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Authors: Boyce, Walter M., and Zarnke, Randall L.

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## Antibody Responses to *Psoroptes* sp. Mites in Dall Sheep (*Ovis dalli*)

Walter M. Boyce<sup>1</sup> and Randall L. Zarnke<sup>2</sup>, <sup>1</sup> Department of Pathology, Microbiology, and Immunology, University of California, Davis, California 95616, USA; <sup>2</sup> Alaska Department of Fish and Game, 1300 College Road, Fairbanks, Alaska 99701-1599, USA

**ABSTRACT:** We determined that antibody responses to *Psoroptes* sp. mites were not present in 403 of 407 sera samples collected opportunistically from 1979 through 1991 from Dall sheep (*Ovis dalli*) from five locations in Alaska, USA (Eastern Arctic,  $n = 61$ ; Central Arctic,  $n = 15$ ; Western Interior,  $n = 122$ ; Central Interior,  $n = 63$ ; Eastern Interior,  $n = 146$ ). Test values for four samples exceeded the positive cutoff value for the immunoassay, but exposure to mites could not be confirmed since the 95% confidence interval for true prevalence ranged from 0 to 2.3%. Therefore, we concluded that these were probably false positive results. Our analysis, coupled with the lack of previous reports of mites or lesions in Dall sheep or other Alaskan ungulates, provided indirect evidence that *Psoroptes* sp. are not enzootic in Dall sheep in Alaska. In contrast, *Psoroptes* sp. have been reported in bighorn sheep (*Ovis canadensis*) and other wild ungulate populations from southern Canada to Mexico. These findings are compatible with the hypothesis that *Psoroptes* sp. were introduced into North America with imported domestic sheep and were not introduced by ancestral wild sheep.

**Key words:** *Ovis* sp. *Psoroptes* sp., mites, serology, biogeography

*Psoroptes* sp. mites have been reported throughout the range of bighorn sheep (*Ovis canadensis*) from Alberta, Canada, to the Mexican border (Cowan, 1951; Boyce et al., 1990). One hypothesis is that *Psoroptes* sp. were introduced into bighorn sheep populations by domestic sheep imported in the 1800s (National Research Council, 1979). However, an alternative hypothesis is that *Psoroptes* sp. colonized North America along with the ancestors of bighorn sheep and Dall sheep (*Ovis dalli*) that migrated from Siberia during the Pleistocene. This latter scenario would be supported if mites were enzootic in Dall sheep populations north of the range of bighorn sheep near the now submerged Bering land bridge. Based on a review of the literature, we did not find any previous

reports of *Psoroptes* sp. mites or lesions in Dall sheep. Therefore, the objective of this study was to utilize a serologic assay to determine whether or not Dall sheep in Alaska have been exposed to mites in the genus *Psoroptes*.

Serum samples were collected opportunistically from 407 Dall sheep in Alaska (USA), from five locations: Eastern Arctic ( $n = 61$ ; 68°30' to 69°N, 144° to 145°W); Central Arctic ( $n = 15$ ; 68°30'N, 149°30'W), Western Interior ( $n = 122$ ; 63°50'N, 147°30'W), Central Interior ( $n = 63$ ; 63°45'N, 145°30'W), and Eastern Interior ( $n = 146$ ; 63°20'N, 143°55'W). Samples were collected from 1979 through 1991 and stored at -20 C by personnel from the Alaska Department of Fish and Game (ADFG) in Fairbanks, Alaska. Exposure to *Psoroptes* sp. was assessed by testing these sera using an enzyme linked immunosorbent assay (ELISA) previously developed and validated for bighorn sheep (Boyce et al., 1991). The mite antigen used in this assay is useful for detecting diagnostic antibody responses in several different hosts including bighorn sheep, mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), domestic rabbits, and cattle (Boyce and Brown, 1991; Ziccardi et al., 1996). Test samples, and positive and negative controls from bighorn sheep, were run in quadruplicate and a mean ELISA value was calculated for each sample. Sensitivity and specificity estimates were based on data derived from bighorn sheep since we did not have known positive and negative control samples from Dall sheep. Based on an ELISA cutoff of 40.5, this assay has a sensitivity (Se) and specificity (Sp) of 95% and 100%, respectively, with confidence intervals (CI) of 81 to 99% and 90 to 100%, respectively (Boyce et al.,

1991). The true prevalence (TP) and 95% CI for Dall sheep were estimated from the apparent prevalence (AP, AP = number positive/number tested) using the formula  $TP = (AP + Sp - 1)/(Se + Sp - 1)$  (Gardner and Holmes, 1993).

Although the *Psoroptes* sp. ELISA was developed primarily for use with bighorn sheep, no technical problems were detected when testing Dall sheep sera. Coefficients of variation among quadruplicate tests of each sample were < 10% and values for internal positive and negative controls were within normal limits. The ELISA test values for four Dall sheep from three locations exceeded the cutoff value of 40.5. The location (and ELISA values) for these four sheep were Eastern Interior (59.4, 44.6), Western Interior (63.4), and Eastern Arctic (40.7). Test values for the remaining 403 Dall sheep were clearly negative (mean = 17.8, SD = 8.9). From these results we estimated an AP of 0.9% and TP of 1.0%. However, exposure to *Psoroptes* sp. could not be confirmed since the 95% CI for TP ranged from 0 to 2.3%.

Our serologic analysis provided indirect evidence that *Psoroptes* sp. are not enzootic in Dall sheep from these locations. Based on probability theory (Gardner and Holmes, 1993), even though TP (1.0%) approximated AP (0.9%), the 95% CI for TP actually overlapped 0.0. Although we cannot exclude the possibility that four sheep were exposed to mites, we believe that the four test values > 40.5 were most likely false positive results. This interpretation is supported by the fact that the four suspect results were from Dall sheep in three different locations. Furthermore, about 1 to 2% of bighorn sheep tested since assay specificity was initially determined (Boyce et al., 1991) have been falsely classified as seropositive when serologic results were compared with parasitologic examination. In addition, *Psoroptes* sp. apparently have not been reported previously from Dall sheep, or any other wild ungulate, anywhere in the range of

Dall sheep in Alaska, the Yukon Territory, or northern British Columbia.

Our results are not compatible with the hypothesis that mites were introduced into North America by ancestral wild sheep. Bighorn sheep and Dall sheep in North America both originated from common Eurasian ancestors that migrated across the Bering land bridge during the Pleistocene (Cowan, 1940; Sage and Wolff, 1986). Therefore, one could expect *Psoroptes* sp. to be enzootic in both sheep species if this host-parasite relationship was established prior to host speciation. This ecological concept is often referred to as "association by descent" (Mitter and Brooks, 1983). In contrast, our results are compatible with the hypothesis that *Psoroptes* sp. were introduced into North America by domestic sheep. In the 1800s, *Psoroptes* sp. were responsible for epizootics in many bighorn sheep populations coincident with the sympatric introduction of domestic sheep (National Research Council, 1979; Lange et al., 1980). Enzootic infestations have apparently been established or maintained in bighorn sheep populations in Montana (Becklund and Senger, 1967), Idaho, Oregon, and Washington (Foreyt et al., 1985; 1990), Wyoming (Muschenheim et al., 1990), California (Mazet et al., 1992), Nevada (Decker, 1970), Arizona (Welsh and Bunch, 1983), and New Mexico (Lange et al., 1980) in the USA. Thus, the distributional pattern of *Psoroptes* sp. among bighorn sheep in North America appears to have been initially determined by the introduction and distribution of mite-infested domestic sheep. This ecological concept is often referred to as "association by colonization" (Mitter and Brooks, 1983). Following this line of reasoning, the apparent absence of *Psoroptes* sp. in Dall sheep may be due to the historic lack of contact between domestic sheep and Dall sheep in Alaska (Heimer et al., 1992).

Our study provided indirect evidence that *Psoroptes* sp. do not occur in Dall sheep in Alaska. These results are also

compatible with the hypothesis that *Psoroptes* sp. did not colonize North America via wild sheep crossing the Bering land bridge. We recognize that our data are limited and that there are other parsimonious interpretations of the existing data. We encourage other investigators to conduct parasitologic examinations of Dall sheep and other wild ungulates in Alaska to support or refute these proposals.

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