

CAUSE AND NATURE OF MORTALITY IN BIGHORN SHEEP

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Terry has discussed the pathology as we see it in these lambs on the range we have in Colorado - specifically Pike's Peak. The question is how does this build up on the range - what has happened on the range that gets us involved in this pathogenic situation - a cycle. Many aspects of the study have been in relation to that. I have studied those portions of the life cycle of this parasite that occur on the range.

Usually when I start this talk, I like to give my definition of wildlife management and how I fit into it, because I am, as we have discussed earlier, a diseasologist or parasitologist. My definition of wildlife management is "the application through knowledge and collection of facts or principles which will manipulate an animal population or several of them and the environment toward achieving the desired end, be it beneficial or detrimental to the animal or the environment."

Now where does the diseasologist come in? In my opinion the diseasologist is a tool to be used when the application of historic management regimes in obtaining desired goals has proven unsuccessful and not indiscriminantly in all situations. That is in my opinion where we would use what we call a diseasologist or parasitologist.

Well, let's start out with the slides.

First I'll review the life cycle that Terry introduced to you. This is the *Protostrongylus ruskii* here. It is one of the two species of lungworms found in bighorn sheep. This one is found in the air passageways and the other one, *Protostrongylus stilesi*, is found, like Terry said, in the parenchyma of the lung. This is the adult parasite. Those are centimeters above.

Terry talked about the first stage larvae. This is the first stage. There are a number of lungworms in bighorn sheep - this lungworm, *Protostrongylus*, is characterized by this distinct tail. It has an inflexion here on the tail where, as some of the others that you may see, have other characteristics that allow us to distinguish them. As Terry said, snails are the intermediate hosts in this life cycle and they have been found naturally infected on bighorn sheep ranges.

To show you what they look like, these are the snails themselves. Here are four genera of snails and this is the tip of a pencil. They are so small that unless you look very carefully you will never find them unless you happen to hit one of these spots where they are very plentiful.

This is *Velonia* - very common in Colorado. This is *Vertigo* - another common species in Colorado. This is *Pupilla blondii* which, in Colorado at least, is the most important species of all of these snails in continuing this

life cycle. This particular snail, one that we examined last summer, contained 63 of these third stage lungworm larvae in it. That's in one snail, so we're talking about a larvae that is quite small and with a lot of snails concentrated in an area, it has a hell of a potential of continuing or seeding the range with this parasite.

This is *Valonia cyclotrilla*. Not important, just to give you an idea of what it looks like. These are drawings. This snail is recognized by vertical ribbing on the shell. This is the other member of this genus - *Valonia pulcherrilla*. Snail introduced from the eastern United States and a drawing to show you it's a smoother shelled snail.

OK, sagebrush, surprisingly enough, you can find these in sagebrush areas. Underneath these bushes are mossy areas providing small foci of concentration of these snails. If you pull apart these beds of moss you will be able to locate snails usually in them.

This is the Trickle Mountain area in southern Colorado. You can find them right here on what looks like a windblown area. Pike's Peak is the subject of this, though, so where do we find them on Pike's Peak? Where are they concentrated on that area? This is typical Pike's Peak range. Another view. We started by wondering what we could do to locate what we theorized was there. These foci of infection, and by that I mean an area utilized by the sheep where snails could be found and which is also suitable for high numbers of infected snails, these are the components you would expect foci of infection to have.

To start out, then, Bob Schmidt and others and ourselves spent a lot of time on Pike's Peak with a topo map and marked in the areas that were possibilities - areas which were heavily utilized by the sheep. After that we backpacked into these areas and began collecting snails in the areas we suspected. We would bring these snails back to the lab and look at them under a microscope to get an idea of the level of infection in them. The next step was to get back to these areas. We found very few snails in some areas and in other areas we found lots of snails. Some of these areas, then, after we had been back to the lab and examined them, we were able to cross off as unlikely sources of this cycle because we found either few snails or those that we found were uninfected.

This is *Pupilla blondii* and because you can't see the characteristics on it we have these drawings. It has a characteristic tothing pattern inside the shell. This is one that I mentioned was most important in Pike's Peak range.

This is the other one I mentioned, *Vertigo*, and this is *Ucaulus fulvus* another snail that's not quite as important in Colorado.

This is the snail after it's infected. First stage larvae when it enters the snail cannot infect a sheep. The first stage larvae is found on the ground, defecated in fecal pellets. That larvae also is incapable of infecting a sheep. It will die on the range in time if it does not enter a suitable intermediate host and I mentioned the ones that can serve. After it enters a suitable intermediate host it must develop to be infective. The third stage of this parasite develops a black cuticle and you can look at these under a dissecting microscope just as you can there. There are two of them.

Dissected out, this is what this parasite looks like - still having the characteristic tail. This is a finer magnification of the same tail.

Ok, where do you find these snails? If you're looking at a range you want to know where to look. Well, you can find them in some numbers almost anywhere. This is a slide of western Colorado in pinon pine/juniper type country, very dry country, and I can find snails here. This is mountain mahogany and if you will look in the little bit of duff and leaf material underneath these plants you can find them, and this is an area that is considered a desert in western Colorado. You won't find them underneath these pinon pines for some reason.

So we approach the last part of this study, the quantification of these areas - that is the degree of utilization, what's in them, what's their exposure and that sort of information.

These areas were bedding grounds, feeding grounds and lambing grounds. The lambing grounds did not prove to be foci of infection; the summer bedding and feeding grounds were.

This is a typical summer bedding ground, and here's a group of rams on Pike's Peak. We found, in those areas where we had large numbers of snails that we had dense mats of vegetation, an absence of evergreens, damp soil or a good deal of organic material, protection from wind/cold dessication, and south to southeast exposures. This is what proved to be one of the foci of infection and this is a better look at what a foci of infection is.

In this kind of area, if you peel back the grass at the edge of these rocks you can find large numbers of snails. This is another sort of area. We looked over 13 areas. Two of them qualify, in my opinion for foci of infection. The point is that we have concentrations of sheep in different areas on a range. Only a few of these areas are going to be sources of this infection, sources of the continuing of this life cycle. In this case two of them, areas 9 and 10, were selected. One of these had 49 out of 173 snails infected and the other one 7 out of 36.

In quantifying these areas we wanted to know their density of snails and parasites and snails themselves. For sheep utilization, we wanted to be able to characterize this in some way - to be able to say that the sheep were using this area more than another area and show that portion of foci of infection that we were interested in. We did that, an imperfect way, but the best we could come up with, by collecting at random from standard sized plots, the feces in the area we thought were foci and then going 200 yards away and again collecting at random from plots of a standard size, feces from that area. In that way we were getting a relative usage of these two areas.

We did the same with snails. We collected snails in that area and outside of it and compared the levels of infection in the snails in that area and outside of it. We did that in the two areas that looked like potential foci of infection.

In area 9 this shows the relative usage by the sheep and this shows the number of snails we found per meter squared. Now I'm talking about live snails here and the levels of infection in those snails. This is the second of those two areas - shows the level of infection and the number of snails. We also found up to 1600 shells per square meter in these areas. By multiplying that out over a foci you can see the potential of this thing in a very, very small

area, and if the sheep are using that area a lot, then there is a potential for completing this life cycle.

The size of these areas I'm talking about is surprisingly small. The first area was perhaps 40 yards by 10 yards, very small, and the second area was about 50 by 100 yards. And so it is, in some cases, like looking for a needle in a haystack. These are the species of snails we found infected on that range, and as you can see, 5 out of 6 possibilities were found there.