

Original Article

What are we losing? Are the personality traits of Italian autochthonous cows different from those of cosmopolitan breeds?

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ABSTRACT

Objective: This study assessed personality traits in five cattle breeds (*Bos taurus*), two cosmopolitan (Holstein Friesian and Brown Swiss) and three endangered Italian autochthonous (Varzese, Rendena, and Modenese). Our aim was to provide an evaluation of the personality dimensions obtained by our questionnaire in order to compare some Italian autochthonous breeds with the cosmopolitan one. Our choice fell upon the comparison of the Varzese, the Modenese, the Rendena, the Brown Swiss, and the Holstein Friesian because the genetic selection at the base of the typical attitudes has induced different characteristics, and as a consequence, detectable differences in personality can be expected between the populations.

Materials and methods: A personality questionnaire was completed by milkers/owners for each subject involved in this study. The milking staff involved in the study have been working with cows for over 20 years; they have experience with numerous breeds, and therefore, can be considered expert evaluators since they certainly have an appreciation of the full range of cow behavior.

Results: The milkers' assessments analysis found breed differences in dairy cattle, showing that certain personality traits are more marked in certain breeds in terms of curiosity, friendliness to milkers, and responses to unknown people.

Conclusion: This pilot survey shows the usefulness of questionnaires in cattle personality studies, highlighting some peculiarity of the endangered breeds.

KEYWORDS

Biodiversity; Cattle; Personality; Welfare

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INTRODUCTION

The 1960s saw a Livestock Management “revolution” in the meat and dairy industries; in about 20 years, the increase of meat consumption in developing countries was almost triple the increase in developed countries, and milk consumption saw more than double the increase that occurred in developed countries ([Steinfeld, 2004](#)). The increase in meat and milk consumption was fueled by urbanization, population growth, and income growth ([Delgado et al., 2001](#)). Between 1970 and 2006, the number of U.S. and Canadian dairy farms decreased by approximately 88% ([Steinfeld, 2004](#)) but remaining farms have considerably increased the size of their operations, in order to meet growing global demand for animal products ([Robbins et al., 2016](#)). Production systems became intensive, with larger farms housing animals in increasingly confined spaces ([Fraser, 2008](#)). In many regions of the world, these management changes threatened the existence of several autochthonous breeds, reducing the livestock biodiversity: The autochthonous cows were abandoned in favor of more productive cosmopolitan breeds.

At present, the numerical consistency of the autochthonous breeds considered in our study, bred solely in Italy, is exiguous. The most endangered breeds are Modenese and Varzese, with a total number of females raised in Italy are of 678 and 513, respectively ([Associazione Italiana Allevatori, 2016](#)). Even the distribution of animals on farms is quite characteristic: for Modenese and Rendena, the mean is around 23 and 35 females/farm, respectively, the mean female presence drops to about 7.8 heads/farm in Varzese breed (**Figure 1A**). The 2014–2016 annual trend for the number of farms rearing the three local breed considered is reported in **Figure 1B**. For the most endangered breeds (Modenese and Varzese), the trend is slight but positive, with 45 to 48 farms in the 2014–2016 range for Modenese and 41 to 49 farms for Varzese, in the same time span. Therefore, the presence of these cows on the territory is “atomized”, and far to be considered an intensive type of breeding, with farmers in strict contact with their animals. The mono-aptitude selective criterion had also a negative impact on many aspects, affecting the reproductive performance and quality of products ([Schennink et al., 2007](#)). When we compare the less selected and lower producing dairy breeds to Holstein Friesian dairy cows, it emerges that selective pressure to increase milk production has led to a higher propensity to disease, including mastitis ([Curone et al., 2016](#)). The negative side of the high production levels in dairy farms

is the increase in culling rates, the reduction of life expectancy, the increased occurrence of diseases, and consequently, the greater use of veterinary drugs ([Communod et al., 2010](#); [Petrera et al., 2014](#); [Curone et al., 2018](#)). According to the technical report of the Italian Breeders Association, the average milk yield of Italian Holstein Friesian cows amounted to 9,884 kg in 2016, with average contents of 3.27% and 3.71% for fat and protein, respectively (**Table 1**). The impact of these performances on animal welfare and health has been considerable ([Varotto et al., 2015](#)). The genetic ability to increase milk production has been associated with a higher risk of metabolic and infectious diseases, as well as with reduced fertility; in North-Eastern USA, cows alive at 48 months of age decreased from 80% in 1957 to 13% in 2002 and the mean calving interval went from 13 to 15.5 months ([Oltenucu and Broom, 2010](#)). As a result, cattle were subjected to dramatic physiological and behavioral changes in their social and physical environments ([Petrera et al., 2014](#)); animals respond to such stimuli in species-specific ways, as well as individually. Modifications of normal behaviors are indicative of a substantial decline in cow welfare. Improving welfare is important, as good welfare is regarded by the public as indicative of sustainable systems and good product quality and may also be economically beneficial ([Oltenucu and Broom, 2010](#)).

Animal personality

Research into animal personality, defined as “individual differences in behavior that are thought to be stable across time and situations” ([Freeman and Gosling, 2010](#)) has grown over the last decade as its relevance to animal health and welfare has become more apparent ([Gartner, 2013](#)). In particular, personality has sometimes been used for aspects of captive management, including decreasing stress, increasing positive health outcomes, successful breeding, and infant survival.

In studying personality traits in animal species, many ethologists have found five main domains similar to the human five-factor model (FFM) of personality ([Gosling and John, 1999](#)). The five domains in the FFM are commonly referred to as neuroticism (featuring anxiety, depression, a vulnerability to stress, and moodiness), agreeableness (featuring trust, cooperation, and a lack of aggression), extraversion (featuring sociableness, assertiveness, activity, and general positive emotions), openness (featuring intellect, imagination, creativity, and curiosity), and conscientiousness (featuring deliberation, self-discipline, dutifulness, and order) ([Gosling and John, 1999](#)).

Within cattle, there is no stated consensus as to how many personality traits may exist. The research tends to focus on those traits which have a clear relationship with welfare, such as fearfulness and sociableness, which may be related to the FFM domains of neuroticism, agreeableness, and extraversion. [Van Reenen \(2012\)](#) showed that within a herd of cows there is variation in the behaviors displayed by individuals and not all cows will display the same aspects of the species' behavioral repertoire to the same degree. These differences can often be seen during certain group activities: Cows must compete at a feeding area but not all cows will show the same levels of aggression to other cows ([Gibbons et al., 2009](#)). Similarly, cattle have the capacity to show fear in response to unexpected stimuli ([Forkman et al., 2007](#)) but the levels of fear displayed by individuals towards the same stimuli will vary, but this variation is consistent within the individual ([Gibbons et al., 2009](#)). Based on these considerations, [MacKay et al. \(2013\)](#) speaks of "aggression" and "fearfulness" as being personality traits in cattle. One of the main methods used to examine individual differences in animals is rating against a set of criteria ([Highfill et al., 2010](#)), whereby an animal's behavioral tendencies are scored against a set of traits or descriptors ([Razal et al., 2016](#)), by the people who know the individual animal best.

Previously, few studies on dog behavior and temperament have used questionnaire survey methods, using dog owners as the singer rater and primary source of information ([Mirkó et al., 2012](#); [Gartner, 2015](#)). Using a questionnaire approach to collecting behavioral data on dogs is based on the assumption that the owner (or primary caregiver) of a dog usually knows more about its typical behavior than anyone else ([Serpell and Hsu, 2001](#)). Similarly, in the present study, given the very small size of the farm enrolled, the milkers had a very close relationship with the cows and therefore, their evaluation can be compared to that of the owner or primary caregiver of a pet. We used a personality questionnaire modified from [Chadwick \(2015\)](#) for this survey. Although it was primarily used in studies surveying felids, it has been shown to be a valid tool applicable to other taxa ([Pastorino et al., 2017a](#)). In the present study, we wanted to evaluate the expression of personality traits in cows of different breeds, managed with the same routine. The purpose of this work was to investigate how personality traits vary in a sample of cosmopolitan and endangered autochthonous dairy cows and if it is possible to identify breed-specific personality trends. In order to verify this hypothesis, we had to provide a preliminary evaluation of the personality dimensions obtained by our questionnaire

and to investigate if personality trait assessment in cattle matches the FFM of personality.

MATERIALS AND METHODS

Ethical approval: The present study did not require the approval of the ethics committee.

Dairy farms: The animals selected for the study were part of three different dairy farms where the management and feeding conditions were similar. All farms were very small and family-owned and conducted and adopted the tie-stall housing system during the lactation and a free loose system for the dry period ([Broucek et al., 2017](#)).

The first farm was located on a mountain (1,050 m a.s.l.), where the cows were fed with hay from permanent meadows (meadow established for over 200 years, consisting of wild-grown herbaceous plants, without the use of chemical fertilizers and weed control). The herd was composed of 20 Varzese cows. The second farm was located in the lowland, where the cows were fed with hay from semi-permanent meadows, with a low energy and protein integration, supplemented with cornmeal and soybean meal. This farm had a mixed herd composed of 35 animals belonging to Holstein Friesian, Brown Swiss, and Italian Red Pied breeds. The third farm was also located in the lowland. Until the 1980s, this was a typical Lombardy farm with 100 Holstein Friesian in milking but in the 1990s the owner decided to focus on Italian endangered native breeds. He started by buying two senior (15 years) cows of Varzese breed, the unique autochthonous breed of Lombardy, and today, almost 30 years on, his farm is one of the greatest examples of farm animal biodiversity; the herd was composed of about 200 animals and included 15 of the 17 Italian cattle native breeds. The owner provided the traditional forage feed for his cows with minimal concentrates.

Animals: For this survey, a total of 40 female cows were employed. The subjects belonged to five breeds, whose brief description is summarized in **Table 1**. The cows were housed in three different farms, distributed as described in **Table 1**. On these subjects, 26 personality variables pertaining to the five-factor personality dimensions were determined. The composition of the five domains, in terms of variables, is reported in **Suppl. Table 1**.

Personality questionnaire: Milkers in the three dairy farms were asked to complete a personality questionnaire for each cow enrolled in the study. The questionnaire

consisted of two parts. The first part intended to evaluate the experience of milkers with bovines, including how long each milker had worked with the cows and how often he/she had contact with them. Due to the very small size of the farms, only one milker was present in each stable. As a consequence, each milker had a close relationship with every single cow.

In the second part of the questionnaire, the cows were scored against 26 descriptors, each focusing a different aspect of the animal's personality. For each descriptor, the milkers were asked to assign a score on a scale of 1 (descriptor was never exhibited) to 12 (descriptor was always exhibited) (Pastorino et al., 2017b, c). The close relationship between milkers and cows meant that questions like "friendly to you", "aggressive to you," and "fearful of you" were deleted from the questionnaire while the small size of the farms and the tie-stall housing system made the scoring of the descriptor "solitary" unreliable, rounding down the descriptors to a total of 26. As is the case for many questionnaire-based dog personality studies with owner-reported responses, inter-rater reliability was not measured because a single milker scored the animals (Wiener and Haskell, 2016).

For the analysis, the descriptors were further grouped into personality domains, using a similar approach of some previous studies that examined personality in bottlenose dolphins, brown bears, and sloth bears (Highfill and Kuczaj, 2007; Pastorino et al., 2017a). This approach utilized each of the five-factor personality dimensions: Extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience. Conscientiousness was removed, as it was found as a relevant trait only in primates (Gosling, 2008). The five-factor dimensions were chosen to provide a framework of possible personality characteristics and to encourage cross-species comparison (Highfill et al., 2010).

Statistical analysis: The considered variables were analyzed through descriptive statistics; for each variable, the minimum value, the maximum value, the range, the first, the third quartile, the median value, the mean, and the standard deviation were calculated. In order to evaluate differences between breeds, every breed was analyzed for the aforementioned variables; the differences between breeds were calculated using the Kruskal-Wallis nonparametric test, calculating the differences between median values. The statistical significance was set at $P < 0.05$. A multivariate multiple factor analysis (MFA) was applied to the variables. Each variable was assigned to the five-factor personality dimensions of competence

(FFM). All statistical analyses were performed with the software XLstat for Windows platform. The statistical significance was set to $P < 0.05$.

RESULTS AND DISCUSSION

The statistical analyses for the four breeds and the results for the Kruskal-Wallis test are reported in the **Suppl. Table 2**. Eight variables out of 26 differ between breeds in median values. The interquartile interval and minimum-maximum interval for personality traits that have shown statistically significant differences between the breeds is reported in **Figure 2**.

Besides, the multivariate MFA of data was applied: It is a particular kind of principal component analysis, that involves several groups of variables instead of a single group (Escofier and Pages, 2008). In our case, two

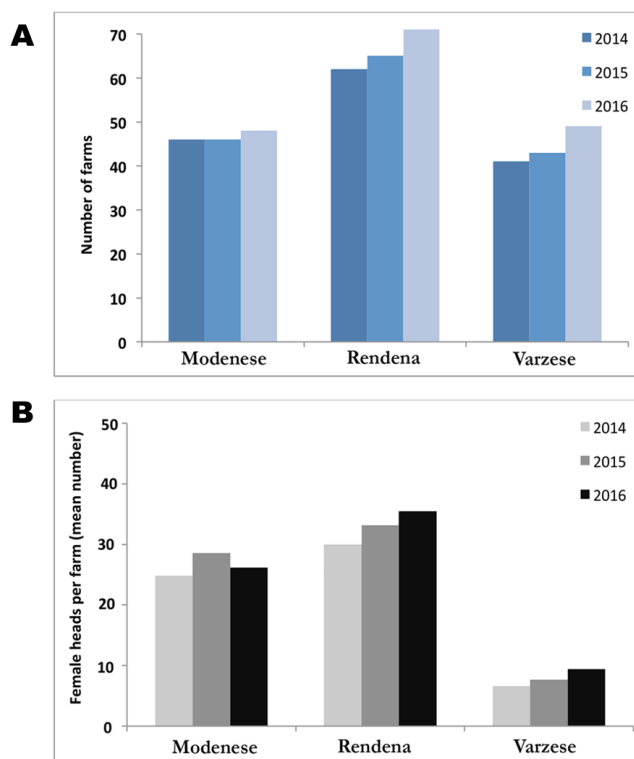


Figure 1. (A) Mean number of heads per farm (in Italy) rearing the local bovine breeds included in the study. While for *Modenese* and *Rendena*, the mean is around 23 and 35 females/farm, respectively, the mean female presence drops to about 7.8 heads/farm in *Varzese* breed. **(B)** the 2014–2016 annual trend for the number of farms (in Italy) rearing the three local breeds considered. For all three autochthonous breeds considered, the trend is slightly positive with 45 to 48 farms in the 2014–2016 range for *Modenese*, 60 to 70 farms for *Rendena*, and 41 to 49 farms for *Varzese*, in the same time span.

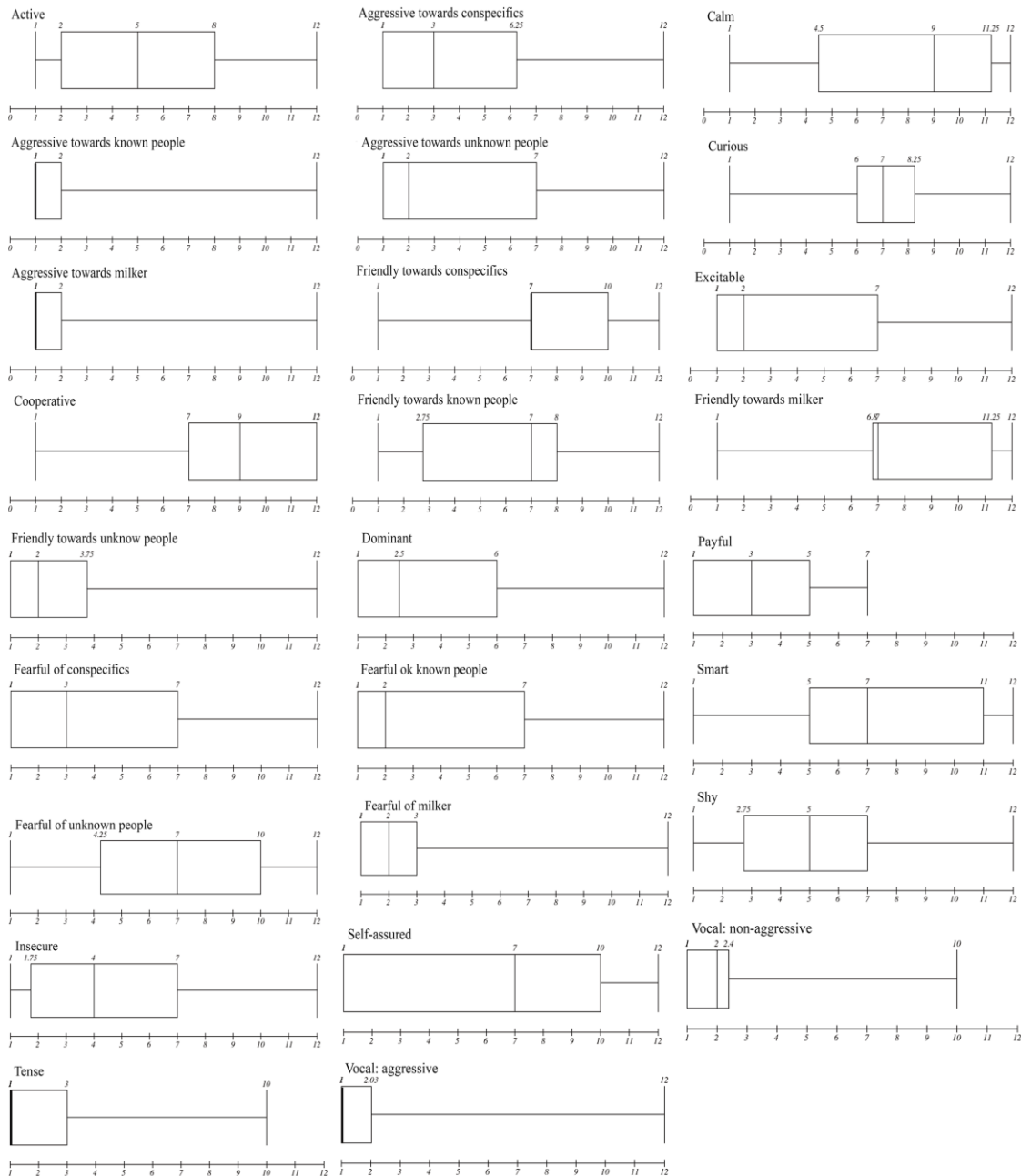


Figure 2. Box and whiskers plots for each personality trait analyzed. The box represents the interquartile interval and the whiskers the minimum–maximum interval.

groups of variables were analyzed: The measured variables and the breed.

The MFA gave, on the basis of the first five multivariate dimensions, the results reported in **Suppl. Table 3**. The table reports for each dimension (Dim.X) correlations of the quantitative and qualitative variables (*e.g.*, the breed). For each multivariate dimension, quantitative variables can be negatively or positively correlated. The same is true for the breed. Henceforth, if we take into

consideration the first dimension (Dim. 1), *i.e.*, the dimension with the stronger variability, two breeds strongly distinguish themselves from the other breeds. The Rendena breed was positively correlated with insecurity, encompassing the four fearful traits and the four aggressive traits. Rendena cows also distinguish themselves through the active, excitable, and shy components. Conversely, Brown Swiss cows were positively correlated with the three friendly traits, the cooperative trait and playful trait from Dim.1, showing an

Table 1. Animals involved in the study: Number of subjects, distribution on farms, and main breed characteristics

Cattle breeds	Cows Enrolled	Farm	Height (cm)	Weight (kg)	Attitude	Mean Milk production	Days open (days)	Services per pregnancy (Average)
Modenese	8	#3	125–140	650	Milk, work, and meat	Kg/lactation: 4,792 (3.44% fat, 3.69% protein)	98	2
Rendena	6	#3	130	550	Milk, work, and meat	Kg/lactation: 4,596 (3.12% fat, 3.28% protein)	161	1.6
Varzese	5 4	#1 #3	135	450	Milk, work, and meat	Kg/lactation: 3,228 (3.35% fat, 3.54% protein)	99	1.4
Holstein Friesian	4 5	#2 #3	130–150	550–750	Milk	Kg/lactation: 9,884 (3.27% fat, 3.71% protein)	173	3
Brown Swiss	4 4	#2 #3	135	550	Milk	Kg/lactation: 6,945 (3.55% fat, 4% protein; high% of k-casein, beta-casein, and beta-lactoglobulin)	182	2.4

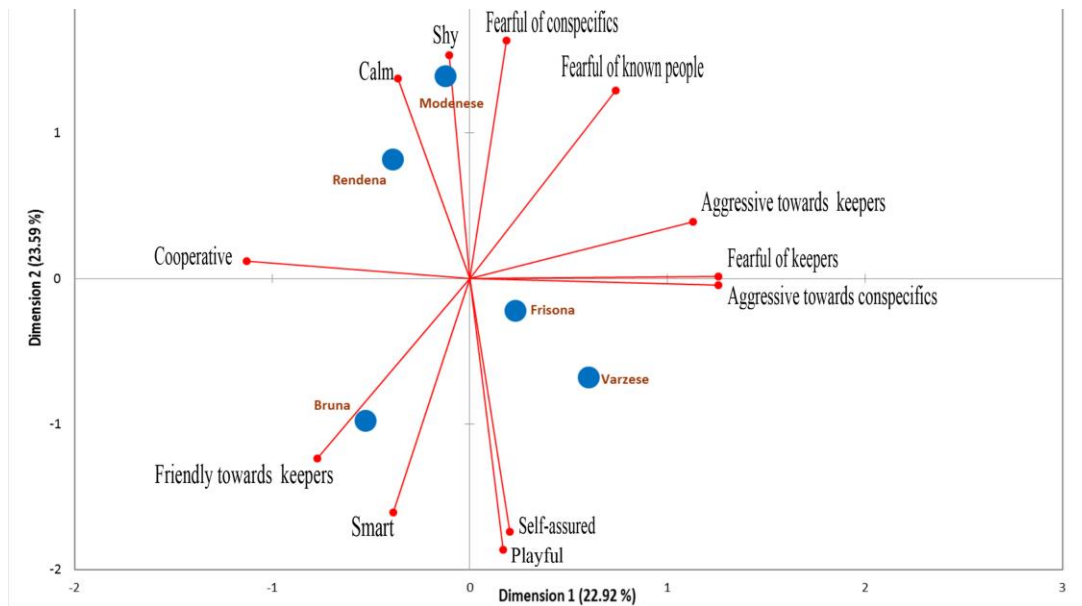


Figure 3. Proximity of the autochthonous breeds versus the cosmopolitan Holstein Friesian. Multiple factor analysis: First two dimensions. As shown in the figure, *Modenese* clusters as the shyest, *Rendena* is calmer then cooperative, *Brown Swiss* clearly friendly towards keepers (milkers) and smart while *Holstein Friesian* appears less defined compared to other breeds. *Varzese* stands in an area between self-assured and playful and aggressive towards conspecifics and fearful of keepers (milkers), mildly showing these traits.

opposite trend to the Rendena (Suppl. Table 3). The second dimension showed less variability; Varzese cows were characterized by curiosity, playfulness, and aggression towards conspecifics (Suppl. Table 3). Modenese featured traits for calmness, cooperation, and friendliness to unknown persons (Suppl. Table 3). The third dimension of MFA was positively related to the activity (Modenese) and negatively to shyness (Rendena). The Holstein Friesian breed showed the weakest

correlations with the first five MFA dimensions (Suppl. Table 3) confirming itself as the less characterized breed.

The proximity of the autochthonous breeds versus Holstein Friesian breed to dimensions 1 and 2 is shown in Figure 3. The graph evidences the proximity of the autochthonous breeds versus the Holstein Friesian in relation to the dimensions measured. Applying the NEO Five-Factor Inventory (NEO-FFI), an inventory that was

developed to measure five major dimensions of personality ([Ashton, 2013](#)), we propose the addition of dominance as the fifth domain instead of consciousness, as proposed for lions ([Gartner, 2015](#)). Rendena scored highly in extroversion, both positively and negatively, and scored positively in neuroticism and dominance. Brown Swiss scored positively in agreeableness, extroversion, and openness but negatively in neuroticism. Varzese positively correlates with extroversion, openness, and mainly positive with neuroticism. Modenese cows relate positively in agreeableness and negatively in neuroticism.

DISCUSSION

In this study, an adapted adjective-based personality questionnaire was applied to measure personality traits in different breeds of cows, at three Italian small dairy farms. Given the close individual relationship with the cows, the farms' milking staff provided responses for the questionnaire; this is similar to what is described in dog personality studies, in which the questionnaires are answered by the owners of the pet dogs ([Wiener and Haskell, 2016](#)). Many years of research have proven that data gathered by means of questionnaires can be accurate, reliable, and consistent in evaluating individual animals for various behavioral traits (e.g., [Gosling, 2008](#); [Hudson et al., 2015](#); [Lush and Ijichi, 2018](#)). However, to date, little has been published about personality in cows or cow breeds. In human personality research, the so-called FFM has been found to be one of the most useful organizing structures attempting to depict some aspects of personality ([Mirkó et al., 2012](#)). In a review, [Gosling and John \(1999\)](#) applied this model to characterize animal personality, where they compared personality structures in 12 species including dogs. [Gosling \(2008\)](#) further examined whether canine personality dimensions represent analogs of the human FFM factors.

The analysis of breed-specific personality profiles could be revealing because it is not clear how genetic and environmental factors may have contributed to behavioral variations among breeds ([Mirkó et al., 2012](#)), though many authors agree to consider differences in animal personality to be the result of adaptive evolutionary processes ([Dall et al., 2004](#); [Wolf, 2007](#); [Réale et al., 2010](#)). As shown in dogs, the differences in an individual's behavior within a breed may exceed variations among breeds. Therefore, an individual-based analysis might be useful in order to unveil whether a given behavioral trait differentiates not only an individual cow but also a greater number of cows belonging to a particular breed ([Mirkó et al., 2012](#)).

The data suggest that the Holstein Friesian was the least reactive of the breeds studied. This could be related to the fact that this breed has been selected for intensive husbandry regimes in dairy farms and these personality traits allow the cows to better adapt to more intensive management systems. The Rendena was the shyest breed, but also the most dominant and the most aggressive towards unknown people. The Varzese breed was more "curious" than other breeds of this study. We suggest that these traits may be connected to the attitude and to the traditional husbandry regimes these breeds have been selected for. Most of these traditional breeds had a triple purpose: Dairy, beef, and work. They were selected to work in small farms, in small numbers, interacting with few humans for different tasks. Today, they survive in reduced numbers, on small-scale local farms, that have changed little of the classic husbandry regimes; this is vastly different compared to the intensive farming that the Holstein Friesians were subject to.

A major limitation of this study is the small number of animals considered, which is itself limited by the poor consistency of the population of autochthonous breeds. Another limitation of the study is the impossibility of measuring inter-rater reliability since only one milker was available on each farm.

We had two main aims. The first aim was to provide a preliminary evaluation of the personality dimensions obtained, in cows, by our questionnaire. Secondly, we wanted to compare some Italian autochthonous breeds with the cosmopolitan one. Our choice fell upon the comparison of the Varzese, the Modenese, the Rendena, the Brown Swiss, and the Holstein Friesian because the genetic selection at the base of the typical attitudes has induced different characteristics, and as a consequence, detectable differences in personality can be expected between the populations.

CONCLUSION

The data presented in this study suggests that the evaluations obtained through the analysis of the questionnaires are able to highlight the presence of differences in the personality traits of the different bovine breeds, while certain personality traits are shared in each of the five dairy breeds considered. We hope that this pilot study will lead to further research on cattle personality, widening the sample of screened individuals and breed types, in order to preserve rare breeds personality characteristics along with their genetic, morphological, and productive distinctiveness.

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CONFLICT OF INTEREST

The authors have no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

AUTHORS' CONTRIBUTION

GQP and GC designed the study, MF interpreted the data, SMM drafted the manuscript. GC collected the data, FV and MF took part in preparing and critical checking of this manuscript.

SUPPLEMENTARY MATERIALS

Supplementary materials are available on journal site.

REFERENCES

1. Associazione Italiana Allevatori, Registro anagrafico delle razze bovine a limitata diffusione, Consistenza RAB. 2016. http://www.aia.it/CMSContent/Documents/Consistenze%20RAB%20al%2031%20Dicembre_2016.pdf (Accessed on August 9, 2018)
2. Ashton MC. Personality Traits and the Inventories that Measure Them. In *Individual Differences and Personality* (2nd Edn.), Academic Press, Elsevier Inc. 2013. p 27–55. <https://doi.org/10.1016/C2011-0-05656-9>
3. Broucek J, Uhrincat M, Mihina S, Soch M, Mrekajova A, Hanus A. Dairy cows produce less milk and modify their behaviour during the transition between tie-stall to free-stall. *Animals*. 2017; 7:16. <https://doi.org/10.3390/ani7030016>
4. Chadwick C. Social Behaviour and personality assessment as a tool for improving the management of cheetahs (*Acinonyx jubatus*) in captivity. PhD Thesis, University of Salford, Manchester, UK. 2015.
5. Communod R, Faustini M, Munari E, Colombani C, Castagna G, Comi M, Torre ML, Chlapanidas T, Lucconi G, Lazzati M, Vigo D. Future perspectives of Varzese breed in an innovative biodiversity enhancement process. *Large Animal Review*. 2010; 16: 267–271.
6. Curone G, Filipe J, Cremonesi P, Trevisi E, Amadori M, Pollera C, Castiglioni B, Turin L, Tedde V, Vigo D, Moroni P, Minuti A, Bronzo V, Addis MF, Riva F. What we have lost: Mastitis resistance in Holstein Friesians and in a local cattle breed. *Research in Veterinary Science*. 2018; 116:88–98. <https://doi.org/10.1016/j.rvsc.2017.11.020>
7. Curone G, Zanini M, Panseri S, Colombani C, Moroni P, Riva F, Faustini M. Milk ketone bodies assessment in a local Italian cow breed (Modenese) vs. Holstein and characterization of its physiological, reproductive and productive performances. *International Journal of Environmental and Agricultural Research*. 2016; 2:15–22. <https://doi.org/10.13130/2283-3927/7072>
8. Dall SRX, Houston AI, McNamara JM. The behavioural ecology of personality: consistent individual differences from an adaptive perspective. *Ecology Letters*. 2004; 7:734–739. <https://doi.org/10.1111/j.1461-0248.2004.00618.x>
9. Delgado C, Rosegrant M, Steinfeld H, Ehui S, Courbois C. *Livestock to 2020: the next food revolution. Outlook on Agriculture*. 2001; 30(1):27–29. <https://doi.org/10.5367/000000001101293427>
10. Escofier B, Pagès J. *Analyses factorielles simples et multiples; objectifs, méthodes et interprétation*. Dunod, Paris. 2008.
11. Forkman B, Boissy A, Meuniersalaun M, Canali E, Jones R. A critical review of fear tests used on cattle, pigs, sheep, poultry and horses. *Physiology & Behavior*. 2007; 92:340–374. <https://doi.org/10.1016/j.physbeh.2007.03.016>
12. Fraser D. Toward a global perspective on farm animal welfare. *Applied Animal Behaviour Science*, 2008. 113:330–339.
13. Freeman HD, Gosling SD. Personality in nonhuman primates: A review and evaluation of past research. *American Journal of Primatology*. 2010. 72(8):653–671. <https://doi.org/10.1002/ajp.20833>
14. Gartner MC, Weiss A. Personality in felids: A review. *Applied Animal Behaviour Science*. 2013; 144(1-2):1–13. <https://doi.org/10.1016/j.applanim.2012.11.010>
15. Gartner MC. Pet personality: A review. *Personality and Individual Differences*. 2015; 75:102–113. <https://doi.org/10.1016/j.paid.2014.10.042>
16. Gibbons JM, Lawrence AB, Haskell MJ. Consistency of aggressive feeding behaviour in dairy cows. *Applied Animal Behaviour Science*. 2009; 121:1–7. <https://doi.org/10.1016/j.applanim.2009.08.002>
17. Gosling SD. Personality in Non-human Animals. *Social and Personality Psychology Compass*. 2008; 2(2):985–1001. <https://doi.org/10.1111/j.1751-9004.2008.00087.x>
18. Gosling SD, John OP. Personality dimensions in nonhuman animals: A cross-species review. *American Psychological Society*. 1999; 8:69–75. <https://doi.org/10.1111/1467-8721.00017>
19. Highfill L, Hanbury D, Kristiansen R, Kuczaj S., Watson S. Rating vs. coding in animal personality research. *Zoo*

- Biology. 2010; 29(4):509–516.
<https://doi.org/10.1002/zoo.20279>
20. Highfill LE, Kuczaj SA. Do bottlenose dolphins (*Tursiops truncatus*) have distinct and stable personalities? Aquatic mammals, 2007; 33(3):380–389.
<https://doi.org/10.1578/AM.33.3.2007.380>
 21. Hudson R, Rangassamy M, Saldaña A, Bánszegi O, Rödel HG. Stable individual differences in separation calls during early development in cats and mice. Frontiers in Zoology. 2015; 12(Suppl 1):S12. <https://doi.org/10.1186/1742-9994-12-S1-S12>
 22. Lush J, Ijichi C. A preliminary investigation into personality and pain in dogs. Journal of Veterinary Behavior. 2018; 24:62–68.
<https://doi.org/10.1016/j.jveb.2018.01.005>
 23. MacKay JRD, Turner SP, Hyslop JJ, Deag JM, Haskell MJ. Short-term temperament tests in beef cattle relate to long term measures of behavior recorded in the home pen. Journal of Animal Science. 2013; 91(10):4917–4924.
<https://doi.org/10.2527/jas.2012-5473>
 24. Mirkó E, Kubinyi E, Gácsi M, Miklósi A. Preliminary analysis of an adjective-based dog personality questionnaire developed to measure some aspects of personality in the domestic dog (*Canis familiaris*). Applied Animal Behaviour Science. 2012; 138:88–98.
<https://doi.org/10.1016/j.applanim.2012.02.016>
 25. Oltencu PA, Broom DM. The impact of genetic selection for increased milk yield on the welfare of dairy cows. Animal Welfare. 2010; 19(S):39–49.
 26. Pastorino GQ, Christodoulides Y, Curone G, Pearce-Kelly P, Faustini M, Albertini M, Preziosi R, Mazzola SM. Behavioural profiles of brown and sloth bears in captivity. Animals. 2017a; 7(5):E39.
<https://doi.org/10.3390/ani7050039>
 27. Pastorino GQ, Viau A, Curone G, Pearce-Kelly P, Faustini M, Vigo D, Mazzola SM, Preziosi R. Role of personality in behavioral responses to new environments in captive Asiatic lions (*Panthera leo persica*). Veterinary Medicine International. 2017b; Vol 2017, Article ID 6585380.
<https://doi.org/10.1155/2017/6585380>
 28. Pastorino GQ, Christodoulides Y, Curone G, Pearce-Kelly P, Faustini M, Albertini M, Preziosi R, Mazzola SM. Personality and sociality in captive tigers (*Panthera tigris*). Annual Research & Review in Biology. 2017c; 21(2):1–17.
<https://doi.org/10.9734/ARRB/2017/38122>
 29. Petrerá F, Napolitano F, Dal Prà A, Abeni F. Plasma parameters related to energy and lipid metabolism in periparturient Modenese and Italian Friesian cows. Journal of Animal Physiology and Animal nutrition. 2014; 99(5):962–973. <https://doi.org/10.1111/jpn.12270>
 30. Razal CB, Pisacane CB, Miller LJ. Multifaceted Approach to Personality Assessment in Cheetahs (*Acinonyx jubatus*). Animal Behavior and Cognition. 2016; 3(1):22–31.
<https://doi.org/10.12966/abc.02.02.2016>
 31. Réale D, Dingemanse N, Kazem AJN, Wright J. Evolutionary and ecological approaches to the study of personality. Philosophical Transactions of the Royal Society Biological Science. 2010; 365:3937–3946.
<https://doi.org/10.1098/rstb.2010.0222>
 32. Robbins JA, von Keyserlingk MAG, Fraser D, Weary DM. Farm size and animal welfare. Journal of Animal Science. 2016; 94:5439–5455. <https://doi.org/10.2527/jas.2016-0805>
 33. Schennink A, Stoop WM, Visker MHPW, Heck JML, Bovenhuis H, Poel JJ, Valenberg HJ, Arendonk JAM. DGAT1 underlies large genetic variation in milk-fat composition of dairy cows. Animal Genetics. 2007; 38(5):467–473.
 34. Serpell JA, Hsu Y. Development and validation of a novel method for evaluating behavior and temperament in guide dogs. Applied Animal Behaviour Science. 2001; 72(4):347–364.
 35. Steinfeld H. The livestock revolution—a global veterinary mission. Veterinary Parasitology. 2004; 125(1–2):19–41.
<https://doi.org/10.1016/j.vetpar.2004.05.003>
 36. Van Reenen CG. Identifying temperament in dairy cows. A longitudinal approach. PhD Thesis, University of Wageningen, Netherlands. 2012.
 37. Varotto A, De Marchi M, Penasa M, Cassandro M. A comparison of milk clotting characteristics and quality traits of rendena and holstein-friesian cows. Italian Journal of Animal Science. 2015; 14(2):3768.
<https://doi.org/10.4081/ijas.2015.3768>
 38. Wiener P, Haskell MJ. Use of questionnaire-based data to assess dog personality. Journal of Veterinary Behavior. 2016; 16:81e85.
<https://doi.org/10.1016/j.jveb.2016.10.007>
 39. Wolf M, Van Doorn GS, Leimar O, Weissing FJ. Life-history trade-offs favour the evolution of animal personalities. Nature. 2007; 447:581–584.
<https://doi.org/10.1038/nature05835>
