LUNGWORM INFECTION IN MONTANA BIGHORN SHEEP -- A RE-EXAMINATION*

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INTRODUCTION

A gradual decline in populations of Rocky Mountain bighorn sheep in western North America during the 20th century has often been attributed to a lungworm pneumonia disease complex (Buechner 1960, Forrester 1971). The occurrence of lungworms of the genus *Protostrongylus* has been documented in all areas inhabited by *Ovis c. canadensis*, from British Columbia (Cowan 1951) and Alberta (Uhazy and Holmes 1971) south through Idaho (Quortrup and Sudheimer 1944, Smith 1956), Montana (Marquardt and Senger 1956, Forrester and Senger 1964), Wyoming (Honess 1942), and Colorado (Moser and Pillmore 1954). Although a direct relationship between lungworm infection and fluctuations in bighorn numbers has not been clearly established, Buechner (1960) stated that the lungworm-pneumonia complex appeared to act as a regulating mechanism in situations where the habitat favored increases in density of bighorn populations. In Colorado, Pillmore (1957) concluded that protostrongylid lungworms can cause significant mortality in wild sheep regardless of the condition of the range or the herd in question. Marsh (1938) found that *P. stilesi* was the primary pathogen in a chronic pneumonia syndrome occurring in bighorns in Glacier National Park. In a related study in western Montana, Couey (1950) attempted to correlate field mortality in the Sun River herd with the presence of lungworms or other disease agents. The first comprehensive evidence of lung nematodes in Montana sheep was compiled by Forrester and Senger (1964), who used both fecal analysis and postmortem data to assess the distribution and extent of protostrongylid infection in 10 geographically distinct populations. The present study was designed to update these earlier findings and reassess the prevalence of *protostrongylus* species in many of the same herds examined earlier. A second objective was to estimate the effect of herd reduction programs currently in use in Montana on the level of lungworm infection in both the parent herd and transplanted animals.

MATERIALS AND METHODS

The prevalence of *Protostrongylus stilesi* and/or *P. rushi* in the study

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herds was determined primarily by periodic fecal examinations at irregular intervals between 1970 and 1975. Eight of the herds studied were also included in Forrester and Senger's 1964 survey. In a few instances feces were available from sheep of known age and sex. Pellets were collected at random from bedgrounds and feeding areas. Because of the method and time of collection, samples were predominantly from ewes, lambs, and young rams on winter or spring ranges. A modified Baermann technique was used to isolate first stage lungworm larvae from feces. The mean number of animals examined in each locality was 43, with samples taken an average of four times from each herd. Pellets usually were stored in paper or plastic bags for 1 to 4 weeks at approximately 4° C. before they were processed. Larval counts were expressed as larvae per gram of feces (LPG).

Supplementary information on species occurrence and intensity of protostrongylid nematodes was obtained by postmortem examination of lungs from hunter-killed animals, road kills, and sheep necropsied for experimental purposes. The pleural surfaces of the lung were examined for the presence of plaques, nodules, or other surface lesions characteristic of the parenchymal lungworm, _P. stilesi_. The trachea, bronchi, and major bronchioles were then opened with scissors and the mucosal surfaces and lumina were searched grossly for _P. rushi_ adults. In most instances, portions of lung tissue from areas having parenchymal lesions were cut into small pieces and baermannized or immersed in warm saline solution and agitated on a mechanical shaker in an attempt to confirm the presence of _P. stilesi_. Worms recovered by either technique were counted and identified to species when possible, using the criteria of Honess and Winter (1956). A total of 610 fecal examinations and 36 lung necropsies form the basis for the present report.

RESULTS AND DISCUSSION

The occurrence of lungworms in 12 western Montana bighorn herds during the period 1970-1975 is summarized in Table 1. Overall, 88 percent of 610 sheep were found infected, with herd incidence ranging from 100 percent in the Gallatin, National Bison Range, and Wildhorse Island herds to 44 percent in the Kootenai Falls area. Current infection rates were higher in two herds, lower in five herds, and similar in one instance to Forrester and Senger's 1964 data.

A major change in species distribution of lungworms noted in the present survey was a decrease of approximately 41 percent from the previous decade in the proportion of sheep infected with _P. stilesi_. Although this may be due in part to minor differences in the geographic origin of the sheep sampled in the two studies, one implication is that parenchymal lesions associated with this lungworm appeared to be much less frequent than those reported by Forrester and Senger (1964). _P. stilesi_ (synonym _P. frosti_) was regarded as the principal agent of verminous pneumonia in mountain sheep by Honess (1942), who concluded that _P. rushi_ alone is relatively nonpathogenic. Both the incidence and intensity of _P. rushi_ infections were essentially the same as in the previous survey: 44 percent infected, with worm burdens averaging 10 in the present study vs. 40 percent with eight worms per infected host during the period from 1958 to 1963. We found pure infections with P. rushi occasionally in both immature and adult sheep, in contrast with the previous study in which P. rushi occurred only in mixed infections with P. stilesi. This apparent shift in species prevalence no doubt is biased somewhat because the majority of our necropsies were performed on sheep from recently introduced herds. Nevertheless, these postmortem findings confirmed evidence derived from fecal examinations that sheep moved to new ranges tended to have fewer lungworms than animals in established herds.

Attempts were made to estimate the severity of Protostrongylus infections in five major Montana herds with the use of quantitative fecal examinations (Table 2). Due to problems associated with interpretation of fecal larval counts, no effort was made to correlate our fecal analysis data with that from previous studies. The two criteria used to compare herd infection levels were the average rate of larval output in the feces and the percentage of counts which exceeded 100 LPG. On the basis of both these indices, the Sun River herd ranked highest and the Ural-Tweed herd lowest in terms of lungworm burdens. Interestingly, the incidence of infection in the Sun River population also was among the highest in the state, whereas in the Ural-Tweed sample it was well below the statewide mean. These results suggest that a lungworm surveillance program based on both incidence and intensity data might be a useful method of monitoring the relative level of herd infection on a routine basis. Possible applications include determining when over-intensive range use has resulted in an excessive buildup of parasitism. Management programs which could be implemented in response to such findings such as trapping/transplanting, either sex hunting, or acquisition of additional grazing areas might avoid serious disease problems as well as deterioration of available ranges.

The only extensive bighorn mortality which occurred in Montana during the current study was the death of approximately 58 sheep on Wildhorse Island during the winter of 1972. Although malnutrition was believed to be a major cause of this die-off (Egan 1975) thorough examination of the digestive tracts and lungs of four adult sheep found dead revealed severe pneumonia in all instances, with major areas of consolidation and scattered pulmonary abscesses and adhesions. Specimens of P. stilesi were recovered from three of the four animals examined. Massive concurrent infections with four or more stomach and intestinal nematode species and ovine coccidia in all animals indicated that severe clinical parasitism of the gastrointestinal tract also was a predisposing factor in the death of these sheep. The significant level of parasitism encountered in the Wildhorse Island sheep suggests that the concurrent effects of verminous pneumonia and gastrointestinal parasitism can be fatal, even in adult rams.

A comparison of infection rates in native and introduced herds suggests that the prevalence of Protostrongylus spp. was higher in established groups which have occupied defined ranges continuously for many years such as the Sun River, Stillwater, and Gallatin herds (Table 3). New herds created by transplanting sheep to ranges which have not supported bighorns in recent years showed a consistent pattern of lower infection rates, accompanied in most instances by reduced prevalence of P. stilesi. The Thompson River herd, which was reestablished in 1959 with sheep moved from the Sun River and

Wildhorse Island, had a level of protostrongylid infection slightly lower than either source herd (86 percent vs. 90-100 percent, respectively). The other introduced herds which we studied showed a more pronounced tendency toward a decrease in infection. The Kootenai Falls herd, a transplant derived from the Sun River, had a 44 percent incidence of Protostrongylus spp. Sheep recently introduced on the east fork of the Bitterroot River showed a 10 percent reduction in lungworm incidence in comparison with their source herd. Based on very limited postmortem data from sheep moved to the Gates of the Mountains area from the Sun River, we found only 50 percent to be positive for lungworms. Although the long-term effects of relocating sheep from ancestral ranges are difficult to predict, our data suggest that at least temporary benefits can be expected in introduced herds from a reduction in the stresses associated with chronic lungworm infection.

Periodic removal of surplus sheep from an expanding native population in the Sun River area has had little apparent affect on the prevalence of lungworms in the herd. In 1950 Couey found that 85 percent of 360 sheep were positive for Protostrongylus. In 1964 Forrester and Senger reported that all of 95 bighorns were infected. Our data indicated that 90 percent of 104 animals from this area were positive for lungworms during the period from 1971 through 1973. Thus, the percentage of parasitized sheep remained essentially the same in spite of the removal of 497 animals from the herd for transplanting during the period from 1941 to 1974 (Egan 1975). Substantial numbers also have been removed by hunting since the early 1950's. It seems possible that reduction programs developed for the Sun River herd may have helped to minimize parasite problems by reducing the intensity of lungworm infections acquired by sheep rather than by preventing exposure to the parasite *per se*.

On the basis of the reduced lungworm prevalence rates noted in adult sheep which were moved to new ranges, it seems likely that the consistently high rates of infection found in established herds grazing on ancestral ranges are the result of constant reexposure to heavily contaminated ranges rather than the persistence of primary infections acquired as lambs. This could be one explanation for the reduction in lungworm incidence observed in the Thompson River, Kootenai Falls, and Gates of the Mountains herds, all of which were originally established with sheep from sources consistently infected with lungworms. Current Montana herd reduction programs which utilize both transplanting and regulated hunting thus appear to have a sound biological basis for parasite control as well as range management purposes. Until more direct measures can be developed for control of sheep lungworms such as medication or eradication of snail intermediate hosts, herd reduction remains the most practical method for minimizing morbidity and mortality resulting from the lungworm-pneumonia complex in the Rocky Mountain bighorn.

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