

# Heritable resistance/susceptibility of red deer to challenge with *Mycobacterium avium* subsp. *paratuberculosis* (MAP)

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**Objectives:** To assess the heritability of resistance or susceptibility in the offspring of two red stags to experimental oral challenge with MAP, to monitor clinical, pathological and immunological changes, and to obtain samples for gene expression studies.

**Introduction:** Paratuberculosis (Johne's disease) results in serious losses of farmed red deer (*Cervus elaphus*) in New Zealand.

Young deer are particularly susceptible, especially to heavy challenge with the bovine strain of MAP. Clinical disease occurs in deer as young as 8 months old. Field data suggests that resistance to paratuberculosis is heritable.

This study describes the progression of paratuberculosis and immunological responses over the 12 month period after challenge with MAP in red deer and demonstrates degrees of genetic resistance/susceptibility.

**Results:** 3 clinical Johnes, euthanised 18-25 weeks pc. 3 with nil or nonspecific lesions (2R, 1S) offspring significantly more severe lesions (P < 0.05). R offspring: mean LSS = 5.9 (mild), 7/9 nil/mild. S offspring: mean LSS = 11.7 (severe), 7/9 severe. In period 13-49 weeks pc, most R offspring, but not S offspring, showed evidence of resolving lesions and a reduction in the number of MAP.

One R offspring appeared to completely cure itself. It had mild culture-positive lesions at Week 13, but had no signs of disease or infection at Week 49.

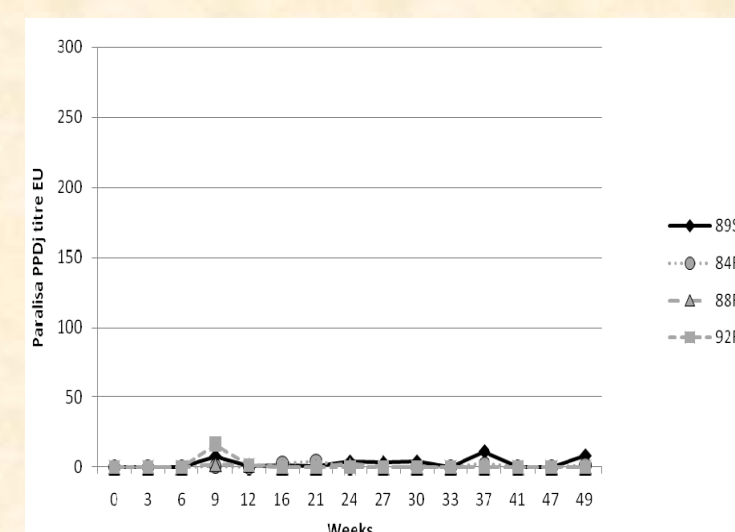
**Overall key differences in immunological responses:** R deer had higher IFN- $\gamma$  levels, lower antibody levels, fewer MAP cultured from JJLN and a less vigorous granulomatous response.

S deer had lower IFN- $\gamma$  levels, higher antibody levels, more MAP cultured from JJLN and a more vigorous granulomatous response, indicating their inability to control infection.



**Method:** Two red stags identified with offspring highly resistant (R) or susceptible (S) to paratuberculosis based on field data (est.  $H^2 = 0.27$ ). Unselected hinds synchronised and AI'd with semen from these two stags, and 9 offspring of each sire were weaned in March 2009. These 4-mo offspring were challenged daily with 4 doses of  $\sim 10^9$  MAP, a virulent bovine strain harvested from the jejunal lymph nodes (JJLN) of a clinically affected deer.

Samples of JJLN were surgically biopsied at 4 and 13 weeks post challenge (pc), and collected at either euthanasia of clinically affected or at the end of the study 49 weeks pc. The disease status for each animal was scaled on clinical outcome, histopathology lesion severity score (LSS: 0-nil, 1-3 nonspecific, 4-7 mild, 8-10 moderate, 11-13 severe).



**Figures:** Paralisa PPDj titres over 49 week study for deer born to an R sire (R suffix; gray or S sire (S suffix; black).

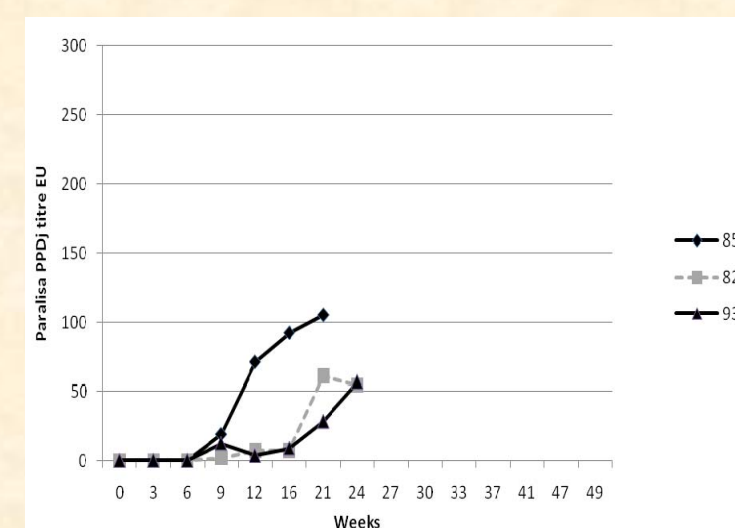


Fig. 1: Four of the most resistant deer (84R, 88R, 89S, 92R) on serology, lesion score and culture.

Fig. 2: Three most susceptible deer that were clinically affected and euthanised 18-25 weeks pc (82R, 85S, 93S).

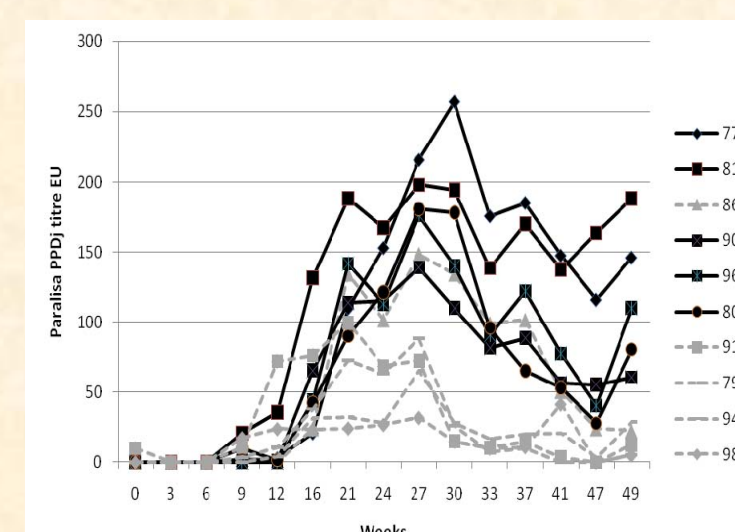


Fig. 3: The remaining 12 deer showing obvious differences in height and changes in responses between R and S animals.

**Conclusions:** This study confirmed that resistance to MAP challenge is a highly heritable trait in red deer. Innate immunity appeared to prevent infection, while acquired immune responses appeared to control infection and limit disease in the majority of resistant, but not susceptible, offspring.

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