

- The Endemic Salamander, Plethodon shenandoah, of SNP
Dr. Richard Highton

We've been hearing about the largest vertebrate in the Park. I think I'm correct in stating that the next two animals we'll be talking about are the smallest or lightest of vertebrate animals in the Park.

You have the first slide. I'll show you a picture of the Shenandoah salamander, Plethodon shenandoah. This animal is only about three inches long. It's found nowhere else in the world but Shenandoah National Park, Not only is it restricted to the Park, but it's restricted to only three talus slopes on northwest facing mountains; three of the highest mountains in the Park, Hawksbill, which is the highest, and Stony Man and The Pinnacles. In all three of these mountains, the entire range of the salamander is no larger than about seven-tenths or three-quarters of a mile in diameter.

The animal occurs in two color phases. This is what we call the unstriped or dark or dusky phase. The next slide shows the striped phase which has a stripe down the back; sometimes red, sometimes yellow, sometimes yellowish-red. These two color phases or color morphs are just genetic variations of a single species.

The next slide shows the two animals together and I think the next slide will show the range of these species in the Park.

Hawksbill Mountain. The solid triangles indicate the range of the species on Hawksbill Mountain. On Stony Man Mountain the solid triangles appear again. And the hollow triangles represent localities where we found the common red-backed salamander, Plethodon cinereus. Maybe you're familiar with it. It's probably the commonest salamander in eastern North America and southeastern Canada. It is a close relative of Plethodon shenandoah. The hollow circles indicate or record localities where we have found the red-backed salamander.

On The Pinnacle, the two occur together. That's why we see the triangles within circles throughout the talus slope on the northwest face of The Pinnacle Mountain.

Now there are many mountains in the Park that have northwest facing talus slopes that do not have Plethodon shenandoah in them. The graduate student who did a lot of work on this animal, Bob Yeager, and I, and Dick Worthington, another graduate student, searched many other mountains in the Park without finding the species. It may occur elsewhere but we have not found it yet. This _____ mountain ranges. Most of this work was done in the late 60's and the animal was described, named as new species, new to science, in 1967.

The animals turned out to be extremely interesting for several reasons. Bob Yeager decided to do his Ph.D. dissertation and research on the ecology of this animal. One of the things that we were particularly interested in was why did this animal occur only in talus slopes on northwest facing high mountains in this the laboratory to

SNP 603631 1967

one small area of the world. Bob brilliantly conceived a number of experiments and a number of different kinds of studies which I think have answered many of the components of this question.

I think the next slide....I'm sorry. This shows the difference between *Plethadon shenandoah*, on top, and the common red-backed salamander, which is one of the commonest vertebrates of all of North America. It occurs all over the East and the red-backed salamander also occurs in both a red stripe, a dark phase. This is the red phase of the red-backed salamander below and the striped phase of *shenandoah* on top.

The next slide will show the unstriped phase of both species. The unstriped phase of the red-backed salamander on the bottom, and *shenandoah* on the top.

Now there are a number of differences between *shenandoah* and *cinereus*. One of the differences is that *shenandoah* is usually larger; has a larger head. You can see it very clearly here in the picture. It also has one more vertebra; one extra vertebra. *Cinereus* is a little longer than *shenandoah*. In the dark phase there is quite a bit of brassy flecking on the back of the *cinereus* and very little on the back of *shenandoah*. In the red-striped phase, the stripe is narrower and wider in *shenandoah*.,

Now this is a map showing the distribution of the closest relatives of *Plethadon shenandoah*. These are the records of *shenandoah* in the Park. The other close relative down here in the Peaks of Otter region, along the Blue Ridge Parkway. There's another relative in the Cheat Mountains, and then less closely related is an animal that occurs in _____. Even less closely related is another species which occurs in West Virginia and Ohio and Kentucky _____. This looks like a relic pattern of distribution. The closest relative is also found in high mountain ranges, the Mountains and the Blue Ridge Mountains in Virginia. It looks as if then that these animals are relics in the sense that they're hanging on in habitats where they still find favorable conditions enough to survive. But at one time they must have had wider distribution and been continuously distributed throughout this area.

Now, first of all, the fact that the *shenandoah* salamander is restricted to these rocky talus slopes might make one think that it was well adapted to this kind of an environment. Whereas *Plethadon cinereus* occurs throughout the eastern North America as a woodland salamander. Perhaps it is best adapted to the terrestrial woodland conditions where the soil is much thicker than the talus slope. Now that was our first hypothesis.

From now on I'll be talking about Bob Yeager's work. Sorry Bob isn't here to tell you about it himself. Now the first thing he thought of was that these talus slopes must be much dryer than the surrounding woodland. So he did some experiments in the laboratory to see how long it took these animals to dry

out under adverse conditions. As expected Plethodon on Shenandoah was more resistant to desiccation and therefore an animal more likely "to survive in an area where the rain passes down through the rocks very quickly and there's very little soil to maintain moisture over long periods of time. Of course these animals are amphibians. They must live in areas that are moist or their skins ... they lose enough water through their skin that they'll dry but and die.

He then tried putting these animals in moisture gradients to see whether Shenandoah liked drier areas than cinereus. And he found out that Shenandoah and cinereus preferred moist soils. There was no difference then, in their moisture preference.

So then he began to wonder why should Shenandoah that liked and was well-adapted and prefers to live in moist soils, why should it be restricted to this drier area?

Well Shenandoah.... Well then the next step was to run some experiments with Shenandoah and cinereus in cages constructed in the two different habitats, in the rocky talus slopes and in the soil outside the talus slopes. I'll simplify this and tell you about one experiment he did.

This involves taking ten cinereus and putting them in one cage, in both habitats; ten Shenandoah and putting them in a cage alone, separately in both habitats. And then putting a mixture of the two species, ten of each, in a cage twice as large, in both habitats. So he had six cages, three in each habitat, one with a pure Shenandoah alone, one with cinereus alone and one with the mixed species. He got some interesting results. Surprising results.

In the talus cinereus died, very quickly. The area was so dry that all of the cinereus failed to survive. In the talus the Shenandoahs were fine, as you might expect. In the terrestrial habitat, the wooded habitat, in normal soil, both species alone did very well. But when cinereus and Shenandoah were mixed, the Shenandoah lost weight and most of them died. In the mixed condition, in the talus, Shenandoah survived and cinereus died. Now Bob interpreted this as follows. Cinereus can not survive in the talus because the conditions there are too dry. Shenandoah being larger is able to withstand desiccation that occurs from one rainy spell to the next. Shenandoah however would rather, would find the woodland areas more to his liking but it cannot survive in the woodland because cinereus is there and is superior competitively to Shenandoah. So Shenandoah then is excluded from the woodland habitat by competition, with cinereus. He then compared the food these animals were eating. He found that the food eaten by Shenandoah was in general; they feed mainly on soil insects, and these animals were able to eat much larger food than cinereus. He found an interesting thing. And that was that the edge of the talus slope, normally you do not find Shenandoah more than two or three feet away from the talus. And normally

you do not find cinereus more than two or three feet into the talus slope area. However occasionally you find shenandoah outside the talus up to one hundred yards, but you only find the very largest shenandoah; those than can eat food larger than any cinereus could possibly eat. It's head is almost twice the width. These shenandoah however can survive then in competition with cinereus in the talus...I'm sorry in the soil because they're feeding on food that is not available to cinereus. It's too large for cinereus to eat. So that shenandoah then can survive competition only in the largest developed of the population. And of course as they reproduce outside the talus, then the young will not be able to survive in the competition with cinereus,

So what is the future of this species? This species which is limited to Shenandoah National Park, Apparently this is an animal surviving only in a situation in which its strong competitor, cinereus, cannot enter because it is unfavorable. Now if these talus slopes erode. Soil is produced by the trees that begin to grow there, dropping their leaves; the trees die, the salamanders live in the rotten wood, the soil formed from the rotting wood and leaves. The area then becomes more favorable for cinereus and where there are these tongues of soil going into the talus, cinereus is moving in and is taking over the habitat. The last remaining place where shenandoah can occur in the area. So this then is a _____ probably of the verge of extinction, as these talus slopes are worn down over the next few hundred or thousand years. The erosion will place and soil will enter into this area and cinereus will probably cause the extinction of this animal. Its nearest relative in the Cheat Mountains of West Virginia and in the Peaks of Otter area are probably also in trouble. This is a remnant of an ancient species, which we believe at one time occurred throughout this area, but a newer, more modern, more evolved animal, Plethadon cinereus, has come in, taken over its range, most of its former range, perhaps all of eastern North America, and is causing, replacing it everywhere else except in these three talus slopes where shenandoah survives, only in this area. One of these of course is just a few yards from here. You can walk right through the talus on the Appalachian Trail, about a half or quarter mile from this building.

OK, I'll be glad to answer any questions.

(Question)

As long as you continue to have large areas of talus which are continually renewed by new landslides, these populations should remain. However, when you go around the Park as we have done, and collected, and measured these different areas; many different north facing talus slopes. Incidentally we think that the species survives only on the north slopes because they receive the least sunlight and remain moist longer after a rain. However, as you go around the Park, in 90% of these talus slopes, there

are none of the shenandoah. We have been unable to find them. I interpret this as meaning that at one time in the history of that talus, there was enough soil in that area that cinereus was able to move in and terminate the shenandoah. So I don't think the future looks very good for this species, except in these very large talus slopes, seven-tenths of a mile across where there are areas where they could survive. But remember right after a landslide, the area is so bare and so dry than even shenandoah cannot survive. In fact some 30% or more of the current talus slopes are not occupied by shenandoah either. It's too dry in there even for shenandoah.

(Question)

Bob certainly did not prove that food is the limiting resource. But he suspects that it is the major resource. Now there is... sorry Bob isn't here to answer this...there is of course the problem of the fact that when the salamanders move down into the soil to get at lower and lower levels, as the top level dries out, after a rain. For four or five days after a rain the animals can be actively feeding on the surface, but after that they have to move down. The soil insects and worms and snails and all the other things that salamanders eat, also must move down. So I always thought that the salamanders would go on feeding in underground burrows down...no matter how far they had to go. But Bob did some other experiments, some studies in which he showed that the salamanders do not feed underground. That they mainly feed, particularly here in the Park, on the surface on wet nights. And they come up and they climb up plants and eat aphids and he says they look like little vacuum cleaners as they're going along eating aphids. Three days after a rain, when he collected animals by digging them out of their burrows, or looked under stones or logs where the ground was still moist, he does not find food in their stomach. So they are feeding mainly on the surface, mainly within the first two or three days after a rain. Then for two or three weeks, or a week or two days, whatever it is, until the next rain, the salamanders are unable to eat. So while there is plenty of food available for the salamanders, Bob's hypothesis is that it is not available except after a rain. Under these conditions he feels that food would be a limiting factor.