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Relationships between deer temperament and production traits

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Abstract

It is well-recognised by producers that the temperament of farmed deer (*Cervus elaphus spp.*) influences how they respond to management practices, such as transport and yarding, but less is known about how temperament influences productivity. This study aimed to investigate relationships among temperament and production parameters by analysing a data set (n=1647) of rising one-year-old deer. Four production categories (growth, immune function, eye muscle and reproduction) and five measures of temperament were recorded from weaning until either pre-slaughter or after first mating (3 to 12 or 18 months of age) at different ages depending on the trait. Temperament traits had low heritability estimates (h^2=0.01 to 0.17, P>0.05), indicating genetic selection for these traits would be slow. The temperament traits of animals were generally consistent from weaning (at 3 months) until slaughter (at 10-12 months). Animals that were calm and easy to handle grew faster and may have better immune function compared to animals that were more agitated in the presence of humans. More research is needed to investigate the relationships between temperament, immune function, reproduction and productivity in farmed deer.

Keywords: red deer; *Cervus elaphus;* temperament; productivity

Introduction

Temperament has been defined and measured in different ways (e.g., Burrow 1997), but the majority of definitions have, as a common element, the response of an animal to handling or the presence of humans. It is well-recognised amongst producers that the temperament of farmed deer (*Cervus elaphus spp.*) has major effects on responses to management practices, such as handling and transport. Calm animal responses to these events are beneficial for animal welfare and product quality, as well as human safety (Hemsworth 2003).

Temperament is influenced by both genetic components and environmental factors (Hearnshaw & Morris 1984), such as management practices, previous handling experiences and the behaviour of the stockperson. Temperament of farmed deer can be reliably scored in the yards (Schütz et al. 2016). One behaviour, agitation in a small pen in the presence of a handler, showed a moderate genetic component and selecting for this could lead to some genetic progress towards reduced agitation. There is little information of how temperament influences productivity in deer, and the aim of this study was, therefore, to investigate the relationships between temperament and production parameters.

Materials and methods

All procedures involving animals were approved by the Invermay Animal Ethics Committee under the New Zealand Animal Welfare Act 1999. The deer utilised in this experiment were born between 2011-2013 on three farms enrolled in the Deer Progeny Test in the South Island (Ward et al. 2014). Over the three years, 35 sires of two breed types: maternal (red deer, n=24) and terminal (wapiti-crossbred, n=11) were used to generate progeny via artificial insemination of 1581 maternal red deer dams (Ward et al. 2014). In total, there were 1798 progeny weaned, 950 slaughtered as rising one year olds (R1) and 762 submitted for first mating as rising two year olds (R2).

Live weight was recorded non-fasted to the nearest 0.5 kg, with all animals in the same mob weighed on the same day in association with other trait recording. Temperament was assessed in the yards before and during routine live-weight recordings at weaning (at 3 months), 6, and 10 months of age, and before slaughter by the same handler each time.

The temperament scoring system used in this study was developed by Schütz et al. (2016). In brief, this involved five different behaviour traits assessed at the time of handling for live weight measurement in a weigh-crate: aggression in the pen towards the handler (Pen aggression), agitation in the pen (Pen agitation), ease of handling (i.e., effort of handler to move the deer to the weigh-crate, Handling ease), agitation in the weigh-crate (i.e., intensity of movement, Crate agitation), and behaviour when exiting the weigh-crate (Exit speed). Each score was measured on a 4- or 5-point scale, which increases with less-desired behaviours (Schütz et al. 2016). Pen aggression and agitation scoring were not undertaken at weaning, as a clear expression of these traits was not considered visible at this time.

In the week prior to slaughter, all progeny were yarded and eye-muscle measurements collected using real-time ultrasound (Ward et al. 2010). All males and terminal-sired females were slaughtered between 10-12 months of age (Ward et al. 2014). Maternal females were retained and submitted to stags for natural mating from 15-18 months of age and their pregnancy status and conception date were determined using rectal ultrasonography (White & McKelvey 1989). The antibody response to parasite ingestion was measured in saliva using CARLA

(Mackintosh et al. 2014). Each trait was defined as the measure combined with the time period and/or age of animal.

This paper reports on four production categories and five temperament traits recorded at different ages from weaning (at 3 months) to pre-slaughter (10-12 months of age) or at first mating (15-18 months of age) depending on the trait. The production traits were classified as: 1) Growth: R1 live weight at weaning, start-winter, spring, pre-slaughter (3, 5-6, 10 and 10-12 months of age, respectively) and associated growth rates; 2) Immune function: CARLA saliva immunoglobulin A antibody (IgA) response at 6 and 10 months of age; 3) Ultrasonic eye-muscle area and width measured at the 12th rib at 10 months of age; and 4) Female R2 reproduction: conception date and pregnancy status following submission for first mating.

Statistical analysis

All traits were analysed using ASREML (Gilmour et al. 2009). Animal was fitted as a random effect in all models. Genomic breed (gBreed) (Cullen et al. 2013) was fitted for three subspecies: Eastern European red deer (*Cervus elaphus hippelephus)*, English red deer (*Cervus elaphus scotticus)* and North American elk (or wapiti, *Cervus elaphus canadensis).* The two red types (Eastern and English) were included in the ASREML model and the third (elk) predicted by difference from 100%. The model included fixed effects of herd by year combination, sex, weaning mob and proportion Eastern and English type. Liveweight traits (excluding pre-slaughter) included dam as a random (maternal) genetic effect. Growth-rate traits included live weight at the start of the growth rate period. Eye-muscle traits included spring live weight and a spline function of measurement sequence within herd by year. After twins and animals with contradictory mob information or missing trait data were excluded, 1647 animals remained in the final dataset. The analysis using ASREML was a two-stage process. Univariate (single-trait) models were run first to estimate direct and maternal (if applicable) heritability, variance and gBreed proportion regression factors. Then bivariate (two trait) models were run to estimate phenotypic and genetic correlations and the average heritability estimates (h^2).

Correlations >1.0 and with high standard errors are presented, suggesting that genetic correlations for temperament traits are likely being overestimated. This could be due to the low heritability of the traits and/or temperament scores being discrete data with small ranges (i.e., scores of 1-4 or 1-5) and with a non-normal distribution.

Results

Heritability of temperament traits

Heritability estimates for the temperament traits are presented in Table 1. All heritability estimates for the temperament traits were low (0.01 to 0.17) and non-significant (P>0.05). The heritability estimate was highest

Table 1 Heritability (diagonal, in bold), genetic (below the diagonal) and phenotypic (above the diagonal) correlations (± SE) between temperament traits in farmed deer. Temperament traits are Handling ease (HEASE), Exit speed (EXIT), Crate agitation (CAGT), Pen agitation (PAGT) and Pen aggression (PAGG), measured at 3 months (3), 6 months (6), 10 months (10) and pre-slaughter (PS, 10-12 months). * indicates significant correlation at P<0.05.

	HEASE	EXIT	CAGT	PAGT	HEASE	EXIT	CAGT	PAGG	HEASE	EXIT	CAGT	PAGT	HEASE	EXIT	CAGT
	3	3	3	6	6	6	6	10	10	10	10	PS	PS	PS	PS
HEASE 3	**0.13 ± 0.07**	0.14 ± 0.03*	-0.14 ± 0.03*	0.05 ± 0.05	0.14 ± 0.03*	0.01 ± 0.03	-0.06 ± 0.03	-0.02 ± 0.04	0.09 ± 0.04*	-0.00 ± 0.04	0.02 ± 0.04	-0.00 ± 0.04	0.13 ± 0.04*		-0.04 ± 0.04
EXIT 3	0.59 ± 0.44	**0.05 ± 0.05**			0.04 ± 0.03	0.19 ± 0.03*		-0.02 ± 0.04	0.04 ± 0.04	0.11 ± 0.04*	-0.03 ± 0.04	-0.06 ± 0.04	0.11 ± 0.04*	-0.05 ± 0.04	-0.09 ± 0.04*
CAGT 3	0.07 ± 0.41		**0.10 ± 0.06**		-0.05 ± 0.03	-0.02 ± 0.03	0.15 ± 0.03*	0.05 ± 0.04	-0.03 ± 0.04	0.05 ± 0.04	0.17 ± 0.04*	0.12 ± 0.04*	-0.05 ± 0.04	0.11 ± 0.03*	0.18 ± 0.03*
PAGT 6	-0.10 ± 3.59			**0.01 ± 0.05**					0.01 ± 0.05	-0.00 ± 0.05				0.08 ± 0.05	0.07 ± 0.05
HEASE 6	0.71 ± 0.51	0.39 ± 0.69	0.01 ± 0.54		**0.05 ± 0.05**	0.13 ± 0.03		0.01 ± 0.04	0.27 ± 0.04*	0.07 ± 0.04	-0.10 ± 0.04*	0.05 ± 0.04	0.23 ± 0.04*	0.10 ± 0.04*	-0.03 ± 0.04
EXIT 6	-0.07 ± 0.38	0.04 ± 0.50	-0.44 ± 0.37		-0.08 ± 0.52	**0.13 ± 0.07**	-0.06 ± 0.03*	-0.05 ± 0.04	0.05 ± 0.04	0.25 ± 0.03*	-0.04 ± 0.04	0.02 ± 0.04	0.08 ± 0.04*	0.06 ± 0.04	
CAGT 6	-0.81 ± 0.87		1.23 ± 1.31			0.17 ± 0.94	**0.01 ± 0.03**	0.05 ± 0.04		0.02 ± 0.04				0.03 ± 0.03	0.21 ± 0.03*
PAGG 10	-0.68 ± 1.35	-0.28 ± 1.00	0.89 ± 0.78		-0.59 ± 1.45	-0.95 ± 0.65	1.04 ± 2.33	**0.03 ± 0.06**	0.06 ± 0.04		0.20 ± 0.04*	0.12 ± 0.04*	0.02 ± 0.04	0.02 ± 0.04	
HEASE 10	0.38 ± 0.39	0.20 ± 0.58	-0.26 ± 0.47	0.18 ± 1.54	1.25 ± 0.32*	0.25 ± 0.41		-0.10 ± 0.84	**0.11 ± 0.07**	0.21 ± 0.04*		-0.01 ± 0.04	0.33 ± 0.03*	0.06 ± 0.04	-0.08 ± 0.04*
EXIT 10	-0.03 ± 0.74	-0.75 ± 1.19	0.11 ± 0.81	0.81 ± 3.42	-0.32 ± 1.13	1.48 ± 1.11	-0.37 ± 1.78		0.27 ± 0.78	**0.02 ± 0.05**	0.02 ± 0.04		0.16 ± 0.06*		
CAGT 10	0.03 ± 0.39	0.19 ± 0.53	0.08 ± 0.43		-0.82 ± 0.51	-0.51 ± 0.31		0.77 ± 0.91		-0.90 ± 0.56	**0.13 ± 0.08**	0.24 ± 0.04*	-0.17 ± 0.04*	0.05 ± 0.04	0.39 ± 0.03*
PAGT PS	-0.08 ± 0.37	-0.63 ± 0.52	0.53 ± 0.35		-0.54 ± 0.51	-0.62 ± 0.30*		1.32 ± 0.40*	-0.55 ± 0.39		0.84 ± 0.24*	**0.17 ± 0.10**	-0.04 ± 0.04	0.16 ± 0.04*	
HEASE PS	0.54 ± 0.35	0.36 ± 0.48	0.11 ± 0.44		1.02 ± 0.30*	-0.07 ± 0.41		-0.05 ± 0.73	1.04 ± 0.18*	0.54 ± 0.67	-0.80 ± 0.31*	-0.50 ± 0.35	**0.13 ± 0.07**	0.02 ± 0.03	-0.19 ± 0.03*
EXIT PS		-0.84 ± 0.70	0.58 ± 0.44	0.31 ± 2.40	-0.26 ± 0.75	0.56 ± 0.43	0.89 ± 1.28	-1.04 ± 0.96	0.15 ± 0.60		-0.63 ± 0.53	-0.17 ± 0.58	0.26 ± 0.50	**0.05 ± 0.05**	0.18 ± 0.03*
CAGT PS	-0.25 ± 0.38	-0.72 ± 0.54	0.76 ± 0.33*	0.36 ± 1.95	-0.71 ± 0.48		1.79 ± 2.41		-0.66 ± 0.39		0.51 ± 0.32		0.13 ± 0.37	-0.29 ± 0.55	**0.13 ± 0.07**

for Pen agitation before slaughter (Table 1).

Genetic and phenotypic correlations among temperament traits at different ages

Genetic and phenotypic correlations between temperament traits are presented in Table 1. The analyses were in general not able to generate reliable correlations between either Pen agitation or Pen aggression and other traits. The exceptions were Pen agitation at 6 months of age and pre-slaughter, and Pen aggression at 10 months of age, and these are the only results shown for the Pen temperament measures. Phenotypic correlations between Handling ease, Crate agitation, and Exit speed tended to increase with increasing age and closeness of measures in time (Table 1). Both Handling ease and Exit speed produced significant low-to-moderate phenotypic correlations within trait type across time points, and also between each other, but there were no significant genetic correlations between the two traits. Handling ease pre-slaughter had high positive genetic correlations ($P<0.05$) with Handling ease at 6 and 10 months of age and a high negative genetic correlation ($P<0.05$) with Crate agitation at 10 months of age. There were several significant low negative phenotypic correlations, between and across different time points for Handling ease and Crate agitation. There were significant genetic correlations between Pen agitation pre-slaughter and both Pen aggression and Crate agitation at 10 months of age. There were significant phenotypic correlations between Pen agitation pre-slaughter and Crate agitation at weaning (at 3 months) and 10 months of age, and Pen aggression at 10 months of age. Pen aggression and Crate agitation at 10 months had a significant phenotypic correlation.

Genetic and phenotypic correlations between temperament and production traits

The genetic and phenotypic correlations between temperament and production traits are presented in Table 2. The temperament trait with the most significant genetic and

Table 2 Genetic and phenotypic (italics) correlations (± SE) between temperament and production traits in farmed deer. Temperament traits are Handling ease (HEASE), Exit speed (EXIT), Crate agitation (CAGT), Pen agitation (PAGT) and Pen aggression (PAGG), measured at 3 months (3), 6 months (6), 10 months (10) and pre-slaughter (PS, 10-12 months). * indicates significant correlation at $P<0.05$.

	Growth rate 3 -6	Growth rate 3 - 10	Growth rate 6 - 10	Eye-muscle area	Eye-muscle width
Genetic correlations					
HEASE 3	-0.62 ± 0.24*	-0.17 ± 0.29	0.13 ± 0.29	-0.04 ± 0.27	-0.13 ± 0.33
EXIT 3	-0.40 ± 0.43	-0.28 ± 0.41	-0.17 ± 0.40	-0.17 ± 0.39	0.11 ± 0.45
CAGT 3	-0.14 ± 0.37	-0.22 ± 0.34	-0.19 ± 0.32	0.29 ± 0.28	0.23 ± 0.36
PAGT 6		-0.36 ± 0.90	0.68 ± 2.90	-0.84 ± 3.68	0.23 ± 1.38
HEASE 6	-0.72 ± 0.26*	-0.60 ± 0.27*	-0.19 ± 0.39	0.59 ± 0.39	0.47 ± 0.45
EXIT 6	-0.56 ± 0.26*	-0.56 ± 0.26*	-0.32 ± 0.29	0.60 ± 0.22*	0.69 ± 0.22*
CAGTN 6	0.28 ± 0.80	0.64 ± 0.75	0.55 ± 0.80	-0.43 ± 1.16	-0.58 ± 1.32
PAGG 10	0.20 ± 0.63	0.09 ± 0.56	-0.02 ± 0.55	-1.32 ± 4.73	
HEASE 10	-0.67 ± 0.27*	-0.59 ± 0.25*	-0.41 ± 0.29	0.32 ± 0.31	-0.06 ± 0.41
EXIT 10	-0.56 ± 0.64			0.78 ± 0.55	1.18 ± 0.58
CAGTN 10	-0.18 ± 0.38	0.12 ± 0.32	0.24 ± 0.29	-0.59 ± 0.29*	-0.69 ± 0.30*
PAGT PS	0.00 ± 0.36	0.03 ± 0.31	0.07 ± 0.30	-0.63 ± 0.24*	-0.80 ± 0.22*
HEASE PS	0.00 ± 0.32	-0.50 ± 0.23*	-0.57 ± 0.20*	0.29 ± 0.26	0.17 ± 0.32
EXIT PS	-0.58 ± 0.44	-0.40 ± 0.35	-0.13 ± 0.37	0.08 ± 0.36	0.14 ± 0.42
CAGT PS	-0.26 ± 0.30	-0.40 ± 0.25	-0.17 ± 0.28	-0.13 ± 0.26	-0.34 ± 0.31
Phenotypic correlations					
HEASE 3	-0.05 ± 0.03	0.02 ± 0.03	0.05 ± 0.03	0.01 ± 0.03	0.02 ± 0.04
EXIT 3	-0.03 ± 0.03	-0.03 ± 0.03	-0.02 ± 0.03	0.02 ± 0.03	0.06 ± 0.03
CAGT 3	-0.04 ± 0.03	-0.04 ± 0.03	-0.03 ± 0.03	0.00 ± 0.03	-0.03 ± 0.03
PAGT 6		-0.04 ± 0.04	-0.01 ± 0.05	-0.05 ± 0.05	-0.03 ± 0.05
HEASE 6	0.00 ± 0.03	0.01 ± 0.03	0.01 ± 0.03	0.01 ± 0.03	0.05 ± 0.03
EXIT 6	-0.07 ± 0.03*	-0.07 ± 0.03*	-0.04 ± 0.03	0.04 ± 0.03	0.06 ± 0.04
CAGTN 6	-0.06 ± 0.03	-0.03 ± 0.03	0.01 ± 0.03	0.00 ± 0.03	-0.01 ± 0.03
PAGG 10	0.00 ± 0.04	0.01 ± 0.04	0.02 ± 0.04	-0.03 ± 0.04	
HEASE 10	-0.09 ± 0.04*	-0.05 ± 0.04	-0.01 ± 0.04	0.08 ± 0.04*	0.09 ± 0.04*
EXIT 10	-0.10 ± 0.04*			0.05 ± 0.04	0.06 ± 0.04
CAGTN 10	-0.03 ± 0.04	-0.03 ± 0.04	-0.02 ± 0.04	-0.08 ± 0.04*	-0.08 ± 0.04
PAGT PS	-0.01 ± 0.04	-0.02 ± 0.04	-0.02 ± 0.04	-0.02 ± 0.04	-0.04 ± 0.04
HEASE PS	-0.03 ± 0.03	-0.06 ± 0.04	-0.05 ± 0.04	0.05 ± 0.04	0.05 ± 0.03
EXIT PS	-0.05 ± 0.03	-0.05 ± 0.03	-0.02 ± 0.03	-0.01 ± 0.03	0.01 ± 0.03
CAGT PS	-0.01 ± 0.03	0.00 ± 0.04	0.02 ± 0.04	-0.05 ± 0.03	-0.09 ± 0.03*

phenotypic correlations was Exit speed at 6 months of age. This trait was negatively correlated with all post-weaning growth rates; the genetic correlations were high whereas phenotypic correlations were low. For Handling ease there was a general trend for significant negative genetic correlations with post-weaning growth rates. The two eye-muscle traits showed high negative genetic correlations with Exit speed at six months of age, Crate agitation at 10 months of age and Pen agitation pre-slaughter.

Genetic and phenotypic correlations between temperament, immune function and reproduction

There was a high negative genetic correlation (r_g = -0.75 ± 0.37, $P<0.05$) between Exit speed and CARLA at six months of age. CARLA measures at 10 months of age had negative phenotypic correlations with Pen agitation at six months of age (r_p = -0.11 ± 0.04) and Exit speed pre-slaughter (r_p = -0.08 ± 0.03).

Rising two-year-olds that were more agitated both in the pen and in the crate, had earlier conception date (r_g = -0.85 ± 0.36, -0.84 ± 0.42, respectively) and there was a significant positive phenotypic correlation between pregnancy status (i.e. 0, or 1 foetuses) and Pen agitation pre-slaughter (r_p = 0.16 ± 0.06).

Discussion

Our results suggest that deer that are calm and easy to handle grow faster. These findings are in agreement with those for other species such as beef cattle. Cattle with low exit speeds from a crush had better average daily gains, feed conversion efficiencies, and body condition than those with higher exit speed (Voisinet et al. 1997; Petherick et al. 2002). Similarly, cattle that were agitated in the crush and had faster exit speed had lower growth rates, feed intake and time spent eating (Cafe et al. 2011). In dairy cattle, animals with a calm temperament habituated faster (measured as milk production) to a novel environment than did more-agitated cattle (Sutherland et al. 2012).

Calm R1 deer were also easier to handle throughout the weighing than were more agitated animals. The temperament of animals was consistent over time from weaning (at three months) to slaughter (at approximately 10-12 months of age.)

Temperament has been shown to be heritable in many species (Voisinet et al. 1997, Burrow & Corbet 2000). However, the temperament traits in the present study had low heritability estimates, thus selection response for these traits would be slow. The heritability estimates were non-significant and generally similar for the same temperament traits at discrete ages compared with the same traits combined across ages as previously reported by Schütz et al. (2016).

Traits with low heritability estimates have high environmental influences, such as previous individual experiences and learnt behaviour (Burrow 1997). Poor human-animal interactions may lead to increased fearfulness in animals, which in turn can lead to increased handling times and risk of injury to both animals and handlers, and ultimately decrease productivity and welfare (Hemsworth 2003; Waiblinger et al. 2006). In the present study, there was an indication that individuals that were more agitated at an older age were more likely to display aggression towards handlers.

Stress in animals can lead to reduced immune function (e.g., Maule & VanderKooi 1999). Our results indicate that calm animals had higher CARLA, an IgA antibody, which suggests improved immune function. However, due to the limited measures of immune function in the present study this is a finding that warrants further research. There was also some evidence that calmer animals may conceive at a later age, females that were more agitated at the pre-slaughter period (i.e., 12 months of age) may be more fertile. It is possible that these were more dominant hinds which were able to command more resources to improve their fertility as R2 hinds.

Despite the heritability for temperament traits being low, temperament should be considered in deer breeding programmes, as calm deer are easier and safer to handle as well as growing faster than agitated animals. More research is needed to investigate the relationships between temperament, immune function, reproduction and productivity in farmed deer.

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