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

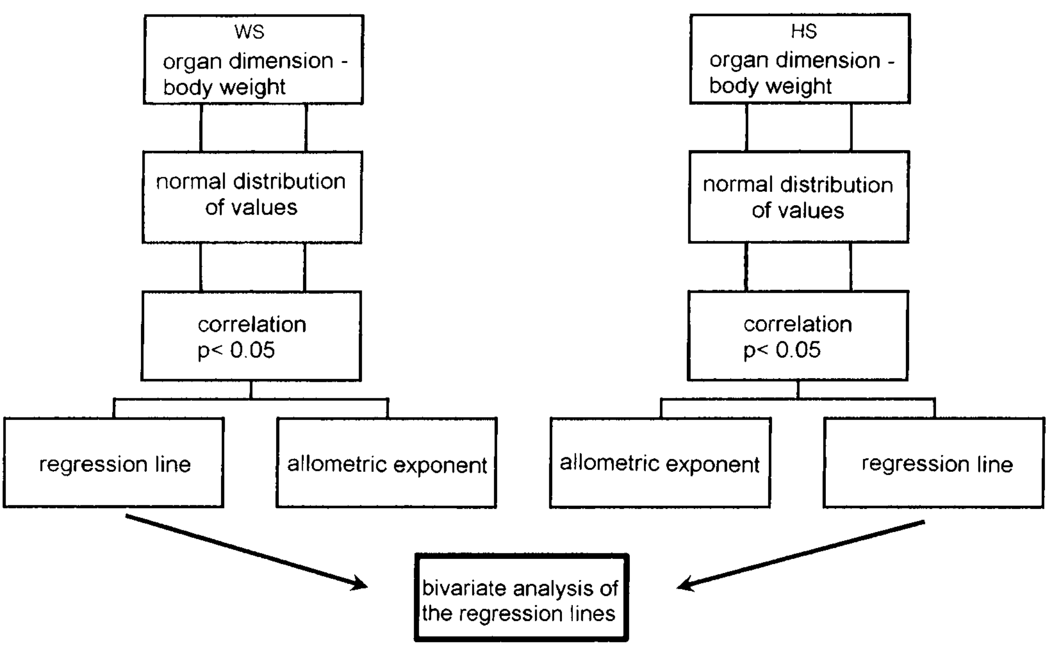

Figure 1 - Succession of steps of data analysis.

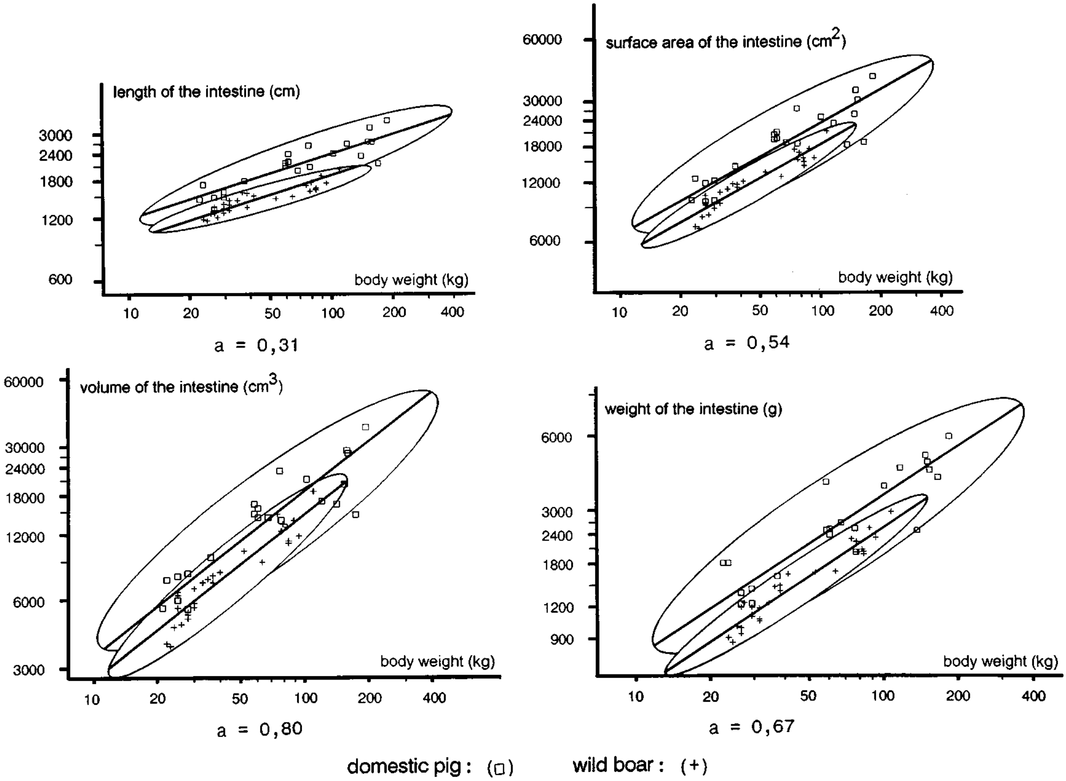

Figure 2 - Relation between the length, surface area, volume and weight of the total intestine and the net body weight of the Wild boar and domestic pig in a double-logarithmic system. The ellipse defines the level of confidence $p < 0.05$.

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

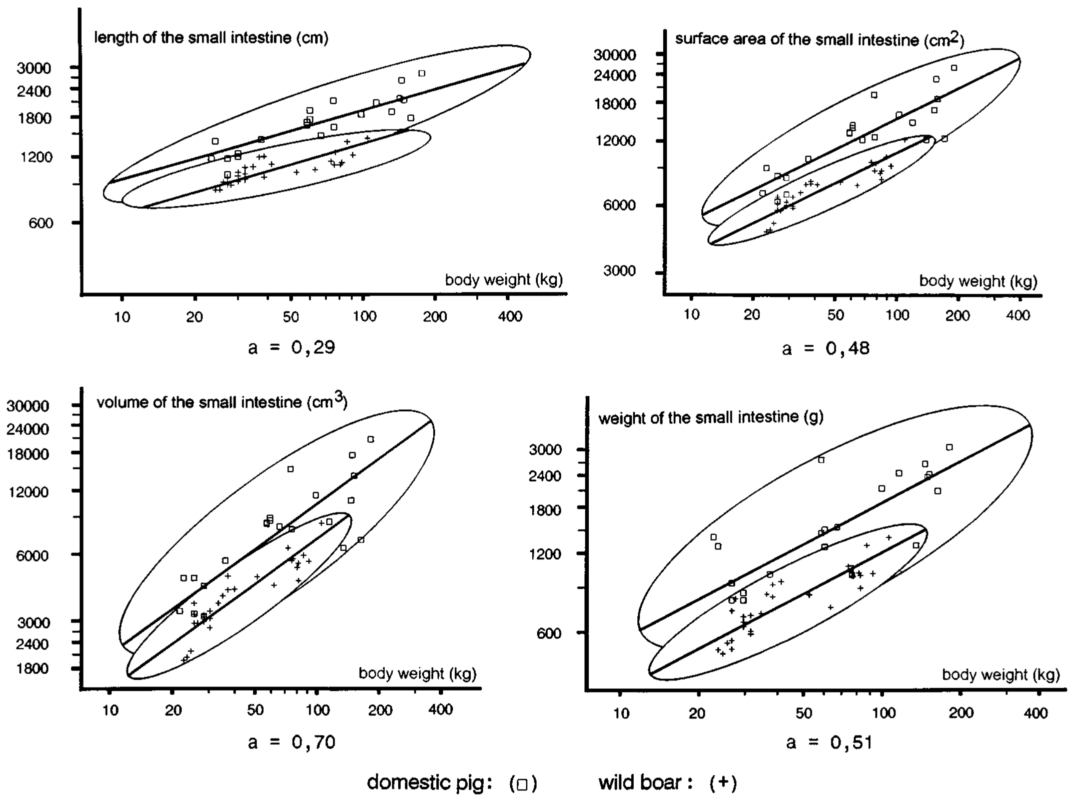

Figure 3: Relation between the length, surface area, volume and weight of the small intestine and the net body weight of the Wild boar and domestic pig in a double-logarithmic system. The ellipse defines the level of confidence p <0.05.

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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