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NOTES ON NORTH CAROLINA SALAMANDERS WITH ESPECIAL REFERENCE TO THE EGG-LAYING HABITS OF *LEUROGNATHUS* AND *DESMOGNATHUS*

BY CLIFFORD H. POPE

The observations recorded in this paper were made during July and August 1924 in and about Flat Rock, near Waynesville, in the Pisgah National Forests, and along the road from Linville to Blowing Rock. The last three localities were only briefly visited but the streams and woods in and about Flat Rock were hunted off and on for two months.

Flat Rock is in Henderson County, two miles southeast of Hendersonville, the county seat. Specimens taken here were found from 2100 to 2300 feet above sea level.

Linville is in Avery County. About twenty miles northeast of Linville, and in the extreme south of Watauga County, is Blowing Rock. Grandfather Mountain, located between these two towns but much nearer the former, rises to a height of 5964 feet. The Linville-Blowing Rock road (Yonahlossee Road on maps) winds around this bulky mountain on its southern flank maintaining for some distance an altitude of 4100 feet. Wilson Creek has its source high up on Grandfather just south of the summit and, in flowing directly south, crosses the Yonahlossee Road at 4100 feet. This stream is part of the Atlantic water-shed. Boone Fork, rising well up on Grandfather east of its summit, flows eastward for some distance parallel to, and just north of, the Yonahlossee Road. The section of this stream to be referred to is about 3425 feet above sea level. Boone Fork belongs to the Gulf water-shed.

Pisgah National Forests ("Pisgah Forest Reserve") lie largely in Transylvania County. Looking-glass Creek flows into Davidson River before the latter emerges from the Forests. These water-courses form part of the Gulf drainage. The well-known Looking-glass Falls are at an altitude of about 2900 feet.

Waynesville is a town in Haywood County. Its altitude is 2638 feet.

The author desires to express his gratitude to Dr. G. K. Noble for encouragement, interest, and many invaluable suggestions. Dr. E. R. Dunn very kindly assisted in identifications.

The specimens discussed in this paper are now in The American Museum of Natural History.

Cryptobranchidæ

***Cryptobranchus alleganiensis* (Daudin)**

One adult specimen taken July seventeenth a mile below Looking-glass Falls, in Looking-glass Creek, Pisgah National Forests, at an altitude of about 2600 feet.

Salamandridæ

***Triturus viridescens viridescens* (Rafinesque)**

One specimen was found crossing a road at Flat Rock (2150 feet), one under a discarded railroad tie in Pisgah National Forests immediately above Looking-glass Falls (2900 feet), and one in the woods by the Linville-Blowing Rock road two miles from the former (4100 feet). All three are examples of the red land-form.

Plethodontidæ

***Plethodon cinereus* (Green)**

Common along the Linville-Blowing Rock road. No specimens were found about Flat Rock, nor in Francis Cove near Waynesville.

***Plethodon glutinosus* (Green)**

Very common about Flat Rock, in Francis Cove near Waynesville, and along the Linville-Blowing Rock road. Less agile and alert than *P. metcalfi* and therefore more easily taken.

***Plethodon metcalfi* Brimley**

Readily found in Francis Cove near Waynesville and about Flat Rock, though in neither place was it as common as *P. glutinosus*. Common along the Linville-Blowing Rock road.

***Gyrinophilus danielsi* (Blatchley)**

One specimen (A. M. N. H. No. 21,177) was taken in Argyle Woods, Flat Rock. It was found under soaking leaves in the bed of a spring

stream and was very hard to catch because of its activity and great strength. Seven larvæ were taken, three in Flat Rock mountain brooks, and four in Wilson Creek, Grandfather Mountain. The largest is 122 mm. long.

***Pseudotriton montanus montanus* (Baird)**

On July tenth an adult female containing ovarian eggs two millimeters in diameter was taken far from water near a dry wood under a pile of logs and boards lying in a grassy yard on a low hill at Flat Rock.¹ Another adult was caught July fifteenth near the foot of this same hill, under a pile of trash in a low meadow near a brook. The third was secured in the same neighborhood August twelfth. No adults were found elsewhere.

Eight larvæ were taken in a small pine-needle-filled spring stream. The largest, measuring 66 mm., is spotted like the adult.

***Pseudotriton ruber schencki* (Brimley)**

Not uncommon about Flat Rock. July 20th, on Trenholm Mountain, Flat Rock, a very dark specimen was taken at the base of a rock wall on the edge of a wood. This female contained ovarian eggs 3 mm. in diameter.

***Eurycea bislineata wilderæ* Dunn**

About Flat Rock specimens were seen only in Argyle Woods. In the Francis Cove woods, near Waynesville, the species seemed to be common.

***Eurycea gutto-lineata* (Holbrook)**

About Flat Rock this species was found with *P. montanus montanus* and *P. ruber schencki* under a pile of trash near a brook flowing through an open meadow. This same meadow and brook are mentioned under *Pseudotriton montanus montanus*. In a perfectly dry place under a lot of boards and logs on the edge of Argyle Woods fifty feet from the Argyle Lake stream, *gutto-lineata* was taken along with *Plethodon glutinosus*, *Plethodon metcalfi*, *Pseudotriton ruber schencki*, and *Eurycea bislineata*. In the spring stream nearby (see under *Desmognathus quadramaculatus*) *Gyrinophilus danielsi*, *Desmognathus quadramaculatus*, *D. phoca*, and

¹Miss Margaret Huger is responsible for the discovery of this locality as well as two of the adults. The author takes this opportunity to express his appreciation of her interest and help.

D. fusca carolinensis were found, the last three species in abundance. *E. gutto-lineata* was common in another locality under débris strewn along the edge of a grassy-banked stream flowing through dry, open woods.

A large specimen was taken in Francis Cove near Waynesville under one of several logs lying far from water in a grassy orchard on a dry hill.

This lizard-like salamander is hard to catch because of its great activity.

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

The author is convinced from his study of *carolinensis* in the field that the latter is similar to *Desmognathus fuscus fuscus* in habits. The two are certainly closely related structurally. Although unacquainted with *D. ochrophæus ochrophæus* in the field, the author prefers to remove *carolinensis* from the species *ochrophæus* and to make it a sub-species of *fuscus*.

In all the shaded brooks about Flat Rock this species was abundant. In the rocky hill-streams females with eggs were found, but only in small numbers. In such places the eggs were deposited at varying depths in the dead leaves, mud, and among rocks above, or just beside, flowing water. Immediately northeast of Trenholm Mountain¹ in a thick, level woods, two or three small spring-streams or brooklets meandered along, spreading at places to some width. The resulting boggy, mossy area swarmed with brooding salamanders. Working alone in these woods on the afternoon of August twenty-first, the author secured fifty-nine egg-clusters, taking an adult with nearly every cluster. Not more than one hundred yards of stream-bed were covered. At its widest section, this particular brooklet spreads out to a width of fifty feet. This gives some idea of the abundance of the species in a favorable locality. Moss grows to a thickness of from one to three inches over roots and decaying wood in and along the bed of these brooklets. It is in this moss that the females congregate to deposit their eggs. They pick out preferably a well-covered log actually lying in the brooklet. In one such log described under *D. phoca*, eight clusters of *D. fuscus carolinensis* eggs, and one cluster of *D. phoca* eggs, were found. These eight clusters were below the moss, i.e., between it and the decayed log beneath. Eggs are found in or just under the moss and always over or immediately beside flowing water. None were found more than two or three feet from flowing or seeping water. One large log lay almost parallel to the flowing water

¹Trenholm Mountain is on the George J. Baldwin property called "Mountain Lodge."

along the low bank. Although well covered with moss along its entire length, and nowhere more than three or four feet from flowing water, only at its lower tip, a few inches of which actually projected out over the brooklet, were egg clusters found. After stripping all of the log but these last few inches (which escaped notice) the author moved on, having found nothing. Returning later, purely by accident he saw the projecting tip still covered with its small patch of moss. There, directly over the water, and within a few inches of one another, several clusters with adults were found. This well illustrates their love for real proximity to water.

A series of a hundred clusters were taken from two or three connected streams in the one locality. In practically every case adults were found with the eggs. The adults were shy and made off unless promptly secured. The mere uncovering of the adult and eggs did not generally suffice to start the former on the run, but any further annoyance did. With a few exceptions, the eggs formed one compact cluster. Some clusters were slightly scattered. The adult was usually coiled about the eggs. A cavity was very evident in the majority of cases. Wilder's comparison of the eggs of *D. fuscus* to a bunch of toy balloons may be used to great advantage here. The prevailing tendency is to join the eggs at one point, thus forming a spherical, compact mass. Sometimes there is an irregular stringing out along a very short, gelatinous cord and sometimes, though seldom, the eggs seem to be stuck or joined at random into an irregular mass or even two shapeless masses. A tiny root or small piece of bark often forms a base of attachment. A typical cluster may be rolled about or dropped without coming apart. It is so compact that only a close examination reveals the way in which the bunch is held together.

Data compiled from study of the series of 100 clusters, 92 of which are accompanied by their respective adults, are given below. Twenty-three of these were found on August eighteenth, fifty-six on August twenty-first, and the rest on August twenty-third.

Five of the clusters had larvæ on the point of emerging; the larvæ of fifty-five more clusters had distinct color patterns and were almost ready to emerge; the color patterns on the larvæ of seventeen other clusters showed only faintly, while twenty-nine clusters had practically unpigmented but well advanced larvæ. Eggs of the remaining four clusters were still in the cleavage and gastrula stages. That the average number of eggs found with one adult is 10.25 is shown by the following table:

2 clusters had		4 eggs each	
2	"	"	5 " "
3	"	"	6 " "
8	"	"	7 " "
7	"	"	8 " "
16	"	"	9 " "
18	"	"	10 " "
16	"	"	11 " "
13	"	"	12 " "
4	"	"	13 " "
2	"	"	14 " "
3	"	"	15 " "
3	"	"	16 " "
2	"	"	17 " "
1 cluster	"	"	18 " "

The average might be raised a fraction to make allowance for the few eggs overlooked or lost.

Formalin eggs in the cleavage and early gastrula stages are 3 mm. in diameter; those with embryos about to emerge, 4.5 mm.; while just emerged embryos measure 15 mm., total length.

Measurements of ten brooding adults taken at random (formalin specimens) follow:

TOTAL LENGTH	SNOUT TO POSTERIOR ANGLE OF VENT
70 mm.	33.0 mm.
65	31.5
61	31.5
60	31.0
60	29.0
59	29.5
57	29.0
56	29.0
55	27.5
48	26.0

Wilder¹ states that *D. fuscus fuscus* from western Massachusetts examined by her ranged from 14 to 28 eggs for each female but averaged 20. In this respect, there is a marked difference between typical *fuscus* and *fuscus carolinensis*.

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

One specimen from Flat Rock dated August fourth, and three from Waynesville dated July twenty-fourth to twenty-sixth.

¹Wilder, Inez Whipple. 1907. 'On the Breeding Habits of *Desmognathus fusca*.' Biol. Bull., XXXII, pp. 13-20.

***Desmognathus phoca* (Matthes)**

In the vicinity of Flat Rock this is the salamander commonly found in and about brooklets and streams of all sizes and called "spring lizard" by the natives. Specimens were often taken in the woods some distance from water. It is frequently seen in protected walled-in springs and is said occasionally to gain entrance to the human mouth by way of drinking water.

July twenty-seventh on Many Pines Plantation, East Flat Rock, with the able assistance of Mr. Bennett, the author found a cluster of thirty eggs fastened to the under-side of a stone (measuring approximately $7 \times 8 \times 4$ inches) in the bed of a clear brook flowing through a gently sloping field. The eggs bore no sign of embryos and measured 5 mm. in diameter. An adult female under the stone was readily taken. This location was just below an open, level wood from which the brook emerges. The bed of the brook, about eight feet wide and five feet below the level of the field, is made up of sand, gravel, and small stones. The banks were covered with a dense growth of briars, weeds, and bushes which well shaded the water. The stone to which the eggs were attached, one foot from the actual flow of water, rested on pebbles, gravel, and sand just beside an eight-inch drop in the bed. At this drop the water flowed swiftly over the few obstructing stones. It should be noted that while these eggs were not in the water, they were approximately at its level and would have been well submerged by any swelling of the brook. In these mountains summer thunder showers frequently occur.

August first at the northeast base of Trenholm Mountain in a brooklet which trickles through a level wood, the author found an adult female apparently guarding a cluster of 21 eggs, also in the early stages of development. The brooklet spreads out over the level woods floor to varying widths. An almost wholly decayed log lay in the bed. The log, ten feet long but not more than one in diameter, was covered with a growth of moss two or three inches thick. Beneath the moss, in a cavity in the remains of the log, this cluster was found adhering to the rotten wood. Between the moss and log, eight clusters of *carolinensis* eggs were found. All of these clusters were from five to eight inches above the very shallow water flowing along the log.

The eggs of *phoca* are attached in the same manner as those of *quadramaculatus*. The twenty-one eggs found in the log were spread out more than the thirty found on the stone, but as much might have been expected. In every essential the method of egg attachment is the same in these two species.

Dunn¹ says of *phoca*: "It is not nearly so aquatic as *quadramaculatus* and is found only in small streams." The author's experience with *phoca* does not allow him to agree with the last part of this statement, for *phoca* was found in every rocky stream hunted. Unlike *quadramaculatus*, it does not frequent deeps and rapids of the larger, swifter streams, but is satisfied to stay among the rocks and trickles along the edge. The remainder of Dunn's admirable account of the habits of *phoca* is confirmed by the author's observations.

***Desmognathus quadramaculatus* (Holbrook)**

At Flat Rock this large salamander was abundant in all the rocky, mountain and hill streams. Stony spring streams, cascading down steep, wooded hillsides, seemed to be their favorite haunts. In Argyle Woods, up on a low mountain, a spring rises. Its small stream flows for less than a quarter of a mile down through a thick jumble of decaying leaves, sections of logs, and small, flat stones. A steep, wooded acclivity rises on either side. In this stream the black salamanders swarmed. The largest specimens seen were taken here. *D. quadramaculatus* is slippery and agile and, in such a difficult place, especially hard to catch. In spite of this, the author, hunting alone, secured more than fifteen specimens in two hours. Here one could walk but a few steps in the stream bed without seeing a specimen dart into the leaves, among the stones, or under a log.

On July thirteenth the author was working up the bed of this stream with Mr. Alexander King.² Mr. King turned over a small stone which was resting in such a manner on a loose mass of leaves and smaller stones that a vacant space was left beneath. Attached to this stone was a cluster of thirty-eight eggs. A large *quadramaculatus*, which was also under the stone, began to dash about confusedly, obviously reluctant to leave the spot. The actions of this individual were in strong contrast to the usual behavior. It was easily caught. The stone was three feet from, and slightly above, the actual flow of the stream but the looseness of the surrounding leaves and stones would have afforded a larva ample opportunity to work its way down to water. The periphery of the under surface of the stone was in complete contact with the leaves and stones on which it rested. The embryos were in an advanced stage, being well pigmented.

¹Dunn, E. R. 1917. 'The Salamanders of the Genera *Desmognathus* and *Leurognathus*.' Proc. U. S. Nat. Mus., LIII, pp. 393-433.

²Mr. King's father, Judge King, is owner of the Argyle estate and it was through his courtesy that the author was permitted to work in the rich Argyle Woods.

July eighteenth on the old Glenroy¹ estate, Flat Rock, in a brook which flows through a gently-sloping, open meadow after descending a wooded, rocky hill, a cluster of thirty-one eggs was found in a shallow concavity of the under-side of an irregularly-shaped stone measuring roughly $2 \times 8 \times 3$ inches. The bed of the brook was rocky and the stone found in the meadow was one of many jammed together at a slight "drop" in the bed. The water flowed swiftly down over the stones and the eggs were probably not actually in the water. The guarding adult did not make off but stayed to bite viciously the hand that picked it up.

On July seventeenth a small, exceedingly rocky brook which cascades down a steep wooded mountain of the Pisgah National Forests was searched by the author. This brook flows into Looking-glass Creek from the northeast about a mile above Looking-glass Falls. *D. phoca* and *quadramaculatus* were abundant, the latter much smaller than those found in Argyle Woods, Flat Rock. Under a stone (about a foot long and ten inches wide) jammed deep in the mass of stones down over and through which the brook poured, was a cluster of twenty-nine eggs, all with embryos well developed, though entirely unpigmented. In the same lot of stones an adult female *quadramaculatus* was taken. Examination shows that this female had recently laid. This brook is not large and the rocks were many, so probably these eggs were not submerged even though well surrounded by flowing water.

We² worked in Wilson Creek August fifth. This stream crosses the road from Linville to Blowing Rock at a point about fifteen miles from the former (4100 feet altitude). Working below the road just above the first high falls in the stream, we found *quadramaculatus* to be extremely abundant both in the water and under stones along the water's edge. Wilson Creek has a greater flow than any of the Flat Rock streams hunted. The bed of this small mountain torrent is one jumbled mass of boulders and rocks of all sizes. Its rapid descent is made down cascades and over high falls.

In four hours we found the following:

- (a.) Cluster of 30 eggs on under-surface of a cylindrical stone a foot long and 5 in. in diameter. The stone was jammed in a tiny waterfall. Eggs well developed, but unpigmented.

¹Glenroy is now owned by Mr. Gordon McCabe and called "Kunmure." Mrs. McCabe extended to the author a very cordial invitation to hunt on her property. The author takes this opportunity to express his gratitude.

²The plural pronoun is used because the author was enabled to visit this out-of-the-way region only through the courtesy, generosity, and help of Mr. Jack Bennett, who not only offered the use of his car for the three hundred mile trip but his own services as well. Mr. Bennett drove the car and put in lick for lick with the author in his search for salamanders along the Yonahlossee Road. More able and willing assistance could hardly have been wished for. The author here expresses his gratitude and thankfulness for Mr. Bennett's companionship and interest as well as for his invaluable help.

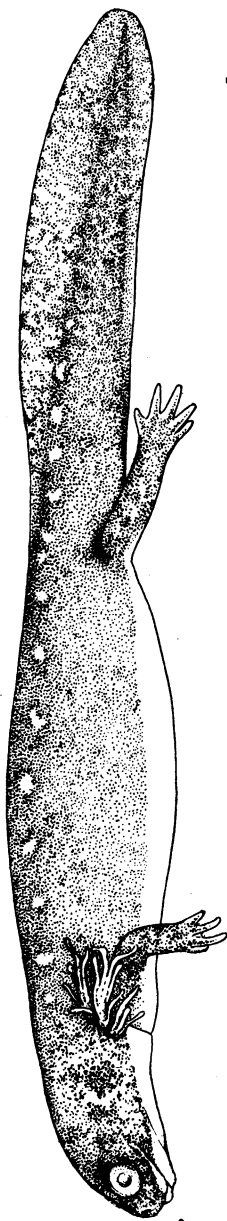


Fig. 1. *Desmognathus quadramaculatus* larva, seven days after hatching. 20 mm. total length, A. M. N. H. No. 21327.

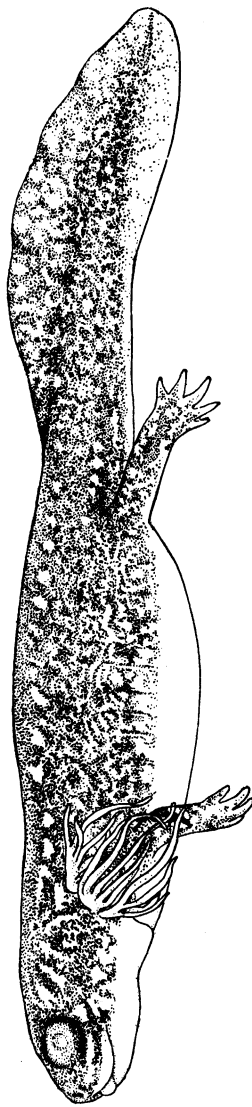


Fig. 2. *Leurognathus marmorata* larva, eight to ten days after hatching. 17 mm. total length, A. M. N. H. No. 21205.

(b.) Cluster of 32 eggs on under-surface of a small flat stone 8 in. long. Eggs in one layer, and faintly pigmented. Stone well submerged in a small "drop" in the stream over which the water rushed.

(c.) Cluster of 15 eggs attached in three irregular groups on the edge of a stone (approximately $15 \times 12 \times 3$ in.). This cluster was found deep in the "drop" and must have been in the water. The scattered arrangement and small number indicate that some eggs were missing. They were found in exceedingly swift water and many had probably been washed away.

(d.) Cluster of 3 eggs on under-surface of a stone about $6 \times 4 \times 2$ in.

(e.) Cluster of 2 eggs on under-surface of an irregularly-shaped stone 18 in. long.

(f.) Cluster of 39 eggs on under-surface of a cylindrical stone 2 feet long and approximately 6 in. in diameter. The stone was deep in a three foot "drop." Eggs in one layer and barely pigmented.

Of these, *a*, *b*, *c*, and *f* are distinct lots, all but *c* complete; *e*, probably the remains of a cluster, had but the two eggs and was far from the other clusters; *b*, *c*, and *d* were found near one another. The volume and swiftness of the flow were probably responsible for our failing to secure any adults that might have been associated with the eggs. All the clusters were either in or under rushing water; and under such conditions, without the use of big nets, it would be almost impossible to secure adults. Even then, one could not be positive as to the identity of specimens taken. In this respect work done here in the mountain creeks could not be as satisfactory as work in the hills of the lower country. It is interesting to speculate on the possibility of brooding in these higher altitude salamanders. We hunted not more than two hundred yards of stream during the afternoon on which the six clusters were discovered.

On August sixth we worked in Boone Fork at a point about ten miles from Blowing Rock. The stream flows in its bed of boulders, stones, pebbles, and sand. Its gradual descent at this point is in strong contrast to the cascades and falls of Wilson Creek. The stream, though half shaded by the dense growth along its banks, does not here flow through woods. In volume it is equal to Wilson Creek. *D. quadramaculatus* was abundant, though hard to catch because of the myriad of rocks crowding the bed. Five clusters were found as follows:

(a.) Cluster of 26 eggs in a notch on edge of one (approximately $10 \times 8 \times 2$ in.) of three flat stones wedged edgewise between two boulders. The stone with the eggs was so placed in relation to one of the others as to form the cavity into which the eggs were neatly fitted. Water flowed between the boulders down over the flat stones. Embryos well advanced.

(b.) Cluster of 30 eggs in a niche in one end of a small discarded stone which lay flat upon a larger one. The eggs certainly were submerged, for much of the creek flowed swiftly over the stones. Eggs in one layer.

(c). Cluster of 30 eggs on a large irregular stone found deep in a small cascade. Eggs not in one layer. Displacement caused the embryos to struggle and many emerged just after exposure.

(d). Cluster of 34 to 38 eggs on a large stone under a still larger one. Both well down in a small cascade. Embryos emerged in rapid succession immediately after being disturbed.

(e). Cluster of 3 eggs on the edge of a large stone set well down in a small cascade. Eggs certainly submerged; well advanced.

Each egg is attached to its stone by a separate gelatinous string which, at its end against the rock, may be barely confluent with another string or so. The eggs, therefore, should be considered separately attached. The two capsules are transparent. The attaching strings, being extremely elastic, have no constant diameter or length. Most of the eggs are held close down against the stone. Those of the sometimes present upper layer are drawn down against the bottom layer, the attaching strings being necessarily stretched a little. The strings or cables are attached near one point so that the typical cluster is held together in a compact mass. A lot may, however, be made up of as many as three clusters, one large and two small. The elasticity of the cables allows great freedom of movement and the eggs are readily shifted about, those in a bottom layer shifted to the top and those on top moved below. Clusters placed on a flat surface are generally spread out, i.e., in a single layer or in one large and one small layer, while those in a cavity or concavity are inclined to be more definitely piled or even bunched. When still-attached eggs are submerged in flowing water, the cables are stretched, and each egg with its extended cable behaves like a toy balloon tied before an electric fan.

The *quadramaculatus* cluster is attached to the under-surface of a stone or in some well-protected cavity or concavity. The stone may vary greatly in size and shape and the eggs may or may not be submerged. Their situation will, in the vast majority of cases, have a very definite relationship to rushing or falling water in the form of a cascade or tiny waterfall. It would be imprudent to generalize beyond this.

Measurements taken from formalin specimens may be of some value in spite of their inevitable inaccuracy:

Length of attachment cable.	3 mm.
Diameter of attachment cable.	1.5 mm.
Diameter of well-advanced eggs.	5-6 mm.

Several larvæ were taken in Wilson Creek and several in Boone Fork. They were abundant in both streams.

***Leurognathus marmorata* (Moore)**

On August sixth, as stated under *quadramaculatus*, we hunted in Boone Fork below the bridge and not far from the Finley Gragg house. During the day twenty-four adults, all but four more than 8 cm. long, were taken. Three larval and one transforming individual were also secured. The largest specimen is 12.5 cm. long.

The first adult was seen resting on a stone in the main stream. When disturbed, it moved away slowly, a few feet at a time. All individuals moved in much the same deliberate way and seemed to be incapable of making the quicker movements that *quadramaculatus* makes. They were generally sighted among stones of the bed, often through two or three feet of crystal water. None were seen out of water. *D. quadramaculatus* was abundant among the stones strewn along the waters' edge but scarcer than *L. marmorata* in the main stream.

L. marmorata is readily caught by either one of two methods. The first is to scan the bottom while slowly advancing against the current in the wider, smoother stretches of the stream. Likely stones should be carefully moved. The salamanders are readily sighted and at once distinguished by their coloration and deliberate locomotion. With a little trouble they may be coaxed into a net or even taken with the hands. Once or twice we were able, by removing obstructing rocks, to lower the water-level over a deeper stretch and thus bring hiding adults near the surface. This procedure enables one to get larvæ and adults only. The second method must be resorted to when eggs are desired. A small "drop" should be found and a net placed immediately below so as to receive the rushing water. All stones about and over which the water rushes should then be lifted out and examined. Adults will be washed into the nets. It is almost useless to hunt elsewhere for eggs in these high-altitude creeks.

On August sixth a cluster of twenty-eight eggs was found attached to the edge of a stone measuring approximately $6 \times 5 \times 2$ inches. This well-submerged stone was jammed deep among others over and about which the water poured. The eggs were grouped together in two layers, the lower having the greater number of eggs. A larva emerged from one of the fifteen that were put in formalin on the spot. Of the thirteen kept in moss, two emerged August eleventh, two more August twelfth, and five on August thirteenth. Six of the nine survived to be put in formalin August twenty-first. One of the six is shown in Fig. 1. No adult was taken and it cannot be proved beyond all doubt from material at hand that they are *marmorata* eggs. The emerged individuals differ

greatly from *quadramaculatus* larvæ of the same age; *phoca* was not found in the actual flow of water; while *marmorata* larvæ and adults were abundant. In fact, the author cannot recall seeing more than one *phoca* in Boone Fork. From the striking similarity of this cluster to the *quadramaculatus* clusters, one is forced to conclude that the egg-laying habits of the two salamanders are the same. Measurements of formalin specimens are:

Length of longest attachment cable.....	3 mm.
Diameter of longest attachment cable.....	0.5 mm.
Diameter of well-advanced egg.....	5-6 mm.

In life the eggs of *quadramaculatus* are noticeably larger than those of *marmorata*. Bishop¹ has recently made interesting observations on the habits of *L. marmorata*.

SUMMARY AND DISCUSSION

Desmognathus quadramaculatus attaches its eggs to stones, either in a niche or crevice or to a protected under-surface. The eggs vary in number from twenty-five to forty, and form, as a rule, one compact single-, double-, or triple-layered cluster. The cluster is deposited in a tiny waterfall and, if not actually in the water, is very near it. Each egg is separately attached to the stone by an elastic, gelatinous string. The female often stays with the eggs.

Desmognathus phoca, though very similar to *D. quadramaculatus* in egg-laying habits, differs from the latter in certain essentials. *D. phoca*, being more terrestrial, deposits its eggs in decayed wood lying in and along brooklets as well as on the under-surface of stones of stream beds. *D. phoca* probably averages fewer eggs to the cluster than *D. quadramaculatus*. The female *D. phoca* stays with its eggs.

Leurognathus marmorata appears to have egg-laying habits similar in every essential to those of *D. quadramaculatus*.

Desmognathus fuscus carolinensis deposits its eggs immediately above, or just beside, flowing water, usually in or under thick moss. The eggs, placed in a shallow depression or cavity shaped by the mother, are guarded by her. They usually form a compact, spherical cluster resembling a bunch of toy balloons. The average number of eggs in a cluster is ten to eleven.

The eggs of *D. quadramaculatus* and *L. marmorata* are herein recorded and described for the first time. The eggs of *D. phoca* have

¹Bishop, Sherman C. 1924. 'Notes on Salamanders.' New York State Mus. Bull., No. 253, pp. 88-102, Pls. I-III.

been recorded by Brady.¹ His description is inadequate. The accompanying notes on the breeding habits are also new. With the exception of two batches mentioned by Dunn,² the eggs of *carolinensis* have never before been described.

The similarity in the egg-laying habits of *L. marmorata*, *D. quadramaculatus*, and *phoca* is very striking. In this respect the three salamanders form a compact group and yet obviously represent three stages of transition from a totally aquatic form like *L. marmorata*, through a semi-aquatic one like *D. quadramaculatus*, to a still more terrestrial form such as *D. phoca*.

¹Brady, Maurice K. 1924. 'Eggs of *Desmognathus phoca* (Matthes).' Copeia No. 127, p. 29.

²Dunn, E. R. 1917. 'Reptile and Amphibian Collection from the Mountains of North Carolina, etc.' Bull. Amer. Mus. Nat. Hist., XXXVII, pp. 593-634.

