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ECHINOCOCCUS GRANULOSUS (CESTODA: TAENIIDAE) INFECTIONS IN MOOSE (*ALCES ALCES*) FROM SOUTHWESTERN QUEBEC

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ABSTRACT: Investigation of the distribution of larval *Echinococcus granulosus* in a moose population from southwestern Quebec revealed a distinct and stable pattern of infection with a prevalence of 44% (n = 580). Positive correlations between moose age and the intensity, mean cyst weight and biomass of the hydatid cysts suggested a process of continued parasite acquisition and cyst growth. The distribution of cyst sizes within individual moose provided circumstantial evidence of interaction between cysts, perhaps mediated through the host's immunological response.

Key words: Cestode, *Echinococcus granulosus*, hydatid cyst, moose, *Alces alces*, timber wolf, *Canis lupus*.

INTRODUCTION

Echinococcus granulosus is a common larval cestode parasite of moose and has been reported from many parts of North America (Anderson and Lankester, 1974; Samuel et al., 1976; Addison et al., 1979; Rau and Caron, 1979). The purpose of this study was to document the distribution of *E. granulosus* in moose from the Rouge-Matawin (163,500 ha) and LaVerendrye (1,361,500 ha) Provincial Game Reserves in southwestern Quebec. The timber wolf (*Canis lupus*) is a known definitive host of this parasite and is present in both game reserves (McNeill et al., 1984). The prevalence, intensity and biomass of hydatid cysts were examined in relation to study area, host age and sex, and site of infection. These data provide some insight to the acquisition and growth of pulmonary cysts. The potential effects of such infections on moose are discussed.

MATERIALS AND METHODS

Moose lungs collected by hunters during the fall of 1978 through 1982 (Rouge-Matawin) and 1980 through 1982 (LaVerendrye) were cut into thin (1 cm) slices and palpated to locate cysts. These were excised and weighed. Voucher specimens were deposited in the U.S. National Parasite Collection, Beltsville, Maryland 20705, USA (No. 78494). Prevalence and intensity (Margolis et al., 1982) were calculated. Mean cyst weight was recorded for the 1979 to 1982 samples. Minimum and maximum cyst weights were recorded also for the 1980, 1981 and 1982 samples. Data were analysed first to verify that moose were sampled from populations with the same age distribution and levels of infection (prevalence, intensity, and mean cyst weight). The Kruskal-Wallis test (chi-square approximation) (Siegel, 1956) was used to test for differences in age distribution and the chi-square test of independence (Siegel, 1956) tested differences in prevalence and sex ratio among the eight samples. Due to a non-normal distribution, intensity data were log-transformed. Univariate analysis showed these data to be approximately normally distributed following the transformation. One-way ANOVA (Sokal and Rohlf, 1982) was then used to test differences in mean intensity across all samples and in mean cyst weight across the 1979 through 1982 samples. Following these initial analyses, chi-square analysis was used to test for differences in prevalence, and the Kruskal-Wallis test for differences in intensity and mean cyst weight, between the sexes. Relationships between moose age and the mean intensity and the mean, minimum and maximum cyst weights were tested using the Spearman rank correlation coefficient (r_s) with corrections for ties (Siegel, 1956). All statistical analyses were done using SAS for Personal Computers (SAS Institute Inc., 1985). Significant differences were determined at $P \leq 0.05$.

RESULTS

Approximately 50% of all moose shot were <2.5 yr, 30% were <6.5 yr and 20% were older than 6.5 yr. This pattern of age distribution varied little between reserves or among years ($H = 9.17, P > 0.05$). Mean age ranged from 3.7 yr (Rouge-Matawin in 1978) to 5.5 yr (Rouge-Matawin in 1982) and did not differ significantly among samples ($F = 1.17, P > 0.05$). More males (65%) than females (35%) were killed ($\chi^2 = 54.67, P < 0.01$, df = 7), and similar sex ratios were observed for all samples ($\chi^2 = 0.72, P > 0.05$, df = 7). There was no significant difference between prevalence ($\chi^2 = 12.80, P > 0.05$, df = 7) or mean intensity ($F = 1.23, P > 0.05$) for any of the samples. There was a significant difference in mean cyst weight ($F = 3.62$, $0.02 < P < 0.05$), but this difference was judged biologically insignificant due to the overriding similarities in prevalence and mean intensity for all eight samples. Thus, the distribution of *E. granulosus* in these moose was examined using the pooled ($n = 580$) data.

Significant differences in prevalence were not detected between the sexes ($\chi^2 = 0.36$, df = 1). Mean intensity was higher in females (24.7) than in males (16.0), but the Kruskal-Wallis test did not reveal a significant difference in this variable ($H = 2.76, P > 0.05$) or in mean cyst weight ($H = 1.19, P > 0.05$).

Overall, prevalence of *E. granulosus* averaged 44% and rapidly increased with age, reaching 100% in older moose. Intensity followed a similar pattern of increase with moose age ($r_s = 0.51, P < 0.01$) (Fig. 1). Mean and maximum cyst weight also were correlated positively with moose age ($r_s = 0.52$ and 0.62, respectively; $P < 0.01$ for both). However, minimum cyst weight remained relatively constant as the moose grew older ($r_s = 0.12, P > 0.05$). The distribution of cyst weights in each infected moose exhibited a distinct pattern. The majority of cysts remained fairly small (1–3 g) while a few attained a relatively large size (25–30 g). This was most common in the older, more heavily infected moose.

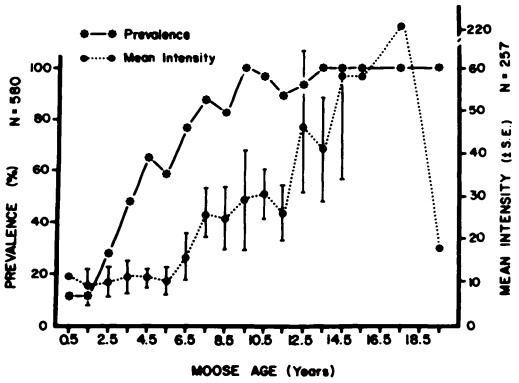

FIGURE 1. Age-prevalence and age-intensity relationships for moose infected with *Echinococcus granulosus*. Bars on mean intensity values indicate ± one standard error and are not given if $n < 3$.

DISCUSSION

The results of this study indicate that sylvatic echinococcosis is a stable, enzootic disease of moose in southwestern Quebec. The absence of significant differences in prevalence and mean intensity, and only slight differences in mean cyst weight, of *E. granulosus* in moose from the two study areas may indicate a homogeneity of factors influencing transmission of this parasite. The increase in prevalence and intensity with age indicated that moose continued to acquire the parasite throughout their lives as previously demonstrated by Ritcey and Edwards (1958), Sweatman and Williams (1963), and Addison et al. (1979). The pattern of cyst weights in infected moose indicated that the continual acquisition of pulmonary cysts may be influenced by some degree of host response. According to Sweatman et al. (1963), experimentally infected lambs exhibit partial resistance to superinfection with *E. granulosus*. Rau and Tanner (1973) demonstrated that pre-existing cysts of *E. multilocularis* in cotton rats suppress the establishment and growth of subsequent

challenge infections. Assuming that moose of any age have an equal chance of becoming infected, the disproportionate number of small cysts found in older moose may indicate a response similar to that shown in cotton rats. This could result from intraspecific competition and/or the continual acquisition of new cysts.

Some authors hypothesize that pulmonary cysts of *E. granulosus* may render the host more susceptible to predation (Crisler, 1956; Mech, 1970; Peterson, 1977; Allen, 1979; Rau and Caron, 1979). Others suggest that *E. granulosus* is nonpathogenic in the intermediate host (Rausch, 1952; Ritcey and Edwards, 1958; Rausch, 1959; Addison et al., 1979). The latter view is based on the lack of any apparent relationship between the host's physical condition and the intensity of infection. It is suggested herein that an infected moose could be in good condition if suitable habitat and food were available. However, a pulmonary infection, which may be of little consequence in a resting or browsing moose, may compromise the vigor of a stressed animal. Considering the keen awareness of wolves to the condition of their prey (Mech, 1970; Allen, 1979), any such effect may increase the chances of a moose being killed by wolves. This may apply especially to older, more heavily infected individuals. However, it is accepted generally that aged or less vigorous individuals are more susceptible to predation. Therefore the presence of pulmonary hydatid cysts cannot be singled out as a cause of death. Rather, it is a factor which, in concert with others, may lead to moose being killed by wolves. This may influence the dynamics of the predator–prey relationship.

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