

Department of Physics, Chemistry and Biology

Master Thesis

Personality and production in dairy cows

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Variation in animal personality, in other words, behavioural responses consistent within individuals over time and/or across contexts, is predicted to be related to life-history traits, such as growth rate and investment in reproduction. How this translates into relationships between personality and milk production in dairy cows is however scarcely investigated and previous studies are showing contradicting results. To further investigate this relationship, individual consistencies in behaviour were related to milk production in two breeds of dairy cows (Swedish red and white cattle, SRB, and Holstein). Variation was found among the breeds in consistency of behaviours and both SRB and Holstein cows were highly consistent over time in stepping behaviour during milking and frequency of performed abnormal behaviours in home pen. Overall were Holstein cows consistent in more observed behaviours than SRB. Variation in neophobia and responses to social separation were more flexible, both among breeds and over time. Nevertheless, behaviour showed limited relationship with milk production. To conclude, the tests here carried out are useful in describing personality in cows; however, personality showed no relationship with milk production, encouraging future studies to explore this expected relationship further in other breeds and species.

Nyckelord/Keyword:

behaviour, coping style, milk production, novel object, temperament, social separation, step-kick

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1. Abstract

Variation in animal personality, in other words, behavioural responses consistent within individuals over time and/or across contexts, is predicted to be related to life-history traits, such as growth rate and investment in reproduction. How this translates into relationships between personality and milk production in dairy cows is however scarcely investigated and previous studies are showing contradicting results. To further investigate this relationship, individual consistencies in behaviour were related to milk production in two breeds of dairy cows (Swedish red and white cattle, SRB, and Holstein). Variation was found among the breeds in consistency of behaviours and both SRB and Holstein cows were highly consistent over time in stepping behaviour during milking and frequency of performed abnormal behaviours in home pen. Overall were Holstein cows consistent in more observed behaviours than SRB. Variation in neophobia and responses to social separation were more flexible, both among breeds and over time. Nevertheless, behaviour showed limited relationship with milk production. To conclude, the tests here carried out are useful in describing personality in cows; however, personality showed no relationship with milk production, encouraging future studies to explore this expected relationship further in other breeds and species.

2. Introduction

Personality is defined as individual differences in behaviour consistent over time and/or across contexts (reviewed by e.g. Gosling, 2001, Dall et al., 2004, Reale et al., 2007). Despite that the definition of personality implies consistency in behaviour, it does not imply that behaviour cannot change with age or environmental conditions as long as the rank differences between individuals are largely maintained (Gibbons et al., 2009b). In other words; all individuals in a population may shift in their level of a certain behaviour between situations, but some individuals will express consistently more of the behaviour than others. The term ‘personality’ is analogous to ‘temperament’ (Wilson et al, 1994, Réale et al., 2007) and is also often discussed in terms of ways to handle stressors in an environment, so called ‘coping styles’ (Koolhaas et al., 1999). However, ‘coping style’ is also assumed to be a personality trait with relations to both aggressiveness (Benus et al., 1991) and the proactive-reactive axis (Koolhaas et al., 1997). To avoid confusion, I will henceforth use the term ‘personality’ when referring to individual consistencies in behaviours and the term ‘abnormal behaviour’ when discussing stereotypies as well as other coping behaviours.

Classical personality gradients on which individuals’ responses can be described are boldness (Wilson et al., 1994, Fraser et al., 2001, Dall, 2004), aggressiveness (Riechert & Hedrick, 1993, Koolhaas et al., 1999, Ruis et al., 2000, Gibbons et al., 2009b), activity (Henderson, 1986, Sih et al., 2003, Gyuris et al., 2012),

explorative behaviour (Dingermase et al., 2002, Dingermase et al., 2003), risk-taking behaviour (Wilson et al., 1994, Fraser et al., 2001), neophobia (reviewed by Forkman et al., 2007) and fearfulness (Riechert & Hedrick, 1993, Boissy, 1995). However, individual behaviour traits should not be studied as isolated situations as they might have evolved together as packages, due to selection pressure as well as genetic correlations (Sih et al., 2004, Bell, 2007). When behaviour traits correlate within an individual, these are said to form a 'behavioural syndrome' which is a term sometimes also used as a synonym for 'personality' (Sih et al., 2004, Bell, 2007). Inter-correlated personality gradients or to be along a personality axis, are typically observed to have positive relationships thus that for example boldness and aggressiveness are both high in more active individuals (Sih et al., 2004).

Animal personality is a relatively new area of research within ethology and behavioural ecology and the evolution of personality is still not fully understood. Consistency in behaviour means that an individual has a tendency to behave in a certain way and is less able to instantaneously modify behaviour adaptively to current circumstances. There are two main group of theories trying to explain the evolution of personality, where the first refers to consistencies in behaviour as adaptive traits; If consistency in behaviour is adaptive, different personality types can be regarded as alternative strategies which all obtain equal overall fitness since the success varies with circumstances and environment (Benus et al., 1991, DeWitt et al., 1998, Dall et al. 2004, Sih et al., 2004, Bell, 2007, Stamps, 2007, Wolf et al 2007, Smith & Blumstein, 2008).

The second group of theories on the evolution of personality is that consistent differences in individual behaviour represent limitations in behavioural plasticity (Dall et al., 2004, Bell, 2007). Plasticity is assumed to be costly or constrained, and behaviours might then be linked, due to selection pressure as well as genetic correlations, to traits that are less plastic (Sih et al., 2004, Bell, 2007). One such suggested trait is variation in growth rate, which has been found to correlate to a set of behaviour traits including boldness, activity and aggressiveness (reviewed by Biro & Stamps, 2007). Animals exhibit consistent differences in growth rate even in situations where all individuals in a population should be able to grow at a maximal rate (Stamps, 2007). This indicates that it is either beneficial to keep life-history traits consistent, or that it is costly to be plastic in these traits (reviewed in Arendt, 1997, Biro et al., 2006, Biro & Stamps, 2007, Stamps, 2007). Link between behaviour and traits with limited plasticity offers an explanation both to why individuals differ in responses, but also why behavioural responses may show limited plasticity.

Certain areas within biology may benefit from including recent work in personality research for a more holistic understanding of variation in life-history traits, behaviour and other physiology. One such area is animal farming. The

links between individual variation in behaviour, or personality, and different production traits are still poorly scientifically investigated, although these are theoretically predicted to be related (Biro & Stamps, 2007). Variation in growth rate may be one such trait, but other traits like production may also be of relevance here. A trait that is suggested to be in a complex relationship with personality is milk production in goats (Lyons, 1989) and dairy cows (Purcell et al., 1988, Rushen et al., 1999, Breuer et al., 2000). There are diverging results found concerning the relationship between behaviour and milk production (Rushen et al., 1999). The far most common behaviour trait studied in relation to milk production is the personality gradient 'fearfulness'. There are studies providing a strong negative correlation between milk yield and fearfulness (Breuer et al., 2000), whereas others do not find this relationship (Purcell et al., 1988).

One reason to assume variation in milk production to be correlated to personality is that behaviour is suggested to be associated with current and future reproduction expectations (Wolf et al, 2007). In mammals, milk yield and milk quality can be regarded as a female's investment in her offspring, and therefore, correlations between behaviours and investment in residual reproduction value (future fitness) are predicted (Wolf et al, 2007). Individuals that expect higher future (compared to current) reproductive success, are expected to behave more carefully and be slower and shyer, compared to individuals with higher current reproductive expectations (Wolf et al., 2007). Linked to expectations based on variation in growth rates, individuals with higher current reproductive expectations are likely to be individuals that also are fast growing and therefore may die earlier (Stamps, 2007, Wolf et al., 2007).

Although the relationship between personality gradients and milk production traits in dairy cows is scarcely investigated, it is shown that cows do display behavioural consistencies in traits reflecting variation in personality. A study of Gibbons and co-workers (2009a) indicates that there is some degree of individual consistency in aggressive behaviour in dairy cows during a competitive situation. Feeding activity (DeVries et al., 2003), behavioural reactions to social separation (Müller and Schrader, 2005a) and different types of fearful situations (reviewed by Forkman et al., 2007), preferred side in milking parlour (Hopster et al., 1998) and activity in home pen (Müller and Schrader, 2005b) are other individual traits shown to be consistent in dairy cows. Additionally, individual differences in spontaneous behaviour in home pen seem to be consistent over a short period of time (Schrader, 2002).

It has been suggested that the understanding of personality in cows may be valuable for basic dairy research as well as for improving management routines (Müller & Schrader, 2005b). Cows in dairy production are handled several times per day and it is of great importance in terms of time, economy and welfare that

the management is efficient. Personality traits are likely to contribute to levels in productivity (Biro & Stamps, 2007) and investigation of the relationship between personality gradients and life-history traits may therefore be valuable to improve our understanding of how personality origin and evolve. For these reasons, I aimed to 1) determine consistent behavioural traits among individuals in a population of loose housed dairy cows, and 2) investigate the relationship between cow personality and individual production level.

3. Methods

3.1 Animals, housing and management routines

The animals studied were housed at Vreta farm school in Linköping (Sweden) and held for education and milk production. The cows were held indoors in two groups of 28 animals each, housed in loose house systems of similar design with two automatic concentrate feeders and four automatic water cups per group. The cows were fed roughage ad lib and an individual amount of concentrate mixture based on lactation status. The cows were milked in a milking parlour every day between 07:30-09:00, 14:30-16:00 and 21.30-23.00 local times. Handling and milking was carried out by students from the farm school and by two altering animal keepers.

Animals were of two different breeds, Holstein (n=35) and Swedish Red and White cattle (SRB, n=34) and in different lactations (first lactation, n=10; second lactation, n=17; third lactation, n=26; fourth lactation, n=3; fifth lactation, n=1; seventh lactation, n=2; lactation unknown, n=10). Sequential lactations roughly mirrors age of the cow, but actual age was also known for most of the cows (3 years, n=18; 4 years, n=27; 5 years, n=15; 6 years, n=3, 7 years, n=1, 8 years, n=1, 9 years, n=1; unknown, n=3). The animals also differed in the number of months since they had their last calving and number of month during pregnancy.

3.2 Behavioural observations

Three batches of observations were conducted with eight week intervals (Test-batch 1-3; TB1, TB2, TB3 respectively) during the period September 2012 – February 2013. All of the test-batches included the same three observations; step-kick behaviour during milking, exposure to novel object and frequency of performed abnormal behaviours in home pen. To investigate behavioural consistency over time, each individual was observed in two test-batches. Animals tested in TB1-2 are in the analysis regarded as equivalent to animals tested in TB2-3 or TB1-3. The individual cow's first test-batch, regardless of whether it is TB1 or TB2, is henceforth called Test batch-a (TB-a) and the individual cows second test-batch, regardless of whether it is TB2 or TB3, is henceforth called Test batch b (TB-b). In total, 69 individuals were present

during at least one test in one batch; however, the n-number differs between batches and observations due to variation in numbers of individuals available for the tests.

3.2.1 Stepping and kicking behaviour during milking

Two behaviours observed in dairy cows kept in intensive dairy production systems related to the personality gradients fearfulness and neophobia are stepping- and kicking behaviour during milking. Stepping behaviour is associated with fear of novelty, increased heart rate and increased milk cortisol concentrations, whereas kicking behaviour rather than initiated by nervousness or anxiousness seems to be expressed by not fearful cows (Rushen et al., 2001, Wenzel et al., 2003, Rousing et al., 2004).

To investigate the frequency of stepping and kicking behaviour during milking in the milking parlour, the behaviour of cows during midday milking (14:30-16:00) was recorded by using between two and four video cameras. Behaviours (Table 1) were recorded from when first teat cup was attached to a cow's teat until the last teat cup was automatically removed. Behaviour during udder preparation and after-treatment was not recorded, and if the milking machine was kicked off by the cow or automatically went off before milking was finished, time and observation stopped until all teat cups were attached again. Time and observation were also stopped if hind legs and/or udder of the cow were out of sight. Hence, the total milking time during which behaviours were recorded (typically 3-6 minutes) is not identical to actual time spent in milking parlour (typically 10-20 minutes). Behaviours were recorded as rates, calculated by dividing frequencies of behaviours over time observed, in seconds. Each animal was recorded during two milkings per test-batch and the value used in the analysis is the individuals mean value of those two recordings.

Table 1. Observed behaviours of dairy cows when milked in milking parlour

Behaviour	Description
Stepping behaviour during milking	Every individual weight shifting from one hind foot to the other with the foot less than 10 cm off the ground
Kicking behaviour during milking	Every individual occasion of lifting the hind foot at least 10 cm off the ground and moving it quickly forward

3.2.2 Exposure to novel object

The far most common behaviour trait studied in relation to milk production is the personality gradient 'fearfulness'. There are studies providing a strong negative correlation between milk yield and fearfulness (Breuer et al., 2000), whereas others do not find this relationship (Purcell et al., 1988).

Observations of reactions to novel object were performed in order to investigate fearfulness and neophobia, assuming novelty to cause behaviour reactions related to fear and fearfulness. The objects used were a blue pilates ball (TB1, Ø 60cm), a pink umbrella (TB2, Ø 1m) and a large blue and white plastic bag (TB3, 60x60x25 cm). A new object for every test-batch was used to avoid habituation to the objects (according to e.g. Kilgour et al., 2006). These three objects were estimated to cause similar or comparable behaviour reactions within each individual, based on results from previous studies (e.g. Hemsworth et al., 1996, Schrader, 2002; Herskin et al., 2004, Van Reenen et al., 2005, Gibbons et al., 2009a).

The arena used for testing was a section of the cows' normal pathway to the milking parlour temporarily blocked with gates, in order to avoid testing behavioural reactions of a new environment rather than the object itself. The cows were individually moved from home pen to the testing arena. When in the arena, the cow was turned with her head towards the gate and the novel object was presented in front of her to make sure all cows immediately took notice of the object (Figure 1).

Behaviours were video recorded for three minutes from when the cow was presented to the object (Table 2). Since cows are strictly social animals and separation from the group induces several stress responses in an individual (Lidfors, 1996, Müller & Schrader, 2005a, von Keyserlingk & Weary, 2007), the social separation in the test-situation may be a factor affecting the behaviour of the cow as much as the novel object in question. Therefore, behaviours related to social separation were recorded as well (Table 2).

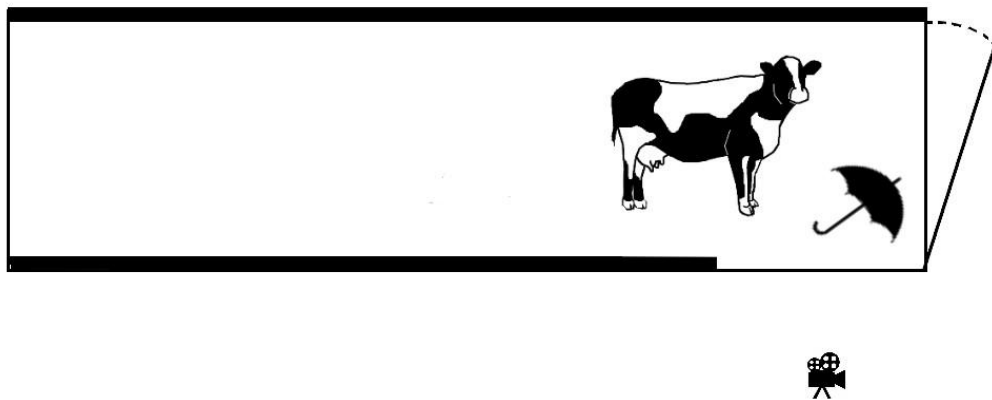


Figure 1. Drawing of arena used when exposed individual dairy cows to novel objects

Table 2. Observed behaviour in dairy cows during exposure to novel object and social separation

Behaviour	Description
Latency to approach novel object	Latency to first interaction (sniffing/licking/butting) with object (in seconds)
Interaction with novel object	Duration of interactions (sniffing/licking/butting) with object (in seconds)
Standing < 2 m from novel object	Time standing with any part of the body within 2 meters of distance from the object (in seconds)
Vocalisations	Frequency of vocalisations with open or closed mouth (number of times performed)
Attraction to heard	Time spending in upright position with head turned in direction to herd (in seconds)

3.2.3 Abnormal behaviours

Individuals housed under stressful conditions may start performing specific behaviour patterns in order to control mental and physical stability (Broom, 1991) and reach homeostasis (Koolhaas et al., 1997). These behaviours are typically shown by individuals housed in unsuitable environments and may be a substitute for behaviours the animal is strongly motivated but hindered to perform (Mason & Latham, 2004, Mason 2006). Abnormal behaviours are assumed to be related to personality gradients such as aggression (Benus et al., 1991) and proactivity/reactivity (Koolhaas et al., 1997).

Observations of abnormal behaviours were performed in order to investigate the individual cows' coping behaviours as a gradient of personality. Observations were performed in the home pen 45 minutes before, after and in between milkings for a total of three days per batch. The method used was a scan-sampling method on individual level with 1 minute intervals, recording the number of times an animal was observed performing an abnormal behaviour during the 45 minute period (Table 3). Value used for statistical analysis is the mean value of those three observations.

Table 3. Observed abnormal behaviours performed by loose-housed dairy cows in home pen

Behaviour	Description
Tongue rolling	Repetitively rolling of the tongue from side to side inside or outside the mouth
Leaning	Pressing nose or forehead against equipment, object or another animal
Drinking/ Playing with water	Standing with nose or tongue in water cup, drinking or lapping water

3.3 Production data

Production data was imported from the IndividualRAM (NorFor) database. The production value (ECM, energy corrected milk) from one month before, one month after and from the actual month the tests were carried out were incorporated in the statistical analysis in order to investigate if current lactation status influenced cow behaviour.

Since cows differed in age, lactation, month of pregnancy and months since last calving, the production values used in the statistical analysis were total amount of milk (kg), percent of fat (%) and protein (%) and total amount of ECM (kg) from the five first test milkings (one per month) during the individual cows' first, second and third lactation. Thus, this was a comparable measure of milk production across cows, independent of their current somewhat varied status.

Each individual cows' production parameters (kg, fat, protein and ECM) from first, second and third lactation were plotted, and 'a' obtain from a linear function ($y = ax + b$) of the individual cows' increase in each value respectively were calculated. The value of increase ('a') on each production parameter (kg, fat, protein and ECM) was used to get a measurement of milk production as a life-history trait, thought to capture any variation in production 'style' of individual cows, in other words whether cows produced more or less milk earlier in life.

3.4 Statistics

Due to nonparametric data, consistency in behavioural responses within individuals and relationships between production traits and personality traits were investigated with Spearman rank-order correlations. However, figures in this thesis are present raw data.

Factors other than personality that could possibly influence cow behaviour were tested for by Kruskal-Wallis tests (current lactation, month of pregnancy and months since last calving).

All statistical analyses were conducted in SPSS.

4. Results

4.1 Current lactation and age

Older cows were in later lactations ($r=0.82$; $p<0.01$; $n=56$), thus, lactation status in henceforth used as a measurement of age in the analysis and discussion.

When analysing behaviour with regard to current lactation, neither SRB nor Holstein cows in different lactations displayed significant differences in

behaviour. Cows in different lactations were therefore pooled for further analyses.

4.2 Month of pregnancy

Behaviours did not differ significantly between neither SRB, nor Holstein cows in different month of pregnancy. Individuals in different month of pregnancy were therefore pooled for further analyses.

4.3 Months since last calving

Behaviours did not differ significantly between neither SRB, nor Holstein cows that were in different months since last calving. Individuals in different months since last calving were therefore pooled for further analyses.

4.4 Breed differences

Breeds differed in number of behaviours shown to be consistent over time, where Holstein cows were consistent in more behaviours than SRB (Table 4).

4.5 Behaviour tests

4.5.1 Stepping and kicking behaviour during milking

The rate of stepping and kicking behaviour during milking were not correlated to each other (Mean \pm SE; Stepping behaviour, 0.041 ± 0.003 ; Kicking behaviour, 0.010 ± 0.002 ; $r = -0.12$, $p = 0.40$, $n = 54$).

The rate of stepping behaviour during milking was consistent over time in both SRB and Holstein (Table 4, Figure 2a-b) whereas kicking behaviour was consistent over time in Holstein (Table 4; Figure 3b) but not in SRB (Table 4; Figure 3a).

Table 4. Correlations within behaviours between first test-batch (TB-a) and second test-batch 8 weeks later (TB-b) by SRB and Holstein cows. Means \pm SE values are given for each breed and behaviour

Behaviour	SRB	Holstein
Stepping behaviour during milking	r=0.56; p<0.01; n=26	r=0.37; p=0.03; n=28
	TB-a; 0.033 \pm 0.003	TB-a; 0.041 \pm 0.006
	TB-b; 0.046 \pm 0.005	TB-b; 0.044 \pm 0.006
Kicking behaviour during milking	r=-0.01; p=0.48; n=26	r=0.65; p<0.00; n=28
	TB-a; 0.007 \pm 0.001	TB-a; 0.012 \pm 0.003
	TB-b; 0.005 \pm 0.001	TB-b; 0.014 \pm 0.004
Latency to approach novel object	r=0.09; p=0.33; n=24	r=0.32; p=0.05; n=28
	TB-a; 46.3 \pm 13.2	TB-a; 75.4 \pm 14.4
	TB-b; 47.8 \pm 12.7	TB-b; 68.2 \pm 13.6
Interactions with novel object (duration)	r=0.42; p=0.02; n=24	r=0.22; p=0.13; n=28
	TB-a; 12.21 \pm 6.31	TB-a; 9.36 \pm 3.36
	TB-b; 21.92 \pm 8.83	TB-b; 19.57 \pm 5.81
Standing < 2 m from novel object	r=0.26; p=0.12; n=24	r=0.45; p<0.01; n=28
	TB-a; 149.5 \pm 9.6	TB-a; 125.0 \pm 11.7
	TB-b; 126.1 \pm 10.3	TB-b; 132.9 \pm 9.5
Vocalisations	r=0.22; p=0.15; n=24	r=0.06; p=0.38; n=28
	TB-a; 0.013 \pm 0.004	TB-a; 0.015 \pm 0.024
	TB-b; 0.020 \pm 0.005	TB-b; 0.005 \pm 0.008
Attraction to heard	r=-0.06; p=0.40; n=22	r=0.55; p<0.01; n=28
	TB-a; 0.281 \pm 0.037	TB-a; 0.232 \pm 0.031
	TB-b; 0.242 \pm 0.035	TB-b; 0.200 \pm 0.025
Tongue rolling	r=0.02; p=0.46; n=26	r=-0.88; p=0.33; n=27
	TB-a; 0.056 \pm 0.027	TB-a; 0.082 \pm 0.027
	TB-b; 0.064 \pm 0.046	TB-b; 0.033 \pm 0.017
Leaning	r=-0.29; p=0.08; n=26	r=0.09; p<0.32; n=27
	TB-a; 1.214 \pm 0.215	TB-a; 0.782 \pm 0.188
	TB-b; 1.346 \pm 0.358	TB-b; 1.062 \pm 0.262
Drinking/Playing with water	r=0.34; p=0.04; n=26	r=0.42; p=0.02; n=27
	TB-a; 0.874 \pm 0.092	TB-a; 0.848 \pm 0.642
	TB-b; 0.788 \pm 0.138	TB-b; 0.097 \pm 0.085
Total frequency of abnormal behaviours	r=0.89; p=0.00; n=26	r=0.83; p=0.00; n=27
	TB-a; 0.714 \pm 0.081	TB-a; 0.575 \pm 0.083
	TB-b; 0.724 \pm 0.094	TB-b; 0.575 \pm 0.077

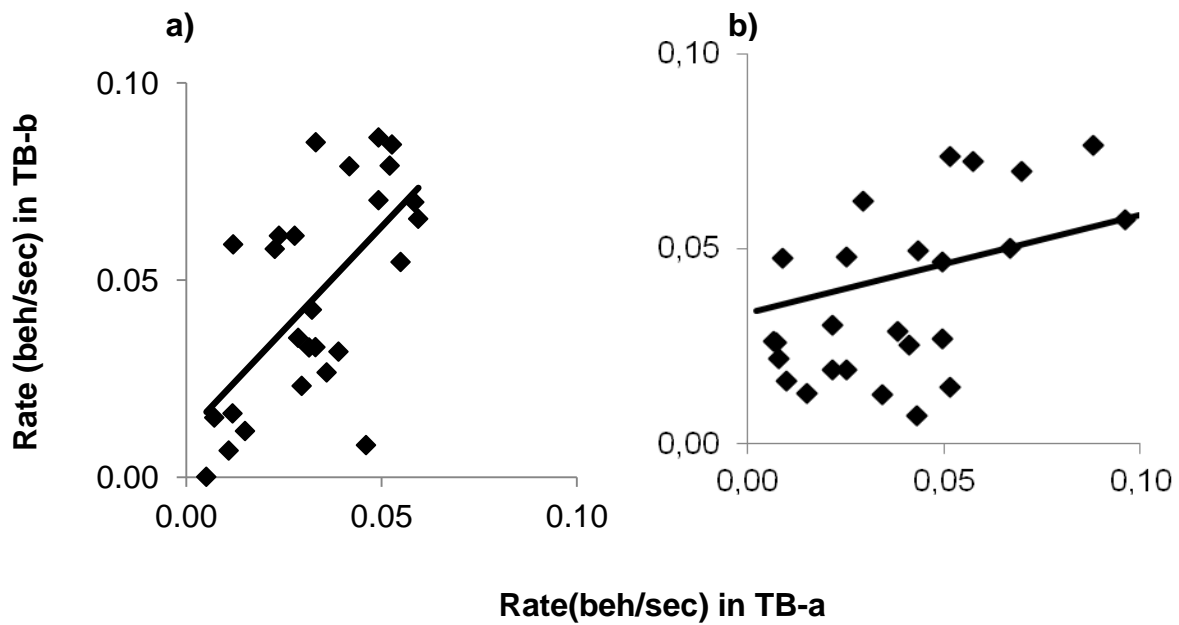


Figure 2. Rate of stepping behaviour during milking in first test-batch (TB-a) and second test-batch 8 weeks later (TB-b) respectively, by a) SRB and b) Holstein cows

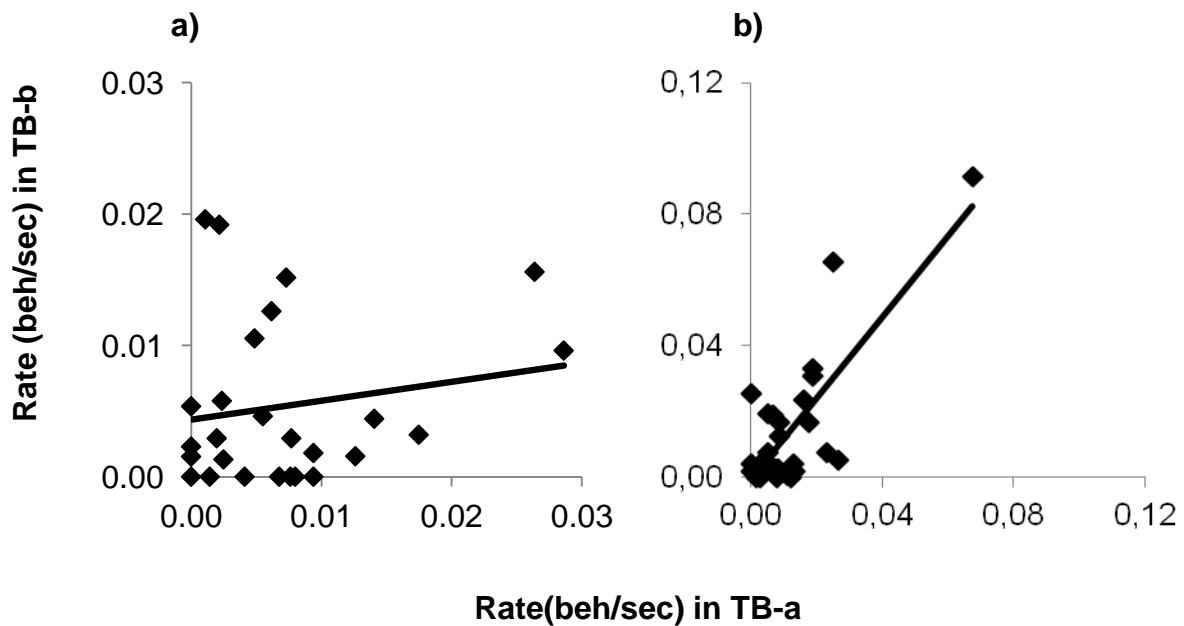


Figure 3. Rate of kicking behaviour during milking in first test-batch (TB-a) and second test-batch 8 weeks later (TB-b) respectively, by a) SRB and b) Holstein cows. The correlation in Holstein cows is true even without the two outliers ($r=0.55$; $p=0.002$; $n=26$; TB-a; 0.009 ± 0.001 TB-b; 0.009 ± 0.002)

4.5.2 Exposure to novel object

SRB cows were consistent over time in duration of interactions with novel object but in no other behaviours recorded when socially separated and exposed

to novel object (Table 4; Figure 4-8a). Holstein cows were consistent in latency to approach novel object (Table 4; Figure 4b), time spent less than 2 meters from novel object (Table 4; Figure 5b) but not in duration of interactions with novel object (Table 4; Figure 6b). Holstein cows were also consistent in time spent in upright position with head turned in direction to heard but not in frequency of vocalisations when socially separated and exposed to novel object (Table 4; Figure 7b; 8b).

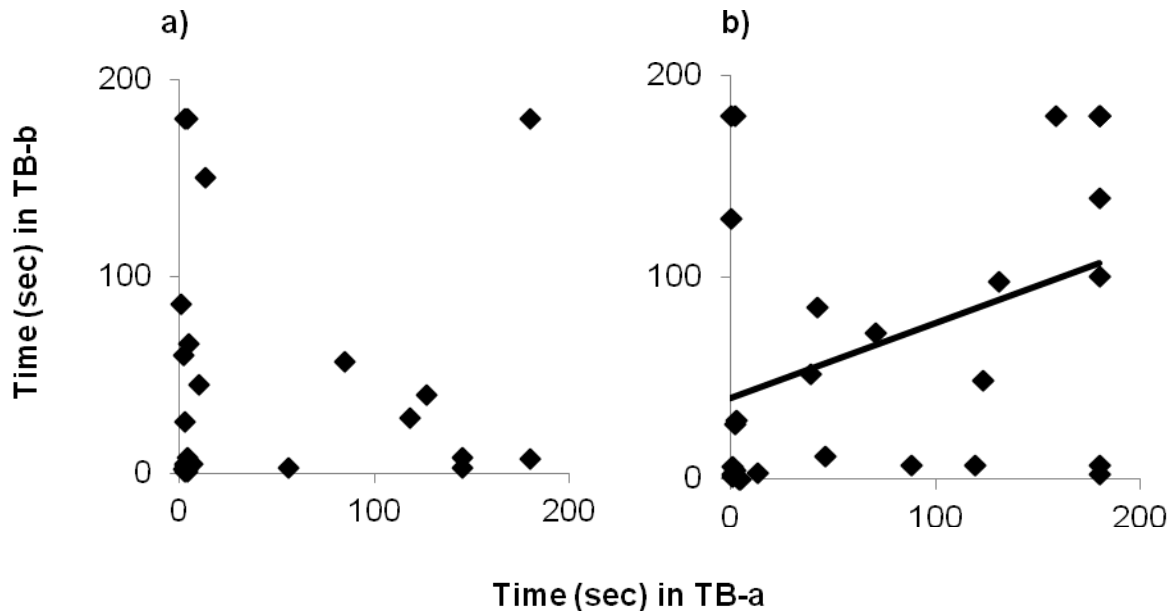


Figure 4. Time to first interaction with novel object in first test-batch (TB-a) and second test-batch 8 weeks later (TB-b) respectively, by a) SRB and b) Holstein cows

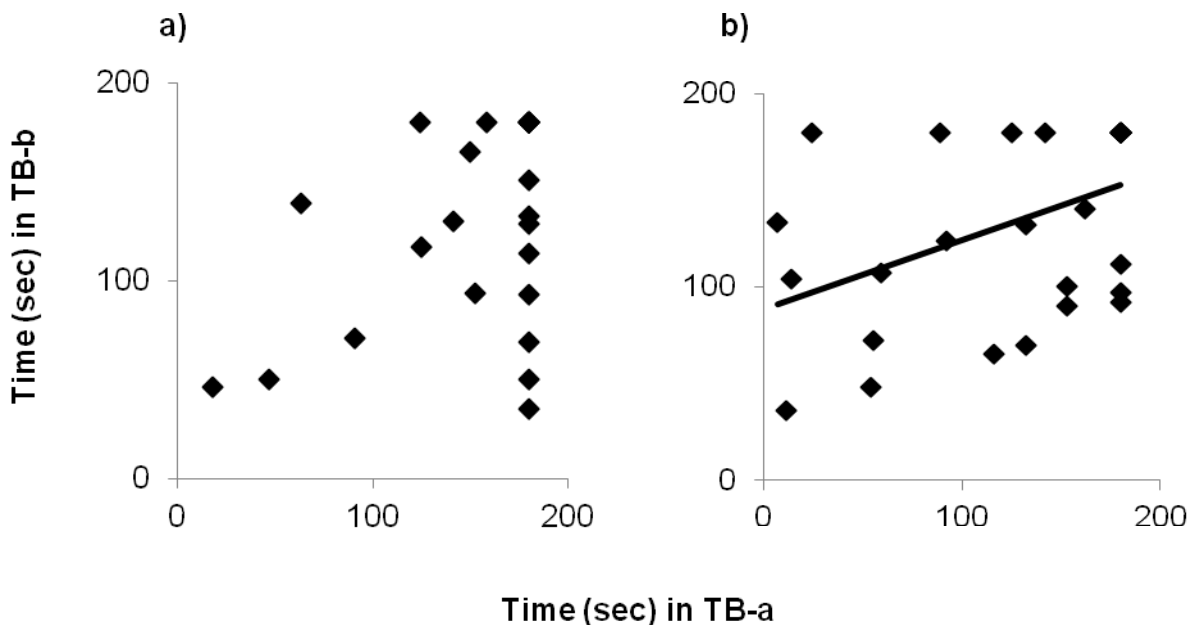


Figure 5. Time spent within 2 meters from object when exposed to novel object in first test-batch (TB-a) and second test-batch 8 weeks later (TB-b) respectively, by a) SRB and b) Holstein cows

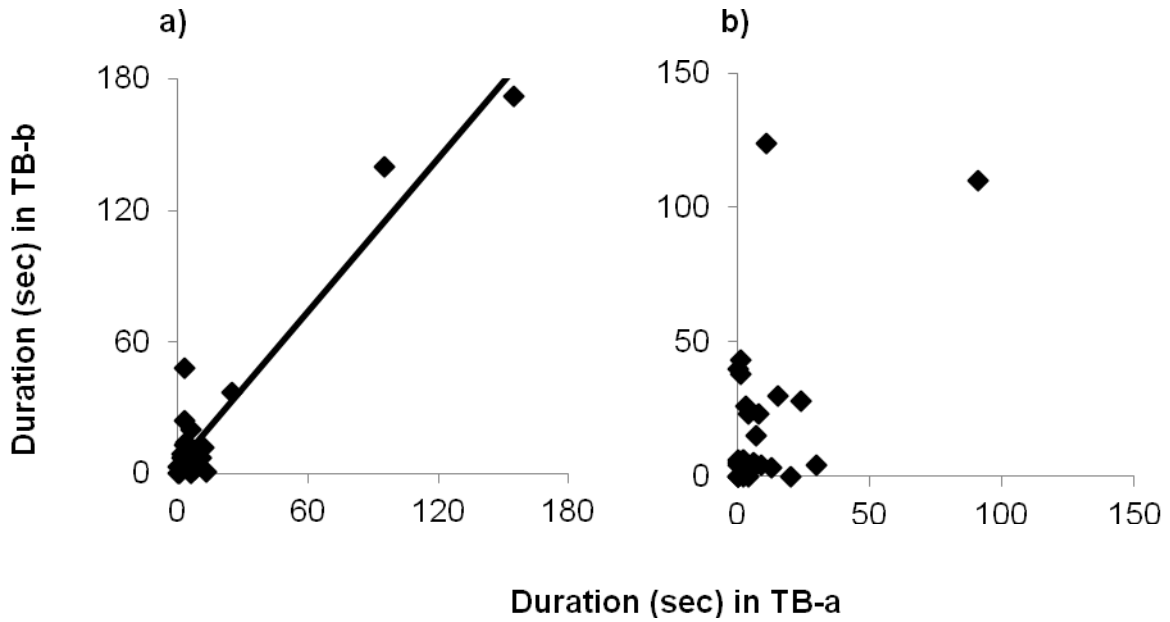


Figure 6. Duration of interactions with novel object in first test-batch (TB-a) and second test-batch 8 weeks later (TB-b) respectively, by a) SRB and b) Holstein cows

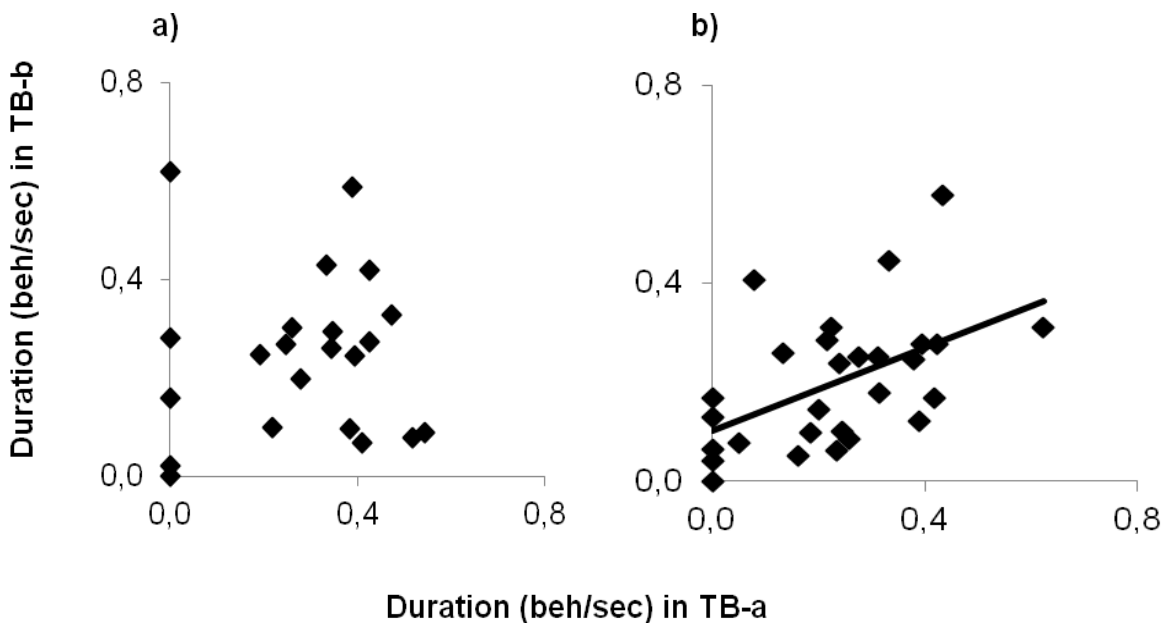


Figure 7. Duration of time spent in upright position with head turned in direction to heard in first test-batch (TB-a) and second test-batch 8 weeks later (TB-b) respectively, by a) SRB and b) Holstein cows

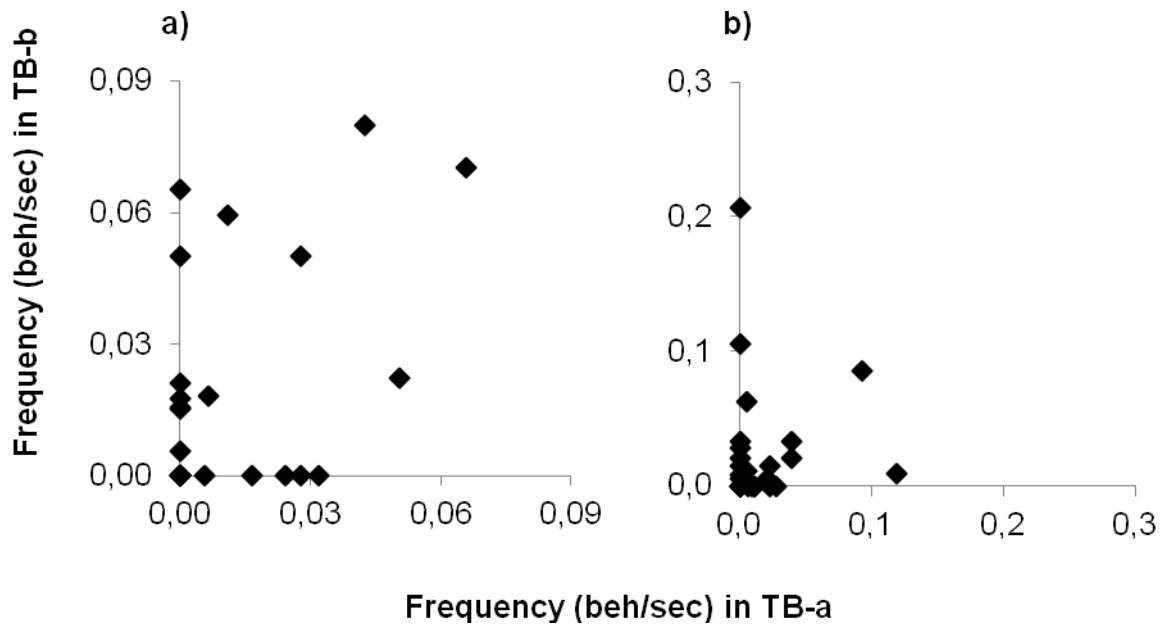


Figure 8. Frequency of vocalisations in first test-batch (TB-a) and second test-batch 8 weeks later (TB-b) respectively, by a) SRB and b) Holstein cows

4.5.3 Abnormal behaviours

The frequency of total performed abnormal behaviours was highly consistent over time in both SRB and Holstein cows (Table 4; Figure 10a-b). However, neither tongue rolling, nor leaning or excessive drinking/playing with water were consistent over time when analysed separately (Table 4).

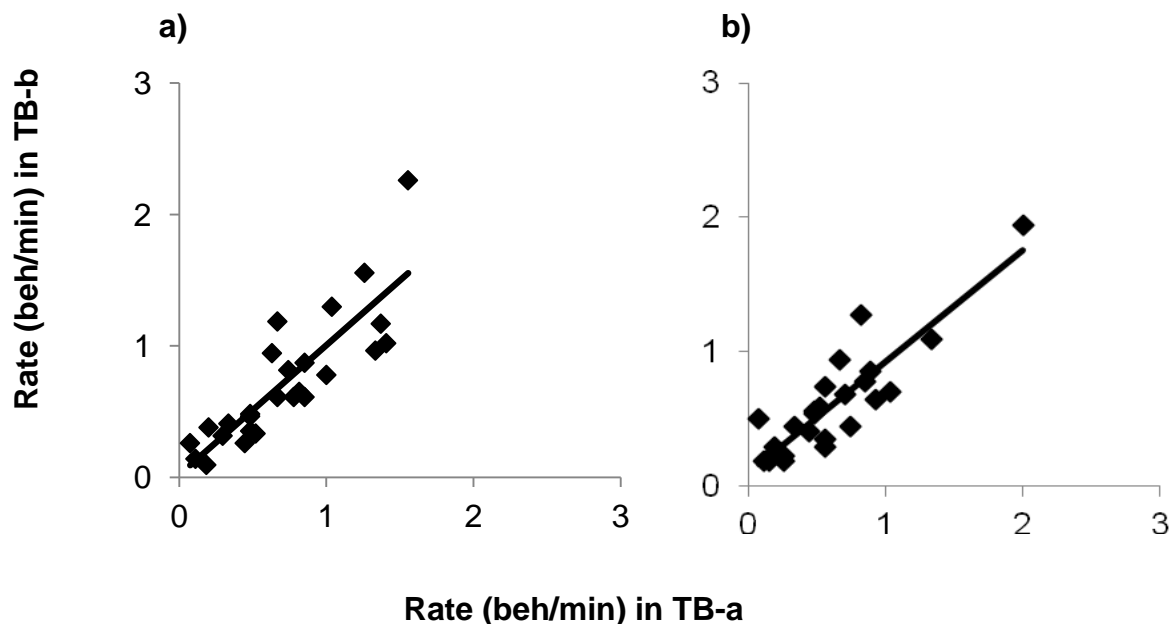


Figure 10. Frequency of performed abnormal behaviours in first test-batch (TB-a) and second test-batch 8 weeks later (TB-b) respectively, by a) SRB and b) Holstein cows

4.6 Production data

Cows were consistent in some of their production traits (for example, see Figure 11). However, none of the behaviours found to be consistent over time were correlated to any production traits. Neither was personality correlated to variation in milk production increase across the three first lactations of an individual, i.e. milk production estimated as a life-history trait. For main results (all correlations between personality and production parameters are showing the same pattern) see SRB, Table 6; Holstein, Table 7.

In addition, cows' current production status, thus the production value (kg, ECM) the actual month when tests were carried out, seems not to affect cow behaviour. For main results (all correlations between personality and production parameters are showing the same pattern) see SRB, Table 6; Holstein, Table 7.

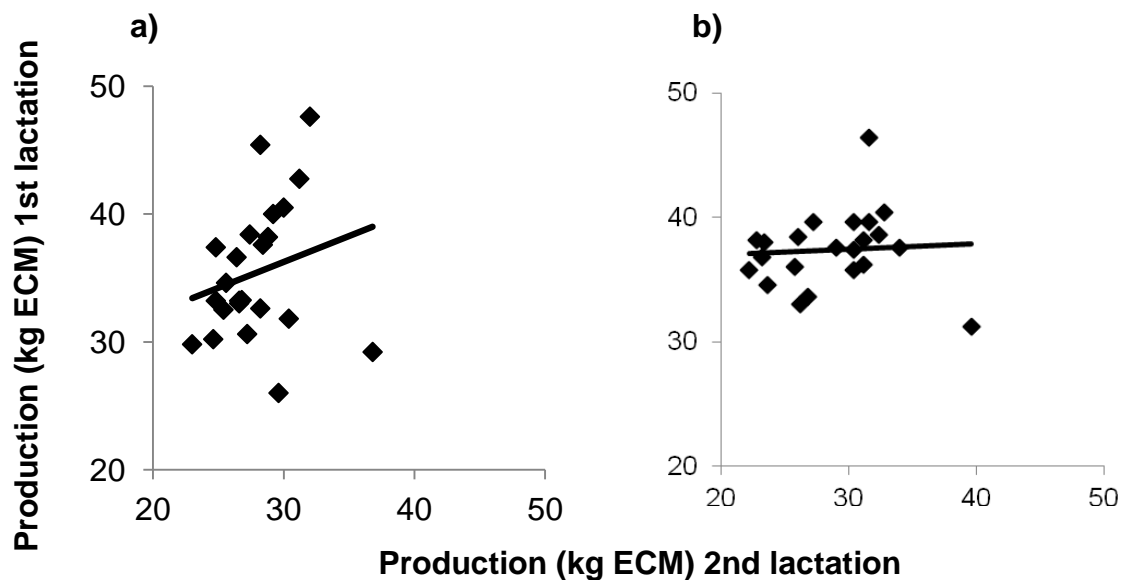


Figure 11. Mean value of milk produced (kg ECM) during the individual cows five first test-milkings during first and second lactation.

Table 6. Correlations between personality traits and milk production parameters in SRB

Behaviour	Milk production 1 st -3 rd lactation (kg ECM)	Current milk production (kg ECM)	Increase in milk production, life-history 'style' (kg ECM)
Stepping behaviour during milking	$r=0.16$; $p=0.45$; $n=24$	$r=0.11$; $p=0.64$; $n=20$	$r=0.11$; $p=0.74$; $n=12$
Total frequency of abnormal behaviours	$r=0.06$; $p=0.77$; $n=25$	$r=0.18$; $p=0.44$; $n=0.21$	$r=0.21$; $p=0.51$; $n=12$

Table 7. Correlations between personality traits and milk production parameters in Holstein cows

Behaviour	Milk production 1st-3rd lactation (kg ECM)	Current production (kg ECM)	Increase in milk production, life-history 'style' (kg ECM)
Stepping behaviour during milking	r=0.16; p=0.43; n=27	r=0.20; p=0.37; n=23	r=0.46; p=0.15; n=11
Kicking behaviour during milking	r=-0.39; p=0.05; n=27	r=-0.20; p=0.36; n=23	r=-0.44; p=0.18; n=11
Latency to approach novel object	r=-0.11; p=0.59; n=27	r=-0.14; p=0.52; n=23	r=-0.27; p=0.43; n=11
Interactions with novel object (duration)	r=0.18; p=0.37; n=27	r=0.12; p=0.59; n=23	r=0.12; p=0.74; n=11
Standing < 2 m from novel object	r=-0.1; p=0.96; n=27	r=0.08; p=0.73; n=23	r=0.11; p=0.74; n=11
Attraction to heard	r=-0.20; p=0.31; n=27	r=-0.13; p=0.56; n=23	r=-0.2; p=0.55; n=11
Total frequency of abnormal behaviours	r=0.29; p=0.14; n=27	r=0.20; p=0.36; n=23	r=0.06; p=0.84; n=13

5. Discussion

This study on personality in dairy cows shows that cows show consistency in several behavioural responses over time, thus that they can be categorised along personality gradients. The two studied breeds of cows differed in number of observed behaviours that they were consistent in. Nevertheless, the results from this study suggest that neither breed showed any relationship between personality and milk production.

Stepping behaviour during milking (in both breeds) as well as kicking behaviour during milking (in Holstein cows) showed intra-individual consistency over time. The frequency of stepping behaviour during milking in dairy cows has previously been associated with nervousness and anxiousness whereas kicking behaviour during milking on the contrary seems to be expressed by cows that otherwise do not show any sign of fearfulness (Rushen et al., 2001, Wenzel et al., 2003, Rousing et al., 2004). The combined results from this study and other studies show that these two behaviours are not associated with each other, meaning they are not describing the same personality types (Rushen et al., 2001, Wenzel et al., 2003, Rousing et al., 2004). Since stepping (both breeds) as well as kicking (Holstein) behaviour in this study was consistent over time, and both behaviours previously have been associated with physiological as well behavioural traits, these two behaviours can be regarded as to from each other independent personality gradients representing fear, anxiety and nervousness in

dairy cows. In other words, cows can be categorised along at least two different personality gradients based on variation in stepping and kicking behaviour during milking, describing variation in fearfulness (or nervousness), but also along a non-fearful gradient.

The results from my study do not show any relationship between production values and stepping behaviour. This contradicts previous findings, where for example Rousing and co-workers (2004) found stepping behaviour to be positively correlated with milk yield in dairy cows. However, the study of Rousing and co-workers (2004) also showed that cows with lower milk yield showing avoidance behaviour were more likely to step during milking. As a conclusion, there seems to be a relationship between stepping behaviour and milk yield, although it is complex and needs further investigation to clarify the relationship between these traits. For variation in kicking behaviour, neither this study, nor the study of Rousing and co-workers (2004) support a relationship between milk yield and kicking behaviour. The relationship between kicking behaviour during milking and milk production is therefore even poorer understood. The behaviour of kicking was in this study more flexible (at least across breeds, only Holstein cows showed consistency in the behaviour over time), suggesting that this behaviour overall may be more flexible and less consistent, which can explain why the lack of a relationship with milk production is repeatedly found.

Behaviour reactions of cows when socially separated and exposed to novel objects were in this study moderately consistent over time and also consistent between different novel objects, which indicate the existence of a single personality trait in responses to novel stimuli in dairy cattle. These results contrast a previous study by Gibbons and co-workers (2009a) that did not find consistency in individual cow's behavioural responses to different novel stimuli. The study of Gibbons and co-workers (2009a) showed that investigatory responses (comparable with number of interactions with novel object in this study) differed within animals depending on the novel stimuli per se. However, Gibbons and co-workers (2009a) did not use 'classical' novel objects, but tested behavioural reactions to striped boards, water spray and flashing lights. The authors discuss themselves that striped boards and flashing lights are visual objects whereas water spray is a tactile stimulus and conclude that these three stimuli activate different senses, which imply that these are totally different experiences for the animal. As a result, the authors' choice of novel objects were not comparable, and consistency in the behavioural responses of the cow was not expected. In my study, three objects of relatively similar appearance (pilates ball, umbrella and plastic bag) presented in the same manner, were used to enable comparisons between the objects and ensure measuring the same underlying personality trait on the first and the second test-batch, explaining the discrepancy of results between studies.

Latency to approach novel object was moderately consistent over time in Holstein. The result confirms the findings in the study of Gibbons and co-workers (2009a) that cows are displaying individual behavioural stability over time in an unfamiliar human approach situation. In this study, the response was to an unfamiliar human. The cows in my study were exposed to different novel stimulus in the different test-batches, thus, the stimuli was novel to the cows also on the later test occasion. It therefore appear that responses to unfamiliar, novel objects (or humans) show consistency within cows, in different studies (here for cows from the Hosltein breed, Gibbons et al., 2009a). However, Hemsworth and co-workers (1996) found no difference in approach behaviour in cows between familiar or novel persons or between familiar or unfamiliar object, which indicates that the novelty of the object is less important in determine whether an individual cow approach it or not, and that this behaviour therefore might be related to something else than neophobia. The behaviour, as a suggestion could instead be related to curiosity. Nevertheless, why there is observed variation across studies in when this behaviour is consistent in cows, needs further investigations.

The Holstein cows in this study were significantly consistent in the time they spent in the proximity of the novel object. However, behaviour reactions to novel stimuli have previously been shown to vary greatly between individuals, where some cows show signs of neophobia (Herskin & Munksgaard, 2000, Herskin et al., 2003, 2004) whereas others display exploratory and approach behaviours (Munksgaard et al., 1997, Rushen et al., 1999, Herskin, et al., 2003, 2004). Exposure to novel stimuli can affect conflicting emotions within an animal, such as reactivity and investigatory (Boissy, 1995, Gibbons et al., 2009a). Thus, spending time near a novel object can be interpreted as non-fearfulness as well as a fear-related exploratory behaviour.

Taken together, Holstein cows seem to be consistent in behaviours when exposed to novel object whereas SRB does not, but what this variation in behaviour reactions may have complex and still not fully understood explanations.

Vocalisation when being socially separated was a behavioural response in which cows in my study showed plasticity in, and they were thus not consistent over time in this behaviour. These results contradict the finding of previous studies (Müller & Schrader, 2005a). The non-consistency of the behaviour in this study might be due to the overall low frequency of observed vocalisation behaviour. Additionally, time spent standing with head towards herd was only consistent in Holstein cows, thus behavioural responses to social separation could generally not be concluded very stable over time for most of the cows in this study. Further studies interested in investigation variation in responses to social separation, or vocalisation propensities of cows should therefore use a different

design, with for example longer observations since it is likely needed to obtain larger variation in the observed responses of individual cows.

In the current study, the amount of abnormal behaviours individuals performed was highly correlated over time for individuals from both breeds. However, neither tongue rolling, leaning nor excessive drinking/playing with water were separately consistent over time within individuals. Different abnormal behaviours are elicited by different triggers in the environment (Mason, 1991) and several factors influence the performance of behaviours in captive animals. Factors such as variation in feeding routines (Redbo et al., 1996, Redbo & Nordblad, 1997, Lindström & Redbo, 2000), management routines, temperature, light, sounds, odours (reviewed by Morgan & Tromborg, 2007), health status of animals (Wiepkema et al., 1987) as well as group sizes and social constellations (Rodenburg & Koene, 2007) can all contribute to stressors that can trigger the performance of abnormal behaviours.

The cows in my study were likely exposed to some or several of these potential stressors, not possible to control for, which could generate variation and therefore different responses of the cows among the different test-batches. This can explain why the abnormal behaviours on their own were not observed to be consistent over time.

Previous studies have shown oral abnormal behaviours in cows, for example tongue rolling and excessive drinking, to be related to variation in feeding routines (Redbo, 1990, Redbo, 1992a;b, Redbo et al., 1996, Redbo & Nordblad, 1997, Redbo, 1998, Lindström & Redbo, 2000). Roberts (1997) describes polydipsia, or lapping of water in the water cup, as a vacuum activity which is a highly repetitive coping behaviour that helps animals to deal with physiological stressors. Further, Roberts (1997) categorises tongue rolling as a frustration or displaced activity performed when prevented from basic behavioural needs.

The presence of leaning behaviour is on the other hand not that well understood, but it is discussed if leaning increases with stall discomfort or pain (Harder Nilsen et al., 1997, Roberts, 1997). Tethering of cows in tied-up housing systems (Krohn, 1994) as well as deprivation of lying down (Roberts, 1997) and decreased size of straw-bedded area (Harder Nilsen et al., 1997) seems to increase the frequency and duration of leaning behaviour. However, cows in my study were not tied-up and the housing system was never over-crowded, which indicates leaning behaviour to be an indicator of something else. Wechsler (1995) describes in a review article four types of coping strategies: escape, remove, search and wait. To actively increase the distance to the aversive stimulus (escape, remove) is an effective way to cope with the situation. However, this is not always possible. If the stressor is for example food deprivation, it is efficient to search for a solution, but if the animal is not able to

escape or remove, and the solution is not searchable, it is not adaptive to repeat any coping strategy over and over again. As an alternative, the animal can conserve energy by doing nothing and wait for the environment to change. As a suggestion, leaning behaviour can be regarded as a waiting coping strategy. If the stressor is something not possible to actively control for, it is likely that the individual 'gives up' or develops a coping strategy where she simply waits for the environment to change. Since leaning is poorly described in literature, the stressors triggering the behaviour need further investigation to be fully understood. However there is a possibility that this behaviour is a 'wait' behaviour, according to Wechler's (1995) description of coping responses.

A previous study of Redbo (1990) shows that abnormal behaviour in heifers are reversible, with changes over time and among environments. This is consistent with my results showing that individuals that showed abnormal behaviour also did so at a later time point, but the abnormal behaviour they performed might have differed. This may be important to be aware of for future studies on abnormal behaviours, since one (and not several behaviours) are studied, which may not give the full picture of how animals cope with stressors in their environment.

The two breeds here investigated differed from each other with regards to how many behaviour here observed, that they were consistent in. Cows from the Holstein breed were consistent in more behaviour traits than SRB, which indicates that SRB are more plastic than Holstein cows in their behaviour. This result might be due to the breeding of the production animals and the selection and current genetic variation within the two different breeds. The results from this study indicate that cows from the SRB breed are more able to adjust their behaviour to each independent situation to a larger extent than Holstein cows did. To further our understanding of what constraints behavioural plasticity, various breeds varying in their level of genetic variation and also the selection pressures they have been exposed to, may offer insight into underlying differences in plasticity. In addition, because breeds differ in responses and consistency of responses, results obtained may therefore not only be species-specific, but may also be breed specific, knowledge of relevance for our understanding of both productivity and the management of animals of different breeds.

No behaviours that were consistent over time, thus personality traits, were correlated to milk production. Previous studies have shown stepping behaviour (Rousing et al., 2004) and fear of humans (Rushen et al., 1999, Breuner et al., 2000) to be correlated to milk production, but there are also studies in which no relationship between behaviour and milk production could be found (Purcell et al., 1988). Both SRB and Holstein cows are intensively bred for milk production for several decades. This strong selection can be the reason for why there were

no correlations to find between any behaviours and any production traits – the variation of milk production in the two populations of dairy cows is simply too low. In addition, milk production is a complex parameter to use when searching for relationships between behaviours and production traits in animals. First of all, dairy cow is a complex, long-living animal and it is almost always impossible to control for parameters such as age, breed, lactation status, history of growth, housing, feeding, management routines, handling, breeding, time of insemination and calving, health status and hoof care when designing studies on dairy cows. Some of these parameters were controlled for in the statistical analysis of this project, but there are parameters other than these which potentially can affect the productivity of a dairy cow. In addition, there are multiple milk parameters one can analyse. Since the prediction of a relationship between personality and production is still in its early days, it is unclear what traits one actually are predicted to be linked. Further studies should therefore search for the underlying common explanation for such a relationship to clarify what behaviour and production trait that are predicted to be linked. Other breeds (e.g. landraces) or other species that have not been strongly selected for milk production may be more fruitful models for further investigations of the relationship between milk production as a life-history trait and personality.

The results from this study show that behaviour during milking and total frequency of performed abnormal behaviours in dairy cows are personality gradients that can be used to describe variation in personality among cows. Exposure to novel object can to some extent be used when estimating fearfulness and neophobia in cows, but the results should be interpreted with caution. Previous studies have shown that cows are consistent in behaviours during social separation (Müller & Schrader, 2005a) although in this study, it was only supported by cows from the Holstein breed. However, the overall results from this study together with previous findings show that cows do display individual differences in behaviours, consistent over time; in other words that they show variation in their personality.

6. Conclusions

Cows do show consistency over time in behaviours during milking and in total performance of abnormal behaviours in home pen. Behaviour reactions when exposed to novel object were moderately stable over time. However, consistency in behaviours differed between the breeds, where Holstein cows were consistent in more behaviours than SRB. Even if cows showed consistency also in milk production traits, the results of my study showed limited relationship between the two. More theoretical and empirical work is therefore needed to fully understand this predicted relationship.

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