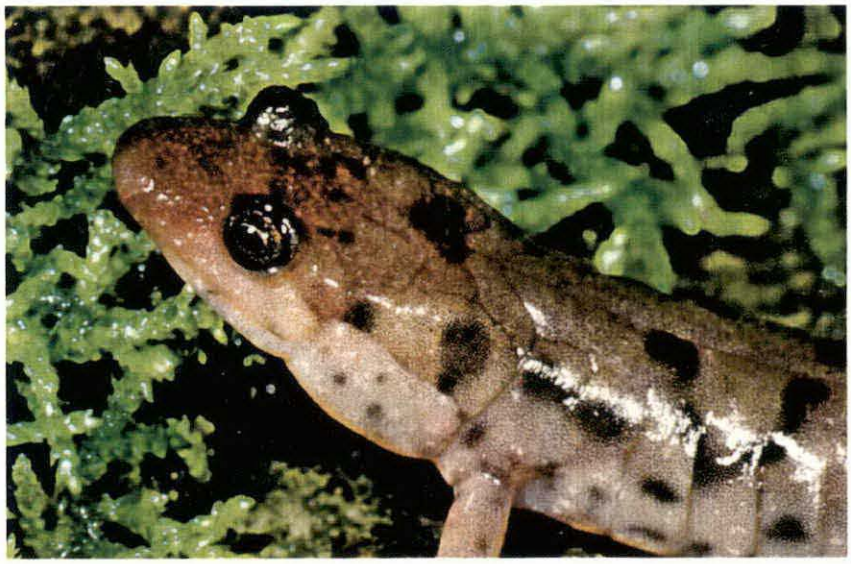

Figure 1. Head of Seal Salamander, *Desmognathus monticola*, showing the gularis muscle.

*orestes* was described as a new species because the other forms had been described by earlier authors. *Desmognathus ochrophaeus* is the only species in the complex that occurs in Kentucky. This species occurs in the Appalachian Mountains from southern Quebec, northern New York, southward to West Virginia, western Virginia and eastern Kentucky (Tilley and Mahoney, 1996).

Green (1818) described *Salamandra fusca* from a type locality he designated as "northern parts of the State of New York." Cope (1875) listed *Desmognathus f. fusca* and *D. nigra*; *Desmognathus nigra* is presently considered to be a synonym of *D. f. fuscus*. Kentucky authors have used the names *D. fusca* (Garman, 1894) and *D. f. fuscus* (Dunn, 1926; Burt, 1933; Hibbard, 1936; Welter and Carr, 1939; Bishop, 1947; Conant, 1958, 1975; and Conant and Collins, 1991, 1998). Matthes (1855) described *Salamandra phoca* from Taylor's Creek, near Newport, Campbell Co., KY. Apparently, the type specimen for *S. phoca* was lost. The original description of *S. phoca* was very general and fits both *D. fuscus* and *D. monticola*. Only specimens of *D. f. fuscus* have been found at the type locality, and the nearest records for *D. monticola* are about 100 miles east. *Salamandra phoca* should be considered as a junior synonym of *D. fuscus*. *Desmognathus f. fuscus* ranges from southern New Brunswick and southern Quebec, southward to the Carolinas, eastern Tennessee, eastern and central Kentucky and southeastern Indiana. Rossman (1958) described *Desmognathus fuscus conanti* from a type locality "near U.S. Highway 60, 2.1 miles S. Smithland, Livingston County, Ky." All other Kentucky authors have followed Rossman (1958) and identified this salamander as a subspecies of *D. fuscus* (Smith,

1961; Barbour, 1971; Conant, 1975; Conant and Collins, 1991, 1998). *Desmognathus f. conanti* ranges from Georgia to Alabama, Mississippi, Louisiana, Arkansas, western Tennessee, western Kentucky and extreme southern Illinois (Conant and Collins, 1991, 1998), and intergrades with *D. f. fuscus* in regions where the two races meet.

Dunn (1916) described *Desmognathus monticola* from "Elk Lodge Lake, near Brevard, North Carolina; altitude about 3000 feet." Most Kentucky authors have listed the Seal salamander as *Desmognathus monticola* (Barbour, 1953; Barbour, 1971; Conant and Collins, 1991, 1998) or *D. m. monticola* (Bush 1957, 1959; Conant, 1975). This species ranges from southwestern Pennsylvania, southward to eastern Kentucky, western and central Virginia, eastern Tennessee, western North Carolina, western South Carolina, northern Georgia and eastern and southern Alabama (Conant and Collins, 1991, 1998).

Barbour (1950) described *Desmognathus fuscus welteri* from the designated type locality of "Looney Creek, near Lynch, Harlan County, Kentucky." Researchers have referred to Kentucky populations of this salamander as *D. f. welteri* (Barbour, 1953; Barbour and Hays, 1957; Conant, 1958; Bush 1957, 1959) and *D. welteri* (Barbour, 1971; Juterbock, 1978, 1984; Conant, 1975; Conant and Collins, 1991, 1998). This species ranges across eastern Kentucky, into West Virginia, south-western Virginia and eastern Tennessee; its exact range is poorly defined.

Dusky salamanders are often difficult to identify. Changes in coloration due to age and size, along with interspecific variation in pigmentation contribute to the

confusion (Conant and Collins, 1991, 1998). Because of similarities in morphology, it is often more important to depend on (1) tail shape (2) adult body size and (3) geography, rather than coloration for identification (Conant and Collins, 1991, 1998).

The range maps found in field guides cover broad areas. However, the actual range of a particular species is localized. Accurate county range maps are needed to show which counties have distributional records for *Desmognathus* and which counties need to be examined more carefully for *Desmognathus*.

The primary objectives of this thesis were to: (1) summarize taxonomic and natural history data for *Desmognathus* in Kentucky, (2) compare Kentucky species and subspecies of *Desmognathus* with regard to sexual dimorphism, (3) analyze interspecific variation in morphology of Kentucky *Desmognathus*, and (4) compile current range maps for *Desmognathus* in Kentucky.

## MATERIALS AND METHODS

### Morphological Data

Salamanders examined came from collections maintained at Morehead State University (MOSU), Austin Peay State University (APSU), Southern Illinois University (SIUC), and additional specimens collected in the field. Specimens from these collections are listed in the Results and Discussion by use of the above acronyms (Leviton et al., 1985; Poss and Collette, 1995).

Specimens collected in the field were placed in plastic bags (with moist leaves) and transported to the lab at Morehead State University in ice-filled coolers. This was necessary because amphibians are very sensitive to heat. After photographing specimens in the lab, salamanders were anesthetized by using MS-222 (tricaine methanesulfonate) and then preserved in 10% formalin. Specimens had been preserved for at least 5 days before measurements were taken to keep distortions due to preservation at a minimum (Lee, 1982). Specimens of each species were examined from as many different Kentucky counties as possible, although geographic coverage was limited by available specimens. Adult specimens used in this study were based on minimum size criteria given by Tilley and Bernardo (1993). Their minimum size criteria for *D. fuscus* (northern type) was used for both *D. f. fuscus* and *D. f. conanti*.

Information collected in the lab included collection and morphometric data from each specimen of *D. ochrophaeus*, *D. f. fuscus*, *D. f. conanti*, *D. monticola*, and *D. welteri*. Collection data included the scientific name, collection site (county and

nearest significant landmark), collection date, and collector's name. A vernier caliper and metric ruler were used to estimate the following morphometric characters to 0.1 mm (Figure 2): total length, snout-vent length, tail length, head length, head width, snout length, and vent length. Additionally, the following ratios were calculated: snout-vent length/total length, tail length/total length, and snout length/head length. Total length was measured from the snout to end of the tail. Snout-vent length was measured from the snout to posterior end of vent. Tail length was calculated by subtracting snout-vent length from total length. Head length was measured from the snout to middle of gular fold. Head width was measured at the widest point of the head. Snout length was measured from the snout to anterior margin of the orbit. Vent length was measured from anterior to posterior end of the cloaca.

The sex of specimens was determined by examination of the cloaca with a Bausch and Lomb dissecting microscope fitted with 10x oculars and a 3x zoom. Males have a series of short papillae at the anterior end of the cloaca (Figure 3a). Females have a series of grooves along the sides of the cloaca (Figure 3b) for sperm pickup and storage in the spermatheca.

**Photographic Data**

Photographs of live specimens were taken for each species of *Desmognathus* to indicate variability in coloration, tail morphology, and general characteristics. Photographs were taken with an Olympus D-500L digital camera; a Pentax SF-10 35mm single lens reflex camera, with a 90 mm Tamron macro lens; and a Pentax ZX-

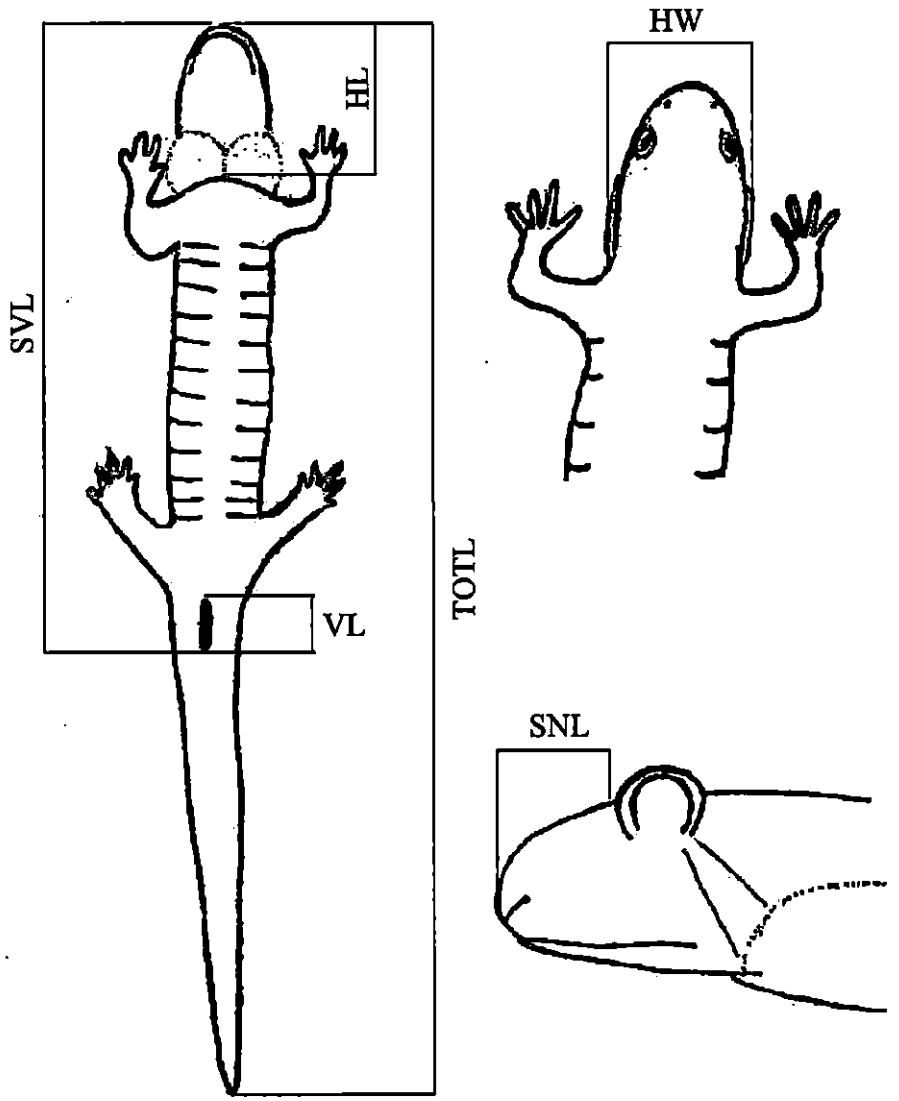


Figure 2. Body measurements used in the morphometric analysis of *Desmognathus*. Measurement abbreviations are (TOTL) total length, (SVL) snout-vent length, (HL) head length, (HW) head width, (SNL) snout length, and (VL) vent length. Not pictured are tail length (TAIL), which was TOTL-SVL, TAIL/TOTL, SVL/TOTL, and SNL/HL.


Figure 3. Vent anatomy in *Desmognathus*. Photographs of (a) male vent of *D. welteri* (b) female vent of *D. fuscus conanti*. Magnification of 30x.

M 35mm single lens reflex camera, with a Pentax 50mm macro lens. Film included Kodachrome 64 (ISO 64) for color slides, and Kodak Gold (ISO 400) for color prints. Photographic figures were prepared to show characters of taxonomic significance for each species in Kentucky.

**Kentucky Distribution**

Distributional records were collected for the five taxa of *Desmognathus* in Kentucky: *D. ochrophaeus*, Allegheny Mountain Dusky Salamander; *D. f. fuscus*, Northern Dusky Salamander; *D. f. conanti*, Spotted Dusky Salamander; *D. monticola*, Seal Salamander; and *D. welteri*, Black Mountain Dusky Salamander. Records were obtained from museum specimens, from journal articles and books, from personal records, and from unpublished field notes and maps of John R. MacGregor (1999), U.S. Forest Service, Winchester, Kentucky. Distribution maps were prepared from the above sources for all species of *Desmognathus* in Kentucky. Dots on each distribution map indicated county records, and showed the range for each form within the state. Any questionable records were not plotted.

Published county records for *Desmognathus* in Kentucky used in constructing the range maps were taken from Garman (1894), Bishop (1926), Dunn (1926), Burt (1933), Bailey (1933), Dury and Williams (1933), Neel (1938), Welter and Carr (1939), Bishop (1947), Barbour (1950, 1953), Cunningham (1951), Bush (1957, 1959), Rossman (1958), Branson et al. (1970), Bertram (1974), Harker et al. (1979),

Barbour et al. (1979), Westerman and Westerman (1980), Moeller (1994), and Campbell et al. (1989, 1992, 1993, 1994).

**Statistical Data**

Statistical analysis of data was used to compare sexual dimorphism and interspecific variation in morphometry of the five taxa of Kentucky *Desmognathus*. Means of all characters were compared at the 0.05 and 0.01 confidence levels. Two confidence levels were used to test for significant or highly significant sexual differences. Sexual dimorphism was compared within each species by using Student's-t test. Interspecific variation in Kentucky forms of *Desmognathus* was compared by using one-way anova, and mean values for these salamanders were then compared by using Bonferroni t-tests. This test was applied to control type I experimentwise error rate due to multiple t-tests.

A multivariate analysis was conducted to compare morphometric variation among the five taxa of Kentucky *Desmognathus*. Multivariate techniques are often used to study variation in amphibian morphology and are used to examine multiple characteristics simultaneously (Chippindale et al., 1993; Irschick and Shaffer, 1997; Wilson and Larsen, 1999). A linear regression using data from all 353 salamanders was calculated for total length, head length, head width, snout length, vent length, and tail length against snout-vent length (SVL). The residuals of each of the characters were used as variables in statistical procedures to eliminate the effect of size differences among salamanders. These variables were subjected to canonical

discriminant function analysis to examine variation in morphometry among Kentucky *Desmognathus*. MANOVA, using Wilk's Criterion, was used to test for significant differences between the forms of *Desmognathus*. Examination of canonical coefficients was then used to assess which morphometric characters were most important in separating these forms. Differentiation between the forms of *Desmognathus* was graphically summarized by plotting canonical scores. The Morehead State University mainframe computer version of SAS was used for all analyses. Additional SAS programming information was obtained from Schlotzhaurer and Littell (1987).

**Species Accounts**

Data concerning the taxonomy, identification, and biology of each species were collected from the literature and from field observations. The Kentucky synonomy contains those names given to each species and subspecies of *Desmognathus* in Kentucky. Etymology was obtained from Webster's New Twentieth Century Dictionary Unabridged (1961). The identification section gives the major distinguishing features for each species of *Desmognathus*. The biology section defines the habitat, foods, microhabitat requirements, behavior, reproduction, sexual dimorphism, and unusual features of each species or subspecies of dusky salamander. Taxonomic data collected from Kentucky specimens were used to complete the sections on identification and variation. Kentucky distribution maps were plotted by using collection data from literature records, museum records,

personal records, and unpublished records of John R. MacGregor (1999). Kentucky counties are shown in Figure 4. Scientific names and common names are those given by Petranka (1998).

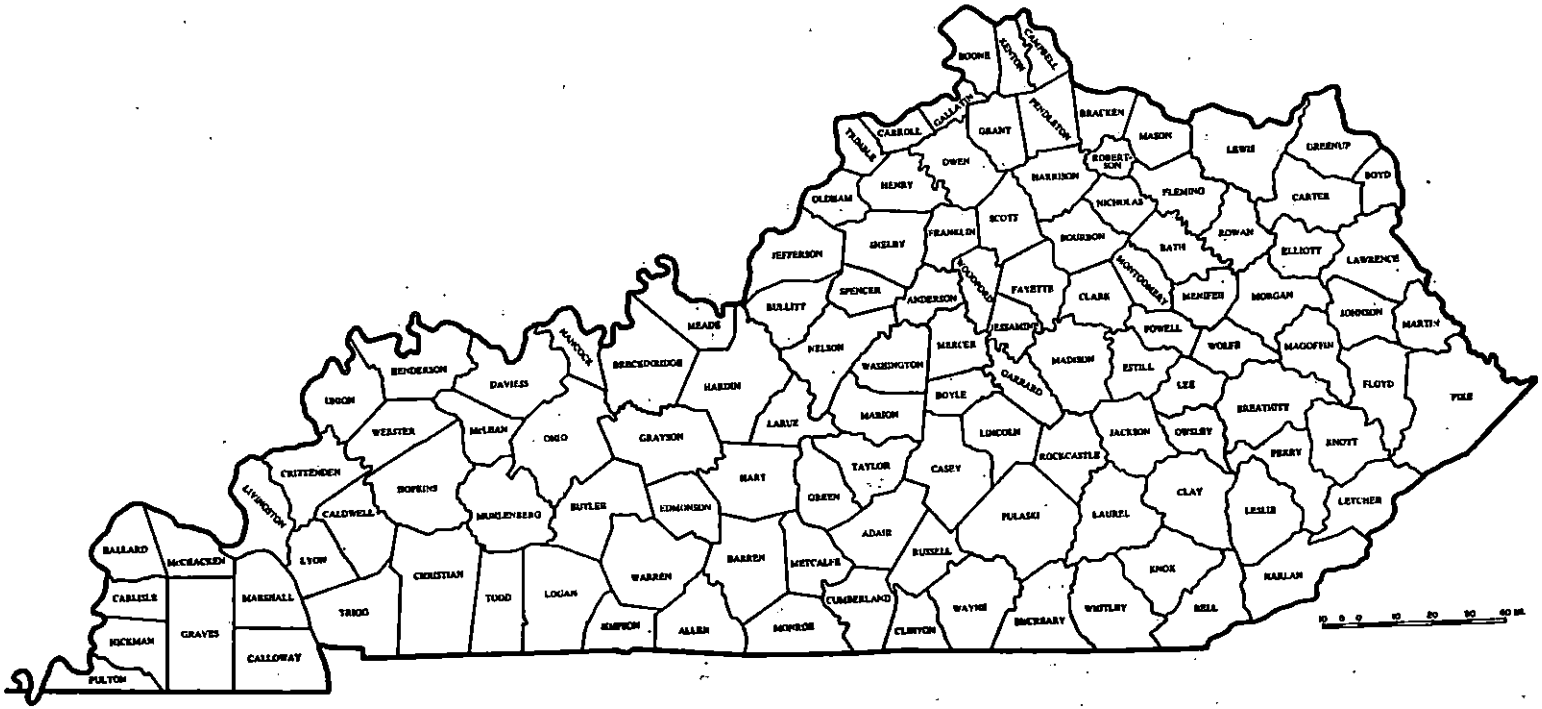


Figure 4. Kentucky counties (after Withington, 1980).

## RESULTS AND DISCUSSION

### SPECIES ACCOUNTS

***Desmognathus ochrophaeus***
Allegheny Mountain Dusky Salamander

**Kentucky Synonomy**

*Desmognathus ochrophaea* Cope (1859); type locality was designated as "Susquehanna County, Pennsylvania"; Cope (1875).

*Desmognathus fuscus ochrophaeus* Dury and Williams (1933).
*Desmognathus o. ochrophaeus* Barbour (1953); Bush (1957, 1959); Barbour (1971).

*Desmognathus ochrophaeus* Conant (1975); Conant and Collins (1991, 1998); Tilley and Mahoney (1996).

**Etymology**

The genus name *Desmognathus* is derived from the Greek *desmos* (= band) and *gnathos* (= jaw). The specific name *ochrophaeus* is from the Greek *ochros* (= pale yellow) and *phaeus* (=light), in reference to the dorsal coloration of some specimens.

**Identification**

*Desmognathus ochrophaeus* has a small, slender brownish body of 2.5-4 inches, with highly variable color patterns; a brownish, straight-edged dorsal stripe, and is often marked with a middorsal row of chevrons; a coloration that darkens with age, so that older adults are uniformly dark brown, with a light brown head (Figure 5a); an immaculate ventral surface (Figure 5b); a tail that is long, tapering and

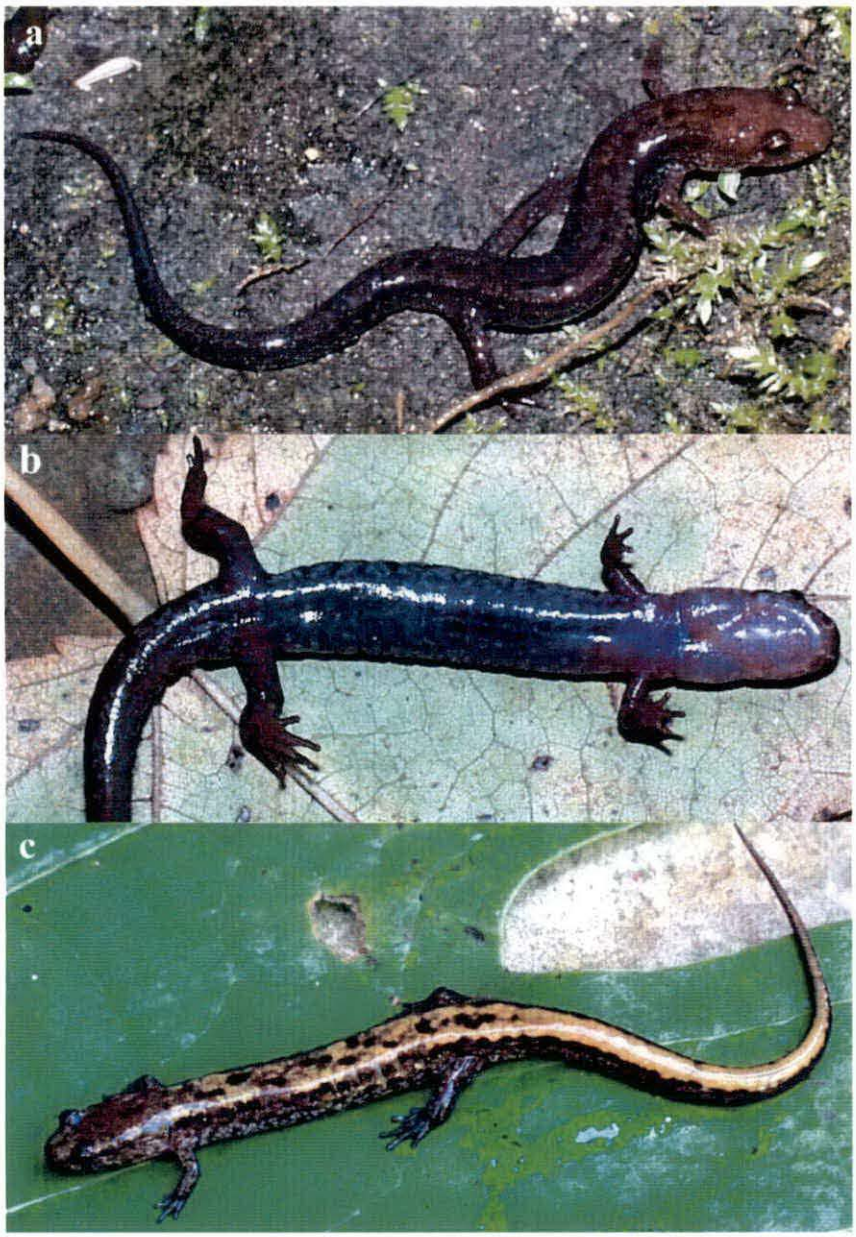


Figure 5. *Desmognathus ochrophaeus*. Photographs of (a) old adult with brown head (b) ventral surface with light mottling (c) young adult with yellow stripe.

rounded at the base; a very sinuous (wavy) mouth line (in adult males); gularis muscles; 14 costal grooves; and juveniles with a yellow (Figure 5c), orange, tan, brown or reddish dorsal stripe.

**Biology**

*Desmognathus ochrophaeus* occupies rocky headwater streams (Figure 6), seepage areas, or wet rock faces. This species is usually found beneath rocks, bark, sticks and leaves on the forest floor (Bishop, 1947). Adult males lack vomerine teeth, have a small mental gland and pointed lower jaw, have a blackish body with a brown head, and like other dusky salamanders have papillae in their vent. In Kentucky, associated species in streams included *D. f. fuscus*, *D. monticola*, *D. welteri*, *Gyrinophilus porphyriticus* (Figure 7a), *Pseudotriton ruber ruber* (Figure 7b), *Eurycea cirrigera* (Figure 7c), and *Eurycea longicauda longicauda* (Figure 7d); associated species at stream edges included *D. f. fuscus* and *E. cirrigera*; and associated species in forest habitats included *Plethodon richmondi* (Figure 8a), *P. glutinosus* (Figure 8b), *P. kentucki* (Figure 8c), and *Notophthalmus viridescens viridescens* (red efts) (Figure 8d). *Desmognathus ochrophaeus* is a nocturnal species that feeds on earthworms, insects (fly larvae, beetles, collembolans) and mites (Pfingsten and Downs, 1989). Holomuzki (1980) found *D. ochrophaeus* foraging with northern dusky and two-lined salamanders in stream-edge habitat during the first hour after sunset. This activity was closely correlated with the activity period of their invertebrate prey (Holomuzki, 1980).

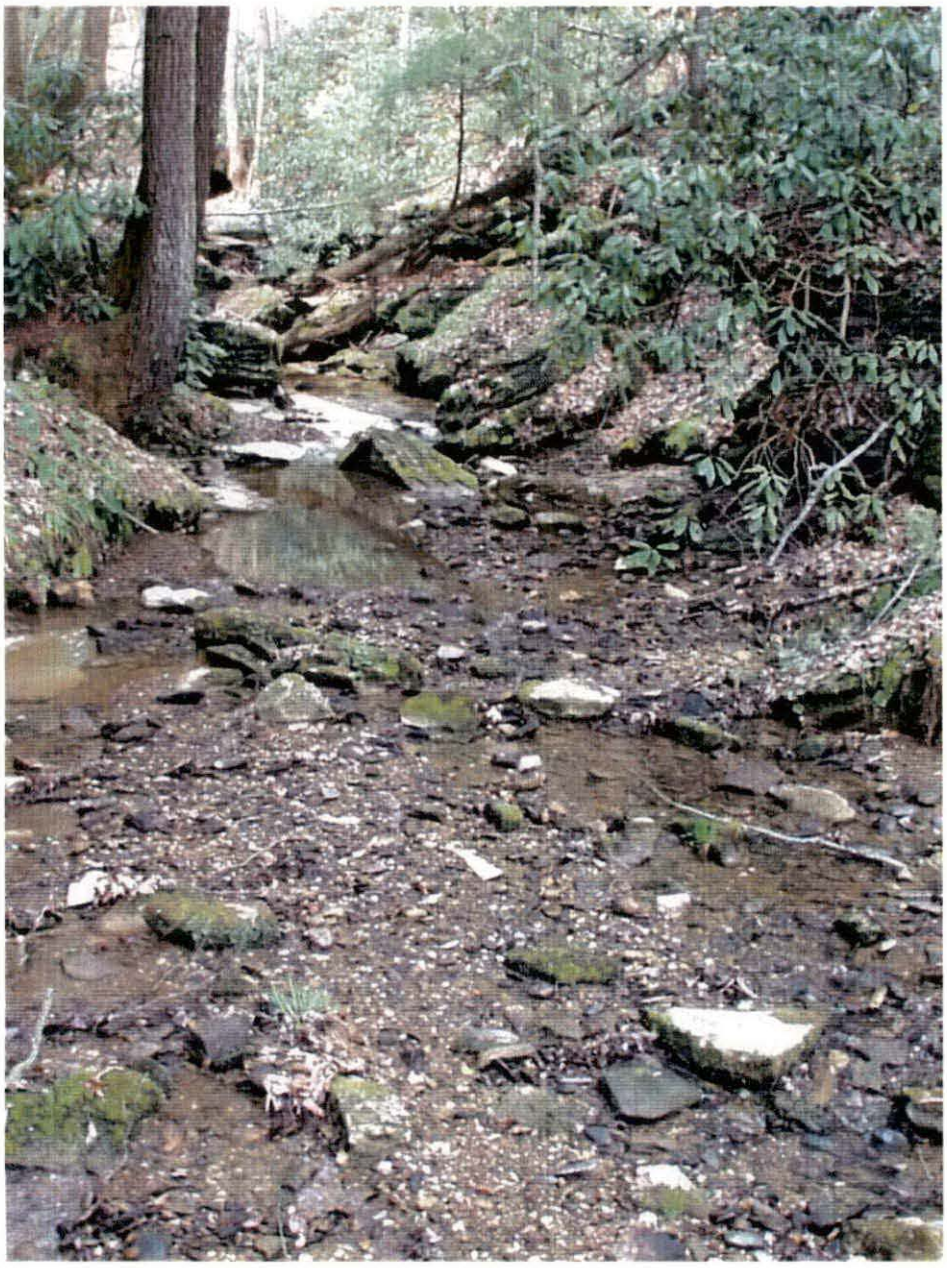

Figure 6. Typical habitat for *Desmognathus*. Photograph taken at Big Caney Creek, Elliott County, Kentucky.


Figure 7. Associated species in stream habitats. Salamanders include (a) *Gyrinophilus porphyriticus duryi* (b) *Pseudotriton ruber ruber* (c) *Eurycea cirrigera* and (d) *Eurycea longicauda longicauda*.


Figure 8. Associated species in forest habitats. Salamanders include (a) *Plethodon richmondi* (b) *Plethodon glutinosus* (c) *Plethodon kentucki* and (d) *Notophthalmus viridescens viridescens*.

Courtship and spermatophore formation in this species is similar to that of other species of *Desmognathus*, and fertilization is internal. Eggs are laid from August to October. There is evidence to indicate that sexual activity also occurs in the spring, as spermatophores have also been found at this season (Bishop and Crisp, 1933). Eggs are laid in small clumps of 10-15, in the shelter of rocks, logs, or clumps of moss found in small streams or seepage areas (Barbour, 1971). The whitish eggs are attached to a common stalk by extensions of the outer membrane (Bishop, 1947). Females coil around their eggs and remain with them until hatching. Forester (1981) found that females contributed to the survival of eggs by defending the eggs against beetle and salamander predators, reducing the spread of fungal infections by eating infected eggs, increasing the oxygenation of eggs through stimulation, and lowering the rate of egg dessication.

Larvae are about 16 mm at hatching, and probably have two rows of unpigmented, dorsal spots. At 6-7 months, the dorsal spots are invaded by melanophores and a dorsal stripe is formed (Pfingsten and Downs, 1989). Short white external gills are also present.

Predators of *D. ochrophaeus* include larger salamanders, snakes, birds and shrews (*Blarina brevicauda*) (Pfingsten and Downs, 1989). Predator induced tail autotomy (release) provides an effective means of escape for *D. ochrophaeus* (Pfingsten and Downs, 1989). Labanick (1984) found tail release in 84 percent of *D. ochrophaeus* he presented to chickens. Their wriggling tails diverted the attention of these birds, and allowed the salamanders to escape.

**Variation**

Sexual dimorphism in *D. ochrophaeus* is summarized in Table 1. Mean snout length, vent length and snout length/head length were significantly different between males and females. Means for all three characters were greater in males. Mean total length, snout-vent length, tail length, head length, head width, tail length/total length, and snout-vent length/total length did not significantly differ with regard to sex.

**Kentucky Distribution**

Distributional records for *D. ochrophaeus* are known for the Cumberland Mountains, Cumberland Plateau and eastern edge of the Bluegrass (Knobs Region) (Figure 9). This salamander has not been found in eastern portions of the Cumberland Plateau.

**Specimens Examined**

**Elliott Co**: Big Caney Creek (MOSU R5036-5046, MOSU 7 uncataloged specimens); Laurel Creek (MOSU 1 uncataloged specimen); **Harlan Co**: Summit of Black Mountain (MOSU R5016-5022, MOSU R5094-5095, MOSU R5137-5148, MOSU 4 uncataloged specimens); **Leslie Co**: Cawood Branch (MOSU R5113-5133, MOSU 11 uncataloged specimens); **Morgan Co**: Craney Creek (MOSU R1802, MOSU R2634, MOSU R3778, MOSU R3780, MOSU 4 uncataloged specimens); **Rowan Co**: Craney Creek (MOSU 1 uncataloged specimen).

**Table 1.** Sexual dimorphism in Kentucky specimens of *Desmognathus ochrophaeus*. Specimens included 37 males and 27 females.

| Character | Range (mm) | Mean (mm) | p |
|---|---|---|---|
| Total Length (TL) | | | |
| Males | 41.0-87.0 | 69.5 | NS |
| Females | 55.0-87.0 | 71.5 | |
| Snout-Vent Length (SVL) | | | |
| Males | 27.0-43.0 | 36.4 | NS |
| Females | 30.0-43.0 | 36.1 | |
| Tail Length | | | |
| Males | 14.0-45.0 | 33.0 | NS |
| Females | 22.0-44.0 | 35.2 | |
| Head Length | | | |
| Males | 6.5-11.0 | 8.1 | NS |
| Females | 6.5-9.0 | 7.7 | |
| Head Width | | | |
| Males | 4.6-7.4 | 6.0 | NS |
| Females | 4.6-7.0 | 5.7 | |
| Snout Length | | | |
| Males | 2.0-3.2 | 2.7 | ** |
| Females | 1.5-3.1 | 2.1 | |
| Vent Length | | | |
| Males | 1.1-3.6 | 2.5 | ** |
| Females | 1.4-2.8 | 2.0 | |
| Tail Length/TL | | | |
| Males | 0.340-0.539 | 0.468 | NS |
| Females | 0.373-0.539 | 0.490 | |
| SVL/TL | | | |
| Males | 0.461-0.660 | 0.532 | NS |
| Females | 0.461-0.627 | 0.510 | |
| Snout Length/Head Length | | | |
| Males | 0.222-0.437 | 0.334 | ** |
| Females | 0.217-0.403 | 0.274 | |

* =significance ($P<0.05$); ** =high significance ($P<0.01$); NS =no significance

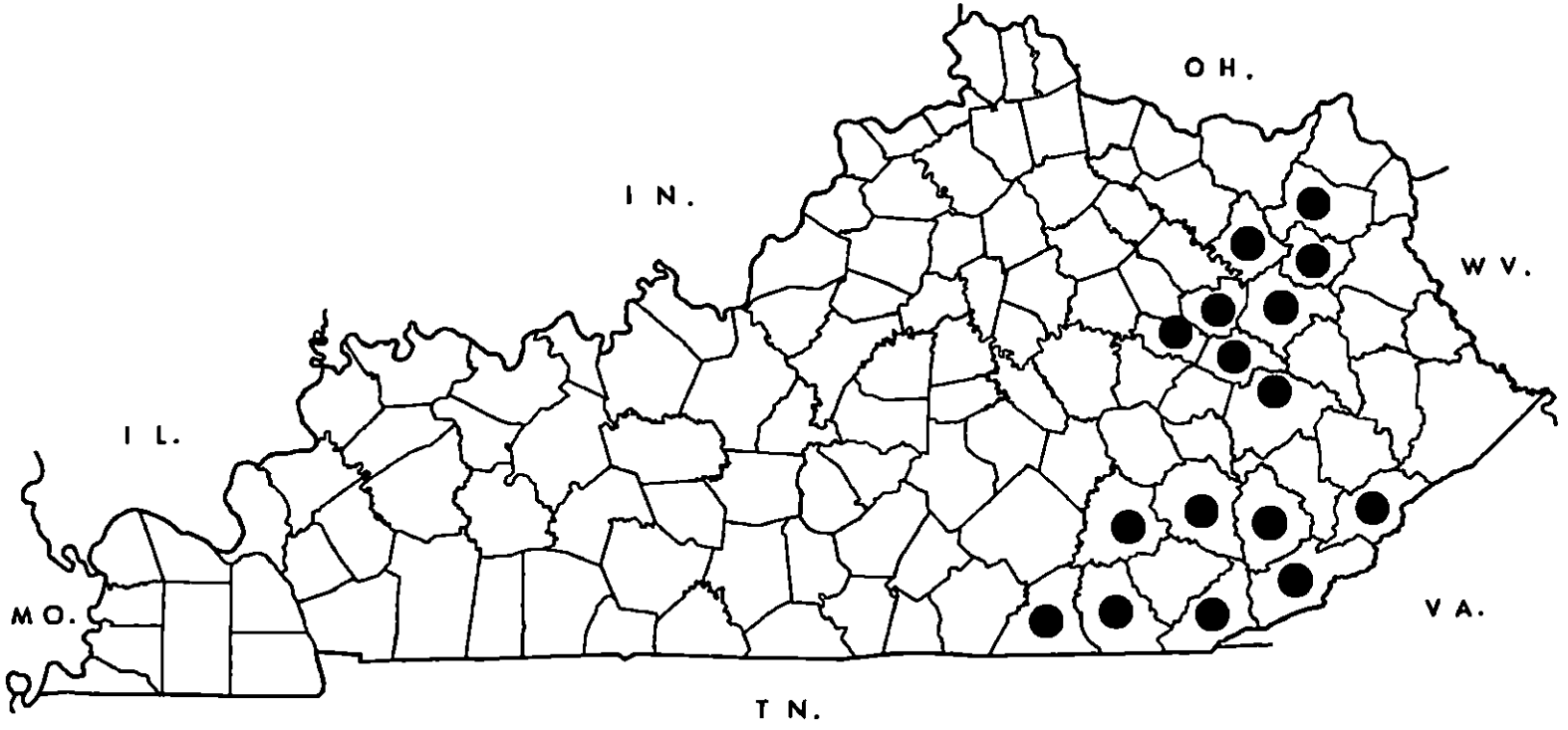


Figure 9. Distribution of the Allegheny Mountain Dusky Salamander, *Desmognathus ochrophaeus*, in Kentucky. Green circles indicate localities of specimens examined.

**Additional Records**

Additional records for *D. ochrophaeus* include those of the Morehead State University Vertebrate Collection: **Rowan, Leslie, Harlan, Elliott, Morgan;** Dury and Williams (1933): **Harlan;** Welter and Carr (1939): **Carter;** Barbour (1953): **Harlan;** Bush (1957, 1959): **Breathitt;** Branson et al. (1970): **Wolfe;** Campbell et al. (1992): **Morgan, Menifee, Rowan;** Campbell et al. (1993): **Carter, Morgan, Elliott, Harlan, Leslie, Clay;** Campbell et al. (1994): **Carter, Morgan, Elliott, Harlan, Leslie, Clay, Laurel.** Additional records provided in unpublished maps prepared by J.R. MacGregor (1999) were from **Bell, Letcher, McCreary, Powell,** and **Whitley** counties.

***Desmognathus fuscus fuscus*** (Green)
Northern Dusky Salamander

**Kentucky Synonomy**

*Salamandra fusca* Green (1818); type locality was designated as "northern parts of the State of New York."

*Desmognathus f. fusca* Cope (1875)

*Desmognathus nigra* Cope (1875)

*Desmognathus fusca* Garman (1894)

*Desmognathus f. fuscus* Dunn (1926); Burt (1933); Hibbard (1936); Welter and Carr (1939); Bishop (1947); Conant (1958, 1975); Conant and Collins (1991, 1998).

**Etymology**

The specific and subspecific name *fuscus* is derived from the Latin *fuscus*

(=brown, dusky) in reference to body coloration.

**Identification**

*Desmognathus f. fuscus* has a small-medium, brownish body of 2.5-4.5 inches; a light brown or tan middorsal region, outlined with dark brown dorsolateral stripes (Figure 10a, b); a keeled tail, often marked with lighter yellowish color at base; a light postocular stripe; a whitish belly (Figure 10c), marked with small lateral flecks, but immaculate at midline; gularis muscles; 14 costal grooves; and juveniles with 5-8 pairs of yellowish dorsal spots on their body, and more on tail (Conant and Collins, 1991, 1998).

**Biology**

*Desmognathus fuscus* occurs along edges of small, rocky woodland streams, and seepage areas, often in hollows or ravines. This species is mostly nocturnal, hiding during daylight hours beneath rocks, leaf litter, rotting logs in the stream, or in burrows (Mount, 1975). When a dusky salamander is exposed, it quickly tries to escape by diving into water, or crawling beneath leaves or rocks. The dusky salamander is seldomly found far from running or trickling water (Conant and Collins, 1991, 1998). Dusky salamanders feed on insects, crustaceans, millipedes, centipedes, spiders and mollusks (Barbour, 1971).

During courtship, males apply their snout, cheeks and mental gland to the females snout (Bishop, 1947). Following courtship or "liebespiel" (love play), the male deposits a spermatophore, and then leads the female forward so that her vent


Figure 10. *Desmognathus fuscus fuscus*. Photographs of (a) typical adult (b) dark adult (c) ventral surface with light mottling at edges.

makes contact with this spermatophore. Sperm are then stored by the female in her spermatheca, and eggs are fertilized at a later date. Eggs are deposited from June to August, in clusters of 12-26 (mean 17), and guarded by the female, who coils around them. Such nest areas are beneath rocks, logs, or bark, and near water (Bishop, 1947). In New York, Bishop (1941) found that mating (spermatophore deposition and pickup) occurred both in the spring and fall. Larvae are of the stream type, about 16-17 mm in total length at hatching, with slender white gills and a broad dorsal band (Bishop, 1947; Orr and Maple, 1978). Larvae also have dorsal light spots (mean 12), and a total of 13-18 gill fimbriae on each side, but lack toe claws (Juterbock, 1984). Larvae reach 44 mm and transform at 8-9 months (Bishop, 1947; Juterbock, 1984).

**Variation**

Sexual dimorphism in *D. f. fuscus* is summarized in Table 2. Mean total length, snout vent length, tail length, head length, head width, snout length, vent length, and snout length/head length were significantly different between males and females. Mean values for these characters were greater in males. Mean tail length/total length and snout vent length/total length did not significantly differ with regard to sex. Bishop (1941) reported that males of *D. f. fuscus* differ from females by having a larger size, broader and longer heads, longer hind legs, papillae in their vent, mental glands, enlarged premaxillary teeth, and a lack of vomerine teeth.

**Table 2.** Sexual dimorphism in Kentucky specimens of *Desmognathus fuscus fuscus*. Specimens included 36 males and 40 females.

| Character | Range | Mean | p |
|---|---|---|---|
| Total Length (TL) | | | |
| Males | 81.0-133.0 | 103.0 | ** |
| Females | 58.0-125.0 | 88.8 | |
| Snout-Vent Length (SVL) | | | |
| Males | 39.0-73.0 | 54.1 | ** |
| Females | 31.0-63.0 | 46.8 | |
| Tail Length | | | |
| Males | 38.0-63.0 | 49.5 | ** |
| Females | 24.0-62.0 | 43.0 | |
| Head Length | | | |
| Males | 9.7-17.8 | 12.2 | ** |
| Females | 7.1-14.0 | 10.1 | |
| Head Width | | | |
| Males | 6.8-12.9 | 9.5 | ** |
| Females | 5.3-12.0 | 8.1 | |
| Snout Length | | | |
| Males | 2.2-5.6 | 3.7 | ** |
| Females | 1.8-4.8 | 2.8 | |
| Vent Length | | | |
| Males | 1.9-5.1 | 3.3 | ** |
| Females | 1.3-3.9 | 2.4 | |
| Tail Length/TL | | | |
| Males | 0.398-0.543 | 0.481 | NS |
| Females | 0.407-0.526 | 0.483 | |
| SVL/TL | | | |
| Males | 0.457-0.602 | 0.519 | NS |
| Females | 0.474-0.593 | 0.517 | |
| Snout Length/Head Length | | | |
| Males | 0.222-0.377 | 0.305 | ** |
| Females | 0.211-0.373 | 0.275 | |

* =significance (P<0.05); ** =high significance (P<0.01); NS =no significance

**Kentucky Distribution**

*Desmognathus f. fuscus* occurs statewide in Kentucky from the Cumberland Plateau to the Jackson Purchase (Figure 11), but is absent from major portions of the Bluegrass and Western Coal Field (Meade, 1992).

**Specimens Examined**

**Boone Co**: (MOSU 1 uncataloged specimen); **Breathitt Co**: Shacks Branch, Jackson (MOSU 17 uncataloged specimens); **Bullitt Co**: near Shepherdsville (UL 687C, UL 1333C, UL 1339C); **Elliott Co**: Laurel Creek (MOSU 27 uncataloged specimens); **Floyd Co**: Hoods Fork, Frasure Creek (MOSU 2 uncataloged specimens); **Harlan Co**: Looney Creek (MOSU 8 uncataloged specimens); Stream along KY 160 (MOSU R3775); **Leslie Co**: Cawood Branch (MOSU 1 uncataloged specimen); **Morgan Co**: Craney Creek (MOSU R3227); **Rowan Co**: North Fork of Triplett Creek (MOSU R1385, MOSU R1387, MOSU R1389-1390, R1392-1397, MOSU R1404, MOSU R1407-1409, MOSU R1412-1413); Upper Lick Fork (MOSU R1039, MOSU R1432-1433, MOSU R1436-1437, MOSU R3323); **Whitley Co**: Paint Creek (MOSU 2 uncataloged specimens).

**Additional Records**

Additional records for *D. f. fuscus* included those of the Morehead State University Vertebrate Collection: **Rowan, Fleming, Elliott, Morgan, Powell, Breathitt, Menifee, Boone, Wolfe, Knott, Harlan, Leslie, Floyd, McCreary, Bullitt**; University of Kentucky Vertebrate Collection: **Breathitt, Trimble,**

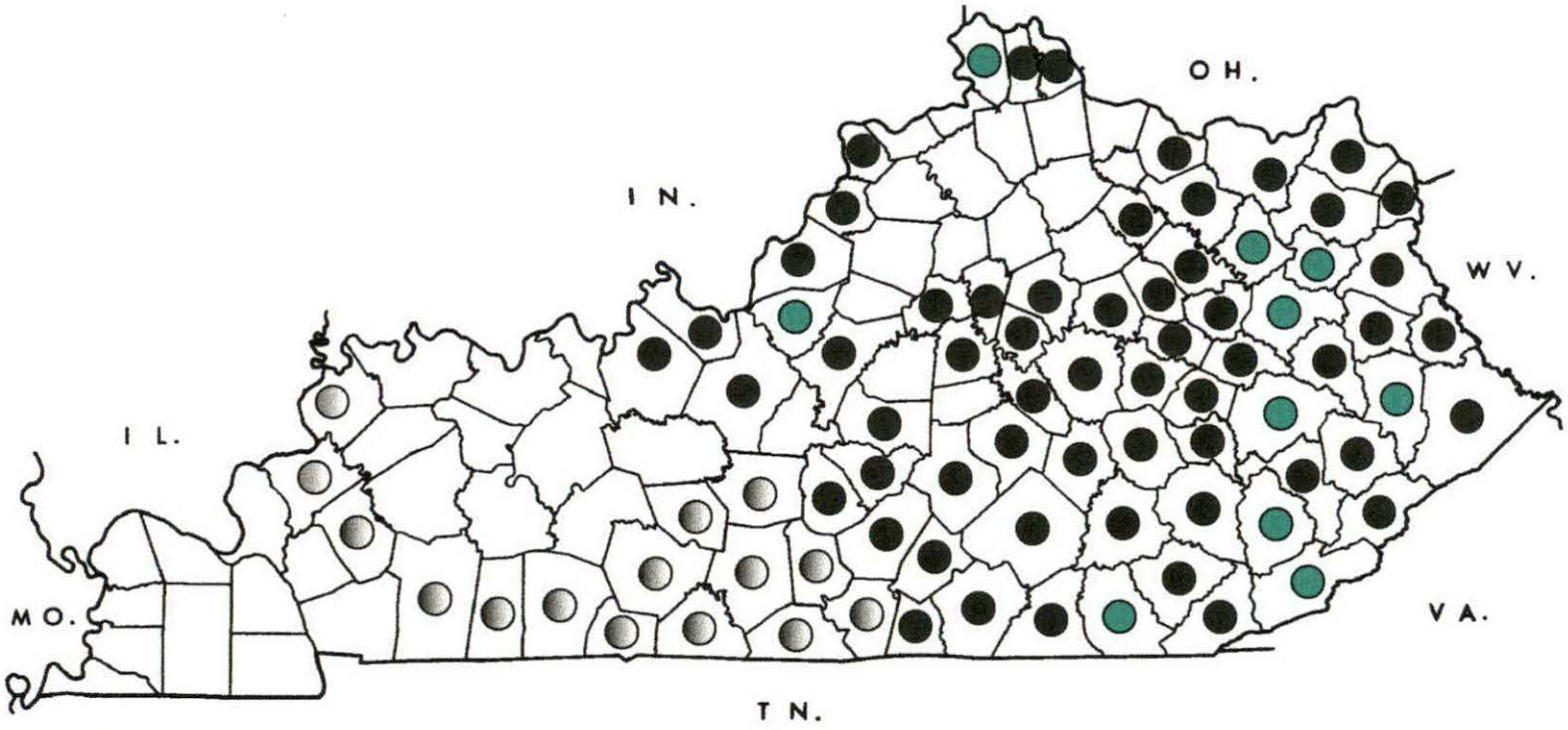


Figure 11. Distribution of the Northern Dusky Salamander, *Desmognathus fuscus fuscus*, in Kentucky. Possible intergrade zone with *D. f. conanti* is shown by shaded circles (Conant and Collins, 1998). Green circles indicate localities of specimens examined.

**Jefferson, Wolfe, Christian, Madison, Leslie, Carter, Pike, Letcher;** Garman (1894): **Pulaski;** Dunn (1926): **Morgan, Bell, Breathitt, Nelson, Kenton, Edmonson;** Bishop (1926): **Breathitt;** Burt (1933): **Metcalfe, Rockcastle, Bell, Cumberland, Estill, Harlan, Knott, Letcher, Morgan, Perry, Pike, Whitley, Wayne;** Dury and Williams (1933): **Kenton, Carter, Laurel, Woodford, Breathitt, Harlan;** Bailey (1933): **Edmonson;** Neel (1938): **Clark;** Welter and Carr (1939): **Rowan, Carter;** Bishop (1947): **Harlan;** Cunningham (1951): **Bullitt;** Craddock and Minckley (1964): **Meade;** Branson et al. (1970): **Wolfe;** Bertram (1974): **Rowan;** Harker et al. (1979): **Laurel, Greenup, Johnson, Letcher;** Barbour et al. (1979): **Bell;** Westerman and Westerman (1980): **Breckinridge;** Juterbock (1984): **Clay, Harlan, Lawrence, Letcher, Menifee, Pike, Powell, Rockcastle, Whitley, Wolfe;** Campbell et al. (1994): **Whitley, Laurel.** Additional records provided in unpublished maps prepared by J.R. MacGregor (1999) were from **Boyd, Martin, Mason, Magoffin, Bath, Montgomery, Lee, Jackson, Owsley, Knox, Fayette, Jessamine, Garrard, Lincoln, Casey, Russell, Green, Anderson, Mercer, Clinton, Marion, Taylor, Adair, Monroe, Hart, Barren, Warren, Allen, Simpson, Logan, Todd, Caldwell, Union, Crittenden, Nicholas, Hardin, Lewis, Oldham,** and **Campbell** counties.

***Desmognathus fuscus conanti*** Rossman
Spotted Dusky Salamander

**Kentucky Synonomy**

*Desmognathus fuscus conanti* Rossman (1958); type locality was designated as

"near U.S. Highway 60, 2.1 miles S. Smithland, Livingston County, Ky"; Smith (1961); Barbour (1971); Conant (1975); Conant and Collins (1991, 1998).

**Etymology**

The subspecific name *conanti* is a patronym in honor of Roger Conant.

**Identification**

*Desmognathus f. conanti* has a small-medium, brownish body of 2.5-4 inches; 6-8 pairs of golden or reddish to golden dorsal spots (Figure 12a) that occurs in both adults and juveniles; or spots may fuse to form a reddish dorsal stripe (Figure 12b); a yellow to orange postocular stripe; a keeled tail, often marked with yellow-orange; a whitish belly, with light mottling on edges (Figure 12c); gularis muscles; and usually 14 costal grooves.

**Biology**

Information concerning the biology of *D. f. conanti* is included with *D. f. fuscus*. This salamander occurs in seepage areas, at the edge of swamps, or in streams. In the Jackson Purchase, these streams may be very rocky, or sandy with leaves as the only cover.

**Variation**

Sexual dimorphism in *D. f. conanti* is summarized in Table 3. Mean head length, snout length, vent length, and snout length/head length were significantly


Figure 12. *Desmognathus fuscus conanti*. Photographs of (a) adult with spotted dorsal surface (b) adult with fused spots on dorsum (c) ventral surface showing light mottling on edges.

**Table 3.** Sexual dimorphism in Kentucky specimens of *Desmognathus fuscus conanti*. Specimens included 25 males and 21 females.

| Character | Range (mm) | Mean (mm) | p |
|---|---|---|---|
| Total Length (TL) | | | |
| Males | 62.0-124.0 | 99.3 | NS |
| Females | 56.0-107.0 | 92.2 | |
| Snout-Vent Length (SVL) | | | |
| Males | 38.0-68.0 | 53.3 | NS |
| Females | 32.0-62.0 | 49.0 | |
| Tail Length | | | |
| Males | 24.0-61.0 | 45.8 | NS |
| Females | 20.0-54.0 | 43.8 | |
| Head Length | | | |
| Males | 8.0-14.8 | 11.5 | * |
| Females | 7.7-12.0 | 10.3 | |
| Head Width | | | |
| Males | 6.2-12.9 | 9.5 | NS |
| Females | 5.3-12.1 | 8.6 | |
| Snout Length | | | |
| Males | 2.5-4.8 | 3.6 | ** |
| Females | 2.1-3.6 | 2.9 | |
| Vent Length | | | |
| Males | 2.0-6.0 | 3.5 | ** |
| Females | 1.9-4.0 | 2.6 | |
| Tail Length/TL | | | |
| Males | 0.387-0.518 | 0.458 | NS |
| Females | 0.357-0.529 | 0.472 | |
| SVL/TL | | | |
| Males | 0.482-0.613 | 0.542 | NS |
| Females | 0.471-0.643 | 0.528 | |
| Snout Length/Head Length | | | |
| Males | 0.270-0.345 | 0.308 | ** |
| Females | 0.228-0.347 | 0.279 | |

* =significance (P<0.05); ** =high significance (P<0.01); NS =no significance

different between males and females. Mean values for these characters were greater in males. Mean total length, snout-vent length, tail length, head width, tail length/total length, and snout vent length/total length did not significantly differ with regard to sex.

**Kentucky Distribution**

*Desmognathus f. conanti* is found in the Jackson Purchase, western edge of the Mississippian Plateau, and western edge of the Western Coal Field (Figure 13). It intergrades with *D. f. fuscus* eastward to Hart, Metcalfe, and Cumberland counties (Conant and Collins, 1998; Meadows, 1989). Edmonson County specimens of *D. f. conanti* from Southern Illinois University at Carbondale were examined for this study. Although Edmonson County is in the intergrade zone, these specimens were included because they strongly resembled *D. f. conanti* and because of small sample size.

**Specimens Examined**

**Carlisle Co**: Seepage area at Back Slough, Laketon (MOSU R2771-2774, MOSU R2776, 1 uncataloged specimen); **Edmonson Co**: Spring near Houchins Ferry, Mammoth Cave National Park (SIUC 5 uncataloged specimens); **Livingtston Co**: Head of small tributary of Davis Creek on US 60, 2.4 miles South of Smithland (MOSU 17 uncataloged specimens, SIUC 3 uncataloged specimens); **Lyon Co**: Duncans Creek Cove (APSU 124A-M); LBL 131, 1.3 miles east of junction with LBL 130 (APSU 3727A-B); Smith Creek, on west side at LBL 308 (APSU 3687A-

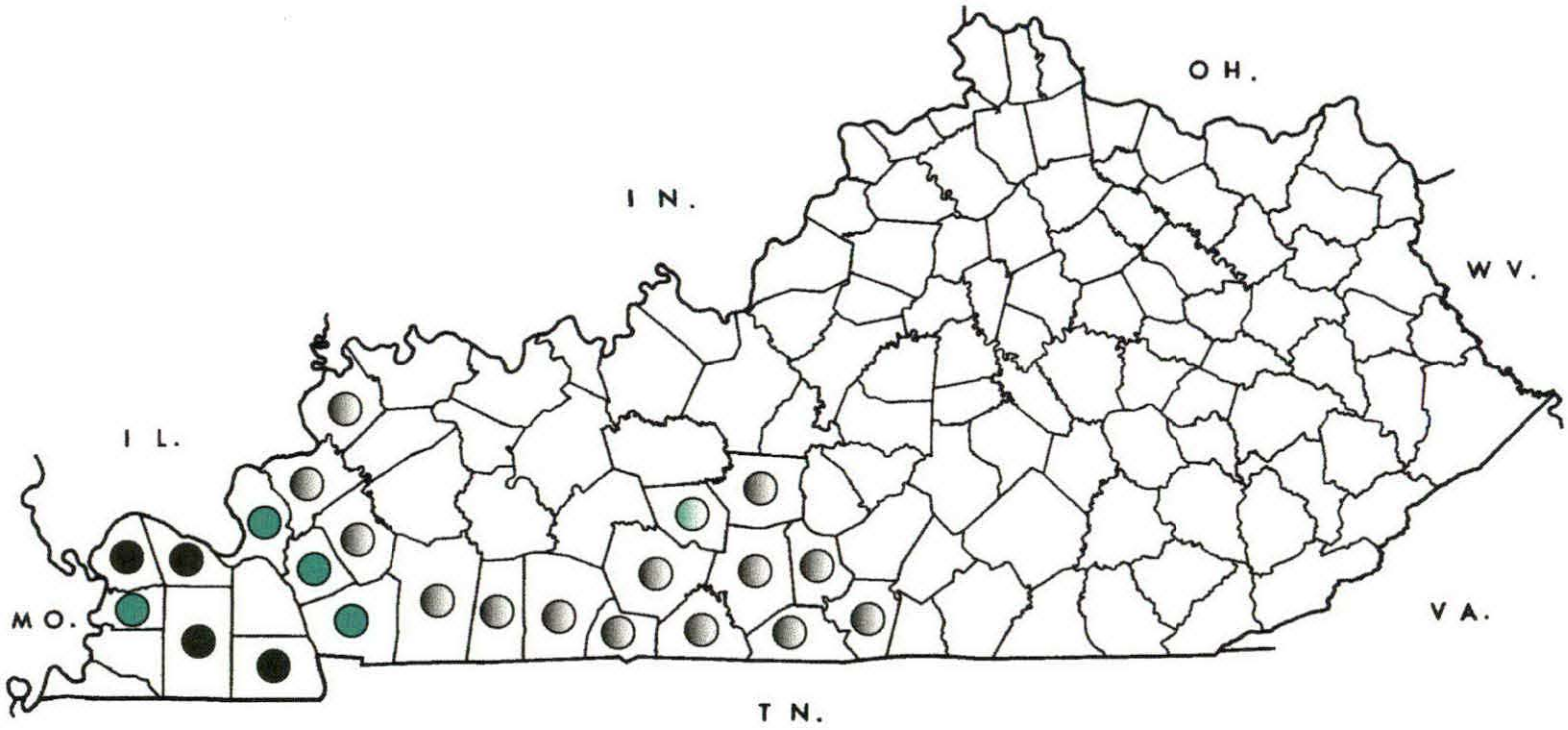


Figure 13. Distribution of the Spotted Dusky Salamander, *Desmognathus fuscus conanti*, in Kentucky. Green circles indicate localities of specimens examined. Possible intergrade zone with D. f. fuscus is shown by shaded circles (Conant and Collins, 1998).

B); Spring near Lofton Cemetery, Duncan Bay (APSU 3739A-D); **Trigg Co**: Arlington Spring (APSU 4787); Linton Fire Tower Road (MOSU 12 uncataloged specimens); Spring near tributary of North Fork of Sugar Creek (APSU 3743A-D, APSU 4793); Tributary of Elbow Creek (APSU 4791-4792, APSU 4794).

**Additional Records**

Additional records for *D. f. conanti* include those of Rossman (1958): **Livingston**; and Moeller (1994): **Lyon, Ballard, Carlisle.** Additional records provided in unpublished maps prepared by J.R. MacGregor (1999) were from **Graves, McCracken,** and **Calloway** counties.

***Desmognathus monticola*** Dunn
Seal Salamander

**Kentucky Synonomy**

*Desmognathus monticola* Dunn (1916); type locality designated as "Elk Lodge Lake, near Brevard, North Carolina; altitude about 3000 feet."; Barbour (1953); Barbour (1971); Conant and Collins (1991).

*Desmognathus phoca* Bishop (1947) Most authors thought this species was identical with *D. monticola.*

*Desmognathus m. monticola* Bush (1957, 1959); Conant (1975).

**Etymology**

The specific name *monticola* is derived from the Latin words *mons* (= mountain) and *colere* (= to dwell), in reference to its habitat. The common name Seal Salamander refers to the similarity between their color pattern and that of seals.

**Identification**

*Desmognathus monticola* has a large, stout, brownish body of 4-6 inches; a dorsal surface marked with dark brown, lichen-like markings on a light brown or grayish brown ground color (Figure 14a); a ventral surface that is whitish and immaculate (Figure 14b); a distinct separation between the dorsal and ventral pigmentation (Conant and Collins, 1991); a tail that is compressed and keeled on the posterior one-half; gularis muscles; 14 costal grooves; and juveniles with 4 pairs of rounded, chestnut-colored spots on their body, and more on their tail. Often specimens captured are dark in coloration and difficult to tell apart from other species of *Desmognathus* (Figure 14c)

**Biology**

*Desmognathus monticola* occupies rocky headwater streams and seepage areas of cool, forested hollows and ravines. These nocturnal salamanders often spend their days hidden beneath rocks, bark and logs (Bishop, 1947). Food habits of this species are poorly known, but they probably feed on worms, insects and crustaceans (Barbour, 1971).

Courtship and mating in *D. monticola* are similar to other species of *Desmognathus*, and fertilization is internal. Eggs are laid from July to September in clusters of 15-40 (Barbour, 1971). Eggs have been found beneath rocks, and in hollow logs, with females coiled around the eggs and larvae (Bishop, 1947). Eggs are


Figure 14. *Desmognathus monticola*. Photographs of (a) light dorsal surface with lichen like markings (b) plain ventral surface with no mottling (c) dark dorsal surface with lichen like markings.

attached singly by extensions of the outer egg envelope. Larvae are 18-20 mm at hatching (Bishop, 1947), and begin metamorphosis at 38-50 mm (Barbour, 1971). Larvae are of the stream type, have toe claws (occasional specimens), dorsal light spots (mean 9), small white gills, and a total of 13-16 gill fimbriae on each side (Juterbock, 1984).

**Variation**

Sexual dimorphism in *D. monticola* is summarized in Table 4. Mean snout-vent length, head length, head width, snout length, vent length, tail length/total length, snout-vent length/total length, and snout length/head length were significantly different with regard to sex. Mean values for these characters were usually greater in males, except that tail length/total length was greater in females. Mean values for total length and tail length did not significantly differ with regard to sex.

**Kentucky Distribution**

*Desmognathus monticola* occurs across the Cumberland Plateau, westward to the eastern edge of the Bluegrass and Mississippian Plateau (Figure 15).

**Specimens Examined**

**Elliott Co**: Big Caney Creek (MOSU 11 uncataloged specimens); Laurel Creek (MOSU 4 uncataloged specimens); **Menifee Co**: Leatherwood Fork of Indian Creek (MOSU 8 uncataloged specimens); Kendrick Ridge (MOSU 1 uncataloged specimen); **Morgan Co**: Craney Creek (MOSU R2639-2642, MOSU R2644-2668,

**Table 4.** Sexual dimorphism in Kentucky specimens of *Desmognathus monticola*. Specimens included 33 males and 27 females.

| Character | Range | Mean | p |
|---|---|---|---|
| Total Length (TL) | | | |
| Males | 98.0-137.0 | 121.1 | NS |
| Females | 84.0-138.0 | 115.4 | |
| Snout-Vent Length (SVL) | | | |
| Males | 54.0-83.0 | 63.4 | ** |
| Females | 47.0-72.0 | 57.0 | |
| Tail Length | | | |
| Males | 42.0-71.0 | 58.0 | NS |
| Females | 37.0-78.0 | 58.0 | |
| Head Length | | | |
| Males | 12.1-16.2 | 14.2 | ** |
| Females | 10.5-16.4 | 12.6 | |
| Head Width | | | |
| Males | 9.4-14.7 | 11.9 | ** |
| Females | 8.4-14.0 | 10.5 | |
| Snout Length | | | |
| Males | 3.7-5.9 | 4.7 | ** |
| Females | 2.8-5.3 | 3.7 | |
| Vent Length | | | |
| Males | 3.0-5.7 | 4.5 | ** |
| Females | 2.0-5.0 | 3.5 | |
| Tail Length/TL | | | |
| Males | 0.376-0.523 | 0.477 | * |
| Females | 0.437-0.582 | 0.500 | |
| SVL/TL | | | |
| Males | 0.477-0.624 | 0.523 | * |
| Females | 0.418-0.563 | 0.500 | |
| Snout Length/Head Length | | | |
| Males | 0.268-0.402 | 0.335 | ** |
| Females | 0.258-0.325 | 0.294 | |

* =significance (P<0.05); ** =high significance (P<0.01); NS =no significance

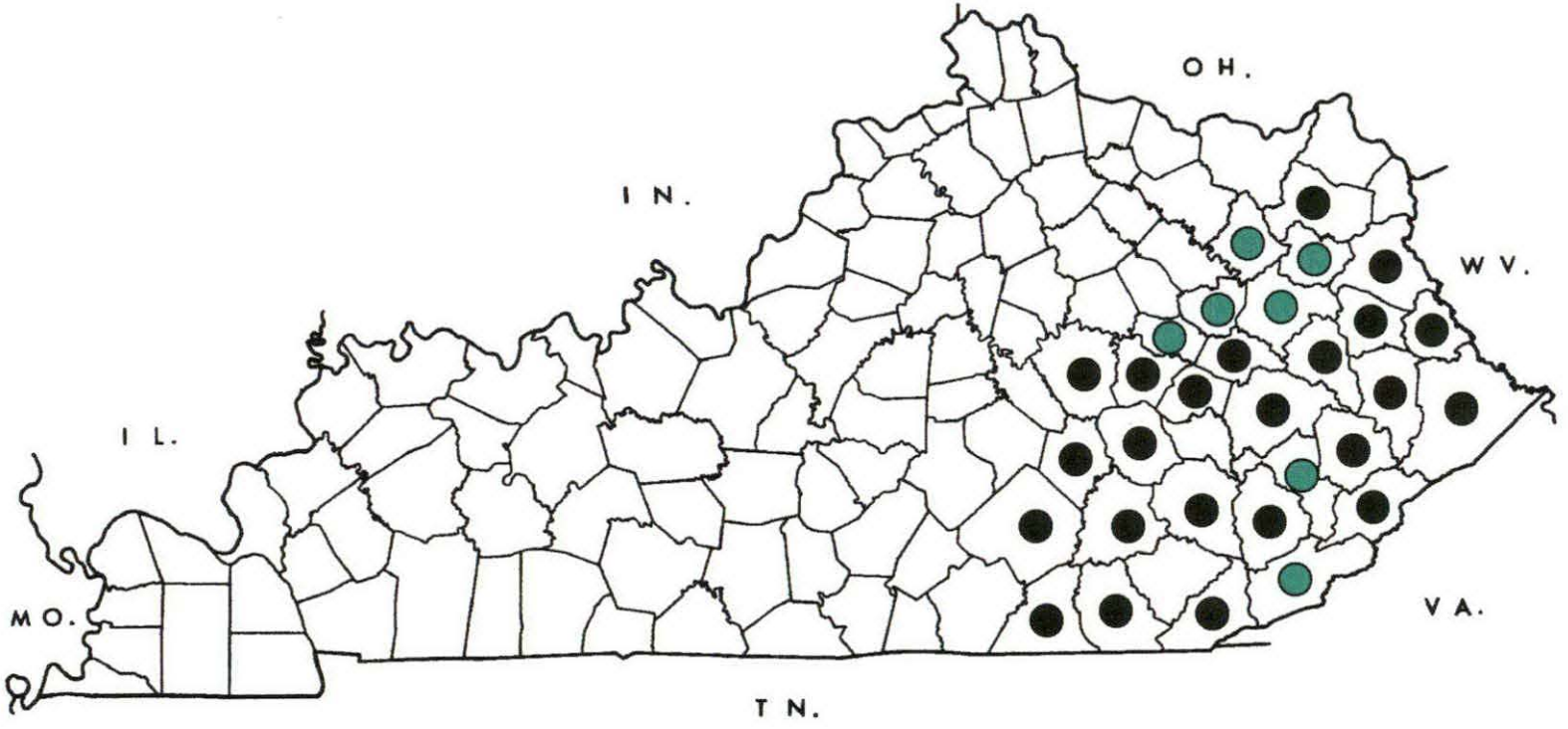


Figure 15. Distribution of the Seal Salamander, *Desmognathus monticola*, in Kentucky. Green circles indicate localities of specimens examined.

MOSU R2671-2672, MOSU 9 uncataloged specimens); **Harlan Co**: Looney Creek (MOSU 10 un- cataloged specimens); **Perry Co**: (MOSU 2 uncataloged specimens); **Powell Co**: Nada Tunnel (MOSU 1 uncataloged specimen); **Rowan Co**: Black Cave Hollow, Craney Creek (MOSU 3 uncataloged specimens).

**Additional Records**

Additional distributional records for *D. monticola* included those of the Morehead State University Vertebrate Collection: **Rowan, Elliott, Wolfe, Morgan, Menifee, Powell, Perry, Harlan**; University of Kentucky Vertebrate Collection: **Jackson, Harlan, Leslie, Carter, Pike, Letcher**; Dunn (1926): **Breathitt**; Bishop (1926): **Breathitt**; Dury and Willams (1933): **Breathitt, Harlan**; Welter and Carr (1939): **Rowan, Carter**; Bishop (1947): **Wolfe**; Barbour (1953): **Harlan**; Bush (1957, 1959): **Breathitt**; Branson et al. (1970): **Wolfe**; Bertram (1974): **Rowan**; Harker et al. (1979): **Johnson, Letcher**; Barbour et al. (1979): **Bell**; Juterbock (1984): **Clay, Harlan, Letcher, Menifee, Pike, Powell**; and Campbell et al. (1994): **Laurel, Whitley**. Additional records provided in unpublished maps prepared by J.R. MacGregor (1999) were from **Lawrence, Martin, Floyd, Magoffin, Madison, Estill, Lee, Rockcastle, Knott, Pulaski,** and **McCreary** counties. Records of Dunn (1926) for Kenton and Edmonson counties were actually records for *D. f. fuscus*.

***Desmognathus welteri*** Barbour
Black Mountain Dusky Salamander

**Kentucky Synonomy**

*Desmognathus fuscus welteri* Barbour 1950; type locality was designated as "Looney Creek, near Lynch, Harlan County, Kentucky";Barbour (1953).

*Desmognathus welteri* Barbour (1971); Juterbock (1978, 1984); Conant (1975); Conant and Collins (1991, 1998).

**Etymology**

The specific name *welteri* was a patronym used by R.W. Barbour to honor W.A. Welter, his former professor and mentor at Morehead State Teachers College.

**Identification**

*Desmognathus welteri* has a large, stout, brownish body of 4-6 inches; a dorsal surface marked with small lichen-like, dark brown spots (Figure 16a, b), however, some large specimens are uniformly plain brown (Figure 16c); a dark dorsal coloration that gradually fades into a whitish ventral color; a belly stippled with small brown flecks (Figure 16d); a tail that is compressed and keeled on posterior one-half; gularis muscles; and 14 costal grooves. Specimens of *D. welteri* and *D. monticola* may have keratinized and darkly pigmented toe tips (Caldwell and Trauth, 1979).

**Biology**

*Desmognathus welteri* frequents rocky headwater streams of cool, forested hollows and ravines in eastern Kentucky. This species is found beneath rocks,

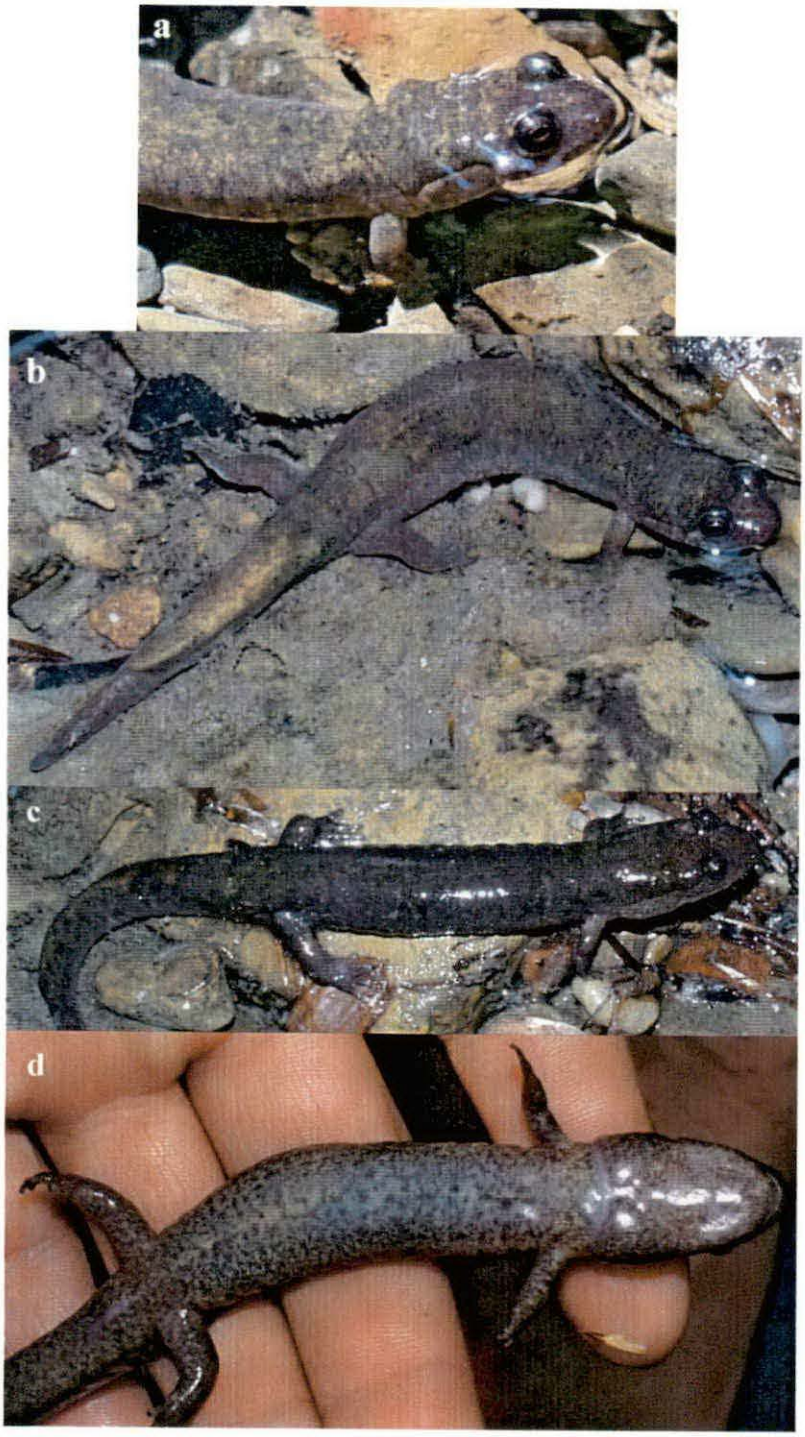


Figure 16. *Desmognathus welteri*. Photographs of (a) head region (b) dorsum with dark lichen-like blotches (c) dorsum uniformally colored (d) ventral surface heavily mottled.

leaf litter and debris adjacent to logs and rocks. The Black Mountain Dusky salamander also has been found on wet rock faces, under rocks at the mouth of caves, and beneath rocks in seepage areas (Barbour and Hays, 1957). When uncovered, these salamanders quickly escape by moving into crevices beneath rocks, entering crevices or burrows (Figure 17a, b) along the stream bank, or diving into the water and hiding. Food items for this species include mostly worms, insects and crustaceans (Barbour, 1971).

Courtship and mating are thought to be similar to those of other dusky salamanders. Fertilization is internal, with eggs being laid from March to August, with an average of 26-27 per season, in the shelter of rocks or hollow logs. Females remain coiled around the eggs until they hatch (Barbour, 1953, 1971). Bush (1957) reported 6-29 eggs, with a mean of 21, for 17 females from Clemons Fork in Breathitt County. Barbour and Hays (1957) found a mean number of 11.6-37.0 eggs in 393 females, with most females averaging between 22.9 and 29.9. Larvae are of the stream type, and have a snout-vent length of 20 mm (or more), toe claws, dorsal light spots (mean 12), small white gills, and a total of 19-22 gill fimbriae on each side (Juterbock, 1984).

**Variation**

Sexual dimorphism in *D. welteri* is summarized in Table 5. Mean total length, snout vent length, head length, head width, snout length, vent length, tail length/total length, snout vent length/ total length, and snout length/head length were significantly


Figure 17. *Desmognathus* burrows. Photographs of (a) *Desmognathus* in stream burrow (b) a second burrow (indicated by arrow) adjacent to stream.

**Table 5.** Sexual dimorphism in Kentucky specimens of *Desmognathus welteri*. Specimens included 52 males and 26 females.

| Character | Range | Mean | p |
|---|---|---|---|
| Total Length (TL) | | | |
| Males | 100.0-152.0 | 128.0 | ** |
| Females | 95.0-138.0 | 111.6 | |
| Snout-Vent Length (SVL) | | | |
| Males | 51.0-88.0 | 70.6 | ** |
| Females | 50.0-73.0 | 60.3 | |
| Tail Length | | | |
| Males | 42.0-71.0 | 57.3 | NS |
| Females | 44.0-65.0 | 53.3 | |
| Head Length | | | |
| Males | 11.3-21.7 | 16.3 | ** |
| Females | 11.9-15.4 | 13.3 | |
| Head Width | | | |
| Males | 9.2-16.5 | 12.9 | ** |
| Females | 9.0-12.8 | 10.6 | |
| Snout Length | | | |
| Males | 3.3-6.8 | 5.2 | ** |
| Females | 2.9-4.9 | 3.9 | |
| Vent Length | | | |
| Males | 3.0-7.5 | 4.7 | ** |
| Females | 2.0-4.8 | 3.4 | |
| Tail Length/TL | | | |
| Males | 0.376-0.500 | 0.448 | ** |
| Females | 0.415-0.505 | 0.478 | |
| SVL/TL | | | |
| Males | 0.500-0.624 | 0.552 | ** |
| Females | 0.495-0.585 | 0.522 | |
| Snout Length/Head Length | | | |
| Males | 0.275-0.373 | 0.318 | ** |
| Females | 0.240-0.359 | 0.292 | |

* =significance (P<0.05); ** =high significance (P<0.01); NS =no significance

different between males and females. Mean values for these characters were greater in males except that tail length/total length was greater in females. Tail length was not statistically significant with regard to sex.

**Kentucky Distribution**

*Desmognathus welteri* ranges across the Cumberland Plateau to the eastern edge of the Bluegrass and Mississippian Plateau (Figure 18).

**Specimens Examined**

**Bell Co**: Cumberland Gap National Historical Park (MOSU R873, MOSU R1425, MOSU R3037-3040); **Carter Co**: KY 182, 0.5 miles North of US 60 (MOSU 1 uncataloged specimen); **Elliott Co**: Big Caney Creek (MOSU 8 uncataloged specimens); Laurel Creek off Carter School Road (MOSU 14 uncataloged specimens); **Menifee Co**: Leatherwood Fork of Indian Creek (MOSU R3004, MOSU R3008, MOSU R3011-3013, MOSU R3015-3017, MOSU R3022, MOSU 1 uncataloged specimen); **Morgan Co**: Craney Creek (MOSU R862, MOSU R868, MOSU R870, MOSU R872, MOSU R874-879, MOSU R1444, MOSU R2122, MOSU R2124, MOSU R2126-2130, MOSU R2135, MOSU R2150, MOSU R2638, MOSU R3735); **Harlan Co**: Long Rock Branch (MOSU 12 uncataloged specimens); Looney Creek (MOSU R2960-2963, MOSU R2965, MOSU 5 uncataloged specimens); **Rowan Co**: Black Cave Hollow, Craney Creek (MOSU 8 uncataloged specimens).

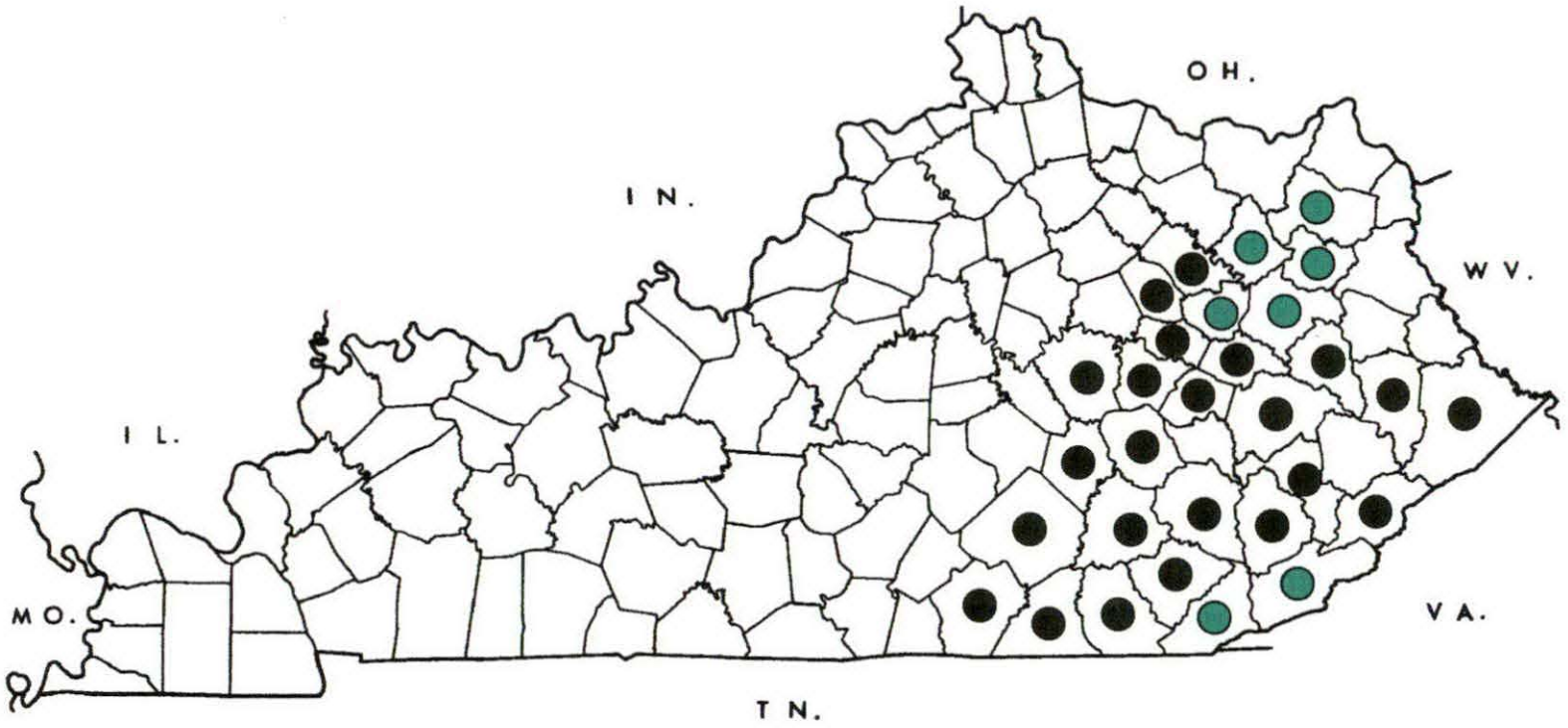


Figure 18. Distribution of the Black Mountain Dusky Salamander, *Desmognathus welteri*, in Kentucky. Green circles indicate localities of specimens examined.

**Additional Records**

Additional records for *D. welteri* included those of the Morehead State University Vertebrate Collection: **Morgan, Wolfe, Rowan, Menifee, Carter, Bell, Elliott, Harlan;** University of Kentucky Vertebrate Collection: **Wolfe, Madison, Bell, Harlan;** Barbour (1950): **Bath, Carter, Elliott, Harlan, Menifee, Pulaski;** Barbour (1953): **Harlan;** Bush (1957, 1959): **Breathitt;** Harker et al. (1979): **Harlan, Letcher;** Barbour et al. (1979): **Bell;** Juterbock (1984): **Clay, Harlan, Jackson, Leslie, Powell, Wolfe;** Campbell et al. (1989): **Lee;** and Campbell et al. (1994): **Laurel.** Additional records provided in unpublished maps prepared by J.R. MacGregor (1999) were from **McCreary, Pike, Perry, Magoffin, Whitley, Wayne, Knox, Floyd, Estill, Rockcastle,** and **Montgomery** counties.

**INTERSPECIFIC VARIATION**

Variation in total length is indicated in Table 6. Results of the Bonferroni t-tests show that *Desmognathus ochrophaeus* is the smallest form of *Desmognathus* in Kentucky, while *D. monticola* and *D. welteri* are the largest. A comparison of snout-vent length is indicated in Table 7. *Desmognathus ochrophaeus* has the smallest snout-vent length and *D. welteri* the largest. Mean values compared by Bonferroni t-tests indicated that four species groups are formed. *Desmognathus ochrophaeus* (Group D) is significantly different from *D. welteri* (Group A), *D. monticola* (Group B), and *D. f. fuscus* and *conanti* (Group C) in snout-vent length.

**Table 6.** A comparison of mean values for total length in *Desmognathus* by using Bonferroni t-tests.

| Species | Bon Grouping | Mean | Number |
|---|---|---|---|
| Dw | A | 122.8 | 47 |
| | A | | |
| | A | | |
| Dm | A | 118.8 | 48 |
| Dff | B | 95.3 | 63 |
| | B | | |
| | B | | |
| Dfc | B | 94.1 | 63 |
| Do | C | 70.1 | 60 |

**Table 7.** A comparison of mean values for snout-vent length in *Desmognathus* by using Bonferroni t-tests.

| Species | Bon Grouping | Mean | Number |
|---|---|---|---|
| Dw | A | 67.2 | 78 |
| Dm | B | 60.5 | 60 |
| Dff | C | 50.3 | 76 |
| | C | | |
| | C | | |
| Dfc | C | 50.2 | 72 |
| Do | D | 36.3 | 67 |

Variation in tail length is indicated in Table 8. Bonferroni t-tests formed three species groups with *D. ochrophaeus* (Group C) significantly different from *D. welteri* and *D. monticola* (Group A), and *D. f. fuscus* and *conanti* (Group B).

A summary of variation in head length, head width, and snout length is indicated in Tables 9-11, respectively. Mean values shown by Bonferroni t-tests indicated four species groups for each character. Again, *D. welteri* (Group A) was the largest species. Head length, head width, and snout length were progressively smaller in *D. monticola* (Group B), *D. f. fuscus* and *conanti* (Group C), and *D. ochrophaeus* (Group D), respectively.

Analysis of vent length is indicated in Table 12. Data from Bonferroni t-tests formed three species groups, with *D. welteri* and *D. monticola* (Group A) having significantly longer vents than those of *D. f. conanti* and *fuscus* (Group B), and *D. ochrophaeus* (Group C).

A summary of variation in tail length/total length is presented in Table 13. Mean values compared by Bonferroni t-tests indicated that three overlapping species groups were formed. Group A included *D. monticola, D. f. fuscus*, and *D. ochrophaeus*. Group B included *D. f. fuscus*, *D. ochrophaeus*, and *D. f. conanti*, and Group C included *D. ochrophaeus*, *D. f. conanti,* and *D. welteri.* The percentage of tail length is greatest in *D. monticola*, and decreases in *D. f. fuscus*, *D. ochrophaeus*, *D. f. conanti*, and *D. welteri*, respectively. *Desmognathus monticola* is statistically significant from *D. f. conanti* and *D. welteri. Desmognathus f. fuscus* is also statistically significant from *D. welteri.*

**Table 8.** A comparison of mean values for tail length in *Desmognathus* by using Bonferroni t-tests.

| Species | Bon Grouping | Mean | Number |
|---|---|---|---|
| Dm | A | 58.0 | 48 |
| | A | | |
| | A | | |
| Dw | A | 56.0 | 47 |
| Dff | B | 46.0 | 63 |
| | B | | |
| | B | | |
| Dfc | B | 43.6 | 63 |
| Do | C | 33.8 | 60 |

**Table 9.** A comparison of mean values for head length in *Desmognathus* by using Bonferroni t-tests.

| Species | Bon Grouping | Mean | Number |
|---|---|---|---|
| Dw | A | 15.3 | 78 |
| Dm | B | 13.5 | 60 |
| Dff | C | 11.1 | 76 |
| | C | | |
| | C | | |
| Dfc | C | 11.0 | 72 |
| Do | D | 7.9 | 67 |

**Table 10.** A comparison of mean values for head width in *Desmognathus* by using Bonferroni t-tests.

| Species | Bon Grouping | Mean | Number |
|---|---|---|---|
| Dw | A | 12.2 | 78 |
| Dm | B | 11.3 | 60 |
| Dfc | C | 8.8 | 72 |
| | C | | |
| | C | | |
| Dff | C | 8.7 | 76 |
| Do | D | 5.9 | 67 |

**Table 11.** A comparison of mean values for snout length in *Desmognathus* by using Bonferroni t-tests.

| Species | Bon Grouping | Mean | Number |
|---|---|---|---|
| Dw | A | 4.8 | 78 |
| Dm | B | 4.3 | 60 |
| Dfc | C | 3.3 | 72 |
| | C | | |
| | C | | |
| Dff | C | 3.2 | 76 |
| Do | D | 2.4 | 67 |

**Table 12.** A comparison of mean values for vent length in *Desmognathus* by using Bonferroni t-tests.

| Species | Bon Grouping | Mean | Number |
|---|---|---|---|
| Dw | A | 4.2 | 78 |
| | A | | |
| | A | | |
| Dm | A | 4.0 | 60 |
| Dfc | B | 3.0 | 72 |
| | B | | |
| | B | | |
| Dff | B | 2.8 | 76 |
| Do | C | 2.3 | 67 |

**Table 13.** A comparison of mean values for tail length/ total length in *Desmognathus* by using Bonferroni t-tests.

| Species | Bon Grouping | | | Mean | Number |
|---|---|---|---|---|---|
| Dm | A | | | 0.486 | 48 |
| | A | | | | |
| | A | | | | |
| Dff | A | B | | 0.482 | 63 |
| | A | B | | | |
| | A | B | | | |
| Do | A | B | C | 0.476 | 60 |
| | | B | C | | |
| | | B | C | | |
| Dfc | | B | C | 0.461 | 63 |
| | | | C | | |
| | | | C | | |
| Dw | | | C | 0.458 | 47 |

A comparison of variation in snout-vent length/total length is indicated in Table 14. Mean values compared by Bonferroni t-tests indicated that three overlapping species groups were formed. Group A included *D. welteri*, *D. f. conanti*, and *D. ochrophaeus*. Group B included *D. f. conanti*, *D. ochrophaeus*, and *D. f. fuscus*. Group C included *D. ochrophaeus*, *D. f. fuscus* and *D. monticola*. The percentage of snout-vent length is greatest in *D. welteri*, and decreases in *D. f. conanti*, *D. ochrophaeus*, *D. f. fuscus*, and *D. monticola*, respectively. *Desmognathus welteri* is statistically significant from *D. f. fuscus* and *D. monticola*. *Desmognathus f. conanti* is significantly different from *D. monticola*.

Variation in snout length/head length is indicated in Table 15. Mean values compared by Bonferroni t-tests indicated that three overlapping species groups were formed. Group A included *D. monticola*, *D. welteri*, and *D. ochrophaeus*. Group B included *D. welteri*, *D. ochrophaeus*, and *D. f. conanti*. Group C included *D. f. conanti* and *D. f. fuscus*. The proportion of snout length to head length is greatest in *D. monticola*, and decreases in *D. welteri*, *D. ochrophaeus*, *D. f. conanti*, and *fuscus*, respectively. *Desmognathus monticola* is statistically different from *D. f. conanti* and *D. f. fuscus*. *Desmognathus welteri* is significantly different from both subspecies of *D. fuscus*, while *D. ochrophaeus* only differs from *D. f. fuscus*.

**DISCRIMINANT FUNCTION ANALYSIS**

MANOVA and canonical discriminant analysis were used to compare all taxa of Kentucky *Desmognathus*. MANOVA revealed significant differences among all

**Table 14.** A comparison of mean values for snout-vent length/total length in *Desmognathus* by using Bonferroni t-tests.

| Species | Bon Grouping | Mean | Number |
|---|---|---|---|
| Dw | A | 0.542 | 47 |
| | A | | |
| | A | | |
| Dfc | A B | 0.539 | 63 |
| | A B | | |
| | A B | | |
| Do | A B C | 0.524 | 60 |
| | B C | | |
| | B C | | |
| Dff | B C | 0.518 | 63 |
| | C | | |
| | C | | |
| Dm | C | 0.514 | 48 |

**Table 15.** A comparison of mean values for snout length/ head length in *Desmognathus* by using Bonferroni t-tests.

| Species | Bon Grouping | Mean | Number |
|---|---|---|---|
| Dm | A | 0.317 | 60 |
| | A | | |
| | A | | |
| Dw | A B | 0.309 | 78 |
| | A B | | |
| | A B | | |
| Do | A B | 0.308 | 67 |
| | B | | |
| | B | | |
| Dfc | B C | 0.297 | 72 |
| | C | | |
| | C | | |
| Dff | C | 0.289 | 76 |

forms ($p < 0.01$). Canonical discriminant score clustering for all forms of *Desmognathus* in Kentucky is shown in Figure 19. Partial separation occurs along the x axis (62.4 %) and y axis (21.5%). Standardized canonical coefficients for the x axis are shown in Table 16. Figure 19 shows that *Desmognathus ochrophaeus* has a smaller head width, smaller total length, and smaller head length in proportion to snout-vent length than the other forms. Standardized canonical coefficients for the y axis are also shown in Table 16. *Desmognathus ochrophaeus* and *D. monticola* have a larger vent length, shorter head length, and wider head in proportion to snout-vent length than *D. welteri* (Figure 19). The subspecies of *D. fuscus* did not show any separation.

Because significant sexual dimorphism was detected for all taxa of Kentucky *Desmognathus*, additional canonical discriminant function analyses were computed separately for males and females. Canonical discriminant score clustering is shown for males (Figure 20) and females (Figure 21). In males, partial separation occurs along the x axis. Standardized canonical coefficients for the x axis are shown in Table 17. Figure 20 shows that *D. ochrophaeus* is smaller in total length, head width, and tail length in proportion to snout-vent length than the other forms. Standardized canonical coefficients for the y axis are also shown in Table 17. *Desmognathus monticola* is larger in most variables in proportion to snout-vent length than *D. welteri* (Figure 20). Again the subspecies of *D. fuscus* are clustered together. For females, partial separation also occurs. Standardized canonical coefficients for the x axis are given in Table 18. Figure 21 shows that *D. ochrophaeus* is smaller in head

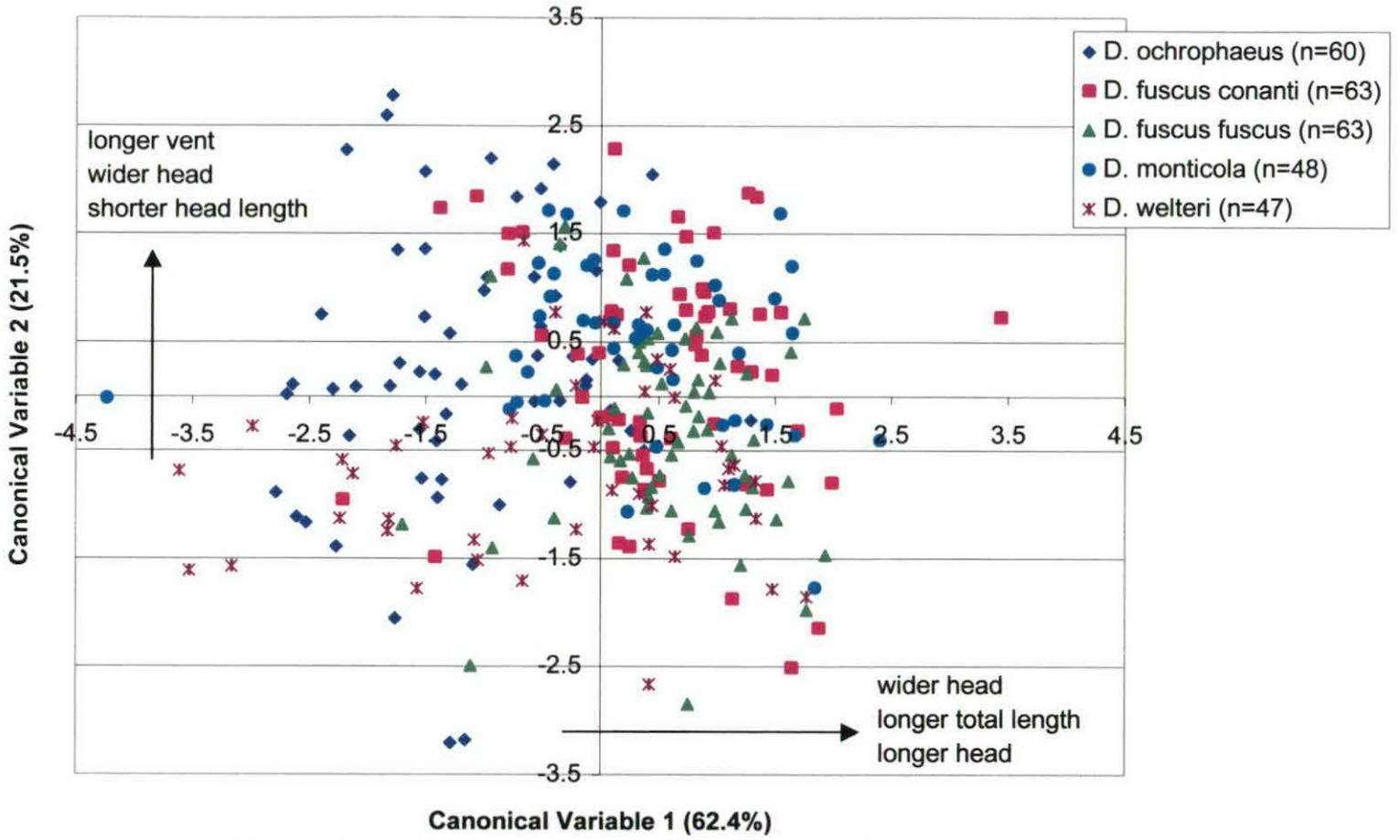


Figure 19. Scores of 281 Kentucky *Desmognathus* on the first and second canonical variables. Percent of variation explained by each canonical variable is in parentheses.

**Table 16.** Standardized canonical coefficients for the first two canonical variables used in the morphometric analysis of salamanders in the genus *Desmognathus*.

| Characters | Canonical Variable 1 | Canonical Variable 2 |
|---|---|---|
| Total Length | 0.433 | 0.250 |
| Head Length | 0.381 | -0.382 |
| Head Width | 0.692 | 0.324 |
| Snout Length | -0.113 | 0.253 |
| Vent Length | -0.291 | 0.662 |
| Tail Length | 0.295 | 0.662 |

**Table 17.** Standardized canonical coefficients for canonical variables one and three used in the morphometric analysis of male salamanders in the genus *Desmognathus*.

| Characters | Canonical Variable 1 | Canonical Variable 3 |
|---|---|---|
| Total Length | 0.578 | 0.406 |
| Head Length | 0.256 | 0.260 |
| Head Width | 0.662 | 0.454 |
| Snout Length | -0.057 | 0.937 |
| Vent Length | -0.063 | 0.417 |
| Tail Length | 0.447 | 0.425 |

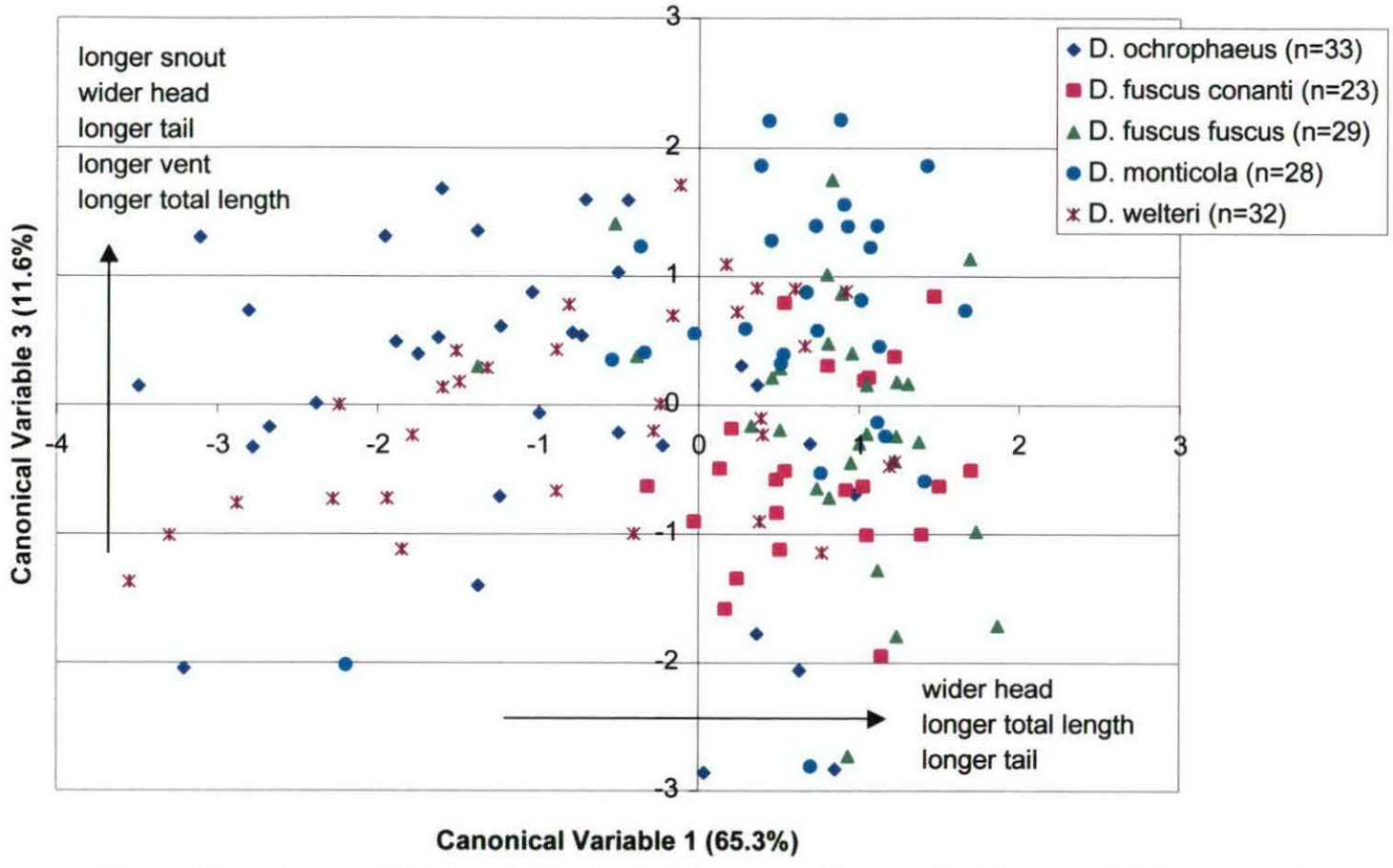


Figure 20. Scores of 145 male Kentucky *Desmognathus* on the first and third canonical variables. Percent of variation explained by each canonical variable is in parentheses.

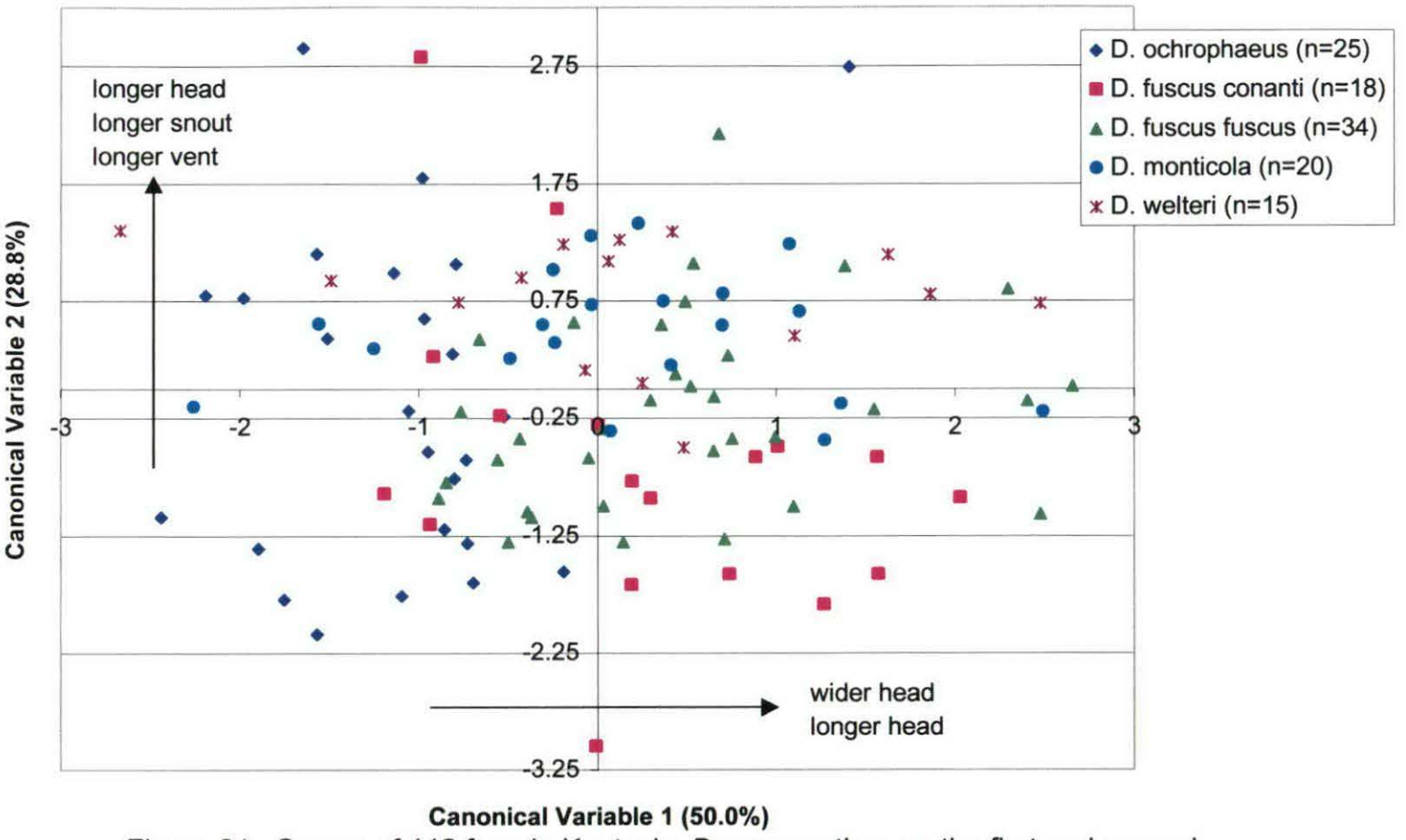


Figure 21. Scores of 112 female Kentucky *Desmognathus* on the first and second canonical variables. Percent of variation explained by each canonical variable is in parentheses.

**Table 18.** Standardized canonical coefficients for the first two canonical variables used in the morphometric analysis of female salamanders in the genus *Desmognathus*.

| Characters | Canonical Variable 1 | Canonical Variable 2 |
|---|---|---|
| Total Length | -0.024 | 0.093 |
| Head Length | 0.620 | 0.626 |
| Head Width | 0.676 | -0.055 |
| Snout Length | 0.149 | 0.589 |
| Vent Length | -0.274 | 0.360 |
| Tail Length | -0.099 | 0.172 |

**Table 19.** Standardized canonical coefficients for the first two canonical variables used in the morphometric analysis of *D. f. fuscus*, *D. monticola*, and *D. welteri*.

| Characters | Canonical Variable 1 | Canonical Variable 2 |
|---|---|---|
| Total Length | 0.619 | 0.179 |
| Head Length | -0.101 | 0.923 |
| Head Width | 0.725 | 0.599 |
| Snout Length | 0.334 | 0.530 |
| Vent Length | 0.565 | 0.224 |
| Tail Length | 0.567 | 0.162 |

width and head length in proportion to snout-vent length than the subspecies of *D. fuscus*.

The three species of the fuscus group that occur together in eastern Kentucky, *D. fuscus*, *D. monticola*, and *D.welteri*, were also compared by using canonical discriminant analysis. MANOVA revealed significant differences between these forms ($p < 0.01$). Canonical discriminant score clustering is shown in Figure 22. Separation of *D. welteri* and *D. monticola* occurs along the x axis. Standardized canonical coefficients for this axis are given in Table 19. Figure 22 shows that *D. monticola* is larger in most variables in proportion to snout-vent length than *D. welteri*. Canonical discriminant score clustering for the males of these species is shown in Figure 23. Again *D. monticola* and *D. welteri* were separated along the x axis. Standardized canonical coefficients for this axis are given in Table 20. *Desmognathus monticola* is larger for most variables in proportion to snout-vent length than *D. welteri* (Figure 23). Canonical discriminant score clustering for females of these species is shown in Figure 24. *Desmognathus f. fuscus* was separate from *D. monticola* and *D. welteri* along the x axis. However, there was not good separation of *D. monticola* and *D. welteri*. This adds to the fact that identification of the two species in sympatric regions is difficult. Standardized canonical coefficients for this axis are given in Table 21. Figure 24 shows that *D. f. fuscus* was smaller in head length, snout length, head width, and vent length, in proportion to snout-vent length than *D. monticola* and *D. welteri*.

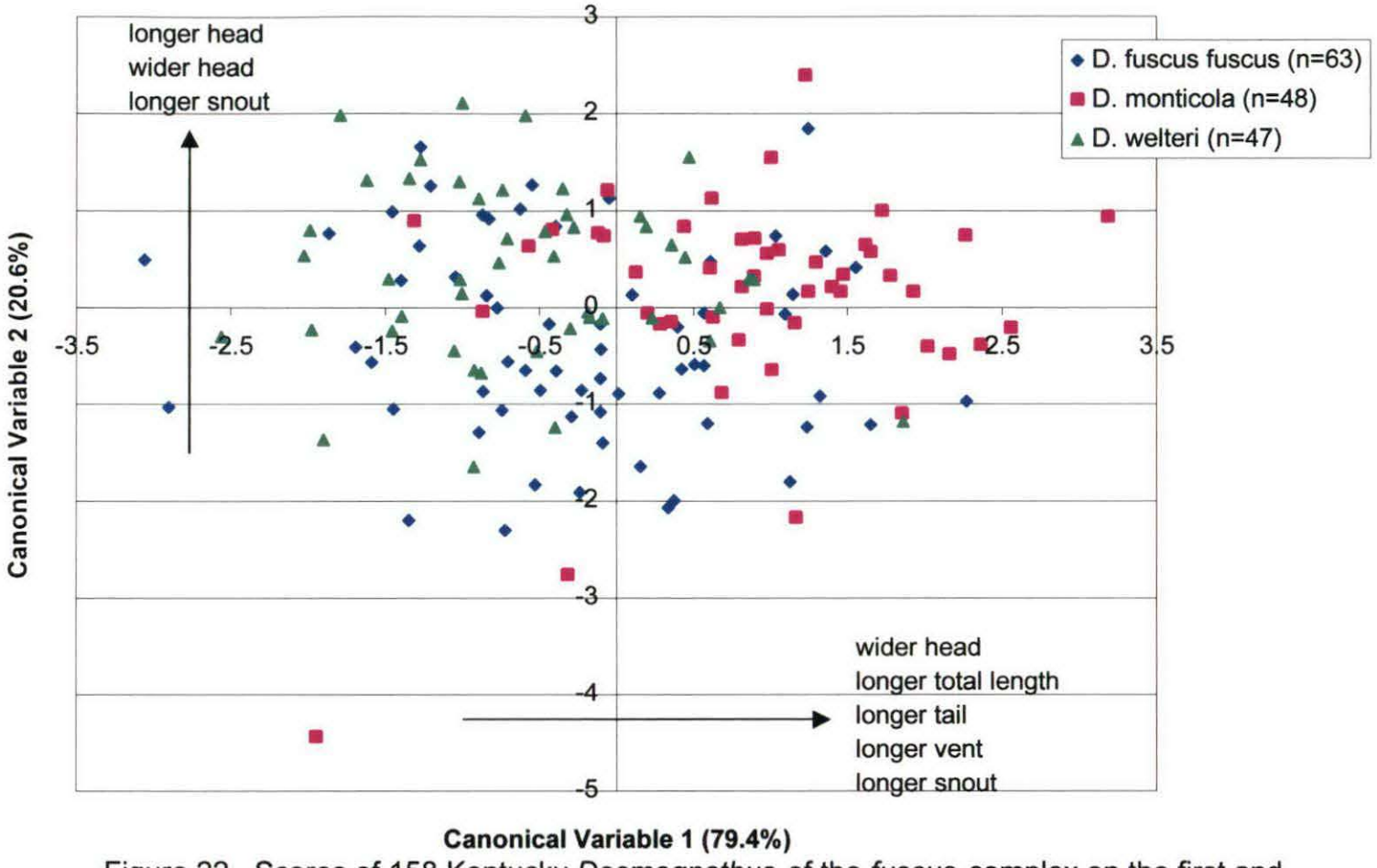


Figure 22. Scores of 158 Kentucky *Desmognathus* of the *fuscus* complex on the first and second canonical variables. Percent of variation explained by each canonical variable is in parentheses.

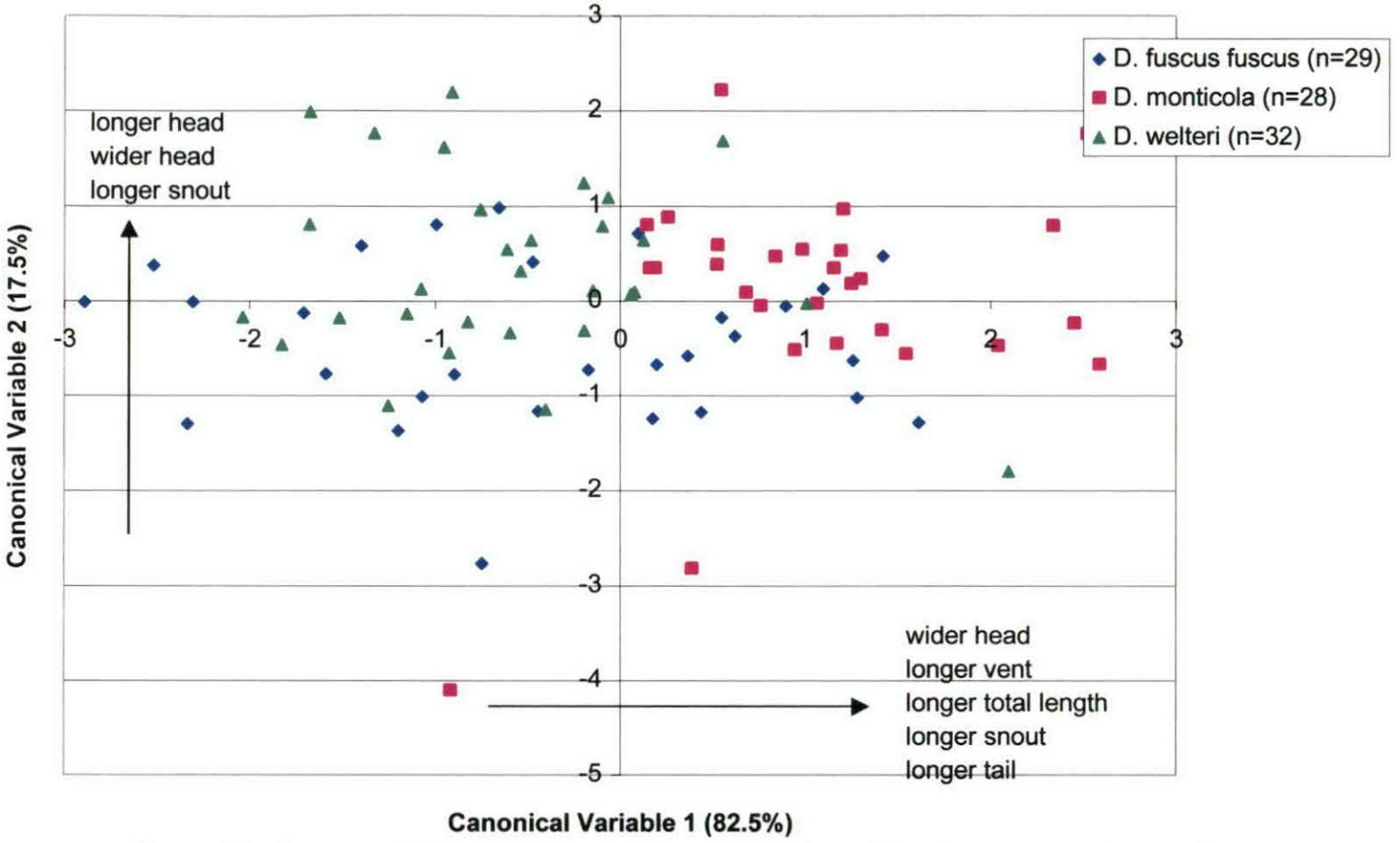


Figure 23. Scores of 89 male Kentucky *Desmognathus* of the *fuscus* complex on the first and second canonical variables. Percent of variation explained by each canonical variable is in parentheses.

**Table 20.** Standardized canonical coefficients for the first two canonical variables used in the morphometric analysis of male *D. f. fuscus*, *D. monticola*, and *D. welteri*.

| Characters | Canonical Variable 1 | Canonical Variable 2 |
|---|---|---|
| Total Length | 0.504 | 0.181 |
| Head Length | -0.186 | 0.824 |
| Head Width | 0.639 | 0.630 |
| Snout Length | 0.483 | 0.496 |
| Vent Length | 0.613 | 0.060 |
| Tail Length | 0.416 | 0.162 |

**Table 21.** Standardized canonical coefficients for the first two canonical variables used in the morphometric analysis of female *D. f. fuscus*, *D. monticola*, and *D. welteri*.

| Characters | Canonical Variable 1 | Canonical Variable 2 |
|---|---|---|
| Total Length | 0.135 | 0.551 |
| Head Length | 0.822 | -0.316 |
| Head Width | 0.571 | 0.653 |
| Snout Length | 0.678 | -0.091 |
| Vent Length | 0.474 | 0.351 |
| Tail Length | 0.118 | 0.565 |

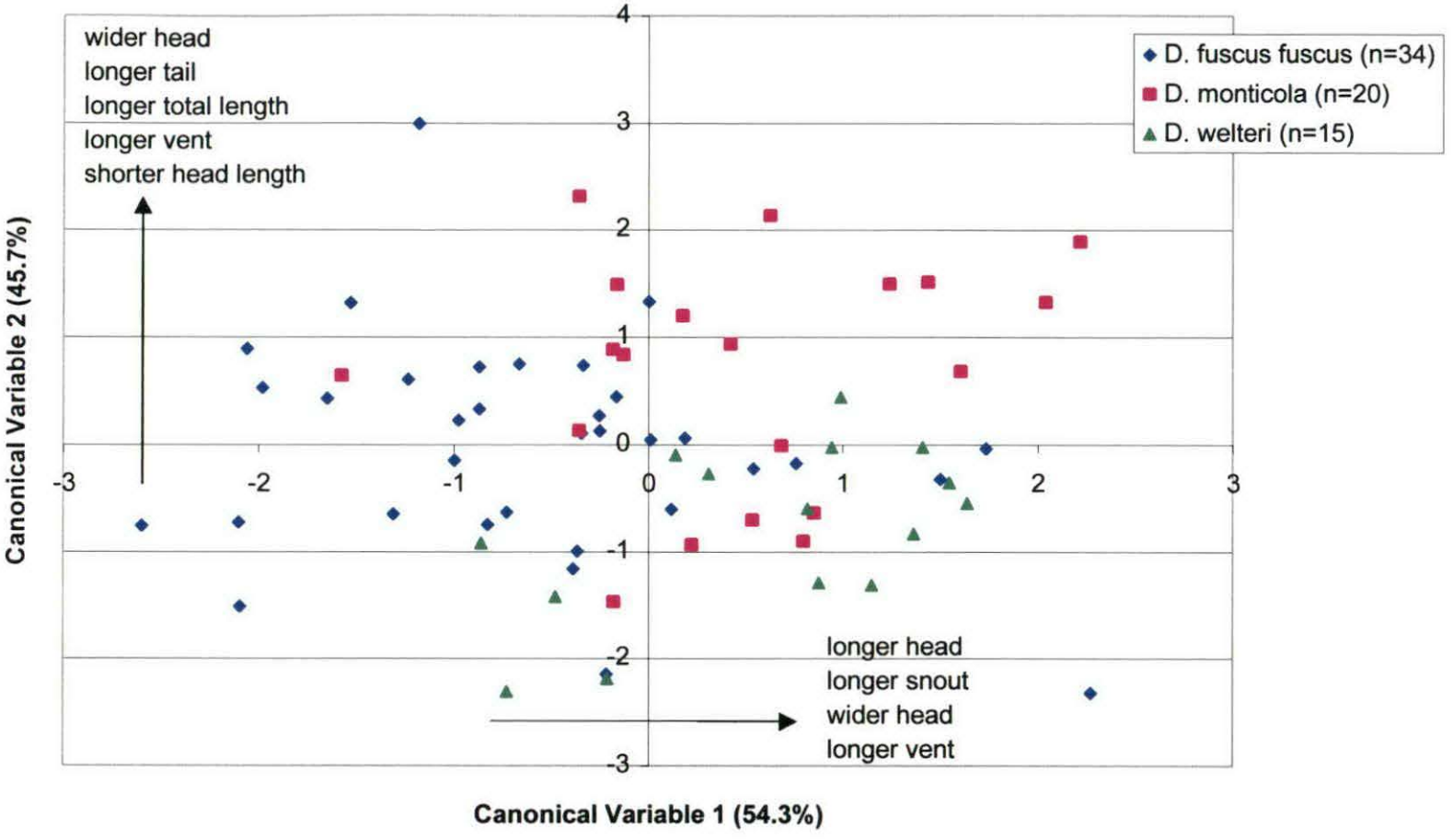


Figure 24. Scores of 69 female Kentucky *Desmognathus* of the *fuscus* complex on the first and second canonical variables. Percent of variation explained by each canonical variable is in parentheses.

A comparison of the two subspecies of the *Desmognathus fuscus*, *D. f. fuscus* and *D. f. conanti,* was completed by canonical discriminant analysis. MANOVA revealed significant differences between these forms ($p < 0.01$). Canonical discriminant score clustering is shown in Figure 25. Separation of *D. f. fuscus* and *D. f. conanti* occurs along the x axis. Standardized canonical coefficients for this axis are given in Table 22. Figure 25 shows that *D. f. fuscus* has a longer tail, longer total length, and shorter vent in proportion to snout-vent length than *D. f. conanti.* Canonical discriminant score clustering for the males of these species is shown in Figure 26. Again *D. f. fuscus* and *D. f. conanti* were separated along the x axis. Standardized canonical coefficients for this axis are given in Table 23. Figure 26 shows that *D. f. fuscus* is larger for most variables, except vent length, in proportion to snout-vent length than *D. f. conanti*. Females of these subspecies were not significantly different.

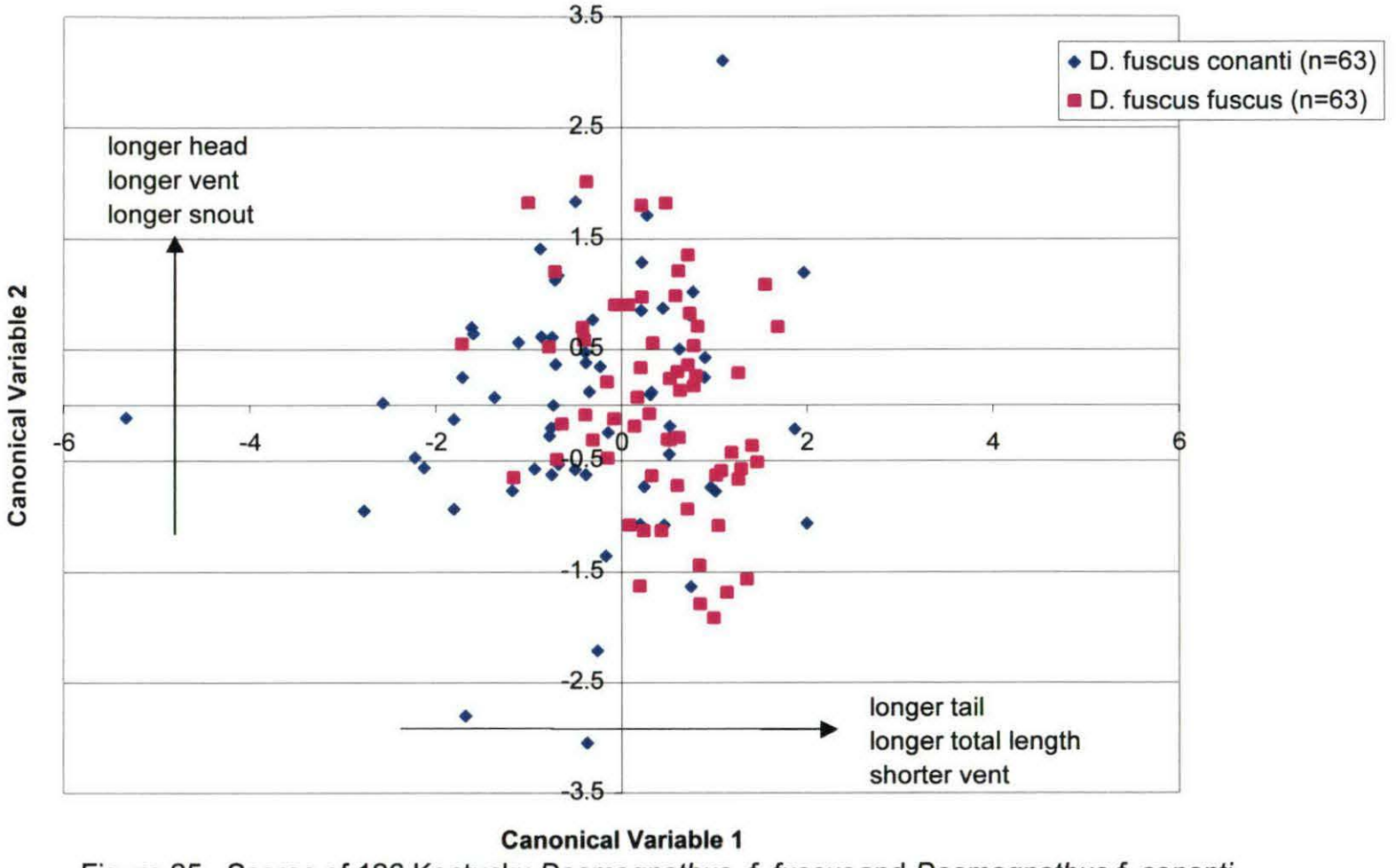


Figure 25. Scores of 126 Kentucky *Desmognathus f. fuscus* and *Desmognathus f. conanti* on the first and second canonical variables.

**Table 22.** Standardized canonical coefficients for the first two canonical variables used in the morphometric analysis of *D. f. fuscus* and *D. f. conanti*.

| Characters | Canonical Variable 1 | Canonical Variable 2 |
|---|---|---|
| Total Length | 0.616 | -0.030 |
| Head Length | 0.190 | 0.943 |
| Head Width | -0.130 | 0.296 |
| Snout Length | -0.252 | 0.481 |
| Vent Length | -0.486 | 0.531 |
| Tail Length | 0.687 | -0.029 |

**Table 23.** Standardized canonical coefficients for the first two canonical variables used in the morphometric analysis of male *D. f. fuscus* and *D. f. conanti*.

| Characters | Canonical Variable 1 | Canonical Variable 2 |
|---|---|---|
| Total Length | 0.546 | 0.090 |
| Head Length | 0.635 | -0.051 |
| Head Width | -0.066 | -0.053 |
| Snout Length | 0.344 | 0.081 |
| Vent Length | -0.406 | -0.028 |
| Tail Length | 0.538 | 0.189 |

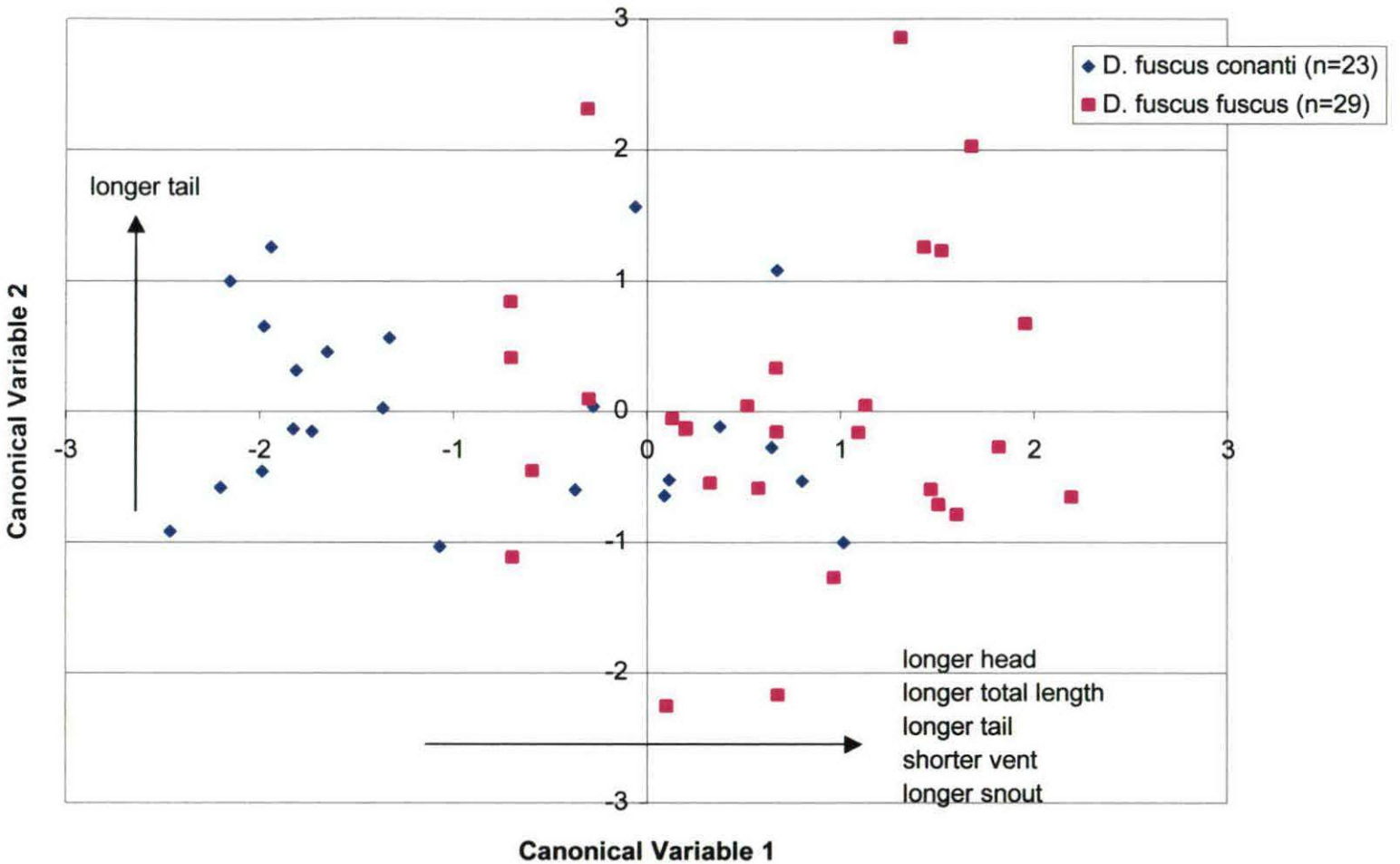


Figure 26. Scores of 52 male Kentucky *Desmognathus f. fuscus* and *Desmognathus f. conanti* on the first and second canonical variables.

# CONCLUSIONS

## Taxonomic and Natural History Data

Dusky salamanders are commonly found in clear, cold, rocky streams with leaf litter. Fallen logs along the bank provide additional cover. Large fish are absent from streams where these salamanders occur, but small fish including darters and minnows may be present. Food for dusky salamanders includes macroinvertebrates and detritus. The larger specimens of *Desmognathus welteri* and *D. monticola* occasionally eat conspecifics. All dusky salamanders lay eggs during the summer months and have aquatic larvae. Typical predators for dusky salamanders include birds, snakes, shrews, and other larger salamanders.

## Sexual Dimorphism

Results from the t-tests indicated that there was statistically significant separation between the sexes of *Desmognathus* in Kentucky. Snout length, vent length, and snout length/head length were the most frequent indicators of sexual dimorphism. Head length also was a good indicator of sexual dimorphism since it was statistically significant in all species except *D. ochrophaeus*. Males were larger in all cases, expect for tail length/total length in *D. monticola* and *D. welteri*. One possible reason for this is that females might store fat in their tail for energy expenditure during reproduction. Sexual dimorphism was most pronounced in *Desmognathus f. fuscus*, *D. monticola*, and *D. welteri* as most characters examined for these taxa showed significance.

**Interspecific Variation**

Results of the Bonferroni tests on the forms of *Desmognathus* in Kentucky showed significant separation. *Desmognathus welteri* and *D. monticola* were the largest taxa for the characters examined, followed by the two subspecies of *D. fuscus* and *D. ochrophaeus*. The three ratios (tail length/total length, snout-vent length/total length, and snout length/head length) showed no overall pattern in separation of species. *Desmognathus welteri* and *D. monticola* were the two largest species of *Desmognathus* in Kentucky. They were significantly different in snout-vent length, head length, head width, and snout length. The subspecies of *D. fuscus*, *D. f. fuscus* and *D. f. conanti*, were not statistically different for any character examined. The three ratios examined were poor indicators of species due to widely overlapping Bonferroni groups.

Based on discriminant function analysis, there was some separation of *Desmognathus* in Kentucky, especially when only one sex was compared across *Desmognathus* forms. Head width, head length, total length, vent length, and total length were the main characters involved in separation of all forms of *Desmognathus*, the *fuscus* complex (*D. f. fuscus*, *D. monticola*, and *D. welteri*), and the subspecies of *D. fuscus*. Male characters that heavily influenced the separation of *Desmognathus* were total length, head width, head length, and tail length. Female separation seemed to be influence mostly by head length, snout length, head width, and vent length. Females of the *fuscus* subspecies were poorly separated from each other. The results

of the separation of the *fuscus* subspecies indicate that there were differences between males, but not females.

**Distribution**

Dusky salamanders are primarily found in mountain stream habitat. *Desmognathus ochrophaeus*, *D. monticola*, and *D. welteri* occur on the Cumberland Plateau of eastern Kentucky (Figures 9, 15, and 18). *Desmognathus f. fuscus* occurs over a broader range and extends westward to the Land Between the Lakes region of Kentucky. However, this subspecies is absent from large portions of the Bluegrass and Western Coal Field regions (Figure 11). *Desmognathus f. conanti* is a coastal plain subspecies and reaches the northern part of its range in southern Illinois and western Kentucky (Figure 13).

**Additional Studies**

There is still much to learn about *Desmognathus* in Kentucky. Tilley and Mahoney (1996) failed to include any specimens from the isolated range of *D. ochrophaeus* in northeastern Kentucky. Specimens from this area need to be included in further research in order to indicate relationships with populations from other areas of their range. The intergrade zone between the two subspecies of *D. fuscus* needs to be investigated further. Titus and Larson (1996) used mitochondrial DNA analysis to raise *D. f. conanti* to the species level. However, they did not use a wide range of specimens from outside the contact zone in their study. Courtship and breeding for *D. monticola* and *D. welteri* is very limited. Although courtship has been observed in

*D. monticola*, it has not been observed in *D. welteri*. A few egg masses of *D. welteri* have been found by different researchers, but the exact breeding season is not known. Further searches for egg masses would also give a range of the number of eggs per nest. Also, the effects of strip mining near streams with *Desmognathus* has not been studied.

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