Evaluation of production traits of red deer skins in the Deer Progeny Test.

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Abstract

Skins, hides and leather from deer are a valuable co-product of New Zealand venison production. Measurement of skin traits was included in the Deer Progeny Test to evaluate options for genetic selection, and to determine if selection for other production traits risks diminishing the quality of deer skins and leather. Skins of slaughtered eleven-month-old progeny (n=310) from terminal (wapiti crossbred) and maternal (red) sire types were evaluated for 18 different quantitative and qualitative traits throughout processing to pearl-crust leather. All processing was carried out by New Zealand Light Leathers. All traits were analysed using least squares means models with sire as the random term and pre-slaughter live weight as a covariate. For all traits except evenness grade of the pearl-crust leather, the relationship with pre-slaughter live weight covariate was significant ($p<0.05$) and positive. Sire had a significant effect ($p<0.01$) on eight traits including critical strength and finished-leather attributes ($p<0.01$), farm was also significant for eight traits ($p<0.01$). Average skin thickness was similar to published values. Sire can have an effect on important traits, and selection for higher slaughter weights of yearling red deer is predicted overall to increase the quality of skins and leather produced.

Keywords: red deer; wapiti; leather; deer progeny test

Introduction

Skins from New Zealand farm-raised red deer (*Cervus elaphus spp.*) can be used to produce high-quality leather suitable for fashion garments and accessories (Drew 1992). Deer skins and leathers are a valuable co-product of the NZ deer industry, returning 10% of deer-industry export earnings in 2013 (DINZ 2014). Deer skins destined for leather production are partially processed before being individually assessed for quality. The Deer Progeny Test (DPT) was established in 2011 to better measure venison production genetics available to the New Zealand deer industry, and aimed to evaluate new traits and generate genetic correlations to allow optimisation of selection goals (Ward et al. 2014). Deer skins used for leather and a range of traits associated with the quality of the leather were measured from the first (2011) progeny cohort. This cohort offered an opportunity to investigate a range of factors including sire, sex and sire type which may have an effect on leather quality of skins from prime (<12 month old) venison production animals.

The strength of leather produced from deer skins is much greater than that of sheep skins which allows the leather to be shaved very thin for garment use (Drew 1992). This strength, coupled with the distinctive grain pattern, makes the finished product highly sought after (DINZ 2007). Deer skins almost always have some damage (faults) on them from recent or old injuries (Scobie & Pollard 2007). This damage is the greatest cause of down-grading of skins. Badly damaged tanned skins are essentially worthless to processors as there is insufficient usable (undamaged) area to manufacture high-value fashion products (R Shanks pers. comm.) This investigation of deer-skin traits aims to understand what, if any, components of skin quality might be influenced by genetic factors, and how selection for venison traits might affect skin quality in the future.

Methods and materials

A general overview of the DPT has been presented by Ward et al. (2014). Skin-trait recording was completed for the 2011 birth cohort only. This cohort was born and raised on two different farms, Whiterock Station and Invermay Research farm, between November 2011 and October 2012. Two sire types, maternal and terminal, representing two different breed types, were used. The same sires were used on both farms. The maternal progeny were from sires of red deer subspecies and the sires of the terminal progeny were from wapiti subspecies.

All progeny were from the result of artificial insemination (AI) of hinds of red deer subspecies from two different age classes, rising-three-year-old (R3), or mixed-age (MA rising-four-year-old and above). There were 14 sires represented in this study, five terminal and nine maternal. Maternal sires had more offspring than maternal sires, as maternal females were retained for breeding, while all maternal males (n=212) and all terminal progeny (n=98) were slaughtered in October 2012 at around 11 months of age. Pre-slaughter live weights were collected the day prior to trucking to the deer slaughter plant (DSP). All progeny were in mobs which represented both sire (breed) types. At Whiterock Station, animals were managed in two mobs pre-weaning (MA hinds and R3 hinds) and together in one mob post-weaning. Smaller paddocks restricted Invermay to five pre-weaning mobs (four MA hind and one R3 hind progeny), and four post-weaning mobs (two per sex).

During mid-October 2012 animals were yarded and restrained in a mechanical or hydraulic crush for ultrasonic eye-muscle measurement (USEMA). This involved shaving a 100 x 150 mm patch of the hair from the back as described by Ward et al. (2010). While the best care was taken with the animals, this extra handling and shaving had the potential to increase skin damage over and above that which might be expected on a normal commercial deer farm.

All progeny from each farm were transported and slaughtered on a single occasion. Transport from each farm used a different transport company, with animals transported as per best practice (different mobs and females kept separate) on a single truck and trailer unit with five animals per pen. Distance for transport to slaughter was 201 km for Invermay and 486 km for Whiterock Station. At the DSP (Alliance Group Makarewa), animals were kept in lairage overnight with access to water and separated by mob/sex, then slaughtered the following day.

Following exsanguination, the carcass was skinned using the inverted dressing system as described by Drew (1989). During the skinning process, three knife hands worked on the carcass, one skinning the head after exsanguination, then two opening the legs and belly skin on the inverted dresser. The same three knife hands carried out all of the skinning on each day, but rotated tasks/stations at regular intervals. Following removal, each skin was loaded into a stainless-steel perforated tumbling drum, where the skin was sprayed with cold water to cool it for two minutes. After exiting the tumbler, skins were punched on the left hand side of the neck with a series of circles and crosses, to provide a unique identifying code. Skins were then trimmed and placed in a large tub. They were later salted using a standard commercial recipe, stacked on wooden pallets and stored covered with plastic for approximately 12 months. All skins appeared to have been adequately salted, with no obvious signs of deterioration during salted storage.

Skins were transported to New Zealand Light Leathers (NZLL) tannery (Washdyke, Timaru, N.Z.) for processing. The batch of skins from each farm was washed and rehydrated in separate Valero tumblers, then fleshed using mechanical fleshing machines (one machine per farm) and trimmed according to standard practice. Following fleshing, each skin was punched on the posterior end using a 3-4 mm hole-punch, with the Leather and Shoe Research Association (LASRA) standard unique coding system. All tannery processing was carried out by NZLL using their standard commercial processes that included pickling, chrome tanning to 'wet-blue' leather, then re-tanning and fat liquoring to produce undyed pearl-crust leather. Skins were not split prior to crusting and the pearl-crust leathers were milled to give a raised-grain effect for crust grading purposes.

Skin grading was carried out by NZLL graders according to their standard commercial practice. There were two wet-blue skin grade types, quality and weight, each with three classes. Wet-blue quality rank is a visual assessment based on the level of faults (i.e. damage) on the skin in the wet-blue stage. D1B is the highest quality grade, D2 the lowest. Wet-blue weight grades were heavy, medium and superlight. Medium and heavy are equally valuable and more desirable grades than superlight. The two wet-blue traits combined provided a wet-blue value ranking. This ranking was from 1-5 with 1 being the highest quality and 5 the lowest. Pearl-crust-evenness grade was a visual grading of the raised grain, from 1-3. Grade 1 skins have the most-even grain pattern, which is most desirable and most-valuable. A combination of the three grades was used to provide a ranking of the most valuable (highest grading overall) skins. This ranking was 15 values from 1-15, with 1 representing the highest quality and 15 the lowest. For this ranking system, the greatest emphasis is placed on the lack of faults or damage to the skin.

Width of wet-blue skins (mm) was measured at two places, wet-blue width 1 (WB width 1) just behind the fore legs, and wet-blue width 2 (WB width 2) just in front of the rear legs. Wet-blue area was measured in 'square feet' (this is the standard unit for measuring leather area (1 ft^2 = $0.092903m^2$)) using a calibrated digital area-measuring device. Thickness of the skins was measured to the nearest 0.05 mm using a Specht leather-thickness gauge. Thickness was measured on the wet-blue skins at four sites: mid-neck, mid-back, mid-side and belly edge.

Tear force (or load) and tear strength were measured using an Instron tensile testing machine. This was carried out according to International Standard ISO 3377-2:2002, with the only variation being that four samples were tested for each direction of pull. Test samples were cut from the Official Sampling Position (OSP) of the skins (ISO 2418:2002). Two sets of four samples were taken from each cut, one parallel to the spine the other perpendicular to the spine. These samples were conditioned at $23^{O}C$ and 48% relative humidity for at least 24 hours prior to testing. A slot was cut in the centre of the rectangular sample and the thickness of the leather at either end of this slot was measured to provide an average thickness for the test sample. The slot was placed over the two hooks of the tensile testing machine and the leather stretched at a constant rate with the long axis of the slot at right angle to the direction of pull. The leather was pulled until it tore. The force (N) required to tear the leather was recorded as the crust leather tear force (parallel or perpendicular to the spine). The average of parallel and perpendicular tear-forces was recorded as the crust-leather-tear mean. The strength of the leather was the tear force normalised by the average thickness of the test sample. This provided a further three traits for crust leather - tear strength (N/mm), parallel, perpendicular and mean.

Statistical analysis

Progeny DNA pedigrees (Ward et al. 2014) were extracted from the DEERSelect database for use in the analysis. Only singleton progeny were included in the data set and animals with contradictory mob information or missing trait data were excluded from analysis. The final number of skins uniquely identified and available for analysis was 286 from a total of 310 animals slaughtered (92.3%). This was a maximum, as numbers recorded for different traits varied (Table 1).

Table 1 Summary of the number of deer-skins with data analysed for a traits of: grades, length, width, area, thicknesses pearl-crust-leather; evenness grade, tear force strength and faults from the 2011-born cohort in a deer progeny test. Progeny were maternal males, terminal males and females from two farms: Invermay (IVY) and Whiterock Station (WR).

Sire Type	Farm	Sex	Grade, length and width	Area	Thickness	Pearl-crust evenness grade, tear force and strength	Faults
Maternal	IVY	M	95	90	95	101	101
Maternal	WR	M	93	92	93	96	94
Terminal	IVY	F	20	21	20	21	22
Terminal	IVY	M	22	21	22	23	23
Terminal	WR	F	22	22	22	23	22
Terminal	WR	M	22	22	22	22	23
Both	IVY	M	117	111	117	124	124
Both	WR	M	115	114	115	118	117
Both	IVY	Both	137	132	137	145	146
Both	WR	Both	137	136	137	141	139
Total			274	268	274	286	285

Table 2 Summary of significance of fixed, random effects, covariates, mean trait responses and covariate responses modelled using least squares means analysis of Deer Progeny Test (DPT) rising-yearling skin traits from 2011-born DPT progeny. All blanks are non-significant.

Trait name	N animals	Mean response	SireType	Farm	SireType*Farm	Sex	Mob[Farm]	SireID [SireType] & Random	Covariate Weight Pre-slaughter (kg)	Covariate response	Covariate response % mean
Wet-blue area (sqft)	264	13.72		p <0.0001					p <0.0001	0.08	0.6%
Wet-blue length from neck edge to butt edge (mm)	270	1457.61							p <0.0001	4.23	0.3%
Wet-blue width from just behind fore legs (mm)	270	833.36		p <0.0001					p <0.0001	2.92	0.3%
Wet-blue width from just in front of hind legs (mm)	270	997.66							p <0.0001	3.54	0.4%
Wet-blue skin thickness at middle of neck (mm)	270	2.61		p <0.01					p <0.0001	0.02	0.7%
Wet-blue skin thickness at middle of back (mm)	270	1.95						p <0.01	p <0.0001	0.01	0.5%
Wet-blue skin thickness at middle of side (mm)	270	1.69	p <0.05	p <0.01			p <0.05		p <0.0001	0.01	0.7%
Wet-blue skin thickness at belly edge (mm)	270	1.16		p <0.0001					p <0.0001	0.01	0.7%
Crust-leather-tear force parallel to spine (N)	282	212.62						p <0.0001	p <0.0001	1.84	0.9%
Crust-leather-tear force perpendicular to spine (N)	282	159.54					p <0.05	p <0.0001	p <0.0001	1.40	0.9%
Crust-leather mean tear force of both axis (N)	282	186.05						p <0.0001	p <0.0001	1.62	0.9%
Crust-leather-tear strength parallel to spine (N/mm)	282	108.4		p <0.0001				p <0.01	p <0.0001	0.26	0.2%
Crust-leather-tear strength perpendicular to spine (N/mm)	282	87.23		p <0.0001				p <0.0001	p <0.01	0.18	0.2%
Crust-leather mean tear strength of both axis (N/mm)	282	97.8		p <0.0001				p <0.0001	p <0.0001	0.22	0.2%
Wet-blue quality rank (1-3)	270	1.32							p <0.001	0.01	1.0%
Pearl-crust-evenness grade (Rank 1-3)	282	1.76						p <0.01	p <0.05	0.01	0.5%
Wet-blue value ranking (Rank 1-5)	270	1.77							p <0.0001	0.04	2.0%
Combined grade value ranking (Rank 1-15)	270	4.09							p <0.001	0.09	2.3%

Data were analysed using least squares means (LSM) analysis to test significance of the skin traits and responses of the various factors (i.e., farm, year, mob, sex and sire type) and predict overall responses of these factors including sire. Least squares means analysis provided predicted mean values for sires as well as predicted means and significance for terms used in the models. The base model used was: siretype (maternal or terminal), farm, siretype*farm, sex, mob[farm] (pre-weaning) as fixed effects and sireID[siretype] as the random term. Pre-slaughter live weight was independently fitted as a covariate to the base model for all of the skin traits. Three alternative models were also run with no covariate, the base model, the base model excluding sire type, and for the grade and value skin traits a model was run excluding sire type and female data. For a number of models sireID[siretype] was run as a non-random term.

Results

The full LSM model including siretype is the only model reported, as it gave the most consistent results across all traits modelled. The covariate pre-slaughter live weight was significant for all traits ($p<0.05$) with the majority being highly significant (Table 2). These covariate responses for all traits except pearl-crust-evenness grade were positive in regard to greater pre-slaughter live weight improving the trait. The significance of the covariate live weight for pearl-crust-evenness grade was lowest overall $p=0.043$ and the response was a reduction in grade of 0.096 for each extra kilogram of pre-slaughter live weight.

Sire had a significant effect ($p<0.01$) on eight traits; all six crust-leather-tearing traits, pearl-crust leather evenness grade and wet-blue thickness mid-back (Table 2.) Range summaries of these traits with significant sire effects are presented in Table 3. Farm had a significant effect ($p<0.01$) on eight traits ranging from wet-blue size and thickness, to crust leather strength (Table 2). Wet-blue area, width behind fore legs, thickness mid-neck and mid-side were all significantly positive ($p<0.01$) for the Invermay Farm. Crust-leather-strength parallel, perpendicular and mean were all highly significantly ($p<0.001$) positive for the Whiterock Station progeny. Wet-blue thickness at the mid-side was the only trait with a significant effect of sire type ($p<0.05$), Farm ($p<0.01$) and mob ($p<0.05$) also significant (Table 2). Crust-leather-tear force perpendicular to the spine was the only other trait on which mob had a significant effect (Table 2), ($p<0.05$). The responses for these two traits were negative for progeny of R3 hinds. The discrete trait data (i.e., rank and grade) presented quite skewed distributions in some cases. Wet-blue quality was the most skewed with 204 skins in the top grade, 73 in the middle and only eight in the bottom grade.

Discussion

This is the largest dataset of its type and the first to permit sire analysis of deer skin and leather production attributes. Predicted quantitative trait means, area (Milnes & Peters 1977, Passman & Halligan 1989) and strength (Clarke & Webster 1985, Passman & Halligan 1989) were greater than those reported by previous studies in similar animals, while thickness was lower (Passman & Halligan 1989) (Table 2). These predicted mean thicknesses were acceptably thick (i.e., all were >1.00 mm, a threshold

Table 3 Deer-skin traits of the 2011 deer progeny test birth cohort predicted by least squares means analysis where sire (n=14) was a significant effect in the model.

Trait name	N progeny	Mean progeny response	Sire mean response	Sire maximum response	Sire minimum response	Sire response standard deviation	Sire response coefficient of variation	Range of sire responses	SireID [SireType] & Random	Covariate Weight Pre-slaughter (kg)	Covariate response	Covariate response % mean
Wet-blue skin thickness at middle of back (mm)	270	1.95	1.95	2.07	1.84	0.07	3.6%	0.23	p <0.01	p <0.0001	0.01	0.5%
Crust-leather tear-force parallel to spine (N)	282	212.62	215.11	234.58	196.74	10.97	5.1%	37.84	p <0.0001	p <0.0001	1.84	0.9%
Crust-leather-tear force perpendicular to spine (N)	282	159.54	161.44	178.04	145.57	8.92	5.5%	32.47	p <0.0001	p <0.0001	1.40	0.9%
Crust-leather mean tear force of both axis (N)	282	186.05	188.26	206.46	170.99	9.96	5.3%	35.47	p <0.0001	p <0.0001	1.62	0.9%
Crust-leather tear strength parallel to spine (N/mm)	282	108.4	109.54	113.72	104.15	2.6	2.4%	9.57	p <0.01	p <0.0001	0.26	0.2%
Crust-leather tear strength perpendicular to spine (N/mm)	282	87.23	88.19	93.89	81.12	3.37	3.8%	12.77	p <0.0001	p <0.01	0.18	0.2%
Crust-leather mean tear strength of both axis (N/mm)	282	97.8	98.86	104.03	92.34	3.03	3.1%	11.69	p <0.0001	p <0.0001	0.22	0.2%
Pearl-crust-evenness grade (Rank 1-3)	282	1.76	1.78	2.14	1.47	0.2	11.2%	0.67	p <0.01	p <0.05	0.01	0.5%

below which production for some clothing types can be compromised (Passman & Halligan 1989)).

Sire was significant for critical leather-traits of tear strength, pearl-crust--evenness grade and mid-back thickness, indicating potential to select for these important traits. The effect of pre-slaughter live weight was significant at the 5% level for pearl-crust--evenness grade, indicating that quality may decrease with increasing live weight (Table 2). However this result may be marginal, p=0.043 was the lowest covariate significance of all traits modelled, and for the sire LSM predictions pearl-crust-evenness grade has essentially no correlation with pre-slaughter live weight when the two are plotted against each other (R^2=0.028).

Environment also appears to be a factor in skin quality with eight traits significant for farm, and two for mob, this effect was negative for R3 hinds (Table 2). Both farms were very different and there could be a range of factors responsible for these farm differences including, climate, feeding and perhaps growth profiles of the animals, but this study could not separate any of these factors. Younger hinds (R3) did produce progeny with leather that had lower perpendicular tear strength and was not as thick at the middle of the side (Table 2).

In this study the predicted attributes for all traits except pearl-crust leather-evenness grade improved with increased pre-slaughter live weight. Sire can significantly influence value-critical strength and pearl-crust-evenness traits. Sex had no significant effect on any of the traits measured, while siretype had a significant effect on only one thickness measurement. Accordingly there appears to be few negative implications for the New Zealand deer industry from this study particularly as there is a goal to increase carcass size. There is potential to select sires to further improve the quality New Zealand deer skins.

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