An Investigation of Lungworm Infestation and Intermediate Host Presence on Two Bighorn Sheep Ranges of Central Idaho

By

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March 28, 1978

Submitted
to the College of Forestry,
Wildlife, and Ranges Sciences
Univ. of Idaho
in
fulfillment of the requirements
of an Honorarium study conducted in
the Summer of 1977.

Fig. 1. Photomicrograph of a Protostrongyline lungworm (400x) as a first stage larva. At this stage, differentiation between Protostrongylus stilesi and P. rushi is difficult.

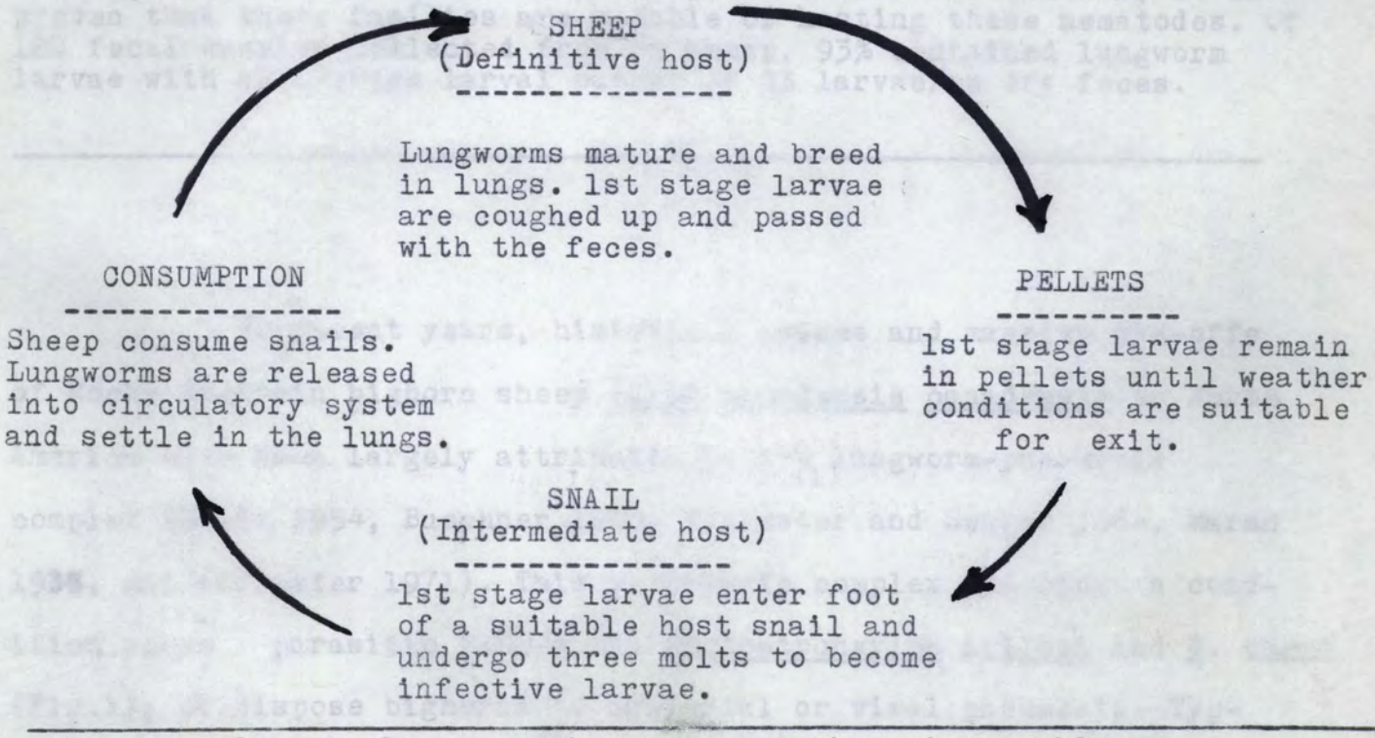

Fig. 2. Diagrammatic representation of the lifecycle of Protostrongyline lungworms.

bronchiolar lung tissue (Packard 1946, Buechner 1960, Marsh 1965, Forrester 1971, and Post 1971). Because bighorn sheep populations appear to be naturally regulated by disease (Buechner 1960, Forrester

volves an understanding of the lifecycle of the parasitic nematode. It is generally believed that the existance of lungworms is dependent on the presence of a definitive host, bighorn sheep, and an intermediate host, thought to be terrestrial snails (Marsh 1965, Forrester 1971) (Fig. 2). Lungworm breeding and early development occur in the lungs of the sheep host. First stage larvae are coughed up, swallowed, and voided with the feces. Under suitable conditions, first stage larvae leave the feces and enter the foot of certain terrestrial gastropods where they undergo three molts to become infective larvae. The minute snails, acting as intermediate hosts, are consumed by sheep where they are released into the bloodstream and migrate to the lungs where breeding again occurs (Marsh 1965, Forrester and Senger 1963, Forrester 1971). Control of the lungworm-pneumonia complex should be considered at all points in this cycle.

Because there have been few investigations into the extent of lungworm infestation in Idaho bighorn herds and intermediate host snails, this study was designed to determine 1) the level of lungworm infestation in a herd of Idaho bighorns and 2) the presence, location, and number of intermediate hosts on two bighorn winter ranges.

STUDY AREA

Research was conducted on two bighorn winter ranges in the Salmon River Mountains of central Idaho. One range bordered Cliff Cr. and Big Cr. and was situated across from the University of Idaho's Wilderness Research Unit at Taylor Ranch. The other was

located along Waterfall Cr., a tributary of the Middle Fork of the Salmon River, approximately ten miles east of Taylor Ranch (Fig. 3).

The study areas were typical of the winter ranges utilized by the sheep in this area. They were mostly south-facing slopes, ranging in elevation from 3500-7000 ft. (1060-2120 m). The ranges were divided, for convenience, into three cover types : grassland, coniferous park, and riparian.

The predominant cover type, grassland, was composed largely of the following species : Bluebunch wheatgrass (Agropyron spicatum), Sandberg bluegrass (Poa sandbergii), Cheatgrass (Bromus tectorum), Locoweed (Astragalus spp.), Yarrow (Achillea lanulosa Nutt.), Arrowleaf Balsamroot(Balsamorhiza sagittata Nutt.), and some Mountain-mahogany (Cercocarpus ledifolius Nutt.). This was an open area and had extremely dry, loose soil with little or no topsoil.

The second cover type considered was characterized by a dispersed coniferous stand with an understory composed mainly of Bluebunch wheatgrass, Balsamroot, Strawberry (Fragaria vesca L.), Gromwell (Lithospermum incisum Lehm.), and Rose (Rosa spp.). Again, the soil was loose and dry but decayed needles, logs, and cones provided a thin duff layer. On the Big Cr. range, Douglas fir (Pseudotsuga menziesii) was the dominant tree species while Ponderosa pine (Pinus ponderosa) was dominant on the Waterfall Cr. range.

The riparian cover type bordered creeks on the winter ranges studied. Typically, this included an area approximately 10-20 meters from each creek bank, extending the length of the designated range. The trees present included Cottonwood (Populus trichocarpa),

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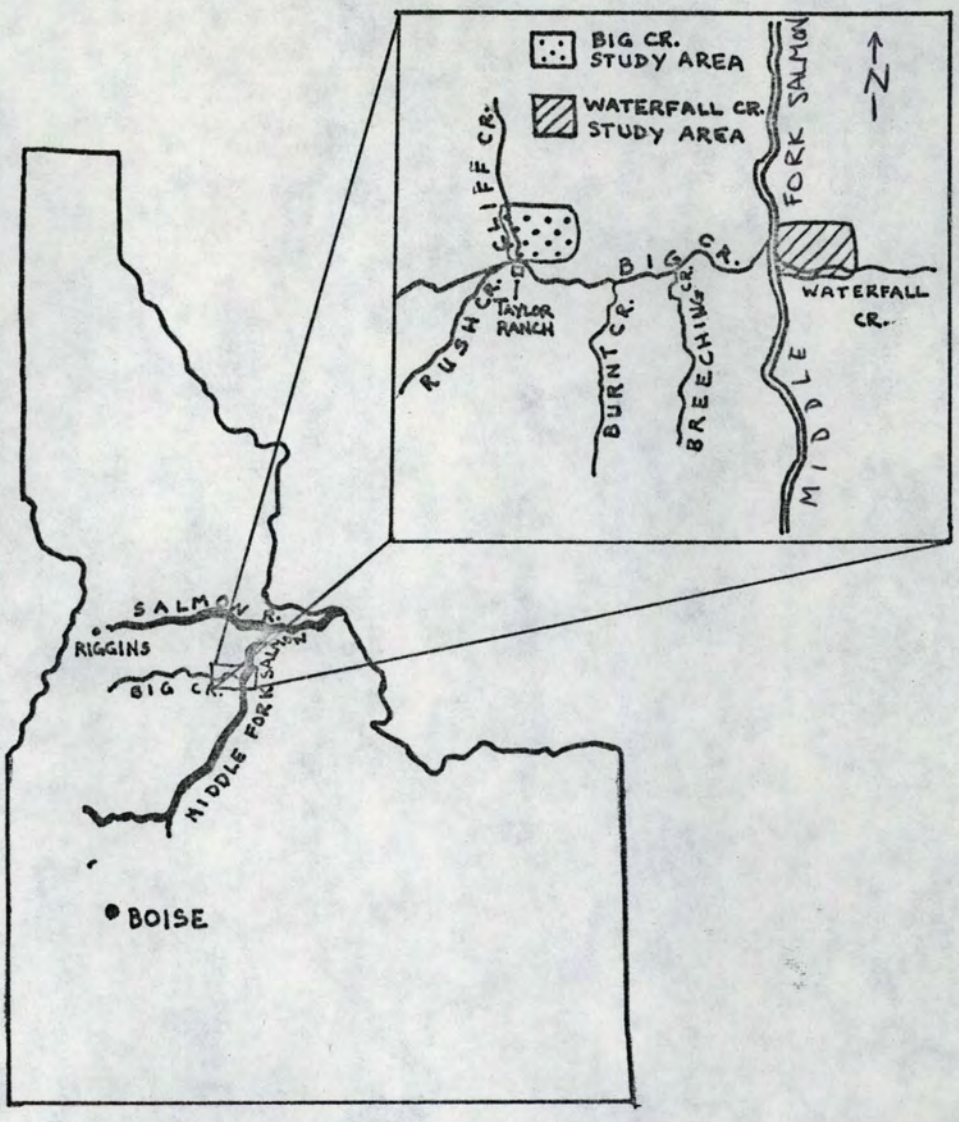

Fig. 3. Location map of study area in central Idaho (not drawn to scale).

Willows (Salix spp.), and Red-ozier dogwood (Cornus stolonifera). Other species present included Cow parsnip (Heracleum lanatum), Thimbleberry (Rubus parviflorus), Syringa (Philadelphus lewisii), Rose (Rosa spp.), Snowberry (Symphoicarpos albus), and Rushes (Juncus). The soil was deep, shaded, and covered with a broadleaf litter.

METHODOLOGY

Land snails were collected from both ranges and pellet groups were collected from sheep wintering on the Big Cr. range.

Snail Collection and Analysis

Twenty randomly arranged sample plots were examined in each of the three cover types on both ranges between June 6 and August 3, 1977. An open-sided quadrat measuring 1 meter X 0.5 meter was used to delineate plots from which the surface litter and top 2 cm of soil were examined. Rocks were overturned, logs separated, and litter systematically examined for live snails and shells. The topsoil was scraped up and filtered first through a 1 cm mesh screen and then through a 1 mm screen to expose all shells and snails present in the soil. All specimens collected were packed securely for later identification. Identification of snail families was based on Burch(1962), Malek (1962), and Forrester (1971). Live snails were examined for the presence of lungworm larvae in the foot tissue, as described by Forrester (1962).

Pellet Group Collection

Fresh pellet groups were collected from 85 sheep of the Big Cr. herd between February 16 and 23, 1978. Collection from 45 of these sheep was done near Cliff Cr. while collection from the remaining 40 was done between Burnt Cr. and Breeching Cr., five miles downstream of Taylor Ranch. Because sheep pellets are easily confused with those of mule deer (Odocoileus hymenoides) which also utilize these ranges, it was necessary to collect fresh pellets from areas that only sheep had foraged in. A total of 120 pellet groups were collected and packaged for analysis.

Pellet Group Analysis

Pellet groups were dried in a 55°C oven for 24 hours prior to analysis. One to five grams of dried pellets were crushed and weighed to the nearest one hundreth on Mettler Analytic Scales. Each sample was then run through a Baermann apparatus (Fig. 4) for at least six hours. 12 ml of the Baermannized product were drawn off and centrifuged to settle larvae to the bottom of the test tube. 2 ml of the bottom contents were pipetted out and examined under 40x magnification to determine what percent of the samples contained first stage lungworm larvae and at what density (larvae/ gm dried feces). This technique has been widely used as an indicator of the extent of infestation in herds of bighorn sheep (Blood 1963, Forrester 1971, Foreyt pers.comm.). Identification of nematode larvae was based on Yorke and Maplestone (1962) and Foreyt (pers.comm.).

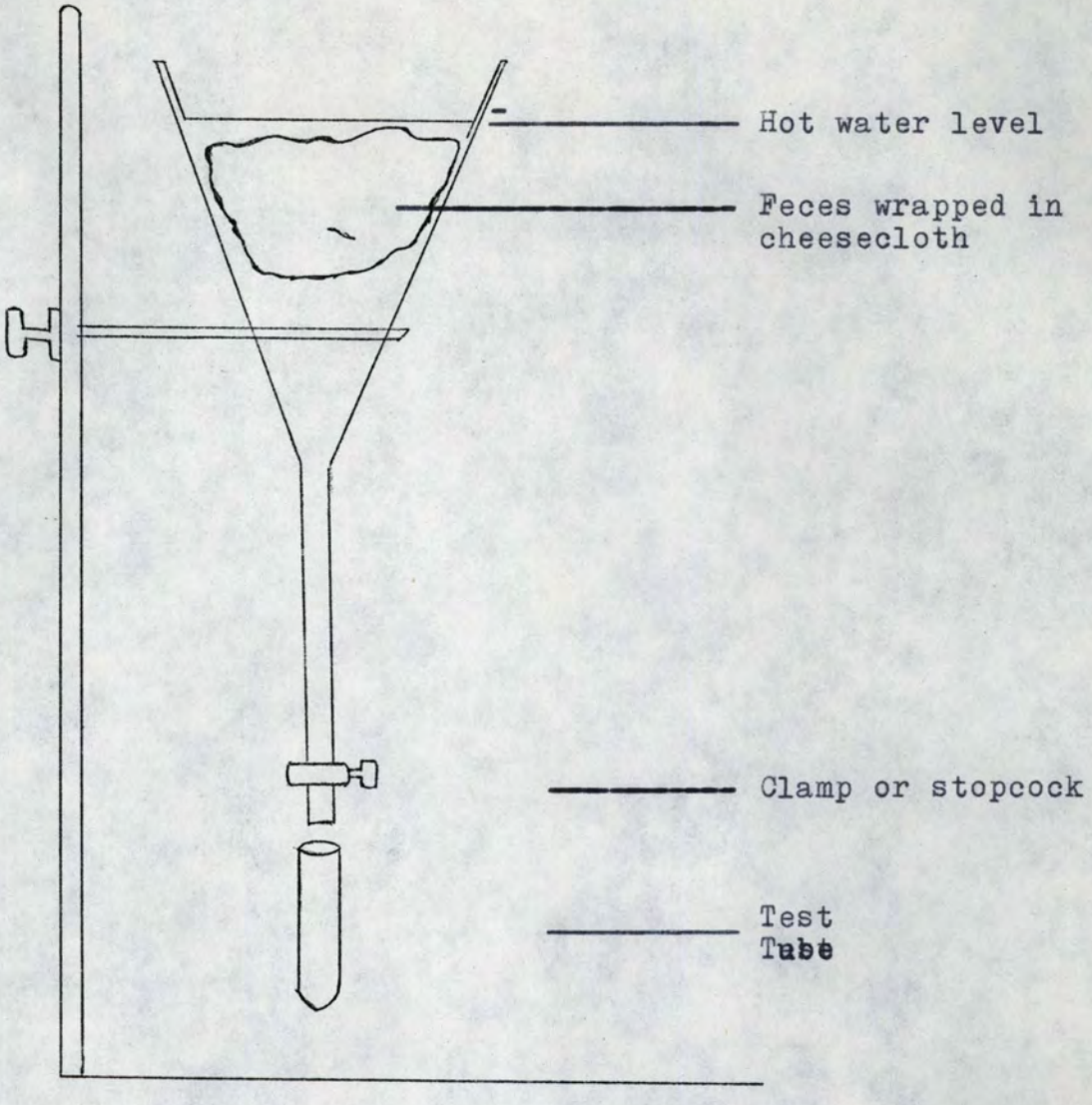

Fig. 4. Baermann Apparatus: One to five grams of fecal sample are wrapped in cheesecloth and placed in hot water for six hours. Nematode larvae, activated by the heat and moisture and unable to swim against gravity, emerge from the feces and sink to the clamp at the bottom of the funnel. A test tube is filled with larvae and water and is later centrifuged. Larvae are pipetted off the bottom of the test tube and counted.

RESULTS

Snail Data

Evidence of terrestrial snails of three families (Zonitidae, Pupillidae, and Vallonidae) was found on both winter ranges. All live snails and shells were found only in the riparian cover type in broadleaf litter. Of 60 plots sampled on the Big Cr. range, only only 13 exhibited any molluscan life. Six live snails and 81 shells were found on this range. Live specimens were of the families Vallonidae and Pupillidae and contained no lungworm larvae.

Of the 60 plots examined on the Waterfall Cr. range, 17 contained either shells or live snails. A total of 124 shells representing the three families above and 23 live specimens of the families Vallonidae and Pupillidae were found. None of the live snails showed any evidence of lungworm larval infestation.

Pellet data

Of the 120 pellet groups analyzed , 112 contained Protostrongyline lungworms. This suggests that 93% of the Big Cr. herd carries lungworms. There were an average of 22.9 larvae present per gram of dry feces. Values ranged between 0 and 171.1 larvae per gram.

DISCUSSION

Snails of the families Zonitidae, Vallonidae, and Pupillidae have been found to be naturally and/or experimentally capable

of hosting Protostrongylus spp. larvae (Buechner 1960, Forrester 1971). From the data collected, it is not possible to determine the level at which these snails have been infested. But since lungworms are present in the sheep here, it is certain that intermediate hosts are available to host the lungworm larvae (Hibler, pers.comm.).

There are several possible explanations for the apparent absence of infected snails on range where sheep have been proven to carry lungworms. Pillmore (1959,1961) has found a correlation between precipitation and the infestation level in the intermediate host; high precipitation elevates the infestation level in the snail host. The converse is assumed true here. Rainfall and snowmelt measurements for the periods March through August 1976 and 1977 at Taylor Ranch are shown in Table 1. Weather data for this area for the years prior to 1975 is not available so there is not adequate data for statistical analysis. This information is provided only to show that 1977 was a relatively dry year and that low precipitation may have been a factor adding to the difficulty of finding live and infested snails.

Table 1. Rainfall and snowmelt measured at the Taylor Ranch weather substation between March and August, comparing the years 1976 and 1977.

	Rainfall and snowmelt (in.)	
	1976	1977
March	1.07	0.85
April	1.33	0.31
May	1.78	1.15
June	1.57	2.51
July	1.07	1.63
August	2.64	0.51
Six month total:	9.46	6.96
April-June only:	4.68	3.97

A second explanation involves sample site location. Hibler (pers.comm.) has found that on Colorado winter ranges 2% of snails found on open range were infested while, in every 2 of 10 well established bedding grounds, snails exhibited 30-40% infestation. Because no bedding grounds were investigated in this study, the number of infested snails was probably significantly underestimated.

A third consideration involves censusing technique and observer biases. As mentioned earlier, areas where sheep frequently congregate should be more carefully examined. Because weather conditions were relatively dry, snails may have been located in soil depths below those investigated. Because the snails censused are often less than 2 mm in size, it is also possible that many were overlooked. Observer bias of this kind has been a problem in many snail studies (Buechner 1960).

Several studies have been conducted to determine the lungworm infestation levels in bighorn herds of North America. Most of these have used fecal pellet analysis of Baermannized samples to estimate the extent of infestation on a herd basis. Couey (1960) performed fecal analyses on a total of 360 pellet groups from eight Montana winter ranges and found that 86% contained lungworm larvae. Forrester and Senger (1964) found 91% of the 900 fecal samples collected in western Montana contained lungworms. Uhazy et.al. (1973) found larvae in all but one of 409 samples collected in British Columbia. Smith (1954) found 50% infestation in herds along the Middle Fork of the Salmon River in Idaho.

These figures and the 93% infestation level determined in this study are meaningless in themselves without the inclusion of data on the density of larvae per gram of feces. Hibler (pers.comm.)

believes that lungworms can be suspected of causing lamb mortality only after the fecal output of larvae reaches 250-1000 larvae per gram dry feces. Uhazy et.al. (1973) considers a burden of 1400 larvae per gram indicative of heavy infestation. Mass die-offs due to the lungworm-pneumonia complex occur when herds are under stress from overcrowding and poor range conditions (Buechner 1960, Uhazy et.al. 1973) at which time the burden and effects of lungworm infestation are amplified. Because the Big Cr. herd carries an average of 23 larvae per gram feces, it is evident that infestation is widespread but the burden is low.

The light lungworm burden observed in this herd can be accounted for in many ways. It is possible that stress on this herd is low and that there is not sufficient crowding to facilitate the spread of a parasitic nematode. It is also possible that there is not a large enough snail host population to support high lungworm burden levels. Forrester and Senger (1964) found that the highest burdens of lungworms in Montana herds studied were in areas with the highest densities of snails.

Weather also plays a role in the infestation rate in the definitive host. Uhazy et.al.(1973) found maximum migration of larvae from feces occurs during periods of high precipitation and, because infestation rates are simultaneously higher in the intermediate host, there is an increased fecal output of larvae in the winter following a moist summer. Forrester (1969) also found that Protostrongylus stilesi and P. rushi infections in fall-killed bighorns were directly proportional to the precipitation levels during the preceding April, May, and June (Table 1.). Thus, low larval output apparent in the winter of 1978 may be due, in part,

to low precipitation in the spring of 1977.

In order to draw sound conclusions about the status of the lungworm-pneumonia complex in bighorn sheep in this area, a more thorough study of the herds and winter ranges must be conducted. Such a study should incorporate weather fluctuations into monthly fecal pellet analyses. An intensive search for snail hosts in areas of heavy sheep congregation should also be conducted. When possible, hunter-killed sheep should be examined for pathological evidence of lungworms as explained by Pillmore (1961). Comparisons of conditions of many herds in this area through extensive collection of pellets on more winter ranges is also advisable. All information should be included in general population studies in order to show what effects lungworms are having on adult mortality and lamb recruitment.

Literature Cited

Blood, D.A. 1963. Parasites from California bighorn sheep in southern British Columbia. Canadian J. of Zool., Vol. 41.

Buechner, H.K. 1960. The bighorn sheep in the United States, its past, present, and future. Wildl. Soc., Wildl. Monograph 4. 174pp.

Burch, J.B. 1962. How to know the Eastern land snails. Wm. C. Brown Co. Publishers, Dubuque, Iowa.

Couey, F.M. 1950. Rocky Mountain bighorn shaap of Montana. Montana Fish and Game Comm. Bull. 2. 90 pp.

Foreyt, Wm. Personal communication at the Dept. of Parasitology, Wash. State Univ., Pullman. March 1977-1978.

Forrester, D.J. 1962. Land Mollusca as possible intermediate hosts of Protostrongylus stilesi, a lungworm of bighorn sheep in western Montana. Proc. of the Mont. Acad. of Sci. 22: 82-92.

———— 1969. Influence of weather on intensity of infection of bighorn sheep with lungworms of the genus Protostrongylus. Abstr. 44th Annu. Meet.,Am. Soc. Parasitol. p.40.

———— 1971. Bighorn sheep lungworm-pneumonia complex. In Parasitic diseases of wild mammals. Edited by J.W.Davis and R.C. Anderson. Iowa State Univ. Press, Ames. Ch.6, pp.158-173.

Forrester, D.J., and C.M. Senger. 1964. A survey of lungworm infection in bighorn sheep of Montana. J. Wildl. Manage. 28: 481-491.

Hibler, Chas. Personal communication from the Wild Animal Disease Center, Colo. State Univ., Ft. Collins. March 1978.

Malek, E.A. 1962. A key to the Gastropods. From Laboratory guide and notes for medical malacology. Burgess Pub. Co., Minneapolis.

Marsh, H. 1938. Pneumonia in Rocky Mountain bighorn sheep. J. Mammal. 19(2): 214-219.

———— 1965. From : Newsom's sheep diseases. Third edition. pp. 258-60. The Williams and Wilkins Co., Baltimore.

Packard, F.M. 1959. Ecology of bighorn sheep in Rocky Mountain National Park, Colorado. J. of Mammal. Vol.27,1: 3-28.

Pillmore, R.E. 1959. Study of lung nematodes of bighorn sheep. Fed. Aid. Div. Quart. Rept., Colo. Dep. Game and Fish. pp. 73-84.

———— 1961. Study of lung nematodes of bighorn sheep. Fed. Aid. Div. Quart. Rept., Colo. Dep. Game and Fish. pp.69-97.

Post, G. 1971. The pneumonia complex in bighorn sheep. From Trans. of First N. Am. Wild Sheep Conf. Colo. State Univ., Ft. Collins. Edited by Eugene Decker.

Smith, D.R. 1954. The bighorn sheep in Idaho : its status, life history, and management. Wildl. Bulletin No.1, 1954.

Uhazy, L.S., J.C. Holmes, and J.G. Stelfox. 1973. Lungworms in the Rocky Mountain bighorn sheep of western Canada. Canadian J. of Zool., Vol 51.

Yorke, W., and P.A. Maplestone. 1962. The nematode parasites of vertebrates. Hafner Pub. Co., N.Y.