2

Relative Abundance, Microhabitat and Behavior of Some Southern Appalachian Salamanders[1]

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(Text-figure 1)

INTRODUCTION

SOME 44 years have elapsed since Emmett Reid Dunn described *Plethodon yonahlossee* and discussed the relative abundance and behavior of the salamanders associated with it in the Linville, Avery Co., North Carolina, area (Dunn, 1917). Many of Dunn's observations concerning the plethodontid salamanders were supplemented in a later publication (Dunn, 1920) and by other workers (Breder & Breder, 1923; Bailey, 1937; Gray, 1939; Wood, 1947; Hairston, 1949; and Pope, 1950).

The type locality of *Plethodon yonahlossee* is given as "near the Yonahlossee Road about 1½ mile from Linville, North Carolina" (Dunn, 1917). The general area in which Dunn worked "most of the time in sight of the road" embraces a hill which "rises to about 4,400 feet," with the road having an average altitude of 4,100 feet. In August, 1960, the authors made observations and collections along the Yonahlossee Road (frequently referred to as "Old Yonahlossee Road") in the vicinity of View Rock, a vantage point overlooking N. C. Hwy. 220. The collection was prompted by a need for an ontogenetic series for investigations of osteology and myology (DBW), comparative physiology (JAM) and behavior and periodicity (REG).

This paper presents (1) a report of the collection, (2) a comparative description of the type locality after 44 years, and (3) a discussion of the habitat, relative abundance and behavior of collected salamanders.

DESCRIPTION OF THE COLLECTING STATIONS

Dunn (1917) gives no detailed description of the flora of the type locality for *Plethodon yonahlossee* nor of the surrounding area, but we infer from his remarks (see p. 595) that the mixed mesophytic forest typical of the undisturbed southern Appalachian Mountains prevailed.

Our collections were made at two stations. The first was a gentle slope 0.5 miles below View Rock (toward Linville); the second was 0.6 miles above View Rock and approximately 1.5 miles from the Linville entrance to the Yonahlossee Road. In our judgment, the second station embraces the type locality as designated by Dunn. The area has been subjected to at least one lumbering since Dunn's visit, as indicated by the presence of well-decayed stumps up to four feet in diameter and numerous fallen logs.

The flora of both stations consists of a second growth mixed mesophytic forest, aptly described as a "rich woods." At the first locality the collecting was concentrated along and on the downhill side of the Yonahlossee Road. We estimate the area covered as one acre. No detailed notes of the flora were made, but the area had less understory, fewer stumps and logs than the second locality.

Distinctive landmarks encountered during the collecting permitted us to measure the total area covered at the second locality. We collected an

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area on the southeast slope (15% gradient) 100 × 200 yards above the road, and 100 × 100 yards below the road. The elevation of the present road is 4,300 ft. at this point. The area was bounded on the east by a fast-flowing stream and on the west by a dense understory of nettle which prohibited effective collecting. The present road bed was laid down to the north, or uphill, from that travelled by Dunn, and remnants of the old roadbed formed a distinctive landmark below the present road, a distance of 100 yards. The total area in which we collected is approximately 2.1 acres.

The flora of the second station was examined both at the time of our collection and on a subsequent trip over the surrounding area. The canopy is dominated by a mixture of red and white oaks, maples, buckeyes, ironwood, gum and tulip trees. A few hemlocks are scattered through the area. The understory is sparse although seedlings of the above, plus chinquapin, catbriar and an occasional rhododendron thicket are present. The most prevalent plants composing the herbal layer are jewelweed, nettle, shield fern, pipsissewa, goldenrod, twayblade, bell flower and clumps of pinesap.

The sandy surface is covered by a 3- to 4-inch loam on top of which leaf litter, minimally 3 inches in depth, occurs. Stumps and logs in various stages of decay are numerous and seem to constitute important physical features of the habitat of *Plethodon yonahlossee*. Occasional outcrops of the underlying granite occur. The leaf litter, logs, stumps, rock outcrops and bases of plants conceal the openings to the refugia of the salamanders.

Methods

Daytime collecting was restricted to the hours of 4:00 to 6:15 P.M. Both stations were examined. Six man-hours were spent hand-collecting salamanders exposed by log rolling and rock turning.

Night collecting with light from two headlamps and a Coleman gas lantern was carried out between 8:30–12:00 P.M. The salamanders were collected by hand, but few objects were turned. The entire night sample was taken from the station 0.5 miles above the View Rock. In all, 10.5 man-hours were spent in collecting at night.

The two samples were maintained separately, so as to permit a comparison between day and night sampling.

The Sample

The total number of salamanders taken, in 16.5 man-hours of collecting at the two stations, was 661. The sample includes the following forms: *Diemictylus v. viridescens, Desmognathus ochrophaeus carolinensis, D. m. monticola; Plethodon c. cinereus, P. g. glutinosus, P. yonahlossee, P. jordani metcalfi, and Eurycea bislineata wilderae.*

A difference between day and night collecting was first noted by Bailey (1937), who obtained much better results for *P. yonahlossee* at night. Nocturnal collecting is effective for almost all species of salamanders; however, no quantitative reports of collecting results have been made. Diurnal collecting yielded 28.3 salamanders per man-hour, whereas nocturnal collecting produced 46.8 per man-hour. In addition, habitat disturbance is minimal during night collecting. The destruction of habitat during diurnal collecting activities has led to reduction of population size (as measured by availability) in some areas that have been visited from time to time by one of us; other areas that have been collected with the same intensity at night with little or no habitat destruction continue to produce large samples of animals.

Another important point not mentioned by previous workers is the composition of a sample as affected by difference in time of collecting (Table 1). While it can be argued that animals taken during the day are not available for sampling at night, only a part of the daytime sample (in our best judgment, 20 per cent.) was taken from the same locality as was sampled at night. The difference in sample composition is striking. If the species were ranked from most abundant to least abundant, not one of the six most abundant taken in the daytime would retain its position when based on nocturnal abundance. This difference is a result of the behavior and consequent availability of the species encountered. *Desmognathus* seemed to occupy the most superficial cover of all species and consequently was more available in the daytime than when it was active at night. *Plethodon yonahlossee* and *P. jordani* retreat into deep burrows and hence are not discovered by rock rolling, log turning, etc., as is *P. glutinosus*, which occupies a more superficial diurnal refuge. Note that the three most abundant plethodons represent only 36 per cent. of the diurnal sample, but 72 per cent. of the nocturnal sample.

Relative Abundance

Although Dunn collected for three days and we for only one, we believe that the results are comparable because the mean number of individuals for one of Dunn's days is equivalent to our single day. Dunn's sample of August, 1916,

TABLE 1. PERCENTAGE COMPOSITION OF SAMPLE BY DAY, BY NIGHT, AND TOTAL COMPARED WITH THAT OF DUNN (1917)

Species	Percent of Total		D + N*	Dunn, 1917
	Day	Night		
Diemictylus viridescens (eft)	1.8	0.0	0.5	9.5
Desmognathus ochrophaeus	57.6	24.2	32.8	29.3
Desmognathus monticola	2.9	1.0	1.5	0.0
Plethodon cinereus	1.2	2.3	2.0	10.4
Plethodon glutinosus	10.6	6.7	7.7	10.2
Plethodon yonahlossee	6.5	16.7	14.1	5.0
Plethodon jordani	18.8	48.7	40.9	32.6
Pseudotriton ruber	0.0	0.0	0.0	0.2
Eurycea bislineata	0.6	0.4	0.5	2.8
Total number individuals	170	491	661	462

*Day and night combined.

probably was made during diurnal forays. There is no indication of time of collecting in either his 1917 or 1920 paper, and night collecting for reptiles and amphibians has been prevalent only in the last twenty years. In view of these points, we believe that the only valid comparison that may be drawn is between our daytime data and those of Dunn. Several differences between the two sets of data (Table 1) may be noted, including (1) an increase in the percentage of *Desmognathus ochrophaeus* in the sample (29.3 to 57.6%); (2) a decrease in the percentages of *Plethodon cinereus* (10.4 to 1.2%) and *P. jordani* (32.6 to 18.8%); and (3) the relative constancy of *P. yonahlossee* and *P. glutinosus*. *Eurycea* was noticeably rare, but this form is lacking in samples from other areas of the southern Appalachians which in recent years had been very productive.

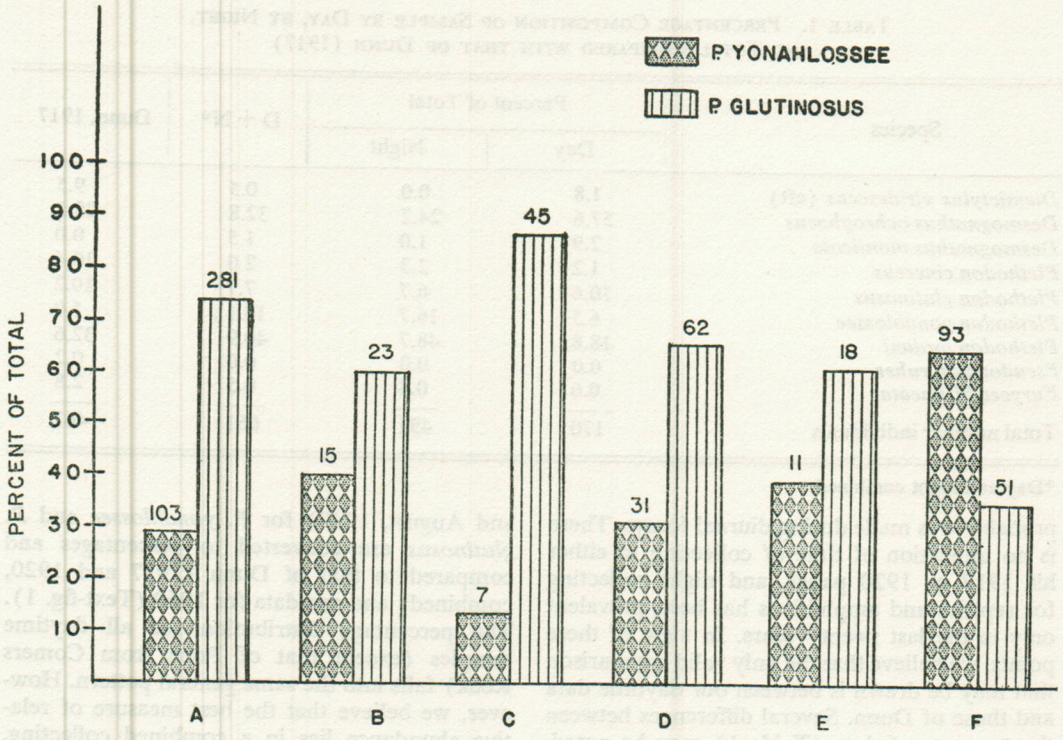
The data may indicate either a gradual shift in the composition of the population, or a short term fluctuation that may be cyclic. The latter, in view of previous collecting (1948-50, by REG), seems to be the case for *Eurycea*.

Whatever drastic effect lumbering might have had upon the area has been negated by subsequent succession, although one is tempted to suggest that the 20 per cent. decrease in the combined plethodon group (primarily *P. cinereus* and *P. jordani*) from that of 44 years ago may be attributed to lumbering. At the same time, the addition of stumps and logs in various stages of decay would seem to enhance the position of *P. yonahlossee*, since these appear to represent conspicuous elements in its habitat (Pope, 1950).

Pope (1950) discusses the relative abundance of *Plethodon yonahlossee*, *P. glutinosus* and *P. j. metcalfi*. His daytime data (obtained in July and August, 1949) for *P. yonahlossee* and *P. glutinosus* are converted to percentages and compared to that of Dunn (1917 and 1920, combined) and our data for 1960 (Text-fig. 1). The percentage distribution for all daytime samples (except that of Pope from Comers Rock) falls into the same general pattern. However, we believe that the best measure of relative abundance lies in a combined collecting, one which samples the individuals not only in their refugia, but also as they are active on the surface. A reversal of the pattern occurs when our data are pooled to illustrate this point. The reversal would be even greater if the individuals taken at night were considered separately. The latter procedure would be misleading, but perhaps not as much as consideration of a daytime sample alone.

MINIMAL AVAILABLE DENSITY

Because of the paucity of data to indicate the number of salamanders per unit area in the southern Appalachian Mountains, we have calculated a density figure for the four most common species on the Yonahlossee Road (Table 2). We recognize that these data have inherent weaknesses. The figures do not represent the total number of salamanders per unit area, and do not represent crude density. Test & Bingham (1948), working with *P. cinereus* in Michigan, showed that the number of animals present on the surface (and *available* for capture) at any one time represents only a portion of the total population present in the area. The term *minimal* density is appropriate because (1) not every animal observed was captured; (2) a portion of the daytime sample was taken from the area collected at night; and (3) an estimate of the surface area covered in the daytime collecting was made. Two sets of figures are presented.



TEXT-FIG. 1. The relative abundance of *P. yonahlossee* and *P. glutinosus* at different localities and under different collecting conditions (**A**—Iron Mt., **B**—Buck Mt., **C**—Comers Rock, data from Pope, 1950; **D**—Linville 1917-20, day, data from Dunn; **E**—Linville 1960 day; and **F**—Linville 1960 night).

The data for the nocturnal sample were collected from a measured area (2.1 acres), but the sample is biased by the daytime collecting in the area. Those for the total sample were calculated from an estimated total area of 3.1 acres. Thus the figures represent minimal available densities and should be treated with caution.

We suggest that future collectors may find that sampling (even of the "one-stop" type) from a measured area will make their data on relative abundance more meaningful if the minimal available density is calculated for each species.

MICROHABITATS, BEHAVIOR AND COMPETITION

Pope (1950) points out that the existence of *P. glutinosus* and *P. jordani* at Linville "is of special interest and calls for further investigation in view of their ecological segregation elsewhere." His subsequent remarks (p. 87) imply that the sympatry of the two may be due to disturbed conditions brought about by lumbering. That this cannot be the case is evident from (1) Dunn's (1917) statement regarding ". . . the primitive condition of flora and fauna, and being rendered accessible by the splendid Yonahlossee Road, is a paradise . . ." and (2) the existence of *P. glutinosus* and *P. jordani* together in the second-growth woods in approximately the same relative proportion today (1:5, respectively) as existed in Dunn's sample (1:3).

In view of the inability of competent taxonomists to distinguish between *P. glutinosus* and the southern representatives of *P. jordani,* we prefer to believe that a genetic difference in the two taxa which permits one to readily distinguish between them in the northern portion of the *P. jordani* range, also reinforces their ecological isolation where the two are sympatric.

TABLE 2. MINIMAL AVAILABLE DENSITY PER ACRE FOR THE FOUR MOST ABUNDANT SALAMANDERS ON THE YONAHLOSSEE ROAD, LINVILLE, NORTH CAROLINA

	Nocturnal Sample	Total Sample
Desmognathus ochrophaeus	56.7	70.0
P. glutinosus	15.7	16.5
P. yonahlossee	39.1	30.0
P. jordani	113.8	87.4

Pope (*op. cit.*) postulates competition between *P. yonahlossee* and *P. glutinosus* on the basis of similarity of "habitat niches" and food items. He was unable to demonstrate a convincing difference in diet. The fact that *P. glutinosus* is more readily available during the day than *P. yonahlossee* (as indicated by our collections and those of Dunn and Pope) leads us to think that there is a difference in microhabitat or behavior between the two taxa. Vernberg (1955) found that *P. glutinosus* was less photosensitive than *P. cinereus*. Our collections reveal an earlier peak of activity for *P. glutinosus* than for *P. cinereus* with *P. yonahlossee* intermediate. This seems to indicate that *P. glutinosus* is less light-sensitive than *P. yonahlossee*. *P. glutinosus* either (1) does not penetrate the subsurface to the depths inhabited by *P. yonahlossee*, or (2) takes advantage of its relatively less sensitivity to light and comes to the surface (beneath cover) during daylight hours more frequently than *P. yonahlossee*. In either case, *P. glutinosus* seems to be effectively isolated by microhabitat from *P. yonahlossee*, at least enough to reduce spatial competition. As long as an abundant food supply exists these two species can be considered only as potential and not actual competitors.

Concerning the habitat of *P. yonahlossee*, we are in essential agreement with Pope (1950) that this species is not "restricted to a zone within 100 feet" of streams as reported by Hairston (1949). The eastern margin of our plot was bounded by a stream, but there was no evidence that *P. yonahlossee* was any more abundant near the stream than it was toward the nettle patch on the western boundary.

Our observations of animals retained in the laboratory are of interest here. The animals were retained on wet leaves in large finger bowls with an excessive amount of moisture in the bottom. A series of pustules appeared on the skin of *P. yonahlossee* but not on the other plethodons retained in the same bowls. *P. yonahlossee* was observed more often on top of the leaves, than were the other taxa and this may represent moisture avoidance behavior.

Activity

Time was noted at intervals throughout the collecting period and determination of activity peaks of the various species was attempted. If peaks of abundance may be considered an index to peaks of activity (see Hairston, 1949), there is a suggestion that adults of the plethodon taxa are isolated during the active portion of the diel cycle on a temporal basis.

The young of all these species were especially prevalent before 9:00 P.M. Subsequent observations indicate that the young appear shortly after dusk and attain a peak of abundance by 8:00 P.M., 1 hour after sundown at this locality. Adults of *P. yonahlossee* attained a peak in abundance between 9:00 and 10:00 P.M., with a minor peak between 11:30-12:00 P.M. Between 10:00 and 11:00 P.M. both *P. yonahlossee* and *P. glutinosus* were often observed in refugia with only their heads exposed. *P. jordani* (juveniles and small adults) were present throughout the evening, but large adults (and *P. cinereus*) were definitely more abundant after 10:00 P.M. Although our sample of adult *P. glutinosus* was not large, we have the impression (at Linville and elsewhere) that the peak of activity outside the refugia is slightly earlier than that of *P. yonahlossee* (8-9:00 P.M.) These observations represent our concensus recorded immediately after the end of collecting. The observations were confirmed by one of us (JAM) who visited the area during August, 1961.

Our observations on behavior of the plethodons at Linville substantiate and supplement those of Dunn (1917) and Pope (1950). *Plethodon jordani* was observed on the leaf litter, near the bases of trees, logs and in open areas. Between 8:30 and 10:00 P.M., individuals seemed sluggish and were captured with the same ease as an individual found beneath a log during the day. However, from 10:00-12:00 P.M., this species became more active and agile and less easily caught. This latter behavior never approached that of *P. yonahlossee*. *P. jordani* climbs more often than the other three species of *Plethodon*. Many were collected on trunks and low branches of shrubs up to 3.5 feet from the ground. Groups were observed feeding on fungal gnats around decaying fungi, or on fruit flies and other insects at the base of trees from which sap flowed. *Plethodon glutinosus* was moderately abundant and easily caught in the early evening. No climbing was observed; practically all individuals were at the bases of plants, near logs or lying with their heads exposed in the openings of refugia. After 11:00 P.M., *P. glutinosus* was conspicuously absent from the surface area. This observation is not in accord with that of Hairston (1949), who reported an abundance peak at 11:00 P.M. in the Black Mountains during late July.

As described by Dunn and Pope, *P. yonahlossee* is the most agile of all eastern plethodons. Usually only one opportunity is available to capture an individual. If the collector misses, the animal retreats into a refugium for the evening. Numerous individuals were first seen with their heads sticking out of refugia. Others were moving at the bases of trees, or beside fallen rotted

logs and stumps. In most instances, this species was associated with a log over 10 inches in diameter, with not more than 1 to 3 inches of the log below the surface. A thick layer of leaf litter accumulation at the log–ground interface was a prerequisite. *P. yonahlossee* climbs more than *P. glutinosus* or *P. cinereus,* but less than *P. jordani.*

Summary

The type locality of *Plethodon yonahlossee* near Linville, Avery Co., North Carolina, was visited in August, 1960. The flora and physical aspects of two sampling areas, 2.1 acres and an estimated 1 acre, are described.

Diurnal collecting yielded 28.3 salamanders per man hour, as opposed to 46.8 salamanders per man hour at night. Ranking of the species according to percentage composition of the sample is shown to vary with the time in which the sample is taken.

The relative abundance of each species encountered is compared with Dunn's figures of 44 years ago. The most significant differences lie in a two-fold increase of *Desmognathus ochrophaeus* and a marked decrease in *Plethodon cinereus* and *P. jordani; Plethodon yonahlossee* and *P. glutinosus* have remained relatively constant.

The relation of *P. yonahlossee* to *P. glutinosus* is examined in terms of relative abundance in diurnal collections made by Pope (1950), Dunn (1917, 1920) and ourselves. Five localities are involved, yet the percentage distribution of the two species remains approximately the same at all but one locality. Competition between these two taxa, postulated by Pope (1950), is believed to be reduced by differences in microhabitat and behavior.

The minimal available density is calculated for the four most common species at the type locality. This density term is explained and its use as a quantitative basis for determination of relative abundance is suggested.

Temporal isolation in activity between age groups and the different species of *Plethodon* was observed and is discussed. General observations on behavior and microhabitat are offered.

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