
NEW ZEALAND SOCIETY
ANIMAL PRODUCTION
VOLUME 62 2002

BRIEF COMMUNICATION: Reticulo-rumen growth and papillae development in farmed red deer calves from four to twelve weeks of age

B.R. THOMPSON[1], G. HOFSTRA[1], K.J. HAMMOND[1,2], C.G. MACKINTOSH[1], S.O. HOSKIN[2], R.P. LITTLEJOHN[1] and D.R. STEVENS[1]

[1]AgResearch Invermay, Private Bag 50-034, Mosgiel, New Zealand
[2]Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Private Bag 11-222, Palmerston North, New Zealand

Keywords: red deer; rumen; reticulum; growth; papillae; tissue thickness.

INTRODUCTION

Ruminants are born with an underdeveloped forestomach (Warner *et al*., 1956) and as such operate as a monogastric animals until the reticulo-rumen (RR) and omasum have developed. The development of the rumen from birth to weaning has been well studied in dairy cattle (Heinrichs & Lesmeister, 2005), but not farmed red deer. Understanding pre-weaning rumen developmental processes is required for feeding programmes aiming to maximise pre-weaning growth rates of young red deer calves for early venison production. This preliminary study aimed to document the changes in rumen growth and papillae development over the first 12 weeks of life in unweaned red deer.

MATERIALS AND METHODS

Rumen development of 12 red deer (*Cervus elaphus* sp.) calves, from four to 12 weeks of age, grazing with their dams on a permanent perennial ryegrass-based (*Lolium perenne*) pasture was studied. All calves were born over a 17 day period and were tagged and weighed within 24 hours of birth. Four calves were randomly selected based on birth date to be serially slaughtered at each of 4, 8 or 12 weeks of age and a full rumen dissection conducted. The animals were weighed to determine live weight, euthanized, and crown-rump length measured. They were placed in dorsal recumbancy, the sternum and abdominal muscles removed and the complete gastrointestinal (GI) tract exposed from the ventral side. The GI tract was removed and the RR tied off and separated. Full and empty weights of the RR were recorded. After a thorough rinsing in tap water, the RR volume was measured using the method described by Sibbald and Milne (1993). Rumen tissue samples were collected from the left side of the caudal dorsal sac, ventral sac, atrium ruminis and cranial dorsal sac, using an adaptation of the technique described by Lesmeister *et al*. (2004). Briefly, the RR was laid flat on the left side with the oesophageal groove facing away, marked and incised around the circumference in line with the oesophageal groove. The muscles forming the rumen pillars were incised and separated in line with the initial incision which allowed the RR to be opened symmetrically (Figure 1).

Samples were fixed in Trumps solution (McDowell & Trump, 1976), to prevent sample shrinkage (Lentle *et al*., 1996). Rumen wall thickness (RWT) and the length and width of two

FIGURE 1: Incised and opened reticulo-rumen of a red deer showing the four reported sampling regions, LB (caudal dorsal sac); LC (ventral sac); LE (cranial dorsal sac); and LD (atrium ruminis).

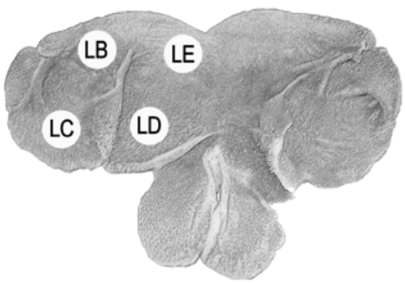

TABLE 1: Effect of the age of red deer calves at slaughter on morphometric measurements, reticulo-rumen (RR) dimensions, and rumen papillae length, width and wall thickness (RWT). LB = caudal dorsal sac; LC = ventral sac; LD = atrium ruminis; LE = cranial dorsal sac.

Measurement	Region	Age of deer at slaughter (weeks)			
		4	8	12	SEM
Live weight (kg)		22.7^{a}	33.3^{b}	46.8^{c}	1.4
Crown-rump length (cm)		91.6^{a}	105.5^{b}	117.2^{c}	1.9
Full RR weight (g)		402^{a}	$1,896^{b}$	$3,591^{c}$	201
Empty RR weight (g)		138^{a}	510^{b}	817^{c}	31
RR volume (L)		1.10^{a}	3.43^{b}	5.78^{c}	0.45
RWT (mm)		1.19^{a}	2.03^{b}	2.08^{b}	0.06
Papillae length (mm)	LB	1.13	1.49	2.41	
	LC	1.15	1.83	2.13	
	LD	1.45	4.17	5.28	0.25[1]
	LE	1.04	1.84	1.91	
Papillae width (mm)	LB	0.44	0.76	1.02	
	LC	0.48	0.68	0.94	
	LD	0.57	1.15	1.70	0.05[1]
	LE	0.43	0.87	0.92	

Means within the same row with different superscripts are significantly different (P <0.001).

[1] SEM for the interaction term comparing region by age at slaughter

papillae were measured manually under a light microscope from each of five thin cross-sections per site. Animal data was analysed by ANOVA (Payne *et al*., 2007), fitting age as the treatment. Papillae length was analysed by ANOVA, with animal as blocks, and age, region within the rumen and their interaction as treatments.

RESULTS AND DISCUSSION

Live weight increased from 9.7 kg at birth to 22.7 kg and 46.8 kg at four and 12 weeks of age respectively (P <0.001) (Table 1). Morphometric measurements also increased significantly (P <0.001) with age (Table 1). RR full weight, empty weight and volume and RWT all increased significantly (P <0.001) with age (Table 1), though RWT did not increase significantly (P >0.05) beyond 8 weeks of age.

To compare with studies in other species, it is necessary to express some results on a live weight basis to remove the effect of differing body size for age. Mean RR volume per unit live weight increased with age, being 49, 103 and 122 (Standard error of mean (SEM) = 7.9; P <0.001) mL/kg at 4, 8 and 12 weeks of age, respectively. The RR volume for four-week-old red deer calves was similar to milk fed bovine calves which had a RR volume of 42.3 mL/kg (Tamate *et al.*, 1962). By 12 weeks of age, the grazing red deer calves in this study were still similar to dairy calves that had been offered *ad libitum* access to hay and a concentrate mix as well as milk, with a RR volume of 114.0 mL/kg (Tamate *et al.*, 1962). The similarity of the relative RR volume of red deer calves to milk-fed dairy calves at four weeks of age and then to the roughage-fed dairy calves at 12 weeks of age is indicative of a dietary transition from milk to grass of red deer calves between weeks 4 and 12.

Age-related values for the RR empty weight per unit live weight were 6.1, 15.3 and 17.4 (SEM = 0.46; P <0.001) g/kg respectively. Stobo *et al.* (1966) also found similar empty weights at three weeks of age with bovine calves, but much higher values (28 g/kg live weight) at 12 weeks of age. In this case, however, the calves had been weaned from milk onto hay and concentrate rations at five weeks of age. When deer in this study and dairy calves (Tamate *et al*., 1962) continued to have access to milk the results were similar but when the dairy calves were weaned early (Stobo *et al*., 1966) their rumen size was greater.

Mean papillae length was 1.2, 2.4 and 3.9 (main effect of age at slaughter SEM = 0.14; P <0.001) mm at 4, 8 and 12 weeks of age, respectively. The increase in papillae length with increasing age was differentially expressed across the rumen, with longer papillae observed in the atrium ruminis, with this difference increasing with age (Table 1; P <0.001). Lentle *et al.* (1996) also found that the papillae of the atrium ruminis were the longest and widest in adult farmed red deer.

There was a significant positive correlation between papillae length and papillae width (r = 0.96, P <0.001) in this study. Papillae width acted similarly to papillae length with age (Table 1) with the increase over time being much greater in the atrium ruminis. Data presented by Lentle *et al.* (1996), when reinterpreted, also showed that length and width were closely correlated (r = 0.92).

RWT increased from 1.2 mm at 4 weeks of age to 2.1 mm at 12 weeks of age. Stobo *et al.* (1966) found similar results with a RWT of 1.4 mm in three week old milk-fed bovine dairy calves increasing to 2.2 mm in 12 week old bovine calves fed the lowest amount of concentrate.

This study has provided baseline information on rumen development in red deer from 4 to 12 weeks of age and shows that they follow a similar pattern of rumen development to bovine calves. These results will help future studies aiming to assess and maximise rumen development and growth rates of farmed red deer calves under different nutritional regimes.

ACKNOWLEDGEMENTS

Thanks to B. Martin, R. Doherty, J. Archer, S. Martin, J. Ward, C Li, M Taylor and students for assistance and the NZ FoRST (C10X0202) for funding.

REFERENCES

Heinrichs, A.J.; Lesmeister, K.E. 2005: Rumen development in the dairy calf. In: Garnsworthy, P.C. ed. Calf and heifer rearing: principles of rearing the modern dairy heifer from calf to calving. Nottingham University Press, Nottingham, UK. p. 53-65.

Lentle, R.G.; Henderson, I.M.; Stafford, K.J. 1996: A multivariate analysis of rumen papillary size in red deer (*Cervus elaphus*). *Canadian journal of zoology* **74**: 2089-2094.

Lesmeister, K.E.; Tozer, P.R.; Heinrichs, A.J. 2004: Development and analysis of a rumen tissue sampling procedure. *Journal of dairy science* **87**: 1336-1344.

McDowell, E.M.; Trump, B.F. 1976: Histologic fixatives suitable for diagnostic light microscopy and electron microscopy. *Archives of pathology and laboratory medicine* **100:** 405-414.

Payne, R.W.; Murray, D.A.; Harding, S.A.; Baird, D.B.; Soutar, D.M. 2007: GenStat for Windows, 10th Edition. Introduction VSN International Ltd., Hemel Hempsted, Hertfordshire, UK.

Sibbald, A.M.; Milne, J.A. 1993: Physical characteristics of the alimentary tract in relation to seasonal changes in voluntary food intake by the red deer (*Cervus elaphus*). *Journal of agricultural science* **120:** 99-102.

Stobo, I.J.F.; Roy, J.H.B.; Gaston, H.J. 1966: Rumen development in the calf. 1. The effect of diets containing different proportions of concentrates to hay on rumen development. *British journal of nutrition* **20**: 171-188.

Tamate, H.; McGilliajrd, A.D.; Jacobson, N.L.; Getty, R. 1962: Effect of various dietaries on the anatomical development of the stomach in the calf. *Journal of dairy science* **45**: 408-420.

Warner, R.G.; Flatt, W.P.; Loosli, J.K. 1956: Dietary factors influencing the development of the ruminant stomach. *Journal of agricultural and food chemistry* **4**: 788-792.