

PAPER

Somatic variability in wild boar (*Sus scrofa* L.) in different areas of Central Italy

Andrea Amici, Fioravante Serrani,
Settimio Adriani

Dipartimento di Produzioni Animali,
Università della Tuscia, Viterbo, Italy

Abstract

A survey of wild boar shot during two consecutive years (hunting seasons 2002-2004) was carried out in order to evaluate which somatic measurements are most significant in identifying and discriminating among different morphotypes in central Italy. Biometric data from 688 wild boars was collected in three different areas of central Italy, two in Viterbo and one in the Province of Rieti. The following somatic measurements were individually recorded for each specimen: head-body length, height at withers, hind-foot length, ear length, ear-snout distance and ear-shoulder distance. Body weight was registered, and age was estimated from tooth eruption and wear. The animals were divided into three age classes: young (aged less than 12 months), sub-adults (aged between 12 and 36 months), and adults (36 months and older). After a preliminary ANOVA procedure, which did not give satisfactory results, a statistical analysis was performed using a canonical discriminant procedure, given an *a priori* classification (geographical area) and several quantitative variables (somatic measurements and weight). The separation between areas was estimated calculating the squared distance of Mahalanobis. The data referring to all 688 specimens was subjected to factor analysis. The results of the canonical discriminant analysis highlight the existence of two distinct groups within all three age classes. There is a statistically significant difference between the southern-Maremma (SM) vs the Apennine (A) and sub-Apennine (SA) areas, for young ($P<0.0001$), sub-adults ($P<0.001$) and adults ($P<0.001$). The difference between the A and SA areas was significant only for sub-adults ($P<0.05$). The first canonical variable account for 92.5, 92.7 and 89.9% of the total variance for the three age classes respectively, but this is unequally correlated with the original variables suggesting that the separation between

the two areas is due to differences in conformation rather than in body size. On the basis of the discriminant analysis large part of the animals were correctly categorised in the sampling areas. As regards the factor analysis results for the adult group, the first three common factors are able to explain 78, 92, and 64% of the covariance for the data of the SM, A and SA groups respectively. These results suggest that, for the SM group, a differentiation among morphotypes may be possible on the basis of a few somatic measurements. These results confirm the need for biochemical and genetic studies to identify if the different morphotypes refer to the autochthonous wild boar strain.

Introduction

Wild boar numbers in Europe underwent a severe decline from the Middle Ages to the Second World War. In contrast, in the post-war period a massive expansion took place both in Europe and in Italy (De Beaux and Festa, 1927; Boitani *et al.*, 1995a; Danilkin, 2001) due to many cofactors difficult to isolate, including land cover changes, feed availability and land management (Schley and Roper, 2003; Bieber and Ruf, 2005; Geisser and Reyer, 2005). The current increase in wild boar numbers and their expansion, into unusual habitats (Cocca *et al.*, 2007) as well as throughout Italy (Amici *et al.*, 2008), have important management implications concerning crop damage (Geisser and Reyer, 2004) and vehicle collision (Primi *et al.*, 2009). The spread of wild boar was due to the massive restocking which was done using animals from central and eastern Europe (Saez-Royuela and Telleria, 1986; Apollonio *et al.*, 1988) and spontaneous colonisation from France. The reproductive potential of animals from central Europe (Nahlik and Sandor, 2003) is of major importance. They show a higher prolificacy in comparison to autochthonous Italian wild boar (Perco, 1987) and this plays an important role in population increase (Massei and Toso, 1993).

According to Randi (1995), Italian and European wild boar can be distinguished into different genotypes on the basis of mitochondrial DNA analyses. Nevertheless, the systematics of wild boar is controversial and recent studies have shown a limited impact of the massive restocking on mitochondrial DNA translocations (Vernesi *et al.*, 2003).

Firstly, it should be underlined that the wild boar populations of central Italy have undergone a massive increase, greater than in other

Corresponding author: Dr. Andrea Amici,
Dipartimento di Produzioni Animali (DIPA),
Facoltà di Agraria, Università della Tuscia,
Via de Lellis, 01100 Viterbo, Italy.
Tel. +39.0761.357443 - Fax. +39.761.357434.
E-mail: amici@unitus.it

Key words: Wild boar, *Sus scrofa*, Morphology,
Somatic measurements, Ecotype.

Received for publication: 10 March 2009.

Accepted for publication: 19 June 2009.

This work is licensed under a Creative Commons
Attribution 3.0 License (by-nc 3.0).

©Copyright A. Amici *et al.*, 2010

Licensee PAGEpress, Italy

Italian Journal of Animal Science 2010; 9:e9

doi:10.4081/ijas.2010.e9

European countries. Secondly, it is interesting to note that this expansion has (probably) helped to maintain pre-glacial diversity (Scandura *et al.*, 2008). In fact, as reported by Scandura *et al.* (2008), restocking with non-autochthonous animals has not produced a strong impact on genetic variation, thus only 7% of the individuals studied was characterised by having a significant proportion of their genome related to central European wild boar. These considerations support the adoption of species management policies aimed at avoiding both accidental escapes from wild boar breeding farms and hybridisation with free-range domestic pigs (Scandura *et al.*, 2008). This also confirms a great interest for local group conservation since genetic differences are evident among wild boar populations in Italy (Vernesi *et al.*, 2003).

In recent decades, several studies on wild boar morphology have been performed with the aim of distinguishing between autochthonous and introduced genotypes (Genov *et al.*, 1995; Tinelli *et al.*, 1999), studying growth patterns (Gallo Orsi *et al.*, 1995; Pedone *et al.*, 1995) and obtaining a morphological characterisation (Massei and Genov, 1993). A large part of these studies was based on craniometrical measures only (Genov *et al.*, 1991; Gallo Orsi *et al.*, 1995; Genov, 2004); even if this type of measurement is one of the most adequate systematic techniques, it has two main limitations. First, it requires very accurate measurements, implying the use of appropriate equipment. Secondly, such measurements are difficult to perform in field conditions, and the specimens should be transferred to a laboratory. Moreover, in the case of wild boar, hunters tend to hand over females heads only,

since males heads are in demand for trophies (Randi *et al.*, 1987). On the basis of the results reported in a large part of the studies performed in Italy in order to discriminate the *Sus scrofa majori*, it is possible to hypothesise that a limited number of somatic measurements match the differences among the phenotypes (Amici *et al.*, 2003, 2005; Adriani *et al.*, 2005). The aim of the present study was i) to determine which somatic measurements allow different morphotypes to be distinguished; ii) to select the somatic measurements to be registered after drive hunting sessions for the purpose of monitoring wild boar population morphotypes; and iii) to point out the different morphotypes for further genetic analysis.

Materials and methods

Biometric data from 688 wild boars (319 males, 379 females) were collected in three different areas of central Italy (Figure 1), during two consecutive years (2002-2003 and 2003-2004, the hunting period lasting from November throughout January). The first of the three areas is a flat zone of the southern-Maremma (SM) in the Province of Viterbo, the second is a hilly sub-Apennine (SA) area (Province of Viterbo) near the borders with Tuscany and Umbria. The third, in the province of Rieti, is a mountainous zone of the Apennines (A) near the Abruzzo border. The first two are divided by a wide urban area and intensively cultivated lands. All three zones match wild boar habitat preferences (Abaigar *et al.*, 1994; Fonseca, 2008).

The data were collected after shooting and before slaughtering. All the animals legally shot in the area during the hunting seasons were included in the data set. Nine animals were excluded from the statistical analysis on the basis of signs of cross-breeding with domestic pigs (Andersson-Eklund *et al.*, 1998; Randi, 2005). As no selective hunting is practised in the three areas, the animals were shot with the technique of dog drive hunting (Massei and Toso, 1993).

On the basis of the literature available (Mayer and Brisbin, 1991; Moretti, 1995; Tinelli *et al.*, 1999) selected morphological traits were measured, using a flexible meter with a mm scale (Figure 2), and recorded in an appropriately designed format. The following somatic measurements were individually recorded for all the specimens: head-body length, measured from the snout to the first caudal vertebra; height at withers, from the

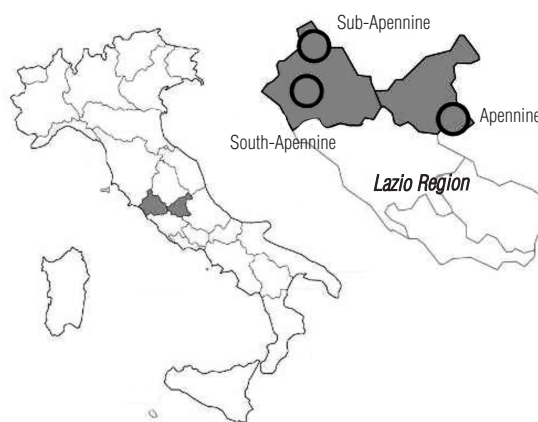


Figure 1. Geographical location of the three study areas.

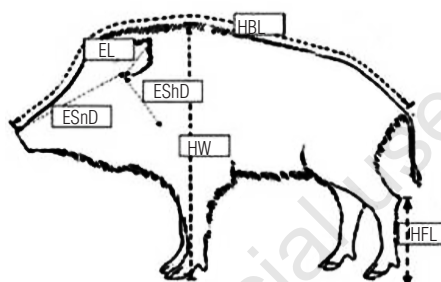


Figure 2. Somatic measurements recorded on the wild boars. BW: Body weight; HBL: Head-body length; HW: Height at Withers; HFL: Hind Foot Length; EL: Ear Length; ESND: Ear-Snout Distance; EshD: Ear-Shoulder Distance.

distal extreme of the fore leg to the upper part of the wither; hind-foot length, from the calcaneum process to the distal part of the nail; ear length, from the base to the tip; ear-snout distance, from the base of the ear to the snout; ear-shoulder distance, from the basis of the ear to scapula-humerus joint. Body weight was measured by a dynamometer (CAMI S.r.l., DIN 1, Accuracy: $\pm 0.5\%$), and age was estimated from tooth eruption and wear (Iff, 1978; Dzieciolowski *et al.*, 1989; Boitani and Mattei, 1992).

The animals were divided into three age classes; young (12 months or less), sub-adults (between 12 and 36 months), and adults (36 months and older). This was performed with reference to the results obtained in previous studies (Amici *et al.*, 2003; Amici *et al.*, 2005).

All the data, separated on the basis of the age class, have been preliminarily analysed with an ANOVA (GLM procedure) including year, sex, area and the interactions area $\times$ year, sex $\times$ year and sex $\times$ area as fixed factors. Since the analysis showed no significant differences between sex and years and contrasting results concerning the areas, the data were merged and a different statistical approach was adopted. The statistical analysis was then performed using a canonical dis-

criminant procedure (SPSS, 2007) that, given an *a priori* classification (geographical area) and several quantitative variables (somatic measures and weight), derives linear uncorrelated combinations of the original variables. In the space defined by the first two canonical variables, the separation among areas was estimated by the squared distance of Mahalanobis that is non affected by linear transformations and accounts for the correlations among the original variables. Discriminant analysis also allowed to categorise the animals in the areas. It should be underlined that the result could be biased, since the same data that has been classified is also used to derive the discriminant function. As a second step the data underwent factor analysis (SPSS, 2007). This procedure is based on the assumption that so called common factors (unobservable latent variables) are able to explain the variance – covariance structure of the original variables. On the basis of the comparison between simple (each pair of variables) and partial (each pair of variables controlling for all other variables) Pearson correlation coefficients, it is possible to calculate the Kaiser measure of sampling adequacy (MSA) indicating the suitability of the data structure for factor analysis.

Table 1. Mean $\pm$ SD of somatic measurements of wild boar, and F probability of the difference among the areas.

Area	SA		A		SM		Probability
	M	F	M	F	M	F	
Young							
Number	32	33	14	18	36	42	
Body weight	27.1±7.2	25.3±6.9	29.0±10.8	31.4±10.5	27.8±7.9	28.8±7.7	0.12
Head-body length	98.5±8.1	96.1±8.6	113.3±13.9	104.9±13.1	102.7±9.4	100.1±8.8	0.08
Height at withers	48.0±6.1	51.2±5.2	59.1±4.6	57.7±4.9	55.2±4.5	52.6±4.2	<0.01
Hind-foot length	22.1±1.6	22.7±2.2	22.1±2.6	22.3±2.1	23.5±2.0	22.5±1.9	0.23
Ear length	10.6±1.8	10.9±1.1	12.8±0.8	12.3±0.9	11.3±1.0	10.8±1.0	0.17
Ear-snout distance	26.2±2.9	25.0±3.3	25.5±3.1	26.8±3.2	24.7±2.1	25.6±2.7	0.65
Ear-shoulder distance	14.6±2.9	15.2±2.2	17.9±3.1	17.1±3.2	17.4±3.0	16.6±3.3	<0.01
Sub-adults							
Number	53	59	32	32	55	69	
Body weight	54.7±11.2	60.1±10.9	52.3±15.3	50.5±14.1	54.0±16.1	51.6±13.2	0.20
Head-body length	126.1±8.6	124.1±8.2	127.0±11.4	121.4±12.2	126.0±11.1	121.4±13.6	0.85
Height at withers	64.3±4.9	64.9±4.8	68.8±6.9	67.6±7.2	67.2±6.5	66.2±7.1	0.17
Hind-foot length	26.2±1.6	27.5±1.9	26.4±1.9	27.2±2.1	26.4±2.7	25.2±3.1	0.03
Ear length	13.7±1.1	14.1±1.2	14.1±1.7	13.1±1.3	13.5±1.2	13.0±1.4	0.35
Ear-snout distance	33.5±2.5	31.8±2.0	33.7±3.1	31.1±2.9	30.9±3.2	31.8±3.1	0.11
Ear-shoulder distance	18.6±3.9	17.6±5.1	18.6±3.2	19.8±3.8	20.9±3.3	19.9±3.8	0.03
Adults							
Number	34	42	15	24	48	51	
Body weight	77.8±16.1	81.2±14.3	75.6±16.0	70.0±17.2	69.0±14.9	65.8±16.2	< 0.01
Head-body length	138.6±9.6	134.0±10.1	143.2±9.3	134.2±8.9	137.2±6.8	132.4±4.3	0.60
Height at withers	73.7±8.9	71.0±6.9	74.7±8.9	71.1±7.2	76.4±5.1	73.0±6.1	0.10
Hind-foot length	28.7±1.9	27.2±1.8	26.6±2.3	24.6±3.1	28.1±2.3	26.7±3.6	0.03
Ear length	14.9±1.2	14.1±1.1	14.4±1.2	14.9±1.5	15.6±1.6	14.6±1.3	0.22
Ear-snout distance	36.9±2.5	34.9±2.4	34.8±3.2	37.6±2.9	36.1±2.5	34.5±2.9	0.54
Ear-shoulder distance	21.1±3.2	19.7±3.5	21.7±4.2	20.8±4.6	23.6±3.9	22.4±3.8	< 0.01

SA: Sub-Apennine; A: Apennine; SM: South-Maremma.

Results and discussion

The results refer to 688 animals, 253 from the SA area (119 males, 134 females), 301 from the SM area (139 males, 162 females), and 135 from the A area (62 males, 73 females). The sex ratio is similar to that observed in field surveys by Perco (1987) and Boitani *et al.* (1995b). Raw means of the somatic measurements are reported in Table 1, according to specimen age class. The analysis of variance showed no significant effect of the year and sex (unreported results). With reference to the sampling areas (Table 1) the results of the statistical analysis put in evidence that some variables were significantly different (ear-shoulder distance, height at withers, hind-foot length), but these differences were not homogenous for all the age classes and were unable to highlight differences among the areas.

These mean values are comparable to those observed in other Italian populations (Randi *et al.*, 1987; Massei and Genov, 1993; Tinelli *et al.*, 1999). However, it should be considered that a large part of the studies reported by various

Table 2. Mahalanobis quadratic distance between the three areas.

Age groups	Young		Sub-adults		Adults	
	A	SA	A	SA	A	SA
SA	0.85 ^{ns}	-	1.19*	-	1.23 ^{ns}	-
SM	3.11***	2.74***	2.95**	2.41**	3.18**	2.48**

* P<0.05, ** P<0.001, *** P<0.0001, ^{ns}non significant.

Table 3. Correlations between canonical and original variables.

Age groups	Young		Sub-adults		Adults	
	1st	2nd	1st	2nd	1st	2nd
Original variable						
Body weight	0.274	-0.233	-0.267	0.257	-0.532	0.489
Head-body length	0.305	-0.146	0.039	0.130	-0.099	-0.008
Height at withers	0.742	0.053	0.282	0.390	0.313	-0.101
Hind foot length	0.211	0.040	-0.447	0.310	-0.409	0.204
Ear length	0.239	-0.002	-0.195	0.144	0.234	0.044
Ear-snout distance	-0.081	0.639	-0.334	0.568	-0.116	0.001
Ear-shoulder distance	0.721	0.391	0.446	0.774	0.560	0.688
Variance explained, %	92.5	7.5	92.7	7.3	89.8	10.2

authors, both in Italy (Randi *et al.*, 1987; Apollonio *et al.*, 1988; Genov *et al.*, 1995; Martinoli *et al.*, 1997; Tinelli *et al.*, 1999) and in other countries (Brisbin *et al.*, 1977; Mayer and

Brisbin, 1991), refer to variables not directly comparable with those of the present study.

Concerning total length of young animals, Moretti (1995) registered higher values in the

Table 4. Simple (above the diagonal) and partial (below the diagonal) correlation coefficients between the somatic variables.

	Body weight	Head-body length	Height at withers	Hind-foot length	Ear length	Ear-snout distance	Ear-shoulder distance
Young							
Body weight		0.61	0.58	0.51	0.44	0.38	0.32
Head-body length	0.34		0.60	0.51	0.44	0.45	0.39
Height at withers	0.20	0.29		0.64	0.50	0.39	0.55
Hind-foot length	0.13	0.03	0.38		0.45	0.58	0.41
Ear length	0.14	0.02	0.16	-0.03		0.54	0.44
Ear-snout distance	-0.01	0.16	-0.19	0.40	0.34		0.42
Ear-shoulder distance	-0.05	0.03	0.32	-0.04	0.14	0.18	
Sub-adults							
Body weight		0.77	0.66	0.75	0.54	0.66	0.14
Head-body length	0.33		0.70	0.64	0.47	0.73	0.24
Height at withers	0.14	0.42		0.50	0.37	0.59	0.26
Hind-foot length	0.44	-0.10	0.08		0.40	0.67	0.16
Ear length	0.30	0.17	0.01	0.06		0.25	0.21
Ear-snout distance	0.08	0.43	-0.02	0.37	-0.25		0.27
Ear-shoulder distance	-0.15	-0.07	0.27	-0.09	0.17	0.24	
Adults							
Body weight		0.57	0.32	0.47	0.23	0.54	0.20
Head-body length	0.38		0.46	0.36	0.30	0.52	0.32
Height at withers	0.03	0.18		0.29	0.36	0.40	0.19
Hind-foot length	0.27	-0.06	-0.01		0.27	0.51	0.12
Ear length	-0.06	0.12	0.27	0.16		0.31	0.20
Ear-snout distance	0.21	0.23	0.17	0.32	0.04		0.22
Ear-shoulder distance	0.00	0.21	0.03	-0.05	0.11	0.06	

Ticino area (Switzerland), compared with the present study (males 107.9 *vs* 100.1; females: 112.5-99.0). A similar trend for adults was registered by Perco (1987), compared with the present study (males 155.0-137.4; females 135.0-132.8). Live weight showed wide differences comparing different studies, and a wide individual variability (Gallo Orsi *et al.*, 1995; Moretti, 1995; Pedone *et al.*, 1995). In addition differences in live weight between sexes can be put in evidence only after two years of age, and do not show statistic significance (Boitani *et al.*, 1995a).

The canonical discriminant analysis reveals the existence of two different area groups within the three age classes, as shown by the quadratic Mahalanobis distance (Table 2). Specifically, there are statistically significant differences among the SM and the A and SA areas, for young, sub-adults and adults. A difference between A and SA is clearly evident only for the sub-adults ($P < 0.05$).

The first canonical variable accounts for 92.5, 92.7 and 89.9 percent of the total variance for young, sub-adults and adults respectively, but is unevenly correlated with the original variables (Table 3). This suggests that the separation between the areas (SM *vs* SA and A) is due to differences in conformation rather than in body size. In more detail, the first canonical

Table 5. Percent of animals correctly categorised with the discriminant analysis, within age class.

Areas	Young (%)	Sub-adults (%)	Adults (%)
SA	78.5	76.8	80.3
A	68.8	71.9	74.4
SM	91.0	87.9	86.9

variable, for the young and sub-adults, shows the highest correlations with height at withers and ear-shoulder distance. For adults, height at withers and ear-shoulder distance but also hind-foot length and body weight (negative correlations) are relevant. In Table 4 the simple and partial correlation coefficients for all the variables are reported. The differences indicate that unobservable factors, able to control the dependence structure of the observed variables, exist. This is also confirmed by Kaiser's Measure of Sampling Adequacy (MSA), which is considered acceptable with values over 0.8 (Cerny and Kaiser, 1977). In fact, the MSA was 0.810, 0.829 and 0.816 for young, sub-adults and adults respectively. Table 5 shows the results of the discriminant analysis in the correct classification of the data in the groups. It is useful to underline that a large part of SM animals are correctly classi-

fied and a higher percentage of misclassification can be observed for A and SA groups. This result is not easily explainable but the effect of artificial restocking for hunting purposes can be supposed.

Concerning the factor analysis results, only the data concerning the adults (Figure 3) are reported. For this age class, the first three common factors are able to explain 78, 92, and 64% of the covariance for the data of SM, A and SA respectively. The first common factor (Figure 3A) is clearly associated with body weight, head-body length, height at withers and hind-foot length, which expresses the largest portion of communality. The percentage of covariance explained by the first common factor was 75, 72 and 68% for A and SA and SM respectively, of the total explained variance. The second common factor (Figure 3B) accounts for a limited part of communality

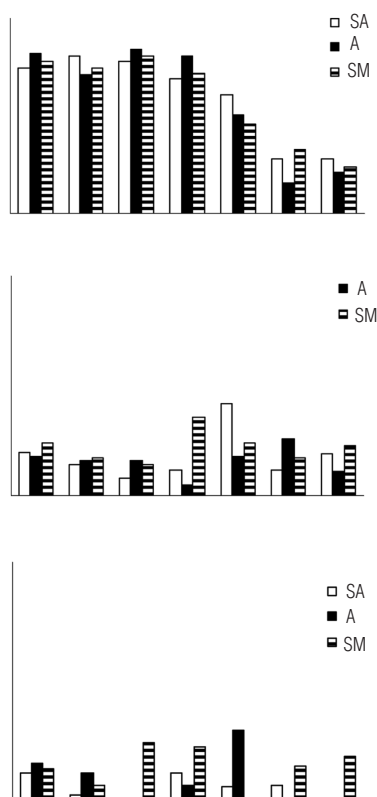


Figure 3. Patterns of the first (A), second (B) and third (C) common factor in the age class of adults.

(14%), mainly related to ear length and ear-snout distance. The third factor accounts only for 9% of communality (Figure 3C), and an explanation of the role of somatic variables was impossible due to the confusion of the results obtained. For the age classes of young and sub-adults, a factorial analysis showed that the first common factor is able to explain large part of the covariance (82%, 72% and 76% for SM, A and SA areas respectively). Also for these age classes the first common factor is associated with head-body length, height at withers and hind-foot length (mainly for sub-adults), but is not associated with body weight.

From an analysis of the results relative to the SM, it can be inferred that a differentiation among morphotypes is possible on the basis of a few selected somatic measures. The animals from SM tend to be shorter and have more developed fore portions (i.e. they are trapezoidal in shape) and thus correspond to a typical wild boar (Mauget, 1979). On the other hand, the animals from the SA area are more rectangular in shape, suggesting hybridisation

with central European animals or with domestic swine (Massei and Toso, 1993). The somatic measurements allowed to differentiate morphotypes of two areas and suggest the existence of two populations. The effect of the environment should be evident with difference in size rather than in conformation, although this component is impossible to separate. To this regard interesting results have been reported by Brisbin *et al.* (1977) indicating that in two feral pig populations height at shoulder contributed in a meaningful proportion to discriminate between two populations. The same Authors also reported that no statistical differences were put in evidence for weight and total length between sexes within populations.

Conclusions

These results confirm that different morphotypes of wild boar are detectable in some different areas of Central Italy. These morphotypes are differentiated on the basis of height and length measurements (head-body length, height at withers and hind-foot length) and body weight can be relevant only for animals over three years of age.

The above mentioned somatic measurements allow different morphotypes to be distinguished and are easily registered after drive hunting sessions, implying that a wide number of field data can be collected. This study highlights the need to perform biochemical and genetic studies to identify the autochthonous wild boar strain presently populating Central Italy. These studies should be done taking into consideration the results of a field survey on population morphology.

References

- Abaigar, T., del Barrio, G., Vericad, J.R., 1994. Habitat preferences of wild boar (*Sus scrofa* L. 1758) in a Mediterranean environment. Indirect evaluation by signs. *Mammalia* 58:201-210.
- Adriani, S., Grifoni, G., Ricci, V., Calderini, P., 2005. Biometric study on wild boars (*Sus scrofa*) in Rieti province, Lazio, Italy. Page 63 (abstr.) in Proc. 4th Int. Symp. Wild Fauna, Tatranska Lomnica, Slovakia.
- Amici, A., Adriani, S., Serrani, F., 2008. Monitoring wild boar (*Sus scrofa*) reproductive traits in Rieti Province, Central Italy. Page 65 (abstr.) in Proc. 7th Int. Symp. Wild Boar (*Sus scrofa*) and on Sub-order Suiformes, Sopron, Hungary.
- Amici, A., Adriani, S., Serrani, F., Sperduti, A., Sabatini, A., 2005. An approach to the interpretation of morphological differences among wild boar (*Sus scrofa*) in different areas of Central Italy. Page 63 (abstr.) in Proc. 4th Int. Symp. Wild Fauna, Tatranska Lomnica, Slovakia.
- Amici, A., Serrani, F., Faggiani, M., Ronchi, B., 2003. Biometric study on wild boars (*Sus scrofa* L.) in two areas of Viterbo Province, Italy. pp 275-279 in Proc. 3rd Int. Symp. Wild Fauna, Ischia, Italy.
- Andersson-Eklund, L., Marklund, L., Lundstrom, K., Haley, C.S., Andersson, K., Hansson, I., Moller, M., Andersson, L., 1998. Mapping quantitative trait loci for carcass and meat quality traits in a wild boar x Large White intercross. *J. Anim. Sci.* 76:694-700.
- Apollonio, M., Randi, E., Toso, S., 1988. The systematics of the wild boar (*Sus scrofa* L.) in Italy. *B. Zool.* 3:213-221.
- Bieber, C., Ruf, T., 2005. Population dynamics in wild boar *Sus scrofa*: ecology, elasticity of growth rate and implications for the management of pulsed resource consumers. *J. Appl. Ecol.* 42:1203-1213.
- Boitani, L., Mattei, L., 1992. Aging wild boar by tooth eruption. pp 419-421 in Proc. Int. Conf. Ungulés/Ungulates 91. Paris - Toulouse, France.
- Boitani, L., Trapanese, P., Mattei, L., 1995a. Demographic patterns of a wild boar (*Sus scrofa* L.) population in Tuscany, Italy. *Ibex Journal of Mountain Ecology* 3:197-201.
- Boitani, L., Trapanese, P., Mattei, L., Nonis, D., 1995b. Demography of a wild boar (*Sus scrofa* L.) population in Tuscany, Italy. *Game and Wildlife Science* 12:109-132.
- Brisbin, I.L., Geiger, R.A., Graves, H.B., Pinder III, J.E., Sweeney, J.M., Sweeney, J.R., 1977. Morphological characterizations of two population of feral swine. *Acta Theriol.* 22:75-85.
- Cerny, A., Kaiser, H.F., 1977. A study of a measure of sampling adequacy for factor-analytic correlation matrices. *Multivar. Behav. Res.* 12:43-47.
- Cocca, G., Sturaro, E., Dal Compare, L., Ramanzin, M., 2007. Wild boar (*Sus scrofa*) damages to mountain grassland. A case study in the Belluno province, eastern Italian Alps. *Ital. J. Anim. Sci.* 6(Suppl. 1): 845-847.
- Danilkin, A.A., 2001. The wild boar: an unprecedented spread or restoration of the species range? *Dokl. Biol. Sci.* 380:457-460.

- De Beaux, O., Festa, E., 1927. La ricomparsa del cinghiale nell'Italia settentrionale-occidentale. *Memorie della Società Italiana di Scienze Naturali e Museo Civico di Storia Naturale di Milano* 3:263-322.
- Dzieciolowski, R.M., Clarke, C.M.H., 1989. Age structure and sex ratio in a population of harvested feral pigs in New Zealand. *Acta Theriol.* 37:259-270.
- Fonseca, C., 2008. Winter habitat selection by wild boar *Sus scrofa* in south-eastern Poland. *European. J. Wildlife Res.* 54:361-366.
- Gallo Orsi, U., Macchi, E., Perrone, A., Durio, P., 1995. Biometric data and growth rates of a wild boar population living in the Italian Alps. *Ibex Journal of Mountain Ecology* 3:60-63.
- Geisser, H., Reyer, H.U., 2004. Efficacy of hunting, feeding, and fencing to reduce crop damage by wild boar. *J. Wildlife Manage.* 68:939-946.
- Geisser, H., Reyer, H.U., 2005. The influence of food and temperature on population density of wild boar *Sus scrofa* in the Thurgau (Switzerland). *J. Zool.* 267:89-96.
- Genov, P., 2004. Craniometric characteristics of the subgenus *Sus* Linnaeus, 1758 and a systematic conclusion. *Galemys* 16:9-23.
- Genov, P., Massei, G., Nikolov, H., 1995. Morphometrical analysis of two Mediterranean wild boar populations. *Ibex Journal of Mountain Ecology* 3:69-70.
- Genov, P., Nikolov, H., Massei, G., Gerasimov, S., 1991. Craniometrical analysis of Bulgarian wild boar (*Sus scrofa*) population. *J. Zool.* 225:309-325.
- Iff, U., 1978. Détermination de l'âge chez le sanglier. *Diana, Suisse* 10:377-381.
- Martinoli, A., Zilio, A., Cantini, M., Ferrario, G., Schillaci, M., 1997. Distribution and biometry of the wild boar (*Sus scrofa*) in the Como and Varese provinces. *Hystrix* 9:78-83.
- Massei, G., Genov, P., 1993. Variabilità morfologica nel cinghiale maremmano. *Ric. Biol. Selvaggina* 21(Suppl.):615-617.
- Massei, G., Toso, S., 1993. *Biologia e gestione del Cinghiale*. Documenti Tecnici 5. INFS ed., Bologna, Italy.
- Mauget, R., 1979. Quelques problèmes de biologie et d'éco-éthologie chez le sanglier. *Office National de Chasse Bulletin Mensuel* 3:14-23.
- Mayer, J.J., Brisbin, I.L. Jr., 1991. *Wild pigs in the United States: their history, comparative morphology, and current status*. University of Georgia Press, Athens, USA.
- Moretti, M., 1995. Biometric data growth rates of mountain population of wild boar (*Sus scrofa* L.), Ticino, Switzerland. *Ibex Journal of Mountain Ecology* 3:56-59.
- Nahlik, A., Sandor, G., 2003. Birth rate and offspring survival in a free-ranging wild boar *Sus scrofa* population. *Wildlife Biol.* 9:37-42.
- Pedone, P., Mattioli, S., Mattioli, L., 1995. Body size and growth patterns in wild boars of Tuscany, Central Italy. *Ibex Journal of Mountain Ecology* 3:66-68.
- Perco, F., 1987. *Ungulati*. Carlo Lorenzini ed., Udine, Italy.
- Primi, R., Pelorosso, R., Ripa, M.N., Amici, A., 2009. A statistical GIS-based analysis of Wild boar (*Sus scrofa*) traffic collisions in a Mediterranean area. *Ital. J. Anim. Sci.* 8(Suppl. 2):649-651.
- Randi, E., 1995. Conservation genetics of the genus *Sus*. *Ibex Journal of Mountain Ecology* 3:6-12.
- Randi, E., 2005. Management on wild ungulate population in Italy; captive-breeding, hybridisation and genetics consequences of translocation. *Vet. Res. Commun.* 29:71-75.
- Randi, E., Apollonio, M., Toso, S., 1987. The systematics of some Italian populations of Wild boar (*Sus scrofa* L.): a craniometric and electrophoretic analysis. *Z. Säugetierkd.* 54:40-56.
- Saez-Royuela, C., Telleria, J.L., 1986. The increased population of the Wild Boar (*Sus scrofa* L.) in Europe. *Mammal Rev.* 16:97-101.
- Scandura, M., Iacolina, L., Crestanello, B., Pecchioli, E., Di Benedetto, M.F., Russo, V., Davoli, R., Apollonio, M., Bertorelle, G., 2008. Ancient vs. recent processes as factors shaping the genetic variation of the European wild boar: are the effects of the last glaciation still detectable? *Molec. Ecol.* 17:1745-1762.
- Schley, L., Roper, T.J., 2003. Diet of wild boar *Sus scrofa* in Western Europe, with particular reference to consumption of agricultural crops. *Mammal Rev.* 33:43-56.
- SPSS., 2007. *Base System User's Guide*. Statistics 13.0. SPSS Inc., Chicago, IL, USA.
- Tinelli, A., Pietrelli, L., Focardi, S., 1999. Dati biometrici della popolazione di cinghiale (*Sus scrofa* L.) di Castelporziano. *Proc. Società Italiana Scienze Naturali Museo Civico Storia Naturale* 2:171-177.
- Vernesi, C., Crestanello, B., Pecchioli, E., Tartari, D., Caramelli, D., Hauffe, H., Bertorelle, G., 2003. The genetic impact of demographic decline and reintroduction in the wild boar (*Sus scrofa*): A microsatellite analysis. *Molec. Ecol.* 12:585-595.