Spring 1984

Distribution Of The Northern Long-Toed Salamander (Ambystoma Macrodactylyum) East Of The Continental Divide In Montana

Robert Walker
Carroll College, Helena, MT

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DISTRIBUTION OF THE NORTHERN LONG-TOED SALAMANDER (AMBYSTOMA MACRODACTYLM) EAST OF THE CONTINENTAL DIVIDE IN MONTANA

Submitted in Partial Fulfillment of the Requirements for Graduation with Honors to the Department of Biology at Carroll College, Helena, Montana

Robert Stuart Walker
March 21, 1984
This thesis for honors recognition has been approved for the Department of Biology by:

Dr. John A. Christenson, Advisor

Dr. James J. Manion, Ph.D.

Rev. Robert N. Butko

March 21, 1984
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ACKNOWLEDGMENTS

In the spring of 1983 I approached the Montana Fish and Game Office of Helena, Montana, for suggestions on an honors thesis topic concerning small animals. I was directed to Mr. Larry Thompson, Coordinator of Biological Sciences at the Department of Natural Resources and Conservation.

He suggested with great enthusiasm a study of the Long-Toed salamander. The creature was of local interest for it was known to be indigenous to the region west of the continental divide but had somehow, for unknown reasons, migrated east of the divide near Helena.

By coincidence, I had encountered a number of the Long-Toed salamanders about five years previous to my meeting with Mr. Thompson while camping below the Park Lake area near Helena, Montana.

Thus, a thesis topic was born.

I would like to express my great respect and appreciation for the assistance of Mr. Larry Thompson.

Great thanks go out to my faculty advisor and readers, Dr. John A. Christenson, Dr. James J. Manion, and Reverend Robert N. Butko.

Appreciation is also due Dr. George Holton and Dr. Clifford Davis for a manuscript they had compiled of the past reported sightings of the Long-Toed salamander in this area.
ABSTRACT

Over the past twenty-six years there have been a relatively small number of reported sightings of the Northern Long-Toed salamander east of the continental divide near the Helena area. The eastern-most reported sighting was near the Tizer Lakes area in the Helena National Forest.

This study of the distribution of the Northern Long-Toed salamander in Montana east of the continental divide is significant because it substantiates the eastern migration currently in progress, provides assumptions about the probable habitat in which they may be found, suggests routes which may have been traversed in the migration over the divide and suggests possible reasons for this migration.
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INTRODUCTION

"Populations of the Long-Toed salamander (Ambystoma macrodactylum) generally have been known to occur from Toulumne County, California, northward in the Sierra Nevada, throughout Oregon with the exception of the extreme southeastern corner, Washington, British Columbia, southeastern Alaska, western Alberta, central and northern Idaho and in Santa Cruz County, California."¹

Since 1958, there have only been 28 reported sightings of the Northern Long-Toed salamander east of the continental divide. Sightings west of the continental divide, particularly in the Pacific northwest, have been relatively frequent.

The secretive habits of the Northern Long-Toed salamander have made analysis of population dynamics difficult. Thus, little is known about the distribution of the Northern Long-Toed salamander east of the continental divide and the reasons which may have prompted this eastward migration.

This paper will attempt to shed some light on these questions and will serve as a reference for further research on the Northern Long-Toed salamander east of the continental divide.

Classification

Of the 2,500 living species of amphibians, there are only 200 species of salamanders (Stebbins 1954). There are 16 species of amphibians in Montana and only five of these are salamanders (Thompson 1982). The Northern Long-Toed salamander is classified as Class Amphibia, Order Caudata, Family Ambystomatidae, Genus Ambystoma, Species macrodactylum, and Sub-Species krausei.

Physiological Characteristics

The Northern Long-Toed salamander is a cold-blooded, nocturnal, non-poisonous amphibian. The salamanders are incapable of defending themselves so their only hope for continued existence lies in not being discovered, a task they achieve quite successfully. The salamander is often mistaken by the layman for a creature similar in appearance, the lizard. The salamander however, differs significantly from the lizard, which is a reptile.

The adult Long-Toed salamander is a four-legged creature with smooth moist skin and a two-ventricle heart. The majority of lizards are also four-legged but have dry cornified skin. The salamander has four toes on the forefeet and five toes on the hindfeet and all of the toes are clawless. Lizards have five toes on the forefeet and hindfeet and all toes have claws. In addition, foot tubercles are present on the Long-Toed but not on the lizards.

The Long-Toed salamander's head is broad and its tail is
flattened laterally. The tail may be used in locomotion and in courtship antics. The tail also serves as a survival mechanism in that if it is injured or lost it can be regenerated. The break occurs in the myoseptum and extends between the vertebrae. The flesh of the discarded tail continues to wiggle which draws the attention of the predatory animal and allows the escape of the salamander.

The Northern Long-Toed salamander averages 2 1/8" - 3 1/4" in snout to vent length. The background color of the body is typically black or dark in color. A greenish yellow to tan stripe extends the length of the dorsal surface from head to tail. The stripe may have fairly well defined borders or may consist of irregular patches of pigment which appear to have coalesced together. A unique characteristic of the Northern Long-Toed salamander which distinguishes it from other subspecies of Ambystoma macrodactylum are the white dots of pigment which speckle its lateral surfaces.

The Northern Long-Toed salamander has 34 or less small conical vomerine teeth, usually in a transverse row on the roof of the mouth and they may be interrupted at the midline and/or laterally.

Salamanders lack auditory organs per se but compensate by being particularly sensitive to vibrations transmitted from the ground through the forelimbs along a specialized muscle to the inner ear. Though they may not be externally evident, lizards generally have a very well developed sense of hearing. Salamanders
have paired nostrils and their sense of olfaction is very well developed. Olfaction may function in feeding and also to a smaller degree in sex recognition during courtship behavior (Grzimeks 1972; Porter 1972).

Salamanders, unlike most other amphibians, are voiceless. Observers often mistake the snapping and popping noises produced by the opening and closing of the nasal valves as being intentionally made sounds, but they are not. The salamander respires both through its moist mucous-covered skin and by its lungs. It has in addition 12-13 and sometimes 14 costal grooves. The Northern Long-Toed salamander has foot tubercles which increase the gripping power of the feet and protect against abrasion. It also has a tail which has no well marked glandular thickening along its dorsal edge. Many other species of salamanders possess this thickening.

A salamander can be sexed by noting the appearance of the vent on the ventral surface of its body. The male vent is lined with papillae while the female vent is lined with folds.

Feeding Behavior

The Northern Long-Toed salamander is generally a carnivorous scavenger in both larval and adult life. The adults of this species feed on insects, annelids, arachnids and other amphibians. Salamanders feed underwater by snapping behavior but capture prey on land by using their tongues. The lizard's tongue is not used directly in feeding. The tongue is thrust forward by contracting muscles associated with the hyoid apparatus on which the tongue
is attached. The adhesive quality of the tongue is maintained by pressing it against glands on the palate when it is withdrawn from the mouth. Also, little or no mastication is utilized as most prey are swallowed whole.

The Long-Toed salamander's vision is especially acute as the salamander only responds to moving objects in feeding (Porter 1972). Salamanders store fat during the summer and utilize this food source during their winter hibernation (Noble 1954). Metabolic rate varies with the season. It increases during the breeding season, particularly in the male, but decreases with age (Stebbins 1954).

Salamanders represent secondary and tertiary trophic levels whereas their predators represent tertiary and quaternary trophic levels (Porter 1972). The salamander's predators are many and varied. Newts will eat salamander eggs; also, crustacea, giant water bugs, water beetle larvae, catfish, pike, bass, herons, raccoons, opossums, weasels and shrews will attack salamander larvae and adults.

Mating Behavior

Breeding is affected by photoperiod, temperature, precipitation, abundance of food supply and reproductive cycles (Porter 1972). The Long-Toed salamander attains maturity after one year and breeds its second year of life in lowland populations and its third year in highland populations. Pedogenesis (larval reproduction) in which larvae mate and produce fertile eggs that develop normally,
is rare but has been known to occur in some cases (Stebbins 1954).

Breeding commences immediately after the snow melts and ponds and lates become free of ice. Movement to the breeding sites is associated with rain and breeding usually only lasts for a few days. Male salamanders precede the females to the breeding sites. Olfaction may function to a small degree in sex discrimination by the male but for the most part it is a trial and error process (Noble 1954). During courtship the male clasps the female just behind the back of her forelegs and gives short shakes.

The male deposits several spermatophores, masses of spermatozoa associated with gelatinous material. The male partakes in underwater antics designed to entice the female to pick up the spermatophore in her vent. The spermatozoa, once picked up, is stored in the spermatheca in the roof of the cloaca until egg deposition. As the eggs pass down the oviducts, the spermatozoa are released from the spermatheca to fertilize them.

Each egg has an outer capsule diameter of 12-17 mm. They are released singly or in groups, commonly 8-10 eggs to a gelatinous packet (Stebbins 1954). The number of gelatinous envelopes deposited varies from one to three. The gelatinous material allows the eggs to become attached to grasses and other vegetation at the edges of ponds and other water bodies.

Out of the eggs eventually hatch free swimming larvae with three pairs of external gills, long body and tail, dorsal fin and ventral fin. Limb buds may or may not be present at hatching but will eventually develop. There are 9-13 gill rakers on the anterior
surface of the third gill arch. The upper body surfaces are brownish-gray, mottled with brown and black and the under surfaces are light colored or white. Mature larvae reach a total length of 2 1/2 - 3". The larvae undergo a two to three month metamorphosis.

Habitat

The salamander is ectothermal (cold blooded) and thus acquires its body temperature from its surroundings. Salamanders are very sensitive to high temperatures but can endure low temperatures at or below freezing. This varying range of temperature endurance determines the distribution and time of appearance of the Long-Toed salamander.

Salamanders are best adopted for the cool moist mountainous conditions of, and have been historically associated with, the Arcto-Tertiary forest. The Arcto-Tertiary forest shifted southward in response to the Pleistocene glacial buildup and associated climatic changes and the salamander populations shifted with it. The climate then warmed and the salamanders retreated northward along with the glaciers. The result of these climatic changes is that North American salamanders now have their major focus of distribution in the Appalachian mountains and the second most abundant number of populations are located in the Pacific Northwest (Porter 1972).

Migration

Important as to whether, how often, and where salamanders migrate
are the abundance of food, moisture, and cover. The salamanders' cruising radius from their home shelter is dependent upon these three commodities. Under favorable conditions of food, moisture, and cover, the salamanders will utilize smaller home ranges (Porter 1972). The opposite is also true.

Several factors are thought to be involved in the control of the migratory response. It is believed that hormones secreted by the anterior pituitary gland cause seasonal hypertrophy of the gonads which serves as the salamander's stimulus to proceed to breeding ponds. The fact that sexually immature specimens do not participate in these migrations reinforces this idea (Noble 1954).

In addition, climatic changes towards warmer temperature and heavy spring showers also function in the migration of salamanders. It is known that climatic conditions can trigger the release of hormones from the anterior lobe of the pituitary gland which in turn directs a rhythmic migratory sequence (Noble 1954). There also appears to be a correlation between the direction of the wind and the direction of migration (Czeloth 1930).

No special sex hormones are developed during the breeding season to function in the direction of migration. Rather, existing perceptual organs are probably supersensitized by the release of sex hormones, then these organs are stimulated to function by an external force such as a climatic change (Noble 1954).
MATERIALS AND METHODS

Previous records of reported sightings were obtained from Dr. George Holton and Dr. Clifford Davis. These two men had done the only organized work on the Northern Long-Toed salamander in this area that I am aware of.

My field study was organized in two phases. The locations of the previous collection sites were first re-searched by myself. I then began searching areas which had not been previously examined.

Waterways and drainages which were to be searched were plotted on the United States Geological Survey quadrangle maps. The areas of six USGS quadrangle maps including Helena, Elliston, East Helena, Basin, Jefferson City, and Clancy were traversed during the study.

The locations of the reported collection sites, including my own were marked with labels and numbered on the USGS quadrangle maps. The numbers indicated on the labels corresponded to the same number designation recorded in Table 1.

The locations of the areas searched with no collections were marked with labels and lettered on the USGS quadrangle maps. The letters indicated on the labels corresponded to the same letter designation recorded in Table 3.

Plotting both the locations of the areas searched with no success and the collection sites on one map made for a cluttered cartographic representation so the following procedure was utilized to simplify the representations. Three counties (Jefferson, Lewis & Clark, and Powell) made up the main study area so I condensed the combined maps of these counties into an 8" x 10"
sheet. Then using a rapidiograph pen set, I traced the major waterways from the condensed county maps onto two different mylar sheets.

On one mylar sheet, I indicated the locations of the areas searched with no collections with letters encased in circular symbols. These letters correspond to the same letter designation in Table 3. On the other mylar sheet, I indicated the locations of the collection sites with numbers encased in square symbols. The numbers correspond to the same number designation as in Table 1.

Photocopies were then made of the two mylar sheets and included in this paper as Figure 4 (collection sites) and Figure 5 (areas searched with no collections). In addition, an overlay reproduction of both Figure 4 and Figure 5 is included in this paper as Figure 6.

The areas searched included every variation of waterways including creeks, streams, ponds, drainages and reservoirs which fell within the previously plotted area. Salamander larvae were searched for by actually observing the water for these free swimming specimens. Adult specimens were searched for by overturning logs, old lumber, rocks, and any other debris which fell within the range of adequate habitat. Care was always taken to return all overturned objects to their original positions so as not to disrupt the natural habitat.

Searches were most often carried out on rainy days or damp and overcast days which immediately followed periods of heavy precipitation.
No specimens were taken from the field so as not to disrupt the scarce populations east of the continental divide. One adult specimen however, was delivered to Larry Thompson at the Department of Natural Resources by Larry Nordell. Mr. Nordell had found the specimen on his property on McClellen Creek. Mr. Thompson maintained the salamander in an aquarium for several months by feeding it meal worms.

A comprehensive list of the past reported sightings and of my personal collections was compiled chronologically and the date, collector, life stage of the specimen, location and elevation of the collection were recorded in Table 1.

Date, area searched, habitat characteristics, amount of vegetation, degree of shading, sunlight exposure, ambient temperature, and water temperature were recorded in Table 3.

Detailed information concerning my personal collections from the summer of 1983 was recorded in Table 2. This information includes date, location, habitat description, amount of vegetation, ambient temperature, temperature of nearest water body, degree of precipitation during collection period, type of water body, degree and type of shading, and the number and description of collected specimens.

Approximately 60 hours were spent searching in the field for the Northern Long-Toed salamander between 6/14/83 and 8/17/83.

The elevation (in feet) of the collection sites from Table 1 were correlated with the number of incidences of collections in the
form of a histogram in Table 5. The elevations were broken down into eight categories: 4000-4500', 4500-5000', 5000-5500', 5500-6000', 6000-6500', 6500-7000', 7000-7500', and 7500-8000'. Note here that I am concerned with the number of separate chronological incidences at a particular sight, not with the number of specimens found at each sight.

Finally, the topography of the area was studied. Assumptions were then made on why the eastward migration of the Northern Long-Toed salamander is occurring, how the salamander may have traversed the continental divide, and upon what kind of habitat the Northern Long-Toed salamander seems to favor.
<table>
<thead>
<tr>
<th>Collection Site</th>
<th>Stage</th>
<th>Elevation</th>
<th>Collector</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Park Lake</td>
<td>Egg mass</td>
<td>0.6001</td>
<td>Lynn Brent</td>
<td>1975</td>
</tr>
<tr>
<td>Pond above Remnant</td>
<td>Adult</td>
<td>6.0001</td>
<td>Robert Lee</td>
<td>1972</td>
</tr>
<tr>
<td>McDonald Pass Campground</td>
<td>Adult</td>
<td>62.41</td>
<td>Chuck Beveridge</td>
<td>1971</td>
</tr>
<tr>
<td>a stream near Grizzly Gulch Road</td>
<td>Adult</td>
<td>50.56</td>
<td>Chuck Beveridge</td>
<td>1971</td>
</tr>
<tr>
<td>unnumbered</td>
<td>Adult</td>
<td>4.0001</td>
<td>Chuck Beveridge</td>
<td>1971</td>
</tr>
<tr>
<td>To the Creek near Remnant</td>
<td>Larvae</td>
<td>48.00</td>
<td>Schwartzen</td>
<td>1970</td>
</tr>
<tr>
<td>beaver pond near McCiettan Creek</td>
<td>Adult</td>
<td>5.0001</td>
<td>McHughes</td>
<td>1969</td>
</tr>
<tr>
<td>McCiettan Creek picnic grounds</td>
<td>Adult</td>
<td>5.0001</td>
<td>Dr. Olaf Jones</td>
<td>1968</td>
</tr>
<tr>
<td>Mergenthaler property</td>
<td>Larvae</td>
<td>4.0671</td>
<td>Dr. George Holton</td>
<td>1969</td>
</tr>
<tr>
<td>unnumbered</td>
<td>Adult</td>
<td>5.0001</td>
<td>Gary Lindstrom</td>
<td>1969</td>
</tr>
<tr>
<td>Pond near Park Lake</td>
<td>Adult</td>
<td>6.0201</td>
<td>unknown</td>
<td>1968</td>
</tr>
<tr>
<td>Terrace Lakes</td>
<td>Adult</td>
<td>7.0801</td>
<td>unknown</td>
<td>1968</td>
</tr>
<tr>
<td>Mergenthaler property near McCiettan Creek</td>
<td>Adult</td>
<td>4.0671</td>
<td>unknown</td>
<td>1958</td>
</tr>
</tbody>
</table>

The continental divide in Montana

Reported collection sites of Ambystoma macrodactyllum east of

Table 1
<table>
<thead>
<tr>
<th>Collection Site</th>
<th>Stage</th>
<th>Elevation</th>
<th>Collector</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>upper grizzley cutch</td>
<td>adult</td>
<td>0.130</td>
<td>Larry Nordell</td>
<td>1983</td>
</tr>
<tr>
<td>travaus creek reservoir</td>
<td>larva</td>
<td>0.089</td>
<td>Robert Walker</td>
<td>1983</td>
</tr>
<tr>
<td>pond below pond near chesman reservoir</td>
<td>young adult</td>
<td>0.062</td>
<td>Robert Walker</td>
<td>1983</td>
</tr>
<tr>
<td>standing camp below park lake</td>
<td>adult</td>
<td>0.062</td>
<td>Robert Walker</td>
<td>1983</td>
</tr>
<tr>
<td>upper grizzley cutch</td>
<td>adult</td>
<td>0.006</td>
<td>Robert Walker</td>
<td>1983</td>
</tr>
<tr>
<td>a well near the forest ranger station</td>
<td>adult</td>
<td>0.000</td>
<td>W. Heydoy</td>
<td>1980</td>
</tr>
<tr>
<td>unfortified area</td>
<td>adult</td>
<td>0.050</td>
<td>unknown</td>
<td>1979</td>
</tr>
<tr>
<td>eggs &amp; larva pond jackson creek</td>
<td>adult</td>
<td>0.045</td>
<td>Troy Smith</td>
<td>1978</td>
</tr>
<tr>
<td>abandoned mining camp below park lake</td>
<td>adult</td>
<td>0.090</td>
<td>Robert Walker</td>
<td>1978</td>
</tr>
<tr>
<td>forest lake below park lake</td>
<td>adult</td>
<td>0.009</td>
<td>unknown</td>
<td>1977</td>
</tr>
<tr>
<td>park lake</td>
<td>adult</td>
<td>0.004</td>
<td>Troy Smith</td>
<td>1976</td>
</tr>
<tr>
<td>beaver pond on park lake road</td>
<td>adult</td>
<td>0.002</td>
<td>Troy Smith</td>
<td>1975</td>
</tr>
<tr>
<td>north fork of quartz creek</td>
<td>egg mass</td>
<td>0.000</td>
<td>Tyran Brent</td>
<td>1975</td>
</tr>
</tbody>
</table>

Table 1 continued
<table>
<thead>
<tr>
<th>Date</th>
<th>Habitat Characteristics</th>
<th>Description of collecting sites from summer, 1983</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/14/83</td>
<td>1. Small adults under a small log in a small silt pond.</td>
<td>From the spilllaje pond.</td>
</tr>
<tr>
<td>6/12/83</td>
<td>1. Med. sized adults; slightly buttressed into grassy area.</td>
<td>From about 6' from the water.</td>
</tr>
<tr>
<td>6/14/83</td>
<td>2. Large adult, med. adults under a low log in a meadow near the creek.</td>
<td>From about 40' from the water.</td>
</tr>
<tr>
<td>Date</td>
<td>Quantity and description of collection</td>
<td>Habitat characteristics</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>8/26/83</td>
<td>(1) Larya, dark in color with external gills.</td>
<td>Traylor's Creek Reservoir Area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small creek is 2' in width and 20&quot; in depth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>58° water temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>70°F ambient temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13&quot; grasses</td>
</tr>
</tbody>
</table>

Little shade tree cover near the creek.
<table>
<thead>
<tr>
<th>Temperature &amp; Vegetation</th>
<th>Date</th>
<th>Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>72°F water temperature, tall grasses, little shade</td>
<td>8/15/83</td>
<td>A</td>
</tr>
<tr>
<td>70°F ambient temperature, tall grasses</td>
<td>8/15/83</td>
<td>B</td>
</tr>
<tr>
<td>53°F water temperature, tall grasses</td>
<td>8/15/83</td>
<td>C</td>
</tr>
<tr>
<td>80°F ambient temperature, tall grasses</td>
<td>8/15/83</td>
<td>D</td>
</tr>
<tr>
<td>80°F ambient temperature, tall grasses and abundant other vegetation</td>
<td>8/15/83</td>
<td>E</td>
</tr>
<tr>
<td>60°F water temperature, little open sunlight</td>
<td>8/15/83</td>
<td>F</td>
</tr>
<tr>
<td>60°F water temperature, little open sunlight</td>
<td>8/15/83</td>
<td>G</td>
</tr>
<tr>
<td>49°F water temperature, tall grasses, little shade</td>
<td>8/15/83</td>
<td>H</td>
</tr>
</tbody>
</table>

The YMCA Camp
Flowing from the divide towards west of the Continental Divide
Telegraph Creek
Mike Rentch Gulch Creek
Mold Camp Creek
Little Blackfoot River
Little Blackfoot River
Little Blackfoot River
Description of areas searched with no success during summer, 1983

Table 3
<table>
<thead>
<tr>
<th>Habitat Characteristics</th>
<th>Area</th>
<th>Letter</th>
<th>Date</th>
</tr>
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Table 3 continued
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<td>Brockley Pear Creek</td>
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<td>60°F water temperature</td>
<td>Jackson Creek</td>
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<td>70°F water temperature</td>
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Table 3 continued
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<th>Habitat Characteristics</th>
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<tbody>
<tr>
<td>McClellen Creek - near the McClellen Creek Ranger Station</td>
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<tr>
<td>Pacctic Reservoir - flowing into the Northern Creek</td>
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<tr>
<td>Northern Pacctic Reservoir - Ranger Station</td>
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<td>- near roadway from Montana</td>
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<tr>
<td>- unnamed mountain-side creeks</td>
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<td>Shingle Creek</td>
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<tr>
<td>Abundant vegetation</td>
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<tr>
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<td>80°F water temperature</td>
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<tr>
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<td>East Fork of Mcclellan</td>
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Table 3 continued
Table 4

Histogram of elevations at which reported collections were made

Elevation in Feet

Number of Collection Areas
Figure 1

External Anatomy of the Salamander

Taken from Stebbins, 1954
Figure 2
Anatomical Characteristics

a) dorsal striping

b) absent parotid glands

c) vomerine teeth arrangement

d) lack of well marked glandular thickening on tail

e) foot tubercles

Taken from Stebbins, 1954
Figure 3

Distribution map of area normally frequented by the Long-Toad

Taken from Stebbins, 1954
Figure 4

Distribution map of the collection sites east of the continental divide in Montana
Figure 5
Map of the areas searched with no success east of the continental divide in Montana.

AREAS SEARCHED
WITH NO COLLECTIONS (lettered - refer to TABLE 3)
RESULTS

The distribution of the Northern Long-Toed Salamander east of the continental divide as substantiated by the reported collection sites in Table 1 is plotted on a map (Figure 4). Collection locations are indicated on the map by both a red mark and a number which corresponds to the identification number in Table 1.

The distribution of areas searched with no success during the summer of 1983 have been plotted on a map (Figure 5). These areas are indicated on the map by both a yellow mark and a letter which corresponds to the identification letter in Table 3.

Table 4 is a histogram representation of the elevations at which specimens were observed. It was found that two of the collection areas were located at an elevation between 4000-45000'; one collection area was located at an elevation between 45000-5000'; seven collection areas were located at elevations between 5000-5500'; none were located at elevations between 5500-6000'; nine collection areas were located at elevations between 6000-6500'; five collection areas were located at elevations between 6500-7000'; three collection areas were located at elevations between 7000-7500'; and one collection area was located at an elevation between 7500-8000'.
DISCUSSION AND CONCLUSION

Attention should be given to the fact that the Northern and Western subspecies of the Long-Toed salamander are nearly identical in appearance. The Northern subspecies is thought to be that which is common to the region west of the continental divide and to the Pacific Northwest, so it is believed that it is this subspecies that is migrating eastward through Montana. However, both the Western and Northern Long-Toed salamanders may possess white flecks of pigment on their lateral body surfaces, a characteristic that distinguishes them from other subspecies of Long-Toed salamanders. All this to say that these two subspecies are easily confused.

I believe that the distribution of collection sites east of the continental divide are indicative of an eastern migration of the Long-Toed salamander currently taking place through Montana. Two bits of evidence attest to this fact. First, it has previously been documented that the Long-Toed salamander is indigenous to the region west of the continental divide. Secondly, the small number of sightings east of the continental divide is not indicative of well established populations in that region.

Very few definitive statements can be made concerning preferential habitat characteristics. The reason that this is so is because the Long-Toed salamander has been sighted in a variety of habitats, from semi-arid desert environments to very moist areas. The particular populations of the Northern Long-Toed salamander
that were dealt with in this study seemed to prefer cool, moist, shaded areas. In fact, no specimens were found in any area which exhibited arid soil conditions or open sunlight. Invariably, collections were only made during rainy periods or on days following heavy precipitation. The precipitation made for the damp soil conditions these Long-Toed salamander populations seemed to prefer.

It is interesting to note that the majority of my collections was found under objects associated with human habitation. These objects included old garbage dumps, old wooden planks and other structural components of abandoned deteriorating dwellings. I think that this is noteworthy, for in so many instances man's encroachment on wildlife has impeded its existence, but in this case human habitation of the salamander's environment seems to have been a boon to the salamander's proliferation.

In general, these populations of the Northern Long-Toed salamander seem to prefer residence near aqueous bodies which are either of slow or still flow. This follows since they rarely enter the water except for breeding purposes and rapid water flow would make breeding difficult.

The data I collected on grass heights in the salamander habitats does not indicate any favoring of a particular length of grass nor does this data suggest the necessity for the presence of any grasses at all. The Long-Toed salamander does, however, seem to prefer shaded areas, so some type of forest vegetation is usually associated with collection sites.
Consideration of the elevations of collection sites revealed that the largest number of collection areas fell within the 6000-6500' category and the least number of collection sites fell within the 4500-5000' and 7500-8000' ranges. No collections were made in the 5500-6000' range. The fact that there have only been 28 collection areas in the last 26 years makes a general statement concerning the preferred Long-Toed salamander habitat elevation impossible.

Analysis of the precipitation levels on either side of the continental divide over the last forty years was also made in hopes that a trend towards greater precipitation on the eastern side of the divide would be revealed as luring Long-Toed salamander populations eastward, but no trend of this nature was discovered.

One investigator (Czeloth 1930) believed that there might be a correlation between wind direction and the direction of migration but he was not able to substantiate this statement. Analysis of wind data in this case did not serve to verify the hypothesis either.

I believe that the migration of the Long-Toed salamander over the continental divide could have occurred by several different means. All of my suggestions are purely speculative but those which I perceive as being most likely are the following:

1. displacement by human beings
2. via mining sluices and aqueducts
3. overland in response to climatic change
4. via ponds, seeps, springs, and creeks near the continental divide
Displacement of the Long-Toed salamander over the continental divide by humans was likely because many of the streams and ponds west of the continental divide are popular picnic and fishing areas. It is common for a child to transport frogs and other amphibians over distances in a coffee can or tackle box. The children are then forced to leave the specimens at the nearest body of water when the child's parents discover the creatures while they are on their way home.

Due to the vast amount of mining activity that occurred on either side of the continental divide during the 1800's and early 1900's, it is likely that the Long-Toed salamanders could have made their way eastward over the continental divide via mining sluices and aqueducts. The Long-Toed salamander's fondness for human dwellings and other shelters reinforces this possibility.

It is entirely possible that some climatic event triggered the overland migration of the Long-Toed salamander but a hint as to what that event might have been has not revealed itself.

I believe that the most probable theory is that Long-Toed salamander populations simply increased in number west of the continental divide and gradually overtook more and more aqueous habitat in the form of ponds, seeps, springs, and creeks. Predation by other animals could have been a contributing factor. Abundant suitable aqueous habitat on either side of the continental divide makes this theory an attractive one. My sighting of a larval Long-Toed salamander in the Travis Creek Reservoir area further reinforces this theory.
If in fact the migration of the Long-Toed salamander eastward over the continental divide did occur via water bodies, it would be impossible to determine a definitive route by which the migration occurred. However, two likely routes could be the Travis Creek Reservoir and McDonald Pass Campground areas because of the two sightings at those locations and their proximities near the crest of the continental divide, but a number of other possible routes could exist.

It is likely that the migration over the continental divide did not occur via any one of the above means but was probably a combination of several of these theories.

At this point, it would be useful to make some suggestions that would make further research on this topic more pertinent. One, it would be beneficial to begin observational studies of this kind in the early spring, as soon as the snow begins to melt for this is the time that the majority of breeding takes place and thus, the likelihood of sightings would be increased. Secondly, it would be helpful if, in the future, specimens were sexed so that it could be determined if a difference existed between the distribution of males and females.

In conclusion, due to the small number of sightings of the Northern Long-Toed salamander east of the continental divide, it would be unwise to make any definite statements concerning the reasons for, and the routes of, migration. These questions will only be answered with further research over a long period of time.

I have enjoyed this experience very much and sincerely hope that this project will be of value in further research of the Northern Long-Toed salamander.
LITERATURE CITED


