

AMERICAN MUSEUM NOVITATES

Number 306

Published by
THE AMERICAN MUSEUM OF NATURAL HISTORY
New York City

April 14, 1928

59.79 (75.6)

SOME PLETHODONTID SALAMANDERS FROM NORTH CAROLINA AND KENTUCKY WITH THE DESCRIPTION OF A NEW RACE OF *LEUROGNATHUS*

BY CLIFFORD H. POPE

This paper is a record of field studies made in western North Carolina and extreme southeastern Kentucky from June sixteenth through July twenty-eighth, 1927. It deals especially with *Plethodon shermani*, *P. jordani*, *P. metcalfi*, and *P. glutinosus*; *Aneides æneus*; *Leurognathus marmorata intermedia*, a new subspecies; and a local Kentucky form of *Desmognathus fuscus fuscus*. Brief mention is also made of *Desmognathus fuscus carolinensis*, *D. quadra-maculatus* and *D. phoca*; *Gyrinophilus danieli*; and *Eurycea bislineata wilderæ*.

The main objects of this field trip were to work out the relationships of the four species of *Plethodon*—*P. glutinosus*, *P. shermani*, *P. jordani*, and *P. metcalfi*—and to find out the affinities of *Aneides æneus* as shown by its life-history. Material that will help determine the status of Dunn's newly described *Desmognathus fuscus imitator* was also secured and a race of *Leurognathus marmorata* discovered.

Highlands is a town in western North Carolina just north of the northeastern corner of Georgia. It is in the Blue Ridge at an altitude of about 3800 feet.

Wayah Bald, the highest peak in the Nantahala Range, reaches an altitude of 5200 feet or more. It is in Macon County, western North Carolina, nine miles west of Franklin.

Waynesville, in the Balsam Mountains of Haywood County, western North Carolina, is just 2638 feet above the sea.

Davis Gap, a pass at an altitude of 3200 feet, is three miles west and a little south of Waynesville. Pigeon Road runs through this Gap.

Andrews Bald, one of the most accessible of the higher peaks of the Great Smoky Mountains, reaches an altitude of 5900 feet and is located in Swain County, eight miles north and a little west of Bryson City. The Tennessee-North Carolina boundary line follows, for some distance, the highest ridge of these mountains.

Pine Mountain Settlement School, Harlan County, southeastern Kentucky, is located on the northern base of Pine Mountain at the head of Greasy Creek. The Bench Mark on the School grounds is at 1756 feet

altitude, while the ridge above maintains for many miles a uniform altitude of 2750 feet.

I wish to thank Mrs. Ethel de Long Zande and her colleagues of the Pine Mountains Settlement School, for giving me a place to stay and making me feel very much at home while collecting *Aneides xneus*.

The trip was made possible by a grant from the Douglas Burden Research Fund of The American Museum of Natural History.

***Plethodon glutinosus* (Green)**

On the mountains about Highlands at an altitude of from 3600 to 4400 feet this salamander was found closely associated with *P. metcalfi* though it was not so common as that species (A. M. N. H. Nos. 25251-3). In the valleys at the base of Wayah Bald, 2300-3000 feet in altitude, *P. glutinosus* was not abundant (A. M. N. H. Nos. 25260-7), nor was it very readily found in Mill Creek Valley near the foot of Andrews Bald at similar altitudes (A. M. N. H. Nos. 25435-8). On the west slope of Pine Mountain *P. glutinosus* was abundant. It lived in greatest numbers under the loose rocks embedded in the débris forming the forest floor.

The following table gives the summary of measurements in millimeters of the fifteen largest specimens of each sex among a series of ninety-five *glutinosus* collected at various places in North Carolina by Dunn, 1916, and by myself, 1927.

	Longest Body	Average Body Length	Longest Head	Average Head Length	Widest Head	Average Head Width
MALES	60	52.1	16.3	14.8	11.5	10.1
FEMALES	65	56.9	16.5	15.1	12	10.5

Among the males there are only four tails more than 70 mm. long while the tails of seven females exceed this length. Sexual dimorphism is marked in this species.

***Plethodon jordani* Blatchley**

Working alone July 14 on Flat Top, I collected in an hour's time thirty-five examples of this species (A. M. N. H. Nos. 25455-25489). Flat Top is a sparsely wooded, flat, grassy area slightly above 5000 feet in altitude near the top of Andrews Bald. On the following day, working in the same area with the help of a local man, I secured seventy-eight specimens in about four hours. Among these are A. M. N. H. Nos. 25490-25531 and 25581. These figures give a good idea of the abundance of this species there. The specimens were found in the rather open woods inside of and under rotten logs, under sticks and pieces of bark of all sizes,

and beneath solid logs. They were most frequently found just beneath the loose bark of prostrate sticks and logs. They are active but easily picked up. I found none under stones.

This was the only *Plethodon* taken at any great altitude on Andrews Bald. *P. glutinosus* seemed to be confined to the lower valleys and even there it did not occur in abundance. No specimens of *metcalfi* were found in this region.

In this new series of seventy-eight individuals the red on the cheeks varies in shade and amount. Though usually a bright coral hue it is sometimes a much duller red and may even approach yellow. Approximately one-fourth of the series had the full complement of color on both cheeks, about one-tenth had only a trace, while only two (A. M. N. H. Nos. 25490 and 25581) lacked the color entirely. On the remainder, slightly more than six-tenths of the whole, the red is present in varying quantities, always more than a mere trace, but never the full complement. Three of thirty-seven *P. jordani* collected on Mt. Sterling (Dunn, 1920) lacked the red stripe, while one of the three had red spots on the legs. I fail to find any among the new series with the latter coloration.

About three dozen specimens were shipped alive to the Museum. They have not been examined. If anything they would average high in amount of red on the cheek since they were picked out in the field with this character in mind. I do not detect any correlation between the red cheeks and sex.

The following table gives a summary of the measurements in millimeters of twenty of the larger examples, ten of each sex.

	Longest Body	Average Body Length	Longest Head	Average Head Length	Widest Head	Average Head Width
MALES	42	39.6	13	11.9	8	7.5
FEMALES	45	41.1	12.5	11.8	9	7.9

A comparison of the tail length is difficult because the tails of four females are incomplete, while that of only one male is damaged. In both sexes the longest tail is 60 mm. There is probably little difference in their averages.

Nos. 25497 and 25498, the smallest of the lot, measure respectively 17 and 16 mm. in body length.

It should be noted that in this species the male is only slightly smaller than the female. Mature males have a conspicuous mental gland.

***Plethodon metcalfi* Brimley**

This is the common *Plethodon* about Highlands. I caught one three feet above ground among dry sticks of wood piled under shelter. Another was found five feet above the ground in a pile of uncovered wood. Local inhabitants say that specimens are often seen thus in wood piles. *P. metcalfi* are sometimes found under small stones in dry, open woods. I collected them in the vicinity of Highlands from 3600 to 4300 feet above the sea.

The following table gives the summary of the measurements in millimeters of the fifteen largest specimens of each sex among a series of 121 *metcalfi* collected at various places in North Carolina by Dunn in 1916.

	Longest Body	Average Body Length	Longest Head	Average Head Length	Widest Head	Average Head Width
MALES	41	38.1	12.5	11.5	8	7.4
FEMALES	47.5	42.8	13	11.9	9	8.1

Only two males have a tail more than 50 mm. long while this length is exceeded by the tails of seven females. The females of this species are decidedly larger than the males.

***Plethodon shermani* Stejneger**

During a four-hour hunt in damp woods around a meadow near the top of Wayah Bald, at an altitude of about 5000 feet, I secured alone on June 28 thirty-five examples of *P. shermani* (A. M. N. H. Nos. 25272-25305 and 25307). Many were taken inside of and under rotten logs, under sticks and bark, and beneath solid logs. Their favorite place of concealment was under the loose bark of prostrate sticks and logs. On June 22, twelve more specimens were secured, among them A. M. N. H. Nos. 25308-25313. The following day I found, without help, thirty more, among which are A. M. N. H. Nos. 25314-25331. These figures give some indication of their abundance. None were seen lower than 4000 feet and it was only in the damper sections of the higher woods that they were so abundant. They prefer woods along streams though they are also found far from the latter. They are active but readily picked up. I saw none under stones.

No other *Plethodons* were found above 4000 feet on Wayah Bald. *P. glutinosus* was common, though not abundant, in the valleys at the base of the mountain. No specimens of *P. metcalfi* were found in this region.

In the series of fifty-seven individuals at hand the red on the legs varies greatly in shade and amount. It is usually a bright coral hue. Approximately one-third of the series has the full complement of color on all four legs, about one-fifteenth has only a trace, while in the remaining three-fifths the red is present in varying quantities, always more than a trace, but never the full complement. There is generally more red on the arms than the legs, while on all four limbs the red is more constant on the proximal than the distal sections.

About two dozen specimens were shipped alive to the Museum. They have not been examined. They would probably average high in amount of red on the legs since they were selected with this character in mind. I fail to detect any correlation between the red cheeks and sex.

The following table gives the summary of the measurements in millimeters of twenty-four of the larger specimens, twelve of each sex.

	Longest Body	Average Body Length	Longest Head	Average Head Length	Widest Head	Average Head Width
111 MALES	51	45.1	14.3	13.2	9	8.5
11 FEMALES	51	45.6	14.	13.1	10	8.3

In both sex series there are six tails more than 50 mm. long but the two longest tails, 75 and 61 mm. respectively, belong to females.

In this species there is almost no difference in size between the sexes. Mature males have a conspicuous mental gland.

The three smallest in the series measure 13, 13 and 12.5 mm. respectively in body length.

***Gyrinophilus danielsi* (Blatchley)**

One adult (A. M. N. H. No. 25270) was taken about 5000 feet above the sea near the top of Wayah Bald under rocks lying in a spring stream.

***Eurycea bislineata wilderæ* Dunn**

One of these salamanders (A. M. N. H. No. 25271) was found on June 21 under a big decaying log with heaps of dead leaves piled along its side. The log lay approximately 5000 feet above the sea near the top of Wayah Bald mountain. *P. shermani* were abundant in the same woods but only the one *Eurycea* was seen. On Flat Top, which is a level space near the summit of Andrews Bald, six more examples (A. M. N. H. Nos. 25439-25442 and 25532-3) were taken June 14 and 15 along with numerous *P. jordani* under logs and other débris lying about 5200 feet above sea-level on the floor of the open, grassy forest there.

***Aneides æneus* (Cope and Packard)**

On July 20th through the 25th, and again on the 28th I hunted this salamander in the vicinity of Pine Mountain Settlement School with Evans Compton, a thirteen-year-old student who acted as guide and assistant collector. Since so little is known of the habits of *Aneides æneus*, I do not spare detail in the following record of our work which I give in diary form.

July 20. We hunted for part of the afternoon on the School grounds just below the reservoir in damp, thick woods and found one specimen inside of a large, decayed log.

July 21. During the morning we hunted in the forest along the Laden Trail, a wagon road that crosses Pine Mountain about a mile southwest of the School, and found five specimens (A. M. N. H. Nos. 25583-25587) as follows:

- (a) a small one under the very loose bark of a solid log lying beside the road.
Only a little bark remained on the log;
- (b) two small ones under the bark of a limb of a large, prostrate water oak. The log was solid and the specimens were about five feet above the ground;
- (c) one more under the very loose bark of a large, prostrate, solid, chestnut log lying by the road;
- (d) the fifth under the bark of a large, solid, prostrate log embedded in a thicket above the road.

A long hunt in the afternoon, along the base of Pine Mountain about a mile northeast of the School, netted only one specimen. It was taken on the edge of a clump of scrub trees under the bark of a solid section of a log lying in a dry, overgrown pasture. The log was exposed to the sun.

July 22. Our morning's search was fruitless but in the afternoon we found one specimen a mile below the School near Greasy Creek under the bark of a section of a solid water oak lying exposed to the sun in an area devastated by lumbermen and another (A. M. N. H. No. 25589) under the remaining loose bark of a solid, prostrate log also well exposed and lying in the same devastated area.

July 23. Hunting in the forest near the base of Pine Mountain about two miles southwest of the School we found four specimens (A. M. N. H. Nos. 25590-25593), the first two under the loose, decaying bark on the upper side of a huge, prostrate, chestnut log and the last under the loose bark of another fallen chestnut tree four or five feet in diameter and not far from the first. Both logs were solid.

The third specimen was found with a batch of fourteen eggs in a prostrate water-oak limb eight feet long and one foot in diameter. The eggs were in a long, shallow cavity one to three inches wide by one deep and near one end of the limb. Much of the bark was missing and the log, though still solid, had a thin layer of decayed wood under the bark where the eggs were found. The cavity was on the side of the log and so the eggs, though virtually suspended, actually rested against the cavity's bottom or the side of the log.

The eggs formed an irregular cluster, adhering closely one against the other, but held by four short mucous cables against the side of the cavity. The main one of these cables was two or three millimeters in diameter while the other three were less than half that size and irregularly arranged and connected. The eggs were not otherwise connected with the wood. In color they were a dirt-brown with a tinge of yellow, but much of the color may have been due to stain from the decayed wood. The egg capsules were probably colorless at first. The outermost capsule of each egg is about five millimeters in diameter. I could detect no sign of arranging or smoothing done in the cavity by the adult. Unfortunately, the eggs were not noticed until the adult had been secured in a vial with one other and therefore I cannot be sure of the sex. One of the two was a male (A. N. M. H. No. 25591) and the other a female (A. M. N. H. No. 25590). Probably it was the female that guarded the eggs.

A. lugubris attaches each egg by a separate cable to the wall of the containing cavity (Ritter and Miller, 1899 and Ritter, 1903). We must conclude that *A. æneus* differs in having its eggs directly adherent one to the other, the entire mass being attached to the cavity's wall by one or more short cables.

July 24. During a long half-day's search we found only one specimen (A. M. N. H. No. 25594). It was taken in the forest near the base of Pine Mountain some two miles southwest of the School under the very loose, decaying bark of a chestnut limb or small tree barely a foot in diameter leaning against other trees. The salamander was about five feet above the forest floor.

July 25. It was not until this date that we really found the true habitat of *A. æneus*. On this day our first three hours netted twelve specimens and yet we hunted just where we had worked before with little result. Searching in the forest along the Laden Trail we found:

- (a) one at the base of Pine Mountain under the very loose bark of a solid chestnut stump five feet high and ten inches in diameter;
- (b) six or seven more not far away under the very loose bark of a solid white walnut limb some twelve feet long and eight inches in diameter lying near a stream in heavy shade with one end propped against small trees and the other resting on the ground;
- (c) two more only twenty feet away on a solid, poplar log placed much as the white walnut just described;
- (d) two more under the bark of the end branches of a large, solid, basswood log lying in a tangle of weeds and bushes about halfway up Pine Mountain, three to four feet above the forest floor;
- (e) two more under the bark of a large, solid chestnut limb lying across a fallen tree; and finally,
- (f) four more under the bark of a large, solid, maple log lying near the road about halfway up the mountain.

July 28. In about an hour's hunting alone in the woods between the School and the reservoir I found five specimens:

- (a) two of which were under the loose bark of a slender, solid, chestnut log leaning against some living trees;
- (b) one more three feet from the ground under the loose bark of a small, solid stump about four feet high; and finally,

- (c) two more, one large and one small, four to five feet from the ground under the loose bark of an upright, dead, white walnut tree still quite solid and only four to six inches in diameter.

Aneides xneus, then, lives under the loose bark of dead trees. Unfortunately, only the popular names of the trees on which my series were taken can be given, though these may be relied upon because they were verified by an advanced student of the Settlement School.

12 examples were living on chestnut
8 or 9 examples were living on white walnut
5 examples were living on water oak
4 examples were living on maple
2 examples were living on poplar
2 examples were living on basswood
1 example was living on pine
1 example was living in a decayed log

Three additional specimens were found on logs which I failed to identify. The names of at least two of these undetermined logs would be included in the above list. The great numbers of fallen chestnuts on Pine Mountain may account for their heading the list. It would seem that *Aneides xneus* shows little preference for the kind of tree but cares very much about the nature of and the condition the bark happens to be in. Bark that, in becoming loose, leaves a continuous cavity beneath, is preferred. In size the logs varied so much that I do not regard size as a significant factor. Twenty-three specimens were seen on prostrate logs and limbs, twelve or thirteen on logs and limbs not upright but supported at various angles, while only four were found on dead trees and stumps standing erect. These figures are misleading because at first we searched almost entirely on fallen logs. My later hunts convinced me that dead trees yet standing are frequently inhabited. That it does not live in or under moss is evident because from the first we scraped moss from dead trees and yet not one did we find in or near moss. Countless rotten logs were broken up but only one specimen, and that one the very first, was found in soft, decayed wood. All the rest were taken on solid logs and limbs. Our examples, for the most part, were found at altitudes ranging from 1700 to 2000 feet. I failed to detect any preference for damp localities, for *xneus* was as abundant in the dry as well as the damp parts of the forests. None was taken more than six feet from the ground. Even though I often peeled bark much higher than this, I made no effort to search among the branches of the larger, upright trees.

When uncovered this species is easily captured for it is slow and deliberate in its movements. As a rule it does not try to escape at once

but remains motionless until further annoyed. It is readily coaxed into bottle or vial. In the laboratory it walks up a perpendicular surface of glass with ease. If motionless, it will remain on the under side of dry glass but cannot walk for more than a few steps without falling off. This shows what a good climber it is. Wherever there is an irregular surface, such as that of rough bark, *A. æneus* can hang from it even with one foot, thanks to the effective terminal expansions on its toes. Though not truly prehensile, the tail may delay or check a fall. It seemed to be unable to

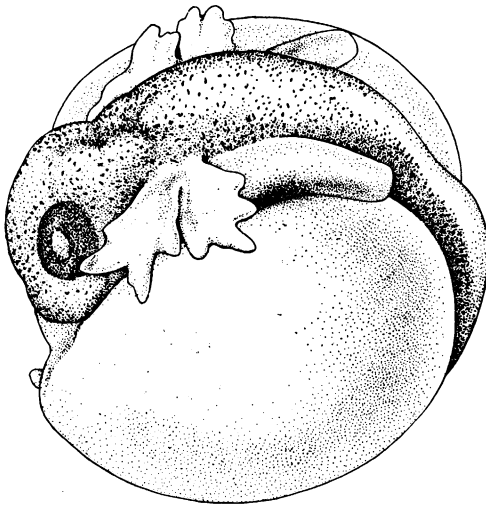


Fig. 1. Encapsuled larva of *Aneides æneus* showing form of gill.

remain suspended by the tail though the latter is often turned about a limb or twig. In the laboratory *A. lugubris* showed more inclination than *A. æneus* to use the tail as a support. When annoyed *æneus* sometimes progresses by a series of short, quick jumps. Otherwise it walks deliberately.

This species is mottled dorsally with very dark but uniform purplish chocolate and stippled green or yellow-green, the yellow being more in evidence on the tail and the region of the limbs next to the body. The yellow is often faint and may even be lacking all together. The ventral surface is uniformly light.

Dunn's (1925) descriptions were made from preserved specimens in which the originally conspicuous green must have long since disappeared.

Measurements (in millimeters) of a series follow: .

MALES				
A. M. N. H. No.	Length of Body	Length of Head	Width of Head	Length of Tail
25583	36.5	12	8.	50
25584	38	14	9	56
25585	32	11.5	7.5	50
25591	43	15	10.	53
25593	34	12.5	8.	29
25594	37	14	9.	67
25602	33.5	12	7.3	47
25604	35	12	7.	50
Averages	36.1	12.9	8.2	—
FEMALES				
25590	47	15	9	60
25592	34	12	7.5	32

The smallest specimen, A. M. N. H. No. 25589, has a body only 17 mm. long. Judging from measurements given by Dunn (1925), *æneus* is the smallest species of the genus.

The gills were just appearing in the eggs when found on July 23, but by the 28th they had developed to the point shown in Fig. 1. Structurally these are intermediate between the very broad "stag-horn" gills of the western *Aneides* and the branched but narrower *Plethodon* gills. The eggs of *A. æneus* are enclosed by two capsules, the outer soft and thick, the inner resistant and thin.

***Desmognathus fuscus fuscus* (Rafinesque)**

I place here 104 specimens (A. M. N. H. Nos. 25193–210, 25605–611, etc.) found on Pine Mountain, July 26 through the 28th. Seven females were found guarding egg clusters and one additional cluster was secured. These clusters are formed in the usual way. The embryos are in advanced stages of development in four of the clusters, though only the eyes are pigmented. The eggs of the remaining four are in earlier stages, only the neural groove being visible in two. The eggs range in number from fourteen to thirty-three with an average of twenty-four for each cluster.

The clusters of Nos. 25606–8 were found under and in thick moss growing on a decayed log lying in a spring stream near the base of Laden Trail. These eggs were not placed directly above a flow of water. Cluster No. 25609 was found on the School grounds in Limestone

Branch under a small, flat stone embedded in a low mud-bank five feet from the main flow of water but at the edge of the rocky stream-bed. No. 25611, the cluster whose guarding adult was not secured, was also found in Limestone Branch. It was deposited some three feet above a flow of water under thick moss growing on a boulder.

The *fuscus* of this series are by no means typical but represent a gigantic local form as the following figures will show. Dunn (1926) gives measurements of a series of twenty-two males and eighteen females, all but one of which come from Virginia and Pennsylvania. For purposes of comparison I have used his measurements of the ten largest of each sex. My own measurements were made from twenty-four adults, eleven males and thirteen females, all but six of which were picked at random from ninety-seven Pine Mountain specimens. The extra six were those found guarding eggs. All measurements are in millimeters (see table on p. 12.)

In only two places do Dunn's average measurements exceed those made from the Pine Mountain *fuscus*, viz., length of tail (4.9) and total length (1.2). The figures below show the degree to which those of the Pine Mountain series exceed the typical ones.

	Length of Head	Length of Body	Length of Tail	Total Length
MALES	4	3.2
FEMALES	5.1	10.7	2.2	18.1

***Desmognathus fuscus carolinensis* (Dunn)**

While collecting Plethodons on Wayah Bald I noticed that one or two of the *carolinensis* taken had colored cheeks. Now I find in the preserved specimens that none of the seven (Nos. 25334-340) taken there has a colored cheek, but two (Nos. 25339 and 340) have light areas where the color must have been. The seven specimens were taken along the banks of the same stream.

Among nineteen specimens (Nos. 25443-454 and 25534-540) taken in one small area on Andrews Bald seven (Nos. 25443-446) still have distinct color patches on their cheeks.

Dunn has recently described a new race of *D. fuscus* from the Great Smokies. His five examples, four of which I have before me, come from Indian Gap which is very near Andrews Bald. He says that the new race, *imitator* is "very similar to *carolinensis* except for color" and gives three characters which are: colored cheeks, lead-black bellies, and lack of distinctly banded backs. Then he says that No. 72761 has an "indefinitely marked" cheek. This one then is similar to my two (Nos.

MEASUREMENTS OF COMPARATIVE SERIES OF *D. fuscus fuscus*

MALES

	Length of Head		Length of Body		Length of Tail		Total Length	
	Extremes	Average	Extremes	Average	Extremes	Average	Extremes	Average
Dunn's Series Pine Mountain Series	11.0-14.0	12.6	41-54	48.8	42-66	49.2	94.0-134	113.6
	14.5-17.5	16.6	49-56	52.0	35-53	44.3	99.5-126	112.4

FEMALES

	Length of Head		Length of Body		Length of Tail		Total Length	
	Extremes	Average	Extremes	Average	Extremes	Average	Extremes	Average
Dunn's Series Pine Mountain Series	7.0-11.5	8.8	25.5-42	35.3	27.0-55	41.5	62-107	85.6
	13.5-14.5	13.9	41.0-50	46.0	32.5-53	43.7	86-115	103.7

25339-340) from Wayah Bald, for certainly Dunn's specimens were selected for their colored cheeks and the color in his No. 72761 has faded just as in my Nos. 25339 and 25340. In my nineteen from Andrews Bald the seven that retain the color correspond to Dunn's four remaining specimens that likewise retain definite traces of color. How many of the remaining twelve from Andrews Bald had some color in life it is impossible to say, but the cheeks of several might be styled "indefinitely marked."

The collector of the type and paratypes of *imitator* was probably unconsciously selecting his material.

As to the indistinctness of the dorsal band, I find that No. 25444, one of the seven from Andrews Bald with colored cheeks, has no dorsal stripe, while in No. 25445, also one of this seven, it is very indistinct. A third from this same lot, No. 25446, has an indistinct band, while the remaining four have normal bands.

Dunn's third character seems to be good, for the bellies of my specimens are generally lighter than those of his that I have examined. This might easily be the result of a different method of preservation.

In size there is only a slight disparity, for the two largest among my seven from Andrews Bald measure only 28 mm. body length, while Dunn's largest specimen retaining the colored cheeks has a body 32 mm. long.

Dunn's *imitator* seems to be little more than a local color variety of typical *carolinensis* and should therefore be placed in the synonymy under that form.

The American Museum of Natural History has received many large specimens of *D. fuscus carolinensis* from Gatlinburg, Sevier County, Tennessee. Andrews Bald, Indian Gap, and Gatlinburg are all in the same region. Seven among a lot of seventeen have white cheeks while the cheeks of the remaining ten are swollen and probably were colored in life. The collector, Mr. Oakley, writes of sending colored cheeked examples. All but one of this lot of seventeen have very dark bellies while the backs of some of them show traces of bands as in typical *carolinensis*. Unfortunately, this lot is in a wretched state of preservation.

From the above data we may conclude that *D. fuscus carolinensis* from the Great Smokies frequently has colored cheeks. Further field studies will show whether or not in certain regions examples without this character are lacking. Apparently here we have a species in the making and this is all the more significant in view of the fact that this same color character has been so well developed in another genus in this same region.

Dunn has called it a "clear case of mimicry." If this cheek character did not arise as a single mutation the question develops, what became of the intergrades between the coral-cheeked *P. jordani* and the species from which it sprang? Further, will the colored-cheeked *carolinensis* finally establish itself as a distinct race? The cheek color probably has little selective value and hence it seems that other changes, perhaps physiological characters which have accompanied the genesis of the cheek character, may give colored or non-colored forms the upper hand in the struggle for existence.

***Desmognathus phoca* (Matthes)**

Under *L. m. intermedia* I tell of securing 146 salamanders on Lee Mountain, the locality from which Dunn records *L. marmorata*. All but one of these I identify as *phoca*. Among them are A. M. N. H. Nos. 25342-25388 and 25390-25431.

***Desmognathus quadra-maculatus* (Holbrook)**

I found this species to be common in the streams about Highlands (A. M. N. H. No. 25254). Such localities are approximately 3800 feet above the sea. I also took it near the top of Wayah Bald (A. M. N. H. No. 25268) and high up on Andrews Bald in the Great Smokies (A. M. N. H. Nos. 25541-3). The body of No. 25541 from Andrews Bald is 70 mm. long and other large individuals were seen there. The species evidently attains a great size in this region.

One specimen taken at Highlands assumed the defensive, opening its mouth threateningly when I reached out to catch it.

***Leurognathus marmorata intermedia*, new subspecies**

TYPE.—A. M. N. H. No. 25557; ♂; Davis Gap, Waynesville, North Carolina; July 17, 1927.

DIAGNOSIS.—This new subspecies may be distinguished from *marmorata* by the presence of vomerine teeth; arched roof of mouth; smaller size; more numerous and smaller markings of the dorsum.

DESCRIPTION.—Vomerine teeth are present in the adult female and generally in the young, but they are frequently lacking in the larger males. Six out of eleven of the largest males in the series lack the vomerine teeth, while all but one of the seven largest females possess them. Even in that one a trace is present. Among seventeen immature examples the vomerine teeth are present in twelve and absent in five.

The arched, narrow roof of the mouth is in marked contrast to the comparatively flat and wide roof in *marmorata*.

The dorsum in *marmorata* is completely covered by two parallel rows of light, indefinitely outlined blotches, about six blotches in each series from the head to the base of the tail. *Intermedia* has two series of widely separated, small spots, one down either side of the back. There are about ten spots in each series to the tail.

The following table shows the relative size of the two forms. The figures represent measurements of a series of twelve adult *marmorata* and eighteen *intermedia*.

MALES

	Longest Body	Average Length of Body	Longest Head	Average Length of Head	Widest Head	Average Width of Head	Longest Tail
<i>Marmorata</i>	60	51.7	16	14.8	12	10.8	48
<i>Intermedia</i>	52	44	15	13.8	11	10.4	40

FEMALES

<i>Marmorata</i>	53	49	15	14.1	12.5	10.2	57
<i>Intermedia</i>	44	40.6	12	11.8	10	9.1	39

Near Waynesville on July 17 I hunted the most easterly source of Raccoon Creek, a small, clear stream that rises in the mountains forming the southern shoulder of David Gap and flows northward until it reaches the Pigeon Road where the latter passes through the bottom of the Gap. While flowing immediately beside the road for the fraction of a mile the stream turns slightly westward to make its way down the valley into Francis Cove. My work began at an altitude of about 3400 feet, just above the point where the stream first approaches the road. There the mountain side is steep and but little shaded, while the bed of the stream is a mass of loose rock and earth with almost no vegetation. Here, only *phoca* was seen, but it was present in numbers.

As one ascends, the valley narrows, becoming steeper and steeper, until it disappears entirely, forcing the water to fall over a little precipice, the top of which is about 4000 feet in altitude, or five to six hundred feet above the point where *phoca* was common. At the top of this cliff I found *phoca* scarce, while *intermedia* was abundant. In fact, they were so numerous that with my own hands I secured fifty-eight specimens (among them A. M. N. H. Nos. 25544-25580) in an hour and a half.

Moore (1899), Bishop (1924) and myself (1924) have all noted the aquatic habits of this genus and former observations are beautifully confirmed by my recent ones in this new locality. Even though living

in such a shallow, open stream the behavior of *intermedia* was in strong contrast to that of the *phoca*. When uncovered *phoca* darts or dashes wildly away over the rocks looking for a place of retreat, but *intermedia* either remains motionless on the bottom or glides gracefully to cover under water. Only when surprised out of water or teased and cornered will it behave like *phoca*.

On July 12 I visited Lee Mountain, which is very near Davis Gap, to see if it is inhabited by *marmorata* (Dunn, 1924). I found the mountain to be only 4200 feet high while the source of the highest stream is not more than 3500 feet. I hunted this stream just below its source and in four hours caught 146 salamanders, only one of which is *intermedia*. Lee Mountain does not attain the necessary altitude for *intermedia* to be abundant on it. Dunn's Lee Mountain *marmorata*, the only specimen known possessing vomerine teeth, is obviously *intermedia*.

In structure and habits this new form agrees with *marmorata*. The frequent loss of the vomerine teeth in the adult male links it up with the *fuscus* group.

SUMMARY AND DISCUSSION

EVOLUTION OF CERTAIN SPECIES OF *Plethodon*

The question of the mutual relationships of the four species of *Plethodon*, *glutinosus*, *metcalfi*, *shermani* and *jordani*, is an interesting one. When different factors are considered these four species arrange themselves in different order. For example, *glutinosus* is the largest with an average body length of 54.5 mm., while *shermani* follows, its average length being 45.3 mm.; *metcalfi* and *jordani* stand together at 40.4 and 40.3 mm., respectively. Considering the amount of difference in size between the sexes we find that *glutinosus* and *metcalfi* come together with the body length of the female exceeding that of the male 4.8 and 4.7 mm. respectively. The respective figures for *shermani* and *jordani* are .5 and 1.5 mm.

Obviously, from the foregoing accounts of habits, *shermani* and *jordani* show remarkable similarity, for both are narrowly restricted in range and live only at the highest altitudes. *Metcalfi* is here intermediate with a comparatively wider range and decided preference for considerable altitude. Quite as obviously *shermani* and *jordani* come together in regard to color, each being distinguished by a small amount of coral red on the body. However, Dunn (1925) says that the black color is deepest in *jordani* and lightest in *metcalfi*. Thus he throws *glutinosus* and *shermani* together with *jordani* and *metcalfi* at the extremes. He also puts

jordani and *shermani* at the extremes as having respectively the longest and shortest vomerine series. Again, *metcalfi* and *glutinosus* are thrown together.

Thus far, then, this discussion has lead us nowhere. The four species arrange themselves in almost as many groupings as factors considered. It would seem, however, that *shermani* and *jordani* have a certain superficial resemblance.

Disregarding the above and considering geographical distribution we find that the ranges of three, *shermani*, *jordani* and *metcalfi*, are circumscribed by that of the fourth, *glutinosus*. This would indicate that *glutinosus* is the primary ancestral stock. The question of direct ancestry remains: did *shermani* and *jordani* split directly off from *glutinosus* or are they more directly related to *metcalfi*? *Glutinosus* and *metcalfi* are intimately associated in the Southern Blue Ridge and are often found under the same log. Moreover, both Dunn (1926) and Noble (1927) record intergrades. It may reasonably be concluded that *metcalfi* has evolved directly from *glutinosus*. *Metcalfi* is not found in the Great Smokies and possibly not in the Nantahalas, but the latter range connects the Blue Ridge with the Great Smokies so it is easy to imagine that *shermani* arose directly from *metcalfi*, the two thus inhabiting adjacent ranges. The only remaining evidence of relationship is a specimen of *jordani* recorded by Dunn (1926) lacking the colored cheek, but having coral on the legs. Thus the available evidence strongly suggests that *shermani* arose from *metcalfi* and *jordani* from *shermani*. However, no good intergrades between *shermani* and *jordani* are present in either of my series. The final solution of this problem must await the discovery of further evidence.

THE STATUS OF *Desmognathus fuscus imitator* DUNN

It is interesting to find among species of two genera living in the same area a character, in the one case fixed and invariable and in the other, unfixed and quite variable. I refer to the colored cheek patch, the most conspicuous character distinguishing *jordani* from *metcalfi*. In the case of *Desmognathus fuscus carolinensis* from the Great Smokies this character frequently appears in a few individuals from any locality, but in *Plethodon jordani* it is sufficiently constant to be called a specific character. Here we see an unstable character in one species becoming fixed in another. In the genus *Plethodon* color characters such as the red legs of *shermani*, the white spots of *glutinosus*, etc., seem to have little survival value. It is hard to see how the intergrades between *jordani* and the

form from which it evolved were eliminated by natural selection. A similar process is going on at present with *carolinensis* and a study of this species might shed light on the mechanism of evolutionary changes. We cannot even conjecture as to why this color character is appearing. Dunn (1927) suggests that it is a case of mimicry but offers no evidence to support his theory.

THE ORIGIN OF THE GENUS *Leurognathus*

It has been assumed that *Leurognathus marmorata* evolved from *Desmognathus quadra-maculatus* in one step. The discovery of the new form *intermedia* shows that the change has been more gradual.

THE RELATIONSHIPS OF *Aneides æneus*

Relationship between *Aneides* and *Plethodon* is evidenced by similarity in structure as well as habits. The former genus is more specialized than the latter in both habits and structure.

All species of *Aneides*, except one, inhabit the extreme West, but this one exception is found on the Cumberland Plateau thousands of miles from its closest relatives, but closely associated with *Plethodon*. Moreover, the less modified teeth of this species indicate its close relationship to *Plethodon*. Storer (1926) maintains that the trans-continental migration of salamanders has for a large part of Tertiary time been very difficult.

In certain habits recorded above *æneus* strongly resembles *lugubris*; in certain others it resembles *Plethodon*, while in larval gill form it occupies an intermediate position.

In brief, then, *Aneides æneus* resembles *Aneides lugubris* in (a) generic characters of skeleton and (b) behavior, especially as shown by its arboreal habits. It resembles certain *Plethodons* in (a) method of egg attachment. In gill form it occupies an intermediate position.

CONCLUSIONS

1. *Plethodon shermani* and *jordani* are good species whose ranges are not intruded upon by their closest relatives, *metcalfi* and *glutinosus*.
2. *Desmognathus fuscus imitator* Dunn is nothing more than an unstable color variety of typical *D. fuscus carolinensis* and should be placed in the synonymy of that form.
3. Pine Mountain, southeastern Kentucky, is inhabited by a gigantic local form of *Desmognathus fuscus fuscus*.
4. *Leurognathus marmorata intermedia*, new subspecies, is distinguished from typical *marmorata* by its smaller size, distinctive color pattern, and possession of

vomerine teeth. It may be considered as a form intermediate between *Desmognathus quadramaculatus* and *Leurognathus marmorata*.

5. Although *Aneides zeneus* is nearer to *Plethodon* than any other member of its genus, it shows still closer relationship to *A. lugubris*. Thus, its position in the genus *Aneides* is firmly established.

BIBLIOGRAPHY

- DUNN, E. R. 1924. 'A New Specimen of *Leurognathus marmorata*.' Copeia, No. 127.
 1926. 'The Salamanders of the Family Plethodontidæ.' Northampton, Mass.
 1927. 'A New Mountain Race of *Desmognathus*.' Copeia, No. 164.
- NOBLE, G. K. 1927. 'The Plethodontid Salamanders; Some Aspects of Their Evolution.' Amer. Mus. Novitates, No. 249.
- POPE, CLIFFORD H. 1924. 'Notes on North Carolina Salamanders with Especial Reference to the Egg-laying Habits of *Leurognathus* and *Desmognathus*.' Amer. Mus. Novitates, No. 153.
- RITTER, W. E. 1903. 'Further Notes on the Habits of *Autodax lugubris*.' Amer. Naturalist, XXXVII, pp. 883-886.
- RITTER, W. E., AND MILLER, L. 1899. 'A Contribution to the Life History of *Autodax lugubris* Hallow., a Californian Salamander.' Amer. Naturalist, XXXIII, pp. 691-704.
- STORER, TRACY I. 1925. 'A Synopsis of the Amphibia of California.' Univ. Calif. Publ. Zool., XXVII, pp. 1-342, Pls. I-XVIII.

