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Does milk supply have long-term benefits for resistance and resilience to nematode parasites in sheep?

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ABSTRACT

The long-term benefit of suckling for the resistance and resilience of lambs to *Teladorsagia circumcincta* infection was investigated in a 20-week after-lambing trial period; during which time the immune response was anticipated to be strengthening. In a two by two factorial arrangement, one factor was 'suckling' with one twin lamb from each of 34 pairs being either weaned (W−) at 39 days of age or allowed to continue suckling (S−) until necropsy at mean ages of either 84, 112 or 140 days. The second factor was 'parasite infection' with lambs in each 'suckling' treatment group either artificially challenged with an equivalent of 1000 L_3 *T. circumcincta* larvae d^{-1} (−I) from day 42 of age until necropsy or not artificially challenged (−N). All lambs and their dams grazed ryegrass pastures throughout the trial; these were intended to be relatively parasite safe, although worm burdens of SN and WN groups suggested there was a considerable parasite challenge from pasture from day 84 onwards. Despite this, suckled lambs consistently exhibited lower faecal egg counts (FECs; $P < 0.05$) and worm burdens at slaughter on days 84 and 112 ($P < 0.05$ for both). Worms from suckled lambs appeared to have reduced egg production indicating either a direct effect of milk proteins on parasite fecundity or an indirect benefit of suckling through the provision of nutrients for enhance immune capacity. Lamb growth rate was reduced by weaning but not by artificial challenge ($P > 0.05$). It was concluded that while the enhanced protein supply from suckling will facilitate greater growth rates in young lambs, weaning may not necessarily be associated with reduced resilience to *T. circumcincta* infection. Furthermore, suckling appears to assist in reducing worm burdens and parasite fecundity either through a direct anti-parasitic effect or through hastening the acquisition of immunity when lambs are exposed to larvae early in life.

1. Introduction

"*Resistance*" and "*Resilience*" represent desirable animal (host) responses to gastrointestinal (GI) nematode challenge (Albers et al., 1987). Resistance is the ability of a host to prevent or limit the establishment or development of infection. It is largely a function of the host's immune system and is assessed following the determination of the concentration of nematode eggs in faeces (faecal egg counts, FECs), by the number of worms and their developmental stage, length and fecundity or through increased circulating immunoglobulins. By comparison, resilience has been defined as the ability of animals to maintain either a level of production (weight gain, milk production) or of indices such as serum proteins or red blood cell numbers under nematode challenge (Van Houtert and Sykes, 1996; Morris et al., 2004). Strategies to improve both resistance and resilience have been frequently explored with the ultimate aim of reducing the impact of GI parasite infection in young lambs. In particular, increasing the resistance to GI

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parasites through the provision of a more capable immune response has been suggested as a method through which resilience may be conferred.

Immunity to nematode infection has been considered to be a function that competes for nutrient resources against the requirement of the host to maintain other body functions (Coop and Kyriazakis, 1999; Colditz, 2002). In young growing lambs, the high protein requirement, relative to energy, for the deposition of lean tissue (Orskov, 1992) may create a situation of competition for protein between immune function and growth. Indeed, post-ruminal protein supplementation of young lambs has been shown to result in decreased faecal egg count and worm burden (Bown et al., 1991), and an increased concentration of mast cell protease in the abomasal mucosa of young lambs (Coop et al., 1995). Milk contains a ratio of 10.7 g amino acid per megajoule of metabolisable energy (Geenty and Sykes, 1983), which avoids microbial degradation in the rumen of suckling young ruminants by passing directly to the abomasum via the oesophageal groove reflex. This will enhance the protein nutrition of the lamb, and could theoretically ensure a sufficient supply of nutrients, particularly protein, to facilitate both immunological development and lamb growth, thereby assisting with the expression of both resistance and resilience to infection in suckled lambs.

Reduced GI nematode burdens in milk-fed compared with early-weaned lambs have been attributed to probable direct adverse effects of milk on larval establishment (Zeng et al., 2001, 2003; Iposu et al., 2008). Contrary to expectation, however, both weaned and suckled lambs in the study of Iposu et al. (2008) had similar weight and carcass gain during infection to their uninfected controls, despite the weaned lambs harbouring almost twice the worm burden of the suckled lambs. It was argued, on the basis of the evidence of Greer et al. (2005) that the immune response *per se* can be responsible for reduced feed intake and nutritional costs, that the lack of difference in resilience was because both groups were too young/immature to exhibit an immune response sufficiently strong to affect nutrient demand and lamb performance (Smith et al., 1985; Kambara et al., 1993; Colditz et al., 1996). If this was the case, the chance of seeing a beneficial effect of milk feeding on resilience during the 6–12 week period after lambing in Iposu et al. (2008) would have been reduced.

This paper describes a follow-up study to Iposu et al. (2008); to test the hypothesis that milk supply through suckling can confer a long-term advantage to both the resistance and resilience of young lambs to infection with the GI nematode *Teladorsagia circumcincta* by extending the trial period to 20 weeks after lambing when immune responses were anticipated to be strengthening.

2. Materials and methods

The experiment was carried out with approval from, and in accordance with authority of a Lincoln University Animal Ethics Committee (Approval No. 58).

2.1. Management of experimental animals

Thirty-four twin-bearing mixed-age Coopworth ewes were selected from a larger flock after scanning for number of lambs carried; these borne the 68 twin-lambs that were used for the study. From 21 days prior to lambing (day−21), ewes were allowed to graze on a perennial ryegrass (*Lolium perenne* L.) – white clover (*Trifolium repens* L.) sward typical of pastures used in New Zealand farming systems. The sward had an estimated yield of 2000 kg DM ha^{-1} at the beginning of the trial, and 1200 kg DM ha^{-1} at the end (C.M. Logan, personal communication, which was expected to contain in excess of 23% crude protein and supply 11 megajoules of metabolisable energy per kg of dry matter. In order to minimise pasture contamination, all ewes were treated upon entry to the pasture with a long acting anthelmintic injection (Eweguard™, 4.5 g/l moxidectin, Fort Dodge New Zealand Ltd., Auckland, New Zealand) at a dose rate of 0.2 mg moxidectin per kg live weight (LW). This was followed by administration of a controlled-release anthelmintic capsule (Extender™ 100; 3.85 g/capsule of albendazole at a minimum dose of 0.5 mg/kg LW per day; Captec New Zealand Ltd, Auckland, New Zealand) on day -21, both treatments of which were expected to provide effective parasite control (R.W. McAnulty, personnel communication). At parturition the lambs were tagged for individual identification to dam, and lambing dates were recorded.

2.2. Experimental design

At a mean of 39 days of age, one member of each set of twins was either weaned (W−) or allowed to continue suckling (S−) until necropsy. At a mean of 42 days of age, each lamb was randomly allocated to one of two larval dosing regimes of either zero (−N) or an equivalent of 1000 (−I) L_3 larvae d^{-1} of the abomasal nematode *T. circumcincta*. Treatment groups were balanced for sex of lamb and live weight (LW; mean ± SEM: 15.4 ± 0.38 kg). This created a two by two factorial trial design *viz*. weaned and not infected (WN; $n = 16$), suckled and not infected (SN; $n = 16$), weaned and infected (WI; $n = 18$), and suckled and infected (SI; $n = 18$). The suckled lambs and their dams were maintained on the ryegrass-white clover sward that was intended to have minimal larval contamination, while weaned lambs were reared in a separate area of the same paddock. A three-paddock rotational grazing of the two flocks was adopted in which ewes and their suckling lambs followed the weaned lambs. This enabled the nursing ewes to maintain equivalent pasture mass and quality and to equalise any pasture larval contamination for weaned and suckled groups.

At weekly intervals lamb live weight was recorded, faecal samples were collected directly from the rectum and blood samples (5 ml) obtained via jugular venipuncture, into lithium heparinized vacutainers (Becton Dickinson, VACUTAINER Systems, Rutherford, NJ, USA). Blood samples were immediately centrifuged at 2000 × *g* for 10 min with the plasma collected and stored at −20 °C until analyses. Lambs were allocated hierarchically, by lambing date, to slaughter groups. Necropsy was carried out on five lambs from each WN and SN group and six lambs from each WI and SI group on days 84, 112, and on six lambs from each group on day 140 after lambing, making totals of 22 lambs on each of slaughter days 84 and 112, and 24 lambs on slaughter day 140. The timings of necropsy were intended to provide information on the accumulation of worms during what was anticipated to be the three critical phases of the trial: prior to the development of immunity (phase 1: days 42–84); during the phase of acquisition of immunity (phase 2: days 85–112); and at a time when a degree of immunity may be expected to have been developed (phase 3: days 113–140) (Kambara et al., 1993).

2.3. Parasitology and necropsy procedure

The equivalent of 1000 infective *T. circumcincta* L_3 larvae d^{-1} (Lincoln Kumeroa strain PB252/14) was administered orally to each animal of the infected (−I) group by pipetting larvae onto filter paper that was rolled and administered using a balling gun on the Monday, Wednesday and Friday of each week, commencing on day 42 and ended 5 days prior to slaughter for each necropsy group. The concentration of nematode eggs in the faeces (FEC) was determined using a modification of the McMaster method (M.A.F.F., 1987) and expressed as eggs per gram (epg) of fresh faeces. Slaughter, worm recovery from both the abomasum and the first 6 m of the small intestine distal to the pylorus, worm enumeration, and worm length measurements were performed as described by Donaldson et al. (2001).

2.4. Plasma analyses

Plasma total protein and plasma albumin were measured on a Cobas Mira Plus™ Auto-analyser (Roche Diagnostics GmbH, Mannheim, Germany) using kits 11929917 and 11970569, respectively. *T. circumcincta*-