Rumen Papillae Morphology of Mule Deer, *Odocoileus hemionus*, and White-tailed Deer, *Odocoileus virginianus*, from East-central Alberta

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Using hunter-harvested deer in the fall of 2003, we compared ruminal papillae density, length, width, surface enlargement factor (SEF) and reticular cell diameter between sympatric Mule Deer (*Odocoileus hemionus*) and White-tailed Deer (*O. virginianus*), and between age-gender classes within each species. There was no difference in papillae morphology or reticular cell diameter between Mule Deer and White-tailed does or bucks or between any age-gender comparisons within species. Female Mule Deer fawns had larger reticular cell diameters than White-tailed Deer fawns, and male Mule Deer fawns had higher papillae density and larger reticular cell diameters than male White-tailed Deer fawns. Papillae widths of male White-tailed Deer fawns were greater than those of male Mule Deer fawns. Comparisons of papillae morphology between Mule Deer and White-tailed Deer sampled during late fall suggests adults of these species may respond similarly to forage quality, but species differences may be evident in fawns.

Key Words: Alberta, Mule Deer, Papillae, Rumen, White-tailed Deer.

Mule Deer (*Odocoileus hemionus*) and White-tailed Deer (*O. virginianus*) occur sympatrically over much of western Canada but despite similarities in habitat use and diet, few studies have documented their foraging ecology on northern ranges (Kramer 1973). Comparing gastrointestinal characteristics of deer is one method to understand their relationship with forage quality and quantity (Hoffman 1989; Ramzinski and Weckerly 2007). The forestomach of deer, like other ruminants, contains a mucosal membrane that is enlarged by papillae. Papillae absorb volatile fatty acids that are products of microbial digestion, and growth of papillae is stimulated by production of these volatile fatty acids (Tamate et al. 1962; Hoffman 1989). The size, density and distribution of papillae can be affected by availability, quality and quantity of forage (Hoffman 1988) and can be used to compare habitats and seasons as well as species, age and gender differences (Zimmerman et al. 2006). Research on rumen papillation of cervids has been conducted on Moose (*Alces alces*) (Hoffman and Nygren 1992), Red Deer (*Cervus elaphus*) (Lentle et al. 1996), Reindeer (*Rangifer tarandus*) (Knott et al. 2005), Mule Deer (Short 1981), White-tailed Deer (Short 1964), and sympatric Mule Deer and White-tailed Deer (Zimmerman et al. 2006).

This study adds to the growing body of knowledge by comparing papillae characteristics of sympatric Mule Deer and White-tailed Deer during the rut on northern ranges when the vegetation has cured (November). We sought differences in these closely related and ecologically similar species that might explain their coexistence. We tested whether papillary characteristics might reveal dietary differences. We predicted that varied diets between genders during the rut would also be evident.

Methods

This study was conducted at the Western Area Training Centre (Department of National Defense) that encompasses about 610 km^2 near the city of Wainwright, Alberta, Canada (52°N, 110°W). The landscape is an aspen parkland environment consisting of trembling aspen (*Populus tremuloides*) bluffs interspersed with grasslands (Strong 1992). Since 1966, there has been a closely regulated deer hunt in the centre with a mandatory hunter check station (Moore 2003*). In November and December of 2003, we gathered forestomach samples from hunter-harvested adult and fawn Mule Deer and White-tailed Deer. These deer were aged according to tooth wear patterns (Severinghaus 1949) with fawns being classed as being 6-8 months old.

We randomly cut one 2 cm^2 subsample from the forestomach (Zimmerman et al. 2006) and one 2 cm^2 subsample from the reticulum of individual deer and placed the samples in a freezer within 12 hours. A 1 cm^2 sample was later used to determine papillae density (number/cm^2) and 10 papillae were measured to determine maximum length and width. We calculated a surface enlargement factor (SEF) following Hoffman and Nygren (1992) where:

[(2 × papillae surface) × papillae number + base surface/base surface].

Ten reticular cells were measured to obtain diameters. Means were calculated for each metric and used to represent one deer. We used a Mann-Whitney *U*-test

to examine differences between deer species (Kamler 2001) and for intraspecies comparisons. Statistical analyses were performed with SPSS (Version 14.0) and considered significant where $P < 0.10$ due to the small number of samples (Zar 1999).

Results

Papillae length, papillae width, papillae SEF or reticular cell diameter did not differ significantly between Mule Deer and White-tailed Deer does or bucks (Table 1). Reticular cell diameters were greater ($P = 0.02$) in female Mule Deer fawns than in female White-tailed Deer fawns. Male Mule Deer fawns had larger reticular dimensions ($P = 0.03$) and papillae lengths ($P = 0.03$) than male White-tailed Deer fawns. However, papillae width was greater ($P = 0.05$) for male White-tailed Deer fawns than male Mule Deer fawns (Table 1).

Discussion

Although species and gender differences were found among fawns, similar differences were not found in adults. These results were based on small sample sizes and only partly meet our prediction of differences between species because of varied diets, and are counter to our prediction of gender differences due to physiological stress associated with the rut. We thought differences in papillae morphology would be reflected during November and December once the vegetation had senesced. Our results of papillae length and width of adult female Mule Deer and White-tailed Deer were only marginally smaller than papillae length and papillae width of taken from lactating Mule Deer and White-tailed Deer during winter in South Dakota (Zimmerman et al. 2006).

Generally, the two deer species consume the same plants but normally do so while foraging in the different areas (Whittaker and Lindzey 2004). Differential papillae morphology responds to chemical components found in plants (Lentle et al. 1997) and the end-products of fermentation, so differences in papillae morphology between deer species may be found in seasonal comparisons (Zimmerman et al. 2006). Behavioral differences in foraging patterns on senescing vegetation have been found for sympatric Mule Deer, Elk (*Cervus elaphus*), and Bison (*Bison bison*) on similar ranges (Kuzyk 2008). Mule Deer can modify their daily foraging times (Kuzyk and Hudson 2007a), diet selection and bite sizes among seasons (Kuzyk and Hudson 2006) and are also able to adjust their seasonal levels of forage intake (Kuzyk and Hudson 2007b; Kuzuk et al. 2009).

Female and male Mule Deer fawns had greater reticular cell diameters than female and male White-tailed Deer fawns which suggests greater intake of richer diets. Reticulum growth of young ungulates is related to the transition from milk to forage (Knott et al. 2005). It is possible that Mule Deer are weaned at an earlier age than White-tailed Deer. In addition, male Mule

TABLE 1. A comparison of reticular cell diameters, papillae surface enlargement factor (SEF), papillae (P.) density, papillae length and papillae width between Mule Deer and White-tailed Deer harvested in November and December, 2003, in the aspen parkland of east-central Alberta. Means are presented ± 1 Standard Error.

	Does			Bucks			Female Fawns			Male Fawns		
	Mule Deer n=14	White-tailed Deer n=9	*P*	Mule Deer n=5	White-tailed Deer n=9	*P*	Mule Deer n=7	White-tailed Deer n=3	*P*	Mule Deer n=11	White-tailed Deer n=5	*P*
Reticular cell (cm)	0.80 ± 0.05	0.77 ± 0.04	0.90	0.88 ± 0.04	0.91 ± 0.09	0.59	0.75 ± 0.03	0.58 ± 0.03	0.02*	0.77 ± 0.03	0.62 ± 0.06	0.03*
Papillae SEF	10.7 ± 0.70	10.3 ± 0.86	0.72	9.7 ± 0.89	9.0 ± 0.97	0.64	9.5 ± 0.59	8.3 ± 1.71	0.38	10.4 ± 0.89	10.5 ± 1.06	0.95
P. Density (#/cm^2)	74.64 ± 4.3	70.0 ± 7.23	0.49	69.0 ± 13.3	59.1 ± 7.04	0.55	86.7 ± 5.7	100.7 ± 19.8	0.73	99.0 ± 7.0	73.2 ± 4.3	0.03*
P. Length (cm)	0.53 ± 0.03	0.53 ± 0.05	0.88	0.52 ± 0.05	0.55 ± 0.05	0.89	0.45 ± 0.03	0.44 ± 0.02	0.82	0.42 ± 0.03	0.49 ± 0.04	0.26
P. Width (cm)	0.13 ± 0.004	0.13 ± 0.007	0.69	0.13 ± 0.007	0.13 ± 0.006	0.68	0.11 ± 0.008	0.12 ± 0.04	0.99	0.11 ± 0.005	0.13 ± 0.005	0.05*

*Denotes significant difference at p<0.10

Note. There were two White-tailed Deer female fawns and 10 Mule Deer male fawns used in comparisons for papillae width and papillae SEF.

Deer fawns had longer papillae than White-tailed Deer fawns, but the papillae were not as wide suggesting that increasing absorptive surface area is achieved in different ways in the two species at least at younger ages.

No intraspecies differences in rumen morphology were found between does and bucks during the rut. Mature bucks reduce their food intake during the rut, but food reduction might not have a large influence on papillae morphology. There was a large influx of hunters during our sampling period (aproximately 100/week) (Moore 2003), which could disrupt foraging behavior among all age and gender classes. Further studies should try to garner larger sample sizes to examine potential seasonal and behavioral effects on papillary morphology of deer in relation to hunting seasons and the rut.

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