BIOMETRIC DATA AND GROWTH RATES OF A MOUNTAIN POPULATION OF WILD BOAR (Sus scrofa L.), TICINO, SWITZERLAND

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Abstract: Biometric data from 386 wild boars *(Sus scrofa)* killed during the hunting seasons 1988-1992 in the Malcantone and Gambarogno regions of Ticino canton (Southern Switzerland) are presented. From each animal many body measurements were collected. Animals were aged from the tooth eruption and tooth wear and divided into age classes. Weight and length of the body appear to be connected with age in both sexes, while weight alone is different between males and females from the 4th age class (19-27 months) on.

Keywords: Wild boar, *Sus scrofa*, Suidae, Biometry, Growth rate.

IBEX J.M.E. 3:56-59

1. Introduction

The population of wild boars in Ticino (Swiss Canton, south of the Alps) is very recent. The first animals were recorded at the beginning of the 80's in the Malcantone region, on the border to the Lombardic Alps region (Italy). In the subsequent years it quickly spread northwardly and the population increased significantly (Baettig, 1985; Moretti, 1991, Moretti, 1992). The presence of Wild boar in Ticino was caused by immigration of some animals coming from Italy, *i.e.* from a boar- and pig-farm in the Varesotto region, a few kilometers away from the Swiss border. At the beginning there was obvious evidence of a hybridisation (genetic contamination) between the wild and the domestic type (spotted fur, curly tails and ears bending forward). The presence of hybrid populations in Europe is also mentioned by several authors (Mauget *et al.*, 1984, Apollonio *et al.*, 1988; Gerard *et al.*, 1991; Gallo Orsi *et al.*, 1992). This is generally due to restoking (for hunting purposes) of animals from East-European countries or to interbreeding between domestic pigs and the local population. Such heterogeneity affects the species' phenotypical and eco-ethological features. On the other hand, environmental conditions (such as water, climate, availability of food, etc.) can modify the growth rate. The aim of this study is to present preliminary biometric data of a relatively recent mountain Wild boar population and to compare it with other European populations.

2. Study area

The Malcantone region (Southern Switzerland) covers an area of 7,000 ha with a southern orientation; altitudes range from 200 to 1,800 m u.s.l. (Fig. 1). The annual rainfall is 1,700 mm (mean of the last 30 years). The environment is as follows: wood 60%; urbanized area 15.5%, agricultural area 10.5%, alpine meadows 10%, uncultivated land 4%. The chestnut *(Castanea sativa)* predominates between 200 and 1,000 m, either pure or mixed with beech *(Fagus sylvatica)* or with oaks (*Quercus* sp.).

3. Methods

During the hunting season (September-January) between 1988 and 1992, 987 wild boars were killed. 39% of them (n = 386, 211 males and 175 females) were examined in order to collect some biometric data. All animals were shot in the study area between 200 m and 1,600 m above sea level. The hunting code did not provide any restriction about the killing of particular age classes and therefore all classes were present in the analysed samples. All animals were aged from tooth eruption and tooth wear according to Iff (1978). Age classes were adapted from the recent works of Boitani and Mattei (1992) and Genov *et al.* (1992) in accordance with Matschke (1965). All body measurements were taken according to Briedermann (1986) and in part to Gallo Orsi *et al.*, 1992 (Fig. 2).
Biometric differences between sexes and age

Table 1: Means and S.E. of the mean for each age class.

	Class 1 (4-8 months)		Class 2 (8-12 months)		Class 3 (13-18 months)		Class 4 (19-27 months)		Class 5 (> 27 months)	
	m (n=50)	f (n=39)	m (n=39)	f (n=29)	m (n=71)	f (n=54)	m (n=21)	f (n=29)	m (n=31)	f (n=23)
Weight (kg)	18.5 ± 0.9	19.5 ± 1.1	30.1 ± 1.5	35.6 ± 1.7	53.6 ± 1.5	47.0 ± 1.7	74.4 ± 3.7	52.8 ± 3.2	86.1 ± 3.3	62.6 ± 3.9
Body length (cm)	91.4 ± 1.9	93.1 ± 2.2	107.9 ± 1.5	112.5 ± 1.8	128.7 ± 1.1	125.9 ± 1.2	138.9 ± 1.7	130.9 ± 1.5	145.1 ± 1.4	137.0 ± 1.7
Height at withers (cm)	53.9 ± 1.3	54.9 ±1.5	64.7 ± 1.1	66.5 ± 1.2	76.1 ± 0.7	72.7 ± 0.8	85.2 ± 1.6	75.6 ± 1.4	85.6 ± 1.7	75.7 ± 1.9
Length of metatarsus (cm)	20.6 ± 0.4	20.4 ± 0.4	23.1 ± 0.3	23.2 ± 0.4	26.6 ± 0.3	24.3 ± 0.3	27.0 ± 0.3	25.5 ± 0.3	27.3 ± 0.4	25.6 ± 0.4
Ear length (cm)	9.6 ± 0.3	10.3 ± 0.3	11.6 ± 0.2	11.7 ± 0.2	13.1 ± 0.2	12.5 ± 0.2	13.6 ± 0.3	12.6 ± 0.3	14.2 ± 0.3	14.0 ± 0.3
Tail length (cm)	13.6 ± 0.4	13.6 ± 0.4	16.1 ± 0.4	16.4 ± 0.5	19.6 ± 0.3	18.6 ± 0.4	21.2 ± 0.6	20.3 ± 0.5	20.7 ± 0.5	20.2 ± 0.6

Figure 1 - Study area.

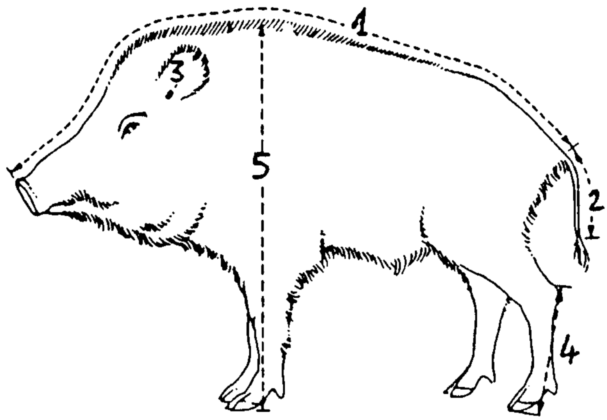

Figure 2 - Measurement methods of: (1) Body length; (2) Tail length; (3) Ear length; (4) Length of metatarsus; (5) Height at withers.

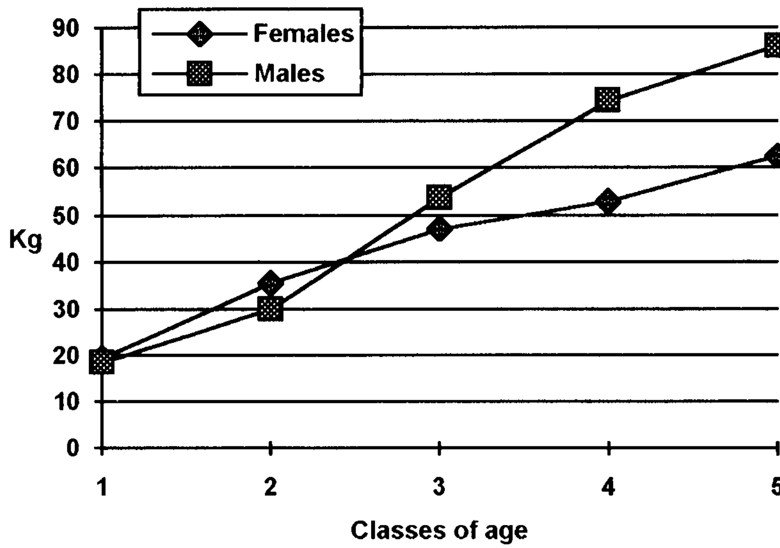

Figure 3 - Development of body weight in relation with age and sex of Wild boar (n = 386). Classes of age: (1) 4-8 months.; (2) 8-12 months.; (3) 13-18 months.; (4) 19-27 months.; (5) > 27 months.

classes were determined through discriminant analysis ($p<0.05$). The data follow a normal distribution.

4. Results

Table 1 shows the mean standard error for each age class. Up to the age of 12 months (classes 1 and 2) females appear larger than males. In all following age classes the males grow faster. Males differentiate significantly to females by weight, body length, height at withers and length of metatarsus ($p<0.05$).

From a deeper analysis of the weight development of both sexes, a difference in body growth between males and females is noticeable. Up to 12 months of age (class 2) the weight increase of males is slower than that of females. It reaches maximum values only between class 2 and class 3 with a body increase of 78%. In the following years it decreases progressively affecting important body variations, especially from the second year on, but after that it does not seem to become stable. On the other hand, the body weight of females increases by 83% between 4-

8 months (class 1) and 8-12 months (class 2), but it increases only by 76% from the second age class on. Even for the females weight does not become stable and seems to increase even more after the 27th month of age (Fig. 3).

5. Conclusions

The body growth progress in both sexes agrees with that of other authors (Mauget *et al.*, *op. cit.*, Meriggi *et al.*, 1988; Baettig, 1988; Gallo Orsi *et al.*, *op. cit.*). Means are also in accordance with those recorded in Europe by Baettig (*op. cit.*), Gallo Orsi *et al.* (*op. cit.*), Klein (1984) and Pepin *et al.* (1986, in Gerard *et al.*, *op. cit.*). Other authors, *i.e.* Marsan *et al.* (1990), Koslo (1975, in Briedermann, *op. cit.*) and Briedermann (*op. cit*)., show biometric data that seem to be inferior by 10-20%, between 13 and 27 months. However, from the 19th month it becomes more difficult to compare the values because the variability of the mean value in each class is too important. Such variations are possibly due to the different environmental resources of the study areas, as shown by the results of Klein (*op. cit.*) and Briedermann (*op. cit.*), and also to the phenotypic appearance of the different genetic polymorphism of the populations (Gallo Orsi *et al.*, *op. cit.*). However, it is important to mention that the authors quoted in these studies used different methods to determine the age (based on tooth eruption) which led to different classifications. Differences of estimates of 2 months (at 14 months of age) and of 4 months (at 24 months of age) are noticeable between the classes named by Iff (*op. cit.*) and by Matschke (*op. cit.*) and most recently by Boitani and Mattei (*op. cit.*) and Genov *et al.* (*op. cit.*). This discrepancy can affect the interpretations of the recorded differences between the various populations.

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BIOMETRIC DATA AND GROWTH RATES OF A WILD BOAR POPULATION LIVING IN THE ITALIAN ALPS

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Abstract: From 328 wild boars *(Sus scrofa)* killed during the 1986-1992 hunting seasons (end of September - early December) the following body variables were measured: full body weight (kg), total length (cm), shoulder height (cm), length of metatarsus (cm) and length of the mandible (mm). Animals were aged from tooth eruption and wear and six age classes were established. The regression curve of the variables for each sex was calculated; the regression fits a multiplicative model $y = ax^b$. The males show higher r and r^2 values than females for every variable. This indicates that males show smaller variability due to sexual selection for bigger and stronger animals.

Keywords: Wild boar, *Sus scrofa,* Suidae, Weight, Biometry, Measurements, Europe.

IBEX J.M.E. 3:60-63

1. Introduction

The Italian Wild boar population was considered as composed by two subspecies: *Sus scrofa scrofa* and *S. s. majori*. Recently Groves (1981), Apollonio *et al.* (1988) and Randi *et al.* (1989), by means of morphologic and electrophoretic analysis, have concluded that the Italian Wild boar population should be considered as belonging to the European subspecies *S. s. scrofa* and stated that the morphologic differences found may be caused by environmental factors affecting the growth of the individuals living in harsh habitat (mediterranean or mountainous). Besides a dimensional cline running NE-SW has been identified with bigger animals found in North-East Europe and smaller in Spain and Italy.

The Piedmontese population is geographically and environmentally located between the peninsular Italian and French populations and thus they should present intermediate morphological characteristics.

The aim of this paper was to study the morphology and the growth rate of the wild boars living in the Piedmontese Alps.

2. Material and methods

On 300 animals killed during the hunting seasons 1986-1992 and aged by tooth eruption and tooth wear (Iff, 1978), the following measures were recorded:

- Weight (undressed or field dressed);
- Total length (from the snout to the base of the tail);
- Tail length (from the base to the tip);
- Shoulder height;
- Metatarsus length.

Besides 89 mandibles were collected and 13 measures taken according to Von der Driech (1976) (Tab. 1). Some measurements were meant to be done only on adult individuals and some minor changes were made to allow their utilization on young animals.

Six age classes were identified: Class 1: ≤ 6 months; Class 2: 7-12 months; Class 3: 13-18 months; Class 4: 19-24 months; Class 5: 25-30 months and Class 6: ≥ 31 months.

In order to describe the growth pattern in the two sexes regression analysis was performed for all measurements using the age class as independent variable.

A Correlation analysis was performed to analyse the relative growth of the measurement.

The differences between males and females within each age class have been tested with the Mann-Whitney U-test in order to assess the development of the sexual dimorphism. This non-parametric test was chosen because the data were not normally distributed.

3. Results and discussion

The regression analysis performed between all measurements resulted in high "r" values indicating that the body growth is uniform. From the regression analysis it appeared that the best fitting model was the multiplicative one ($y = ax^b$). Regression analysis resulted highly significant but the weight (undressed weight in males

Table 1 - Measures taken on mandibles. Numbers are those used by Von der Driech (1976). Measures marked with # are those that have been modified in order to be taken also on young animals.

1	Length from the angle Gonion caudale - Infradentale
2	Aboral border of condyle process - Infradentale
3	Gonion caudale - aboral border of the most aboral alveolus #
5	Gonion caudale - aboral border of the alveolus of P_2
9a	Length of the Premolar row measured along the alveoli on the buccal side
11	Oral border of the alveolus of P_2 - aboral border of the alveolus of I_3
12	Mental prominence - Infradentale
13	Gonion ventrale - highest point of the condyle process
14	Gonion ventrale - deepest point of the mandibular notch
16a	Height of the mandible behind fast erupted molar, from the most aboral point of the alveolus #
16b	Height of the mandible in front of M_1
16c	Height of the mandible in front of P_2
21	Greatest diameter of the canine alveolus

and field dressed weight in females) showed the best "r" and "r^2". Among the mandible measurements the regression analysis resulted in "r" and "r^2" statistics closer to the maximum value (unity) than the body ones (except weight). The measurements taken on the mandible are more reliable in assessing the age than the body measurements. This may be due also to the better working condition because the body measurements were taken "on the field" while mandible measurements were taken later in the laboratory. Again females showed lesser variation within each age class than males.

All most reliable measurements (*i.e.* those measurement that showed higher "r" and "r^2" values) indicate that the differences between males and females within each age class are statistically highly significant from age class 4 onward (*i.e.* after at least 19 months).

The growth is fast in the first 18 months (age classes 1-3) for both sexes, later the growth of the females slows down and the difference from males emerges (Fig. 1a,b,c).

The reduction of the growth rate occurs when most of the females become pregnant and give birth to their first litter (Kratochvil *et al.*,

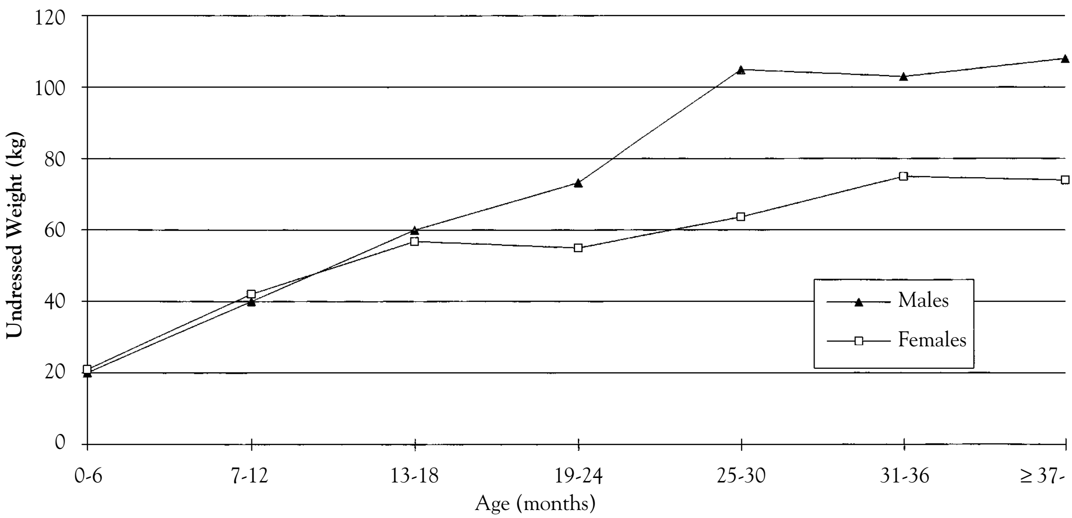

Figure 1a - Dynamics of undressed weight in males and females.

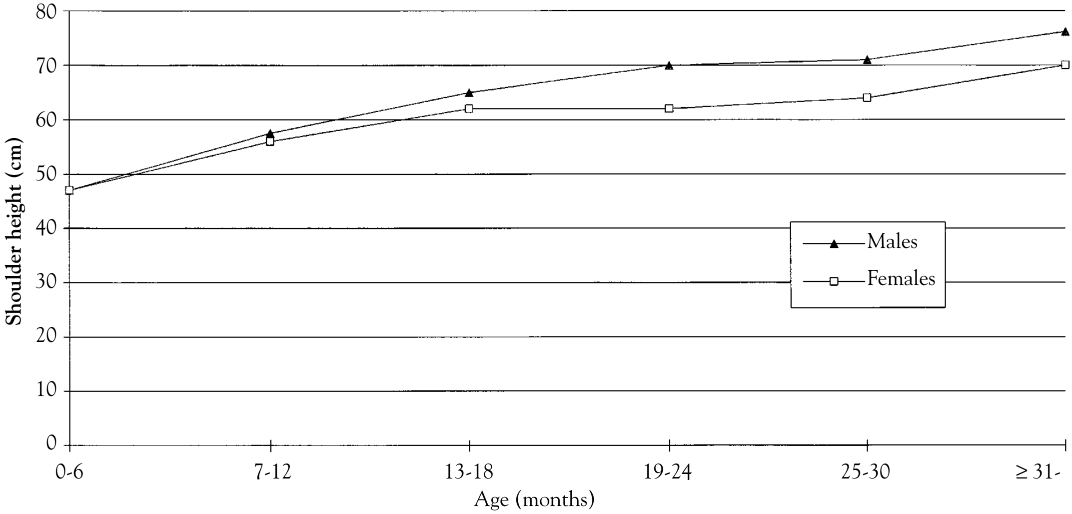

Figure 1b - Dynamics of shoulder height in males and females.

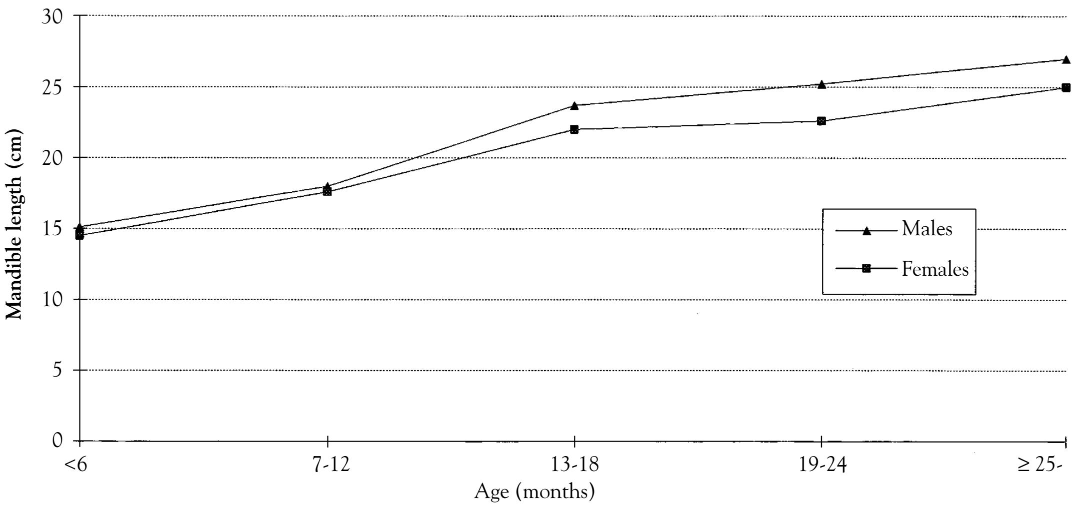

Figure 1c - Dynamics of mandible length in males and females.

1986; Pedone *et al.*, 1991): the effort of the pregnancy may be the main cause of the observed phenomenon.

The growth of the males continues at least up to age class 4 and this result is consistent with the observation of Genov (1992). In this sample, anyway, only one male resulted older than 3 years and for this reason the male's growth rate do not reach the predictable "plateau".

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BODY GROWTH IN A CONFINED WILD BOAR POPULATION

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Abstract: We have studied a high density population of Wild boar in a fenced area. As expected, overcrowding and food shortage have heavily influenced body growth, with differential effects on the two sexes. Mean live weight of adults was only 38.3 kg.

Keywords: Wild boar, *Sus scrofa,* Suidae, Body weight, Sexual dimorphism, High density.

IBEX J.M.E. 3:64-65

1. Introduction

It is a well known fact that high density greatly affects body growth. In sexually dimorphic species males and females tend to respond differently to stressful environmental conditions; in polygynous animals subjected to overpopulation male growth is more sensitive to the associated food shortage and social pressure (Clutton-Brock *et al.,* 1982; Fowler, 1987).
We have studied a Wild boar population exposed to a very high density, to verify the differential effects of density on members of both sexes. In addition a comparison has been drawn with wild boars at low density from neighbouring areas.

2. Study area, material and methods

The study area is located at the “Azienda Il Giardino” (43° 20’ N, 10° 32’ E; province of Pisa, Italy); it is a game production center owned by the Regional Administration of Tuscany and used to rear wild boars for restocking operations. The enclosure covers 290 ha. During late winter about 20-25% of animals are caught and removed; this number is not sufficient to maintain the population at acceptable levels. Supplementary feeding was virtually limited to special fodder for piglets and bait for traps. Between 1989 and 1991 1435 captures were carried out and 409 animals were weighed; 380 weight data are used in our analysis. By the Lincoln-Petersen method the confined population present at 31 December 1989 was estimated in 460 head, equal to 160 head per km^2 (reduced to 120/km^2 after removal and sale). In the same period data concerning body weight of 359 wild boars from the neighbouring areas were collected; from hunting statistics it was possible to assess a mean winter density of about 2-3 free-ranging animals per km^2.

3. Results and discussion

As can be seen in table 1 the body weights of fenced wild boars are extremely low in all age classes and in both sexes. In adults (> 24 months old, combined sexes) mean weight was just 38.3 kg (n = 95): confined adult males weighed on average only 54.1% of free-roaming adults (44.0 kg vs 81.4 kg), while adult females at high density weighed on average 62.3% of females at low density (36.3 kg vs 58.2 kg). Sexual size dimorphism, typical of the species (males being larger than females) was absent in piglets (about 4 months old), young (7-11 months old) and subadults (12-23 months old). In fact, in subadult wild boars from the enclosure females were on average 1 kg heavier, although this difference is not statistically significant. Dimorphism in size can be lacking in adults, as observed in 1989-90, when males were on average 1.8 kg heavier than females ($t = 0.429$; $p > 0.1$). The heaviest sampled animal in the fence was a sow weighing 70 kg. Five of 22 adult males (22.7%) weighed < 30 kg.

Table 1: Mean live weights (x, in kg) of two neighbouring populations of Wild boar: a comparison.

		CONFINED			FREE-RANGING*		
age class	sex	weight	sd	n	weight	sd	n
piglets	m	12.2	2.9	22	-	-	-
	f	11.2	2.7	24	-	-	-
	u•	10.5	2.4	8	-	-	-
young	m	16.2	3.8	69	27.7	8.6	81
	f	17.1	3.3	62	26.0	8.3	70
subadults	m	28.9	5.6	42	60.1	12.4	79
	f	29.9	5.5	56	52.7	11.9	32
	u•	31.7	4.9	2	-	-	-
adults	m	44.0	14.6	22	81.4	14.4	66
	f	36.3	9.6	70	58.2	14.2	31
	u•	42.4	5.6	3	-	-	-

* reconstructed live weights (by the formula $y = 1.4154 + 1.1735x$ following Mattioli & Pedone, this volume)
• undetermined

As expected, growth rates differed greatly in both sexes: by their first 23 months of age males reached just 65.6% of their final mass, while females in the same period attained 82.3% of their ultimate weight (against 73.9% and 90.4% in the free-ranging population).
In the fenced area both sexes exhibited an attenuated body growth, reaching remarkably low adult weights. Overpopulation influences environmental conditions reducing in quality and quantity available food; moreover it increases inter- and intra-sexual competition. Even at low density in polygynous species body growth patterns are different in males and females; females reach final weight earlier in life, allowing the allocation of more energy to reproduction and parental care for later; males, contributing little to offspring production and care, tend to devote more energy to mass accumulation. In high density conditions males grow even more slowly and reach a modest final weight. In young and subadults these sex-specific differences may be principally due to the greater energetic requirements and to the particular metabolism of males (lesser fat deposition and faster proteic catabolism). In adult males this may depend on costs associated with competition for mates and on a lesser ability to select high quality food (cf. Clutton-Brock *et al.*, *op. cit.*).

4. Acknowledgements

We are grateful to R. Frosali and L. Biancani for their assistance during trapping sessions. R. Giusti, C. Lovari and L. Mattioli helped us in gathering data. The study was funded by the Regional Administration of Tuscany.

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BODY SIZE AND GROWTH PATTERNS IN WILD BOARS OF TUSCANY, CENTRAL ITALY

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Abstract: We have examined 790 weights of Italian wild boars collected in Tuscany from 1988 to 1991. We describe patterns of body growth and try also to assess microgeographical and temporal variation.

Keywords: Wild boar, *Sus scrofa,* Suidae, Body weight.

IBEX J.M.E. 3:66-68

1. Introduction

The region of Tuscany harbours one of the most abundant Italian populations of Wild boar. Although accurate figures are lacking, annual harvests are possibly assessable at 20,000-30,000 head. In a previous paper (Pedone *et al.*, 1991), we used 613 weight data to outline general trends in body growth of wild boars from internal Tuscany. Here we present a preliminary analysis of an augmented sample from the same zone; in particular we describe body size and patterns of growth, seeking to evaluate differences related to age, sex, area and year.

2. Study area, material and methods

From 1988 to 1991 a total of 885 wild boars shot by hunters was examined; weight data were available for 790 animals (396 males and 394 females). The global sample originates from 4 different areas: Casentino (CA), Valtiberina (VT), both in the province of Arezzo, Valdelsa (VE), in the province of Siena, and Val di Cecina (VC), in the province of Pisa. CA and VT are mainly mountainous; the climate is cool temperate, woods cover 60-80% of the territory, and agriculture is not particularly developed. VE and VC are hilly areas; the climate is warm temperate, woods and maquis scrub account for 20-40% of the surface, and cultivations (vineyards, oliveyards, cereal growing) are frequent. Shot animals came from both traditional hunting districts and protected areas (State forests etc.). Age was estimated by tooth eruption, replacement and wear patterns (Matschke, 1967; Briedermann, 1986; Boitani & Mattei, 1992); wild boars 4 or more years old were pooled in a single category. Three main age classes are generally considered: young (7-12 months old), subadults (13-24 months old), and adults (more than 24 months old).

3. Results and discussion

The overall mean dressed weight of males was 42.6 kg (SD = 20.0), whereas the overall mean figure for females was 37.6 kg (SD = 16.0). Sexual dimorphism in size was not statistically detectable in the young and subadult classes. Actually sex-specific differences in growth rate begin to appear at around 18-19 months of age. In the adult class males were on average 25.2% heavier than females (65.7 kg vs 52.5 kg, see table 1). Only 6.8% of adult males had a body mass > 90 kg. The maximum dressed weight reported was 102.3 kg, which probably approaches the normal limits for wild boars in Tuscany.

A polynomial growth curve was fitted for each sex (males: $y = -1.749 + 3.628x - 6.491e - 2x^2 + 4.319e - 4x^3$, $R^2 = 0.752$; females: $y = -6.495 + 4.73x - 0.1256x^2 + 1.102e - 3x^3$, $R^2 = 0,631$; where: y = weight - x = age - e = Neperian number) (Fig.1).

Males attained 50% of their adult weight at about 12-14 months of age, and 75% by 20-22 months; actually weight gain continued over 36 months of age. Females reached 50% of

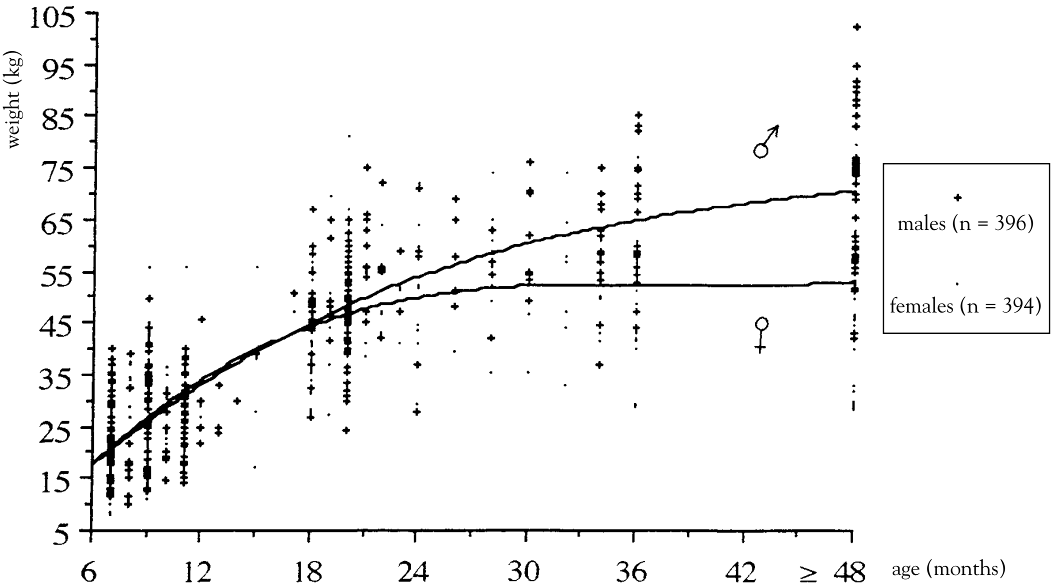

Figure 1: Growth curves for dressed weight of Tuscan wild boars.

their ultimate mass at about 9-10 months, 75% by 16-17 months, and 90% by 22-23 months; body weight of sows 48 months and older did not differ from that of sows 25-36 months old.
ANOVA showed significant differences in mean weights of the four areas, both in males and females. But much variation due to environmental effects was not detectable; differences were partly masked by the compound origin of subsamples, with specimens coming from localities at various levels of density, protection and hunting pressure.
Within areas body size showed evident variations among years. In VC animals shot during the winter 1989-90 after an "acorn year" were on average 33% heavier than those harvested in 1988-89 and 1990-91; the most sensitive to annual changes in seed crops were young wild boars, whose mean body weight changed from a maximum of 29.1 kg to a minimum of 20.5 kg.
As previously reported (Pedone *et al.*, *op. cit.*), body weights and growth rates of Tuscan wild boars are substantially modest in each age class and in both sexes, but fall within the range of most European populations (Tab 1).

Table 1: Comparison of dressed weights (x, in kg) of Tuscan wild boars with those from other European Wild boar populations.

	Age class								
	Young		Subadults		Adults				
					males		females		
Location	x	n	x	n	x	n	x	n	Authority
F. Czecholsovakia	30.8	186	64.9	126	103.8	30	84.2	53	Hell & Paule 1983
E. Germany	30.5	298	50.8	276	88.0	26	58.1	39	Stubbe *et al.* 1980
Switzerland	24.6	161	53.0	174	87.2	45	66.3	18	Moretti 1993
E. Germany	25.1	1383	52.9	533	70.7	116	65.9	234	Briedermann 1986
Central Italy	25.1	363	47.6	219	65.7	103	52.5	105	this study
E. Poland	24.9	370	37.5	1094	64.6	1058	57.8	439	Milkowski & Wojcik 1984

4. Acknowledgements

We wish to thank R. Giusti, C. Lovari, V. Mazzarone and N. Siemoni for their cooperation in the collection of data. F. Calovi and R. Mazzoni della Stella kindly made available further figures from the province of Siena. The study was funded by the "Comunità Montana Val di Cecina".

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MORPHOMETRICAL ANALYSIS OF TWO MEDITERRANEAN WILD BOAR POPULATIONS

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Abstract: 67 skulls of adult wild boars from an Algerian and Italian population were measured and compared. The discrimination between the two populations and between sexes was mostly based on skull size. Italian wild boars were less dimorphic than the Algerian ones, probably because they had recently crossbred with semi-domestic pigs.

Keywords: Wild boar, *Sus scrofa,* Suidae, Craniometry, Biometry, Populations, Italy, Algeria.

IBEX J.M.E. 3:69-70

1. Introduction

The aims of the present study were to compare craniometric variation in two geographically well separated populations of Mediterranean Wild boar and to evaluate sexual dimorphism within each population.

2. Methods

67 skulls of adult wild boars (more than four years old) were measured: 24 males and 27 females from the Natural Park of Maremma (Central Italy) and 7 males and 9 females from near Alger, Algeria. Ten measurements (Total length, Condylobasal length, Palatal length, Greatest frontal width, Maximum width of the skull, Height with jaws clenched, Occipital width, Mandible length, Height of mandible, Length of symphysis) were taken on each skull. The overall pattern of variation was examined using Factor Analysis (FA) computed on both the observed values and the ratio between each variable and the presumed general skull size (Total length) to remove the influence of size variation among groups from the observed values. Discriminant Analysis (DA) was employed to classify observations.

3. Results and discussion

In the FA performed on observed values the first three factors accounted for 85.4% of the total variance. The factor coefficients indicated the contribution that each character made to the discrimination of the samples and they are shown in table 1. Factor I represented skull size and all characters showed high and positive loadings on it so that size is responsible for discriminating among groups. Plot of first two factors scores showed a complete separation between males and females from Algeria, while a partial overlap occurred between males and

Table 1: Factors coefficients obtained from Factor Analysis performed on observed values.

VARIABLES	FACTORS 1	2	3
Total length	0.905	0.162	-0.184
Condylobasal length	0.942	0.035	-0.179
Palatal length	0.893	-0.154	-0.151
Greatest frontal width	0.825	0.190	-0.100
Maximum width of the skull	0.873	-0.188	-0.082
Height with jaws clenched	0.885	0.066	-0.305
Occipital width	0.744	0.495	0.220
Mandible length	0.855	-0.373	0.092
Height of mandible	0.746	0.226	0.483
Length of symphysis	0.783	-0.397	0.372
Perc. Var.	71.9	7.2	6.3

females from Maremma (Fig.1). FA computed on the ratio-transformed data produced a large overlap among all the four groups due to the removal of the variation linked to different skull size.
DA based on the observed values appeared to be better (100% for both sexes in Algeria and for the males in Maremma and 85.2% for the females in Maremma) (Tab. 2) than the one based on the ratio-transformed data.
In summary, it is mainly the growth of the skull to a greater extent, which distinguished the populations from each other and separated morphometrically the two sexes.
Sexual dimorphism was confirmed for both populations, specimens from Maremma overlapping more than specimens from Algeria. Differences in sexual dimorphism within the two populations might be related to the "history" of each group. Italian wild boars have crossbred up to 18 years ago with semi-domestic pigs (Massei & Tonini, 1991), while according to Kowalski and Kowalska (1991) the wild boars from Algeria can be regarded as pure because the breeding of domestic pigs is not common in a Muslim country.

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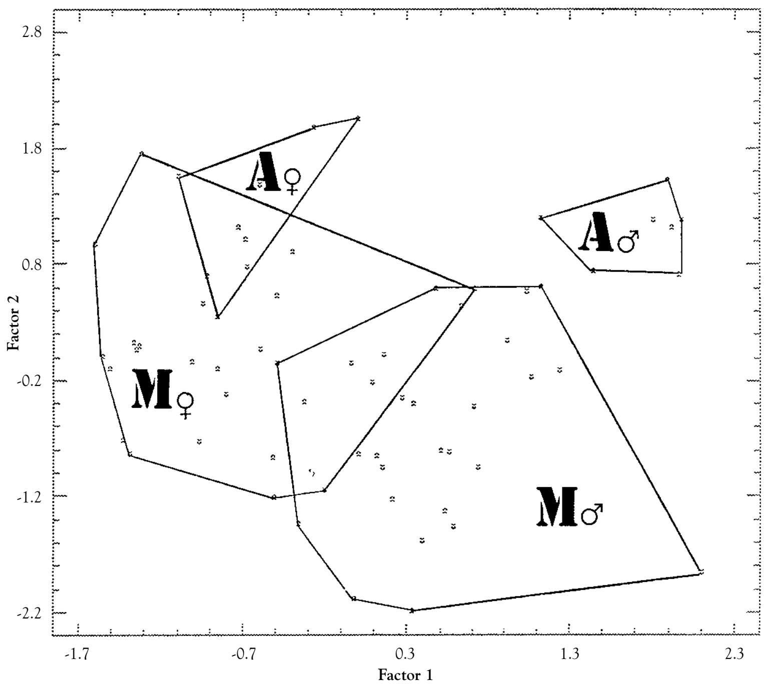

Figure 1 - Plot of the first two factors scores. A = specimens from Algeria; M = specimens from Maremma.

Table 2: Percent correct classification based on Discriminant Analysis performed on observed values. M = Maremma; A = Algeria.

DISCRIMINANT ANALYSIS Classification results				
Predicted Group	1	2	3	4
Actual Group				
1 M males	100	0	0	0
2 M females	11	85.2	0	3.7
3 A males	0	0	100	0
4 A females	0	0	0	100

GROWTH AND SURVIVAL IN PIGLETS

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Keywords: Wild boar, *Sus scrofa,* Suidae, Survival rate, Growth rate.

IBEX J.M.E. 3:71

During five years (1985 to 1991), 299 Wild boar piglets between 2.5 and 19 kg were caught, sexed, weighed, marked using eartags and released in an enclosed reserve managed by the Office National de la Chasse (Chizé, West France, 2,660 ha, Fig. 1).

The aim of our analysis was to determine whether survival rates of Wild boar piglets depend on their growth rate. We constituted 14 groups of piglets based on sex, year of birth and weight at marking.

We then analyzed for each group the relationship between growth and survival estimated using recent capture-mark-recapture-models. We found high monthly survival rates (higher than 0.85) whatever the sex, the year or the weight at marking. On the other hand, the daily growth rate was highly variable (from a loose of 10 g/*die* to an increase of 109 g/*die*). As expected from the high stability of piglet survivorship observed in this study, we did not find any relationship between growth and survival for piglets (Fig.2). These results strongly contrast with previous studies that usually report a marked positive relationship between growth and survival in young ungulates like Red deer, Roe deer or Reindeer. This suggests that Wild boar (and Suidae in general) could exhibit a different demographic tactic relatively to ruminants.

Figure 1 - Location of the study area.

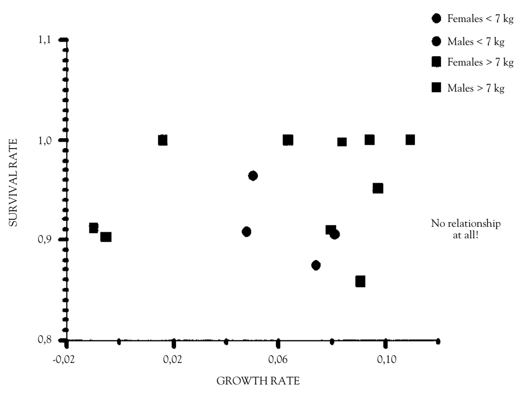

Figure 2 - Relation between growth rate and survival rate in piglets.

DRESSED VERSUS UNDRESSED WEIGHT RELATIONSHIP IN WILD BOARS (Sus scrofa) FROM ITALY

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Abstract: We have examined a sample of 176 wild boars from Tuscany (Central Italy) to investigate the relationship between eviscerated and whole weights. Regression lines were fitted, which resulted in equations enabling more accurate comparisons between data from capture and shooting.

Keywords: Wild boar, *Sus scrofa,* Suidae, Dressed weight.

IBEX J.M.E. 3:72-73

1. Introduction

As for many other Ungulates, body size and body growth of the Wild boar *Sus scrofa* are known mainly from hunting statistics, which use dressed or eviscerated weight; whole or live weights are very rare and generally result from capture. Knowing the whole weight of the animal can be useful in many cases, but becomes indispensable for studies on productivity (biomass estimates) and bioenergetics (metabolic rate calculations).

According to Briedermann (1986) the dressed weight of the Wild boar normally equals about 80% of the whole weight. From Central Europe Stubbe *et al.*(1980) and Bader (1983), with samples of only 11 and 33 individuals respectively, found a mean dressed/live weight ratio of 0.765 and 0.795. In the U.S.A., from a sample of 121 Wild boar x feral pig hybrids, Henry (1969) reported a mean value of 78.6% for dressed mass of males and 76.5% for females, also fitting two distinct regression lines. Landry (in Gaillard & Jullien, 1993) from a sample of double weights from 49 Wild boar females obtained a formula to reconstruct live weight.

There is no published data for Italy. We have investigated the relationship between dressed and undressed weights in a sample of 176 wild boars from Tuscany, Central Italy. Determining the relationship between the two kinds of weight will enable easier and more correct comparisons between data from capture and shooting.

2. Study area, material and methods

The study was conducted in different areas of Tuscany (Casentino, Valtiberina, Valdelsa, Val di Cecina) during late autumn and winter from 1988 to 1991. Animals brought to the check stations were weighed on a platform scale or a hanging scale to the nearest 0.1 kg.

The undressed or bled carcass weight is the weight of the freshly shot animal, *i.e.* the carcass minus blood and tissue loss from gunshot wounds. Here we take the undressed weight as a good approximation of the whole weight, however bleedable blood can amount to a not negligible quantity (Briedermann *op. cit.*, tab.3/1). The dressed weight is the weight of the animal without thoracic and abdominal organs ("field-dressed weight" of Langvatn, 1977).

3. Results

Whole weights ranged from 23.2 to 123 kg for males (n = 72) and from 15.5 to 97.2 kg for females (n = 104). Dressed weights ranged respectively from 18.8 to 102.3 kg and from 14.2 to 81 kg.

On average for medium-sized animals dressed weight represented 82.8% of undressed weight in males and 83.0 % in females. In other words males lost an average of 17.2% of their weight in dressing, while females averaged a loss of 17.0%: ranges were 8.7-26.7% for males and 8.4-25.7% for females. The corresponding partial-to-whole-weight conversion factors (reciprocal of dressing percentages) were 1.208 and 1.204 respectively.

Linear regression lines were fitted to the data, resulting in distinct equations for males and females. The regression lines were not significantly different in variance, slope or elevation. Combining both sexes, the dressed *vs* undres-

Table 1. Conversion chart (rounded numbers).

Dressed weight	live weight
11.8	15.0
15.0	19.0
16.0	20.0
20.0	24.9
24.5	30.0
25.0	30.8
28.7	35.0
30.0	36.6
33.0	40.0
35.0	42.5
37.2	45.0
40.0	48.4
41.4	50.0
45.0	54.2
45.7	55.0
50.0	60.0
54.1	65.0
55.0	66.0
58.3	70.0
60.0	71.8
62.6	75.0
65.0	77.7
66.8	80.0
70.0	83.6
71.0	85.0
75.0	89.4
75.3	90.0
80.0	95.3
83.7	100.0
85.0	101.2
87.9	105.0
90.0	107.0
92.2	110.0
95.0	112.9
96.4	115.0
100.0	118.8
100.6	120.0
105.0	124.6

sed weight regression was y = 1.4154 + 1.1735 x, where y is the undressed weight and x is the dressed weight (R^2 = 0.993; $F_{1, 174}$ = 23582, $p < 0.001$) (Fig. 1). The mean deviation of estimated undressed weight from the actual whole weights was 1.3 % (SD = 1.1).
If we know the whole weight, we can predict the weight after dressing by using the equation y' = -0.8784 + 0.8459x', with y' representing dressed weight and x' the undressed weight.
The internal organs account for a larger proportion of the whole weight in small animals than in larger ones: the dressing percentage estimated by the formula varies from 79% in wild boars of 18-19 kg (live weight) to 84% in individuals of 120-125 kg (see tab. 1).

4. Aknowledgements
We wish to thank C. Lovari, L. Mattioli, V. Mazzarone and N. Siemoni, who assisted us in the data collection. F. Calovi and R. Mazzoni della Stella kindly made available further weight figures from the province of Siena. The study was financially supported by the "Comunità Montana Val di Cecina".

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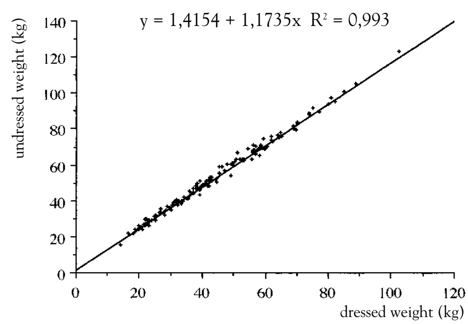

Figure 1 - Regression of undressed weight on dressed weight for 176 wild boars from Central Italy.

SENSORY INNERVATION OF THE UPPER LIP IN THE DOMESTIC PIG (Sus scrofa f. *domestica)*

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Abstract: The corpuscular sensory structures in the corium of pigs' lip are mostly represented by simple lamellar corpuscles, which occur in 3 basic variants: with the axon straight or bended, with the axon divided into branches and with division of the distal part of the corpuscle. The last two types occur only in 9.4% of cases and are also called Golgi-Mazzoni corpuscles. Glomerular sensory corpuscles occur only sporadically. Both these kinds of sensory corpuscles serve the mechanoperception and adapt rapidly.

Keywords: Domestic pig, *Sus scrofa,* Suidae, Neuroanatomy, Sensory corpuscles.

IBEX J.M.E. 3:74-76

1. Introduction

Simple lamellar corpuscles were described in different regions of the pig skin - see Malinovsky *et al.* (1982), also for review, Ortonne *et al.* (1987), Rettig and Halata (1990) and Corona *et al.* (1991). Malinovsky *et al.* (*op. cit.*) described in the pig lip skin also glomerular corpuscles.

0nly little attention was paid to variability of sensory corpuscles, to comparison with other kinds of animals and to character of glomerular sensory corpuscles. These problems became therefore the aim of our work. In accordance with Malinovsky (1990) we refuse the term "nerve ending" as each sensory structure represents a structural system formed by several subsystems. The same concerns the term "receptor" which is used in modern biology for binding capacities on the cells' level. Therefore the above author proposed the new term "sensory nerve formation - SNF".

2. Material and Methods

The sensory innervation of the upper lip of the domestic pig was studied in 5 adult individuals. Nervous structures were demonstrated using silver impregnation according to Bielschowski - Gross - Lawrentyev for light microscope; for electron microscopic examination the material was firstly fixed in glutaraldehyde and then processed in the usual way.

3. Results

In the epidermis simple SNF were found. In the corium occure subepidermal arborizations of nerve fibres, numerous lamellar sensory corpuscles and sporadic simple glomerular corpuscles (Fig. 1).

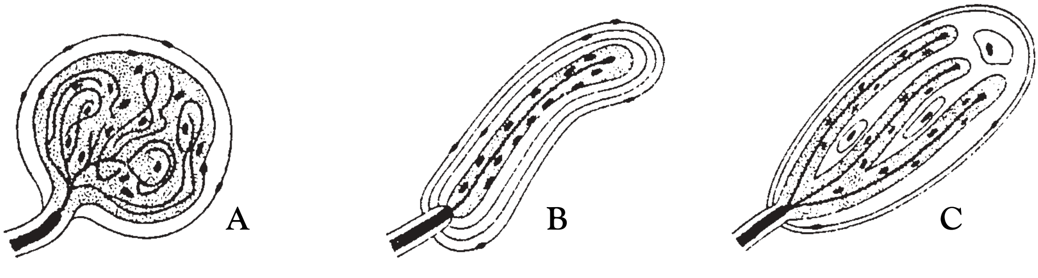


Figure 1 - Glomerular (A), simple lamellar (B) and Golgi-Mazzoni (C) sensory corpuscles.

Lamellar sensory corpuscles occur in 3 basic variants: a) with the axon straight or bended (90.5% of cases); b) with axon divided into 2 or several branches (9.0%) and c) with division of the distal part of the corpuscle (0.4% of cases). The axon or its branches are always situated within the inner core, formed by several lamellae of modified Schwann cells. The surface of the corpuscle is covered by a relatively thin capsule. The ultrastructural examination confirmed the usual structure of simple lamellar corpuscles only with a greater amount of thick collagenous microfibrils in the interlamellar spaces.

Glomerular sensory corpuscles were found only sporadically. One or two axons enter the corpuscle and form inside it a ball - like (glomerular) formation. The capsule is very thin. The electron microscope proved that these corpuscles are formed by accumulation of dendritic zones and irregularly arranged modified Schwann cells. The capsule is formed only by several perineural lamellae.

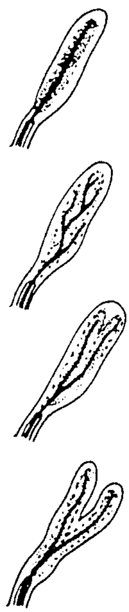
4. Discussion

The results demonstrate morphological variability of lamellar sensory corpuscles (Krause cylindric end - bulbs) and Golgi-Mazzoni corpuscles as a variety of the first group. In comparison with the goat's lip skin (Malinovsky & Matonoha, 1968) and with cat's lip skin (Malinovsky, 1966b) there occurs a smaller amount of Golgi-Mazzoni corpuscles in the pig's skin (Fig. 2). This difference could be connected with different function of the upper lip in the pig in comparison with that in the goat and in the cat in which the upper lip is more used as a touch organ. Ramification of the axon, of the inner core and of the whole corpuscle is probably joined with an enhanced touch perception. In cat's foot-pads a still greater amount of Golgi-Mazzoni corpuscles was found (Malinovsky, 1966a).

Ortonne *et al.* (*op cit.*) think that lamellae of the inner core are of the same origin as those of perineural cells forming the capsule and correspond to the epithelial cells. This view is in a strong contradiction with all other works concerning the origin of both kinds of these cells.

The glomerular sensory corpuscles are less frequent in non-primate mammals (Malinovsky *et al.*, 1993); the simple lamellar and Golgi-Mazzoni corpuscles are less frequent in Primates, in which the glomerular corpuscles of different varieties prevail.

Both these kinds of sensory corpuscles are therefore commonly considered as equivalent structures serving the mechanoperception. While for simple sensory corpuscles and Golgi-Mazzoni corpuscles a rapid adaptation was proved, the adaptation velocity of the glomerular corpuscles was not stated till now. Notwithstanding with regard to their structure a rapid adaptation of these corpuscles can be anticipated, too.



PIGS lip	GOAT lip	CAT lip	CAT foot pads
90.5	80.4	82.1	51.4
9.0	17.9	16.8	37.2
0	0.4	0.3	2.3
0.4	0.7	0.6	4.1

Figure 2 - Comparison of variability of lamellar corpuscles in the upper lips of the pig, the goat and the cat and in foot pads of the cat. The numbers indicate the occurrence percentage. The rest to 100% is represented by other types of corpuscles.

In the pig lip skin no Meissner corpuscles were found. The only described finding by Dubreuil (1937) probably was a glomerular sensory corpuscle described by us.

Ortonne *et al.* (*op. cit.*) described in deep layers of epidermal ridges of pig snout skin numerous Merkel cells. Rettig and Halata (*op. cit.*) found in the epithelial pegs of the anal canal Merkel complexes associated into groups (more than 200 complexes). The hair follicles are innervated by simple SNF, Ruffini SNF, Merkel complexes and hair bulbs.

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THE INTESTINAL TRACT AND THE PEYER'S PATCH DIMENSIONS OF WILD BOARS (Sus scrofa L., *1758) AND DOMESTIC PIGS (Sus scrofa* f. *domestica). AN ALLOMETRIC COMPARISON*

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Abstract: Since about 10,000 years process of domestication has led the domestic pig to become strongly dissimilar from its ancestor, the Wild boar. This affected structure and physiology of nearly all organs. This paper deals with a comparative study about intestine and Peyer's patch (important elements of the Gut Associated Lymphoid Tissue) in Wild boar and domestic pig. Small intestine of domestic pig is consistently more developed and Peyer's patch even more. Implications and causes are discussed.

Keywords: Domestic pig, Wild boar, *Sus scrofa,* Suidae, Intestine, Biometry, Lymphoid tissue, Domestication, GALT.

IBEX J.M.E. 3:77-82

1. Introduction

It is well substantiated that the domestic pig descends from the Wild boar. Archaeological and palaeozoic findings demonstrate that the process of domestication began during the neolithic revolution about 10,000 years ago. Small groups of individuals were separated and lived in sexual isolation from their wild forms. Over generations an adaptation to the conditions of household occurred. A directed selection by man took place and numerous large stocks were formed. Races originated that show an abundance of hereditarily directed possibilities of development. As a result the domestic pig is getting more and more dissimilar from its ancestor. Changes concern the anatomy and physiology of nearly all organs as well as the animal behaviour (Herre & Röhrs, 1990).

Domestication which is a model of directed evolution (Storch & Welsch, 1989), gives insights as how to selection works. In order to find out the causes and mechanisms that effect these changes, primarily the question has to be answered whether an organ change occurs in the domestic form. Allometric techniques are useful tools for characterizing the size differences of organs between wild and domestic forms. The aim of the present study is to find out whether the intestinal tract and the Peyer's patches are affected by the process of domestication.

Peyer's patches (PP) are important elements of the Gut-Associated Lymphoid Tissue (GALT). The GALT is of importance for the installation of local and secretory immunity as well as for the induction of systemic tolerance (Mouwen *et al.*, 1983; Egberts *et al.*, 1984, 1985; Kagnoff, 1987; Pabst, 1987; Nagura & Sumi, 1988).

2. Material and methods

The gut of 22 domestic pigs of the German Landrace and 29 wild boars of different sex and an age of 3 months to 6 years were studied. The animals were weighed without gastrointestinal tract and abdominal organs, but with body fat and coat (= net body weight). The estimation of the age was made by use of the tooth development or abrasion (Heck & Raschke, 1980; Briedermann, 1990). The female animals were not pregnant or lactating. Intestinal tracts of the domestic pigs were obtained from the slaughterhouse, those of the wild boars were immediately prepared after shooting. After intraluminal fixation with buffered formol after Lillie (1954) the total intestine remained in the fixative till further processing. The intestine was cut into its parts and measured without stretching using a linear scale. The separation of intestinal parts occurred as follows: the small intestine reaches from pylorus to ostium ileale, the caecal length extends from ostium ileale to apex caeci, the colon begins at the junction to the caecum and ends at the canalis analis. Circumferences were taken in order to calculate the volume and surface area by use of the mathematical formula of the cylinder. This was done at each position of the small intestinal

PP, at the site where the caecum has its largest cross-section and every 10 cm along the colon + rectum.

The small intestine was opened along the mesenteric fastening in order to visualize the aggregated lymphoid follicles. Their lymphoid follicles could clearly be differentiated because they partly displace the muscles and approach the serosa. Only Peyer's patches of the duodenum and jejunum (DJPP) were studied, because the ribbon-like PP of the ileum involute during ontogenesis (Carlens, 1928; Binns & Pabst, 1988; Pabst *et al.*, 1988). The DJPP outlines were transferred to transparent foil and the area enclosed by the line was calculated with an image analyzing computer (Videoplan, Kontron). Additionally, PP were cut out and weighed (Sartorius 1219 MP). All measurements were made under the same conditions.

Without specifying the statistical methods applied, the present organigram (Fig. 1.) shows a succession of steps. The data have to fulfil the conditions demanded at each step in a hierarchical way. A methodical description of the bivariate analysis can be found in Rempe (1962). The calculations were made with the statistical program DIVA (Plogmann, 1990).

3. Results and discussion

Figure 2 shows the relation between dimensions of the total intestine and the net body weight of both the domestic pig and the Wild boar. The data are presented in a double-logarithmic system. Using bivariate analysis the regression lines of the two data groups compared run parallel and their positions differ significantly from each other. The regression lines represent the elliptic major axis, the ellipse defines the level of confidence at $p< 0.05$. Thus the relation of the intestinal values to the body weight is identical in the domestic pig and the Wild boar but they differ in quantity. The distance of the domestic pig regression line to the regression line of the Wild boar can be expressed as percentage in relation to the data of the Wild boar.

As a result the total intestine of the domestic pig is 27.7% longer, has a 27.8% larger surface area, a 28.4% greater volume and is 35.6% heavier than that of the Wild boar.

The allometric comparison of the different

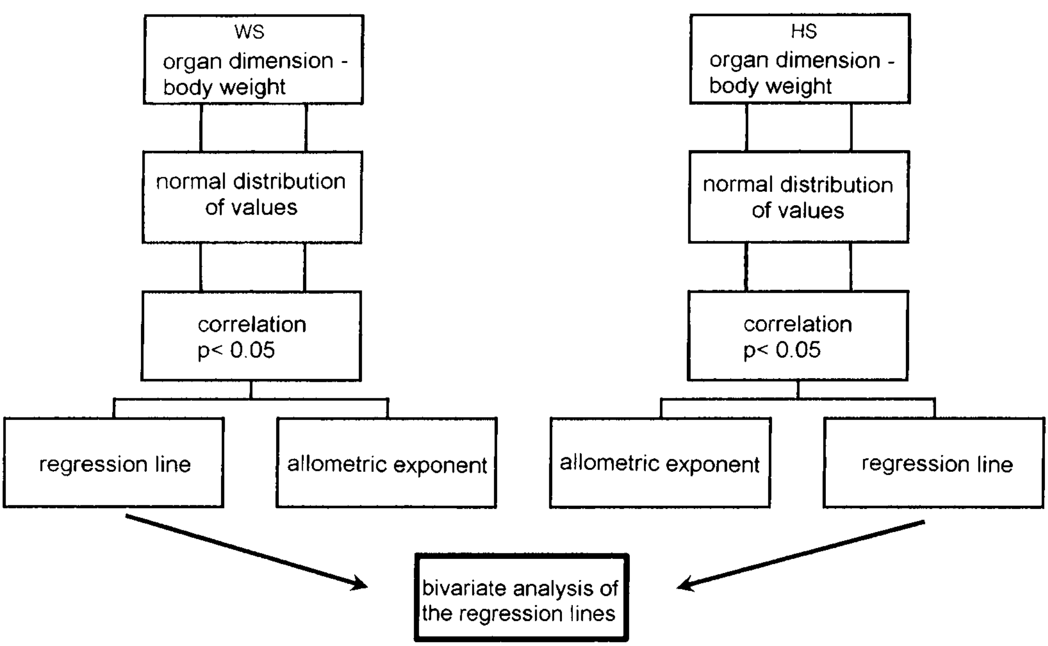

Figure 1 - Succession of steps of data analysis.

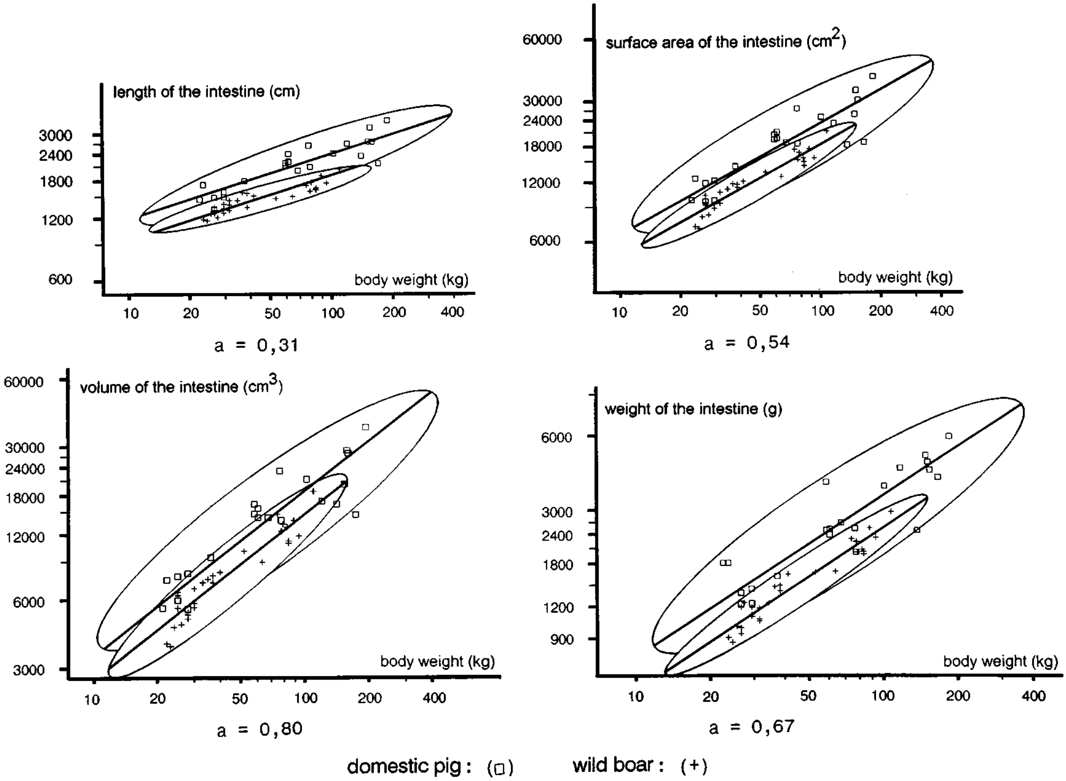

Figure 2 - Relation between the length, surface area, volume and weight of the total intestine and the net body weight of the Wild boar and domestic pig in a double-logarithmic system. The ellipse defines the level of confidence $p < 0.05$.

parts of the intestine clearly shows that the increase of dimensions in the total intestine depends exclusively on the change in the small intestine (Fig.3). As described for the total intestine both regression lines have the same rise but differ in location. By comparison the domestic pig has a 39.1% longer small intestine, its surface area is 43.2% larger, the volume is 45.7% larger and 53.5% heavier than the corresponding values of the Wild boar.
Differences regarding the dimensions of the caecum and colon + rectum could not be found. The regression lines have the same rise but reveal no significant difference in position.
The increase of small intestinal dimensions does probably not originate from a modification but from hereditary changes during domestication.
Various experimental studies show that an increase of the body growth rate cannot be achieved by an artificial enlargement of the small intestinal surface area by feeding fibrous food (Hessling, 1921; Haesler, 1930 Mangold, 1950; Wussow & Weniger, 1954; Weniger, 1956; Petersson *et al.*, 1979; Kuan *et al.*, 1983).
Accepting the premise that an increase of organ dimension is linked with an increase of function it can be stated that the intestine of the domestic pig digests and absorbs more food than that of the Wild boar. This is not surprising because the growth rate and the increase of body weight in the domestic pig are considerably greater than in the wild form. Within six months the domestic pig reaches a body weight of about 100 kg (Handbuch Sauen, 1986), a young boar at nearly the same age, however, weighs about 35 kg. This can only be achieved in the tissue of the domestic pig when the high protein biosynthesis correlates with a high rate of digestion and absorption at the site where

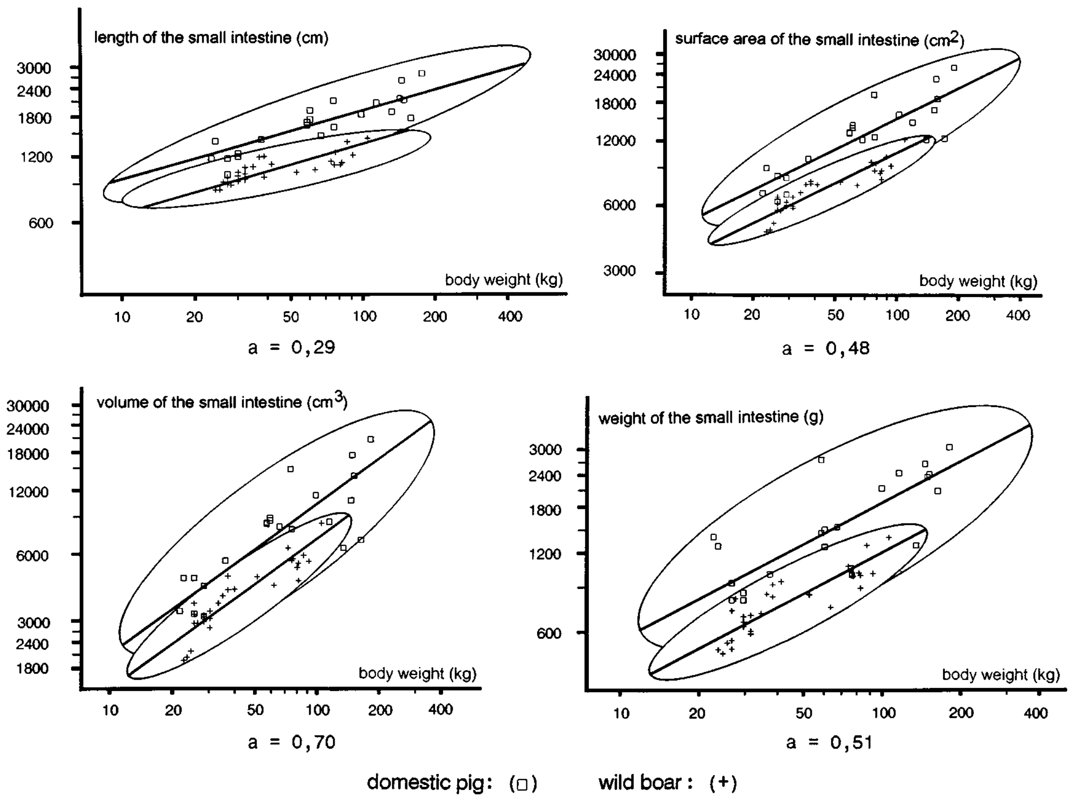

Figure 3: Relation between the length, surface area, volume and weight of the small intestine and the net body weight of the Wild boar and domestic pig in a double-logarithmic system. The ellipse defines the level of confidence $p < 0.05$.

intake of food takes place. Additionally, the different kinds of energy metabolisms have to be considered in order to explain the increase of small intestinal dimensions in the domestic pig. The basal metabolism is obviously greater in the Wild boar than in the domestic pig [Wild boar of 100 kg body weight: ca. 16,800 kJ/24h (Jezierski & Myrcha, 1975), domestic pig of 100 kg body weight: 5446 kJ/24h (Püschner & Simon, 1973), 7980 kJ/24h (Kolb, 1989)]. Considering the extremely different ways of life, which are on the one hand the continuously changing conditions in the wild and on the other hand the directed and monotonous life in modern animal husbandry, it can be assumed that the maintenance metabolism of the wild form exceeds that of the domestic form. The maintenance metabolism includes the basal metabolic rate, the energy cost of digestion and assimilation, the cost of thermoregulation and the cost of activity (Gordon, 1982).

The findings can be summarized as follows: the domestic pig digests and absorbs more food than the Wild boar by elongation of the small intestine and enhancement of the intestinal surface area. The digestive processes probably occur more slowly and more continuously and with a smaller expense of energy, but provide more substances for an intensive protein biosynthesis than this comes true for the Wild boar. The shorter small intestine of the Wild boar, which has a smaller surface area but significantly greater basal and maintenance metabolism, must consequently have a higher metabolic activity. Moreover, the physiology of the small intestine has to adjust to a quantitatively and qualitatively different food-supply that demands a permanent readiness in digestion and absorption.

The comparative evaluation of Peyer's patch dimensions in the domestic pig and the Wild boar revealed unexpected findings. In the domestic pig the PP surface area is 108.6% larger and the PP weight is 136.5% heavier than in the wild form. The reason why these changes occur in the domestic pig is still under debate. It is highly probable, however, that these changes are genetically fixed. Postnatal studies showed that the number and location of PP remain the same even when the animals grow older (Kawanishi & Kiely, 1989; Rothkötter & Pabst, 1989; Owen & Ermak, 1990). By allometric comparison of the PP dimensions with the corresponding intestinal dimensions it can be shown that the increase of PP dimensions exceeds the increase of intestinal dimensions. Thus the enlargement of the PP is not simply an adaptation to an enhanced intestinal surface area.

My interpretation of these findings is as follows: only the fittest pigs were selected for breeding. Pigs that could not endure the unnatural conditions of husbandry suffered from stress (Ewbank, 1970). Being well known that pigs fall ill under stress such individuals were excluded from further breeding. It is generally accepted that stress causes an involution of lymphoid tissue which is probably the cause for an enhanced susceptibility to diseases (Golub & Gershwin, 1985; Abraham, 1991; De Giorgi & Altomare, 1992). Therefore it is very probable that those pigs were selected for breeding which contained more lymphatic tissue and thus were able to build up a stronger immune defence.

Summarizing the present findings it can be stated that in the domestic pig the dimensions of the small intestine as well as the dimensions of the Peyer`s patches changed during the process of domestication.

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