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SHORT COMMUNICATION

Morphological traits and inbreeding depression in Bracco Italiano dog breed

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Abstract

This paper reports the first results of a survey on morphological traits in Bracco Italiano dog breed, and analyzes the effects of various levels of inbreeding on these measures. Traits were taken from 155 adult (mean age 4.18±2.60 years) dogs (79 males and 76 females) belonging to 57 different farms. For each animal, the following biometrical measurements were considered: height at withers (WH), height of chest (ChH), body length (BL), length at rump (RL), height at rump (RH), iliac width of rump (RIlW), ischiatic width of rump (RIsW), circumference of chest (ChC), circumference of cannon (CaC), length of ear (EL), and length of head (HL). The ratio of rump length/withers height (RL/WH), cannon circumference/chest circumference (CaC/ChC) and head length/withers height (HL/WH) were also calculated. ANOVA was used to test the differences between males and females and among farms in terms of morphological measurements and ratios. Significant differences between males and females were observed for many morphological traits. The measures coincided with what reported in the current breed standard, apart from the length of the rump, which was around ¼ of the withers height rather than the 1/3 required in the standard. No significant effect of inbreeding on conformation traits was observed.

Introduction

Mating among relatives generally changes genotype frequencies in populations and can result in a decline in mean phenotype and fitness - a phenomenon known as inbreeding depression which manifests itself above all in terms of the animal's fitness problem and can also lead to a decrease in selection response for economic traits. Inbreeding effects have mainly been studied in wild populations (Keller and Waller, 2002; Brzeski *et al*., 2014) and it is well documented in many species or populations for a variety of traits. Many studies are also available for the livestock species such as sheep (Hossein-Zadeh, 2012), goat (Khan *et al.*, 2007) horse (Curik *et al.*, 2003), pig (Silió *et al.*, 2013), cattle (Gonzalez-Recio *et al.*, 2007), buffalo (Malhado *et al.*, 2013), and chicken (Niknafs *et al.*, 2013). Finally, inbreeding depression has been documented in various dog breeds (Ubbink *et al.*, 1998; Ólafsdóttir and Kristjánsson, 2008).

The Italian Bracco is present above all in Italy with approximately 4,500 living subjects. Every year about 700 puppies are registered (Cecchi *et al.*, 2013). In Italy it is one of the oldest pointing dog breeds, and has been used for hunting ever since the Renaissance. In fact, paintings from the 14th century show hunting scenes with dogs similar to the present Bracco. The breed was officially registered by the Italian Cynological Club (ENCI) in 1949, when the definitive standard was established. Bracco Italiano is also reared in Holland and Britain, as well as the U.S. and South America.

In previous papers we analyzed the genetic variability of the breed through molecular (Ciampolini *et al.*, 2011) and genealogical data (Cecchi *et al.*, 2013). Both methods showed a low genetic variability of the breed. The genealogical data highlighted that the average inbreeding coefficient was 6.7%, and that the average increase in inbreeding was 1.29% ($N_e = 38.86$). The data underlined the importance of reducing the inbreeding coefficient through the exchange of breeding animals as well as avoiding mating between animals that are too closely related.

Dog breeders choose animals on the basis of standard characteristics, so it would be interesting to know the effects of inbreeding on morphological traits in order to estimate the magnitude of changes associated with an increase in inbreeding. The aim of the present study was thus to analyze the first results of a survey on morphological traits of the Bracco Italiano and to assess the effects of inbreeding on these traits.

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Materials and methods

Body measurements were taken from 155 adult (mean age 4.18±2.597 years) Bracco Italiano dogs (79 males and 76 females) belonging to 57 different farms (most of these had 1-3 dogs and/or one sex). Body measurements were carried out using a Lydtin stick and tape measure; dogs were put on a flat floor and held by the respective owners. The eleven body measurements obtained were: height at withers (WH), height of chest (ChH), body length (BL), length at rump (RL), height at rump (RH), iliac width of rump (RIlW), ischiatic width of rump (RIsW), circumference of chest (ChC), circumference of cannon (CaC), length of ear (EL), and length of head (HL). The ratio of rump length-withers height (RL/WH), cannon circumference/chest circumference (CaC/ChC) and head length/ withers height (HL/WH) were also calculated. Individual inbreeding was evaluated using CFC software (Sargolzaei *et al.*, 2006) considering the complete electronic record of the breed downloaded from the ENCI database which included 24,613 animals registered from 1970 to 2011, and subdivided into 16 traced generations (Cecchi *et al.,* 2013). Up to 97% of the individuals had registered parents, and 86% registered grandparents. ANOVA was used to test the differences between sexes fitting for each trait a model including as fixed effects the sex, and the age at measurements as covariate. The coefficient of variation (CV%) of each trait was calculated.

A linear regression of each trait on inbreeding coefficient was added to the model to estimate inbreeding depression.

The farms (n=8) with more than 6 dogs (70 animals, 32 males and 38 females) were used to evaluate the effect of farm, sex and sex per farm (with the age at measurements as covariate). All experimental data were analyzed by JMP software version 5.0 (2002).

Results and discussion

Table 1 reports the differences in the traits between males and females. Differences were found for all traits with the exception of rump measurements (length, iliac and ischiatic width of the rump). Table 1 also shows the measures of sexual dimorphism (m/f) in order to express these differences between males and females. The global mean of m/f was 1.04 which was 7.0% higher than females. The coefficient of variation of all traits ranged from 4.27% for WH to 26.15% for RIlW. The coefficient of variation of the traits showed that the variability of some zoometric measures, such as WH, ChC and RH, were low. Moreover, the high coefficients of variation observed for rump measurements in both sexes suggest the possibility of using selection. The age at measurement did not show significant effects. No significant differences in morphological measurements were observed in the ratios. The analysis performed on the farms constituted by a greater number of animals did not reveal significant differences among farms while significant differences were detected between sexes within the farm for all traits with the exception of rump measurements.

In the breed standard (SABI, 2013), the height at withers is the only parameter for which ranges are reported: 55 and 67 cm (58-67 cm in males and 55-62 cm in females). Two centimeters more or less than these measurements are considered to be a defect. In this research the height at withers was 62.59 ±2.67 cm in males, and 58.64 ±2.97 cm in females. These values fall exactly in the expected ranges defined by the current breed standard. Only two males in the sample exceeded the maximum value (69 cm).

Concerning ratios, the current breed standard states that the body length should be equal or slightly greater than the withers height; the head length should be 4/10 of the withers height, and the rump length would be one third of the withers height. Our results showed that the withers height was 96.38% of the body length in males, and 96.63% in females. The ratio HL/WH corresponded to the value given in the standard, while the RL/WH ratio was outside the required values, ranging from 0.26 in males to 0.28 in females (Table 1).

Only a few studies have been performed on the morphological parameters of dog breeds. These studies have been conducted with breed dogs with a very different morphology, such as Spanish water dogs (Barba Capote *et al.*, 1996), Bolognese dogs (Beretti *et al.*, 2008), Lagotto dogs (Vaccari Simonini *et al.*, 2007), and Basset Hounds (Cecchi *et al.*, 2011).

In order to be able to make selective actions it is important to know the genetic correlations between characters, especially those involved in the ratios reported in the breed standard. In this study the phenotypic correlations were calculated since in many cases a very high correlation with the genetic correlations was observed (Koots and Gibson, 1994). In other studies the phenotypic correlations were smaller or larger than the genetic correlations (Roff, 1995). As reported by Cheverud (1988), phenotypic correlations are likely to be fair estimates of their genetic counterparts in many situations.

Table 2 shows correlations between traits for males and females. Significant correlations between traits were 47.27% and 45.45% in females and males respectively, and r=0.70 (P<0.01) was the highest value in females between the traits HL and TL. A negative and significant correlation was found in both sexes only between CaC and RIsW (-0.53 in females and -0.47 in males; P<0.01) and in females between RL and RH (-0.36; P<0.05). Concerning the traits involved in the ratios,

Table 1. Means, standard deviation, coefficient of variation for each morphological trait in both males and females.

		Males statistics Mean ± SD	CV, %	Females statistics Mean ± SD	CV, %	Sexual dimorphism (m/f)
Animals	N°	79		76		
Traits						
WH	cm	62.59 ± 2.67^{A}	4.27	58.64 ± 2.97^{B}	5.06	1.07
ChC	“	73.61 ± 3.94^{A}	5.35	70.52 ± 5.15^{B}	7.30	1.04
ChH	“	28.25 ± 2.33^{A}	8.25	27.02 ± 2.55^{B}	9.44	1.05
CaC	“	14.16 ± 2.17^{A}	15.32	13.14 ± 2.15^{B}	16.36	1.08
BL	“	64.94 ± 5.38^{A}	8.28	61.32 ± 5.01^{B}	8.17	1.06
RL	“	16.24±2.20	13.55	16.28±1.71	10.50	1.00
RH	“	61.98 ± 4.07^{A}	5.57	57.19 ± 3.79^{B}	6.63	1.08
RIlW	“	8.38±2.02	24.11	8.49±2.22	26.15	0.99
RIsW	“	13.71±2.30	16.78	13.85±2.34	16.90	0.99
EL	“	20.61 ± 1.90^{a}	9.27	19.86 ± 1.90^{b}	9.57	1.04
HL	“	25.65 ± 2.13^{A}	8.30	24.28 ± 2.49^{B}	10.26	1.06
Ratios						
WH/BL		0.96±0.049	5.10	0.96±0.051	5.31	1.00
RL/WH		0.26±0.035	13.46	0.28±0.031	11.07	0.93
HL/WH		0.43±0.196	45.58	0.42±0.130	30.95	1.02
CaC/ChC		0.20±0.040	20.00	0.20±0.049	24.50	1.00

WH, height at withers; ChC, circumference of chest; ChH, height of chest; CaC, circumference of cannon; BL, body length; RL, length at rump; RH, height at rump; RIlW, iliac width of rump; RIsW, ischiatic width of rump; EL, length of ear; HL, length of head. Different letters on the same row show significant differences: $^{A,B}P<0.01$; $^{a,b}P<0.05$.

Table 2. Phenotypic correlations among all measured traits in males (above the diagonal line) and in females (below the diagonal line).

	WH	ChC	ChH	CaC	BL	RL	RH	RIlW	RIsW	EL	HL
WH	*1.00*	0.43**	0.48**	0.32*	0.37**	0.02	0.58**	0.03	0.12	0.22	0.37**
ChC	0.34*	*1.00*	0.32**	0.06	0.25*	0.11	0.23	0.10	0.24	0.10	0.24
ChH	0.41**	0.31*	*1.00*	0.17	0.57**	0.24	0.43**	0.12	0.21	0.37**	0.42**
CaC	0.37**	0.25*	0.11	*1.00*	0.41*	-0.02	0.18	-0.14	-0.47**	-0.003	0.20
BL	0.41**	0.03	0.50**	0.36**	*1.00*	0.21	0.43**	-0.06	-0.12	0.32*	0.34*
RL	0.24	0.19	0.30*	-0.08	0.08	*1.00*	-0.16	0.57**	0.46**	0.27*	0.36**
RH	0.29	0.13	0.44**	0.17	0.37*	-0.36*	*1.00*	0.14	0.01	0.19	0.21
RIlW	0.36**	0.20	0.32**	-0.076	-0.02	0.48**	0.24	*1.00*	0.30*	-0.001	0.13
RIsW	0.08	0.05	0.33**	-0.53**	-0.06	0.31*	0.01	0.40**	*1.00*	0.34*	0.33*
EL	0.10	0.175	0.26	-0.10	0.26	0.37**	-0.02	0.21	0.47**	*1.00*	0.43**
HL	0.29	0.41**	0.51**	0.20	0.70**	0.11	0.35*	0.26	0.26	0.38**	*1.00*

WH, height at withers; ChC, circumference of chest; ChH, height of chest; CaC, circumference of cannon; BL, body length; RL, length at rump; RH, height at rump; RIlW, iliac width of rump; RIsW, ischiatic width of rump; EL, length of ear; HL, length of head. **P<0.01; *P<0.05. Diagonal line is represented by 1.00 values in italics.

positive and significant correlations between CaC and ChC (P<0.05) in females and between WH and BL in both sexes (r=0.41 in females and 0.37 in males; P<0.01) were observed; this last value is different from that observed by Cecchi *et al.* (2011) in Basset Hounds (r=-0.334; P<0.05), and this is probably due to the different conformation of dogs belonging to the two breeds. WH was correlated positively but not significantly with RL in both sexes, as reported by Cecchi et al (2011) in Basset Hounds, while it was correlated positively and significantly with HL only in males (P<0.01).

The average inbreeding coefficient in the population was 0.046±0.025 (0.041 in females and 0.049 in males) with F=0.20 as maximum value. About 70% of the dogs had an inbreeding smaller than 0.05, thus reflecting what we previously reported for the entire Bracco Italiano database (Cecchi *et al.*, 2013).

All regression coefficients of traits on inbreeding were not significant and among such coefficients, only WH and RL were negative (data not shown).

Different breeds and populations, as well as different traits, vary in their response to inbreeding: some populations may show a very pronounced effect of increased inbreeding for a trait, whereas other populations may not demonstrate much of an effect. Several studies on livestock species have shown the heterogeneity of inbreeding depression with neutral or negative or positive effects on different traits (Leroy, 2014). As reported by Barczak *et al.* (2009), in a given population, "bad" and good inbreeding effects are mixed. Furthermore, the degree of inbreeding depression in a population depends on the extent of inbreeding, the original frequency of deleterious recessives, the environment, and inbreeding depression may be greater under more stressful conditions (Marr *et al.,* 2006).

To our knowledge, there are no published reports on the effect of inbreeding on traits in dogs. The effects of inbreeding on morphological traits have been studied in horse breeds: Gandini *et al.* (1992) found a significant decrease for withers height and chest circumferences due to inbreeding in Haflingers. Gomez *et al.* (2009) found significant inbreeding depression for several biometrical measurements in Spanish Purebred horses. On the other hand, Curik *et al.* (2003) in Lipizzan horses and Sierszchulski *et al.* (2005) in Arabian horses found no effect of inbreeding on morphological traits. Wolc and Balińska (2010) reported that inbreeding was associated with a decrease in whither height in Sieraków horses, but not in Dobrzyniewo and in Kobylniki horses.

Conclusions

This study highlighted that sexual dimorphism in Bracco Italiano dogs was evident, and measures coincided with those reported in the current standard of the breed except for the rump length, which was around ¼ of the withers height rather than the 1/3 required in the standard. To increase this ratio, breeders could act primarily on the length of rump, which has a high variability in the population. However, although the positive phenotypic correlation observed between the two parameters was not significant, it could make it difficult to achieve the objectives. A study of heritability and of the genetic correlations among traits is necessary to find out whether selective actions can be made on the traits.

Our results show that inbreeding does not significantly affect the conformation traits. However, the inbreeding depression was calculated on a sample that had F= 0.20 as a maximum value. Moreover, the majority of animals had an inbreeding coefficient of less than 0.05. We don't know the effects that F values greater than 20% might have on these traits. In fact, some Authors have reported, in other species and for other traits, that the strongest effects are in highly inbred animals (F≥0.25). Furthermore, it would be interesting to calculate inbreeding depression on other very important aspects such as the neonatal survival, stress resistance, fertility, reproductive success, longevity, and birth weight.

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