ESTIMATION OF MUSCLE/BONE RATIO OF HAM FROM CONFORMATION MEASUREMENTS

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INTRODUCTION

It does exist in pig a great variation in the carcase conformation which greatly affects its shape, mainly at the level of the hind limb (ham). This variation has been more or less considered in pig buying procedures of the different countries and the question to know which importance must be given to conformation is largely still not answered. The relationships existing between conformation and composition have been studied for many years but mainly for practical purposes, and without sound biometrical basis. This situation can be explained to a great extent by the difficulties involved in the quantification of the variation of conformation. It is clear that if photographic standards may provide a valid basis to define scales for conformation assessment in pig carcase grading scheme, the objective assessment of conformation by some appropriate measurements is more difficult, and, finally, has been poorly explored up to know.

This paper presents the results obtained in one study of the relationships between :
1) the variation of the ham conformation, measured from the values of some transverse apparent diameters,
2) the relative composition of ham, expressed by the muscle/bone ratio.

MATERIALS AND METHODS

Sixty five pigs of three sexual types [(entire male (N=44), castrated male (N=5), female (N=16)] and four breeds [(Landrace Belge (N=7), Landrace Français (N=14), Pietrain (N=15) and Large White (N=39)] were used in this study. Twenty four hours after slaughter, left half-carcases were photographied in standardized conditions and two views were considered [(dorso-lumbar (D) and internal medium (M)], carcases being hung vertically by the Achilles' tendon. The photographs were Kodacolor diapositives.Carcases were then cut according to the French research normalized system (OLLIVIER, 1970) and the left ham was dissected by using the method of MESLE *et al* (1959). From the individual anatomical data obtained the sum of the bones (B) and muscles (M) present in the ham and the muscle-to-bone ratio (M/B) were calculated. Table 1 gives the statistical parameters of the population studied for the weights of ham, M and B and for M/B ratio.

Table 1

	Mean	C.V.%	min	max
Ham weight (g)	7597	15.99	5490	10290
Muscle weight (g)	5323	18.84	3644	7496
Bone weight (g)	641	15.70	415	949
M/B ratio	8.41	19.76	6.05	12.74

The diapositives of the photographs were then projected on a screen by considering successively the two views (Fig.1). The medial view was projected so that CS=25 cm (C=apparent calcaneum tuber, S=cranial edge of the symphysis pubis). The outlines of the ham and the symphysis pubis were drawn with a sharp pencil on a sheet of drawing paper covering the screen.

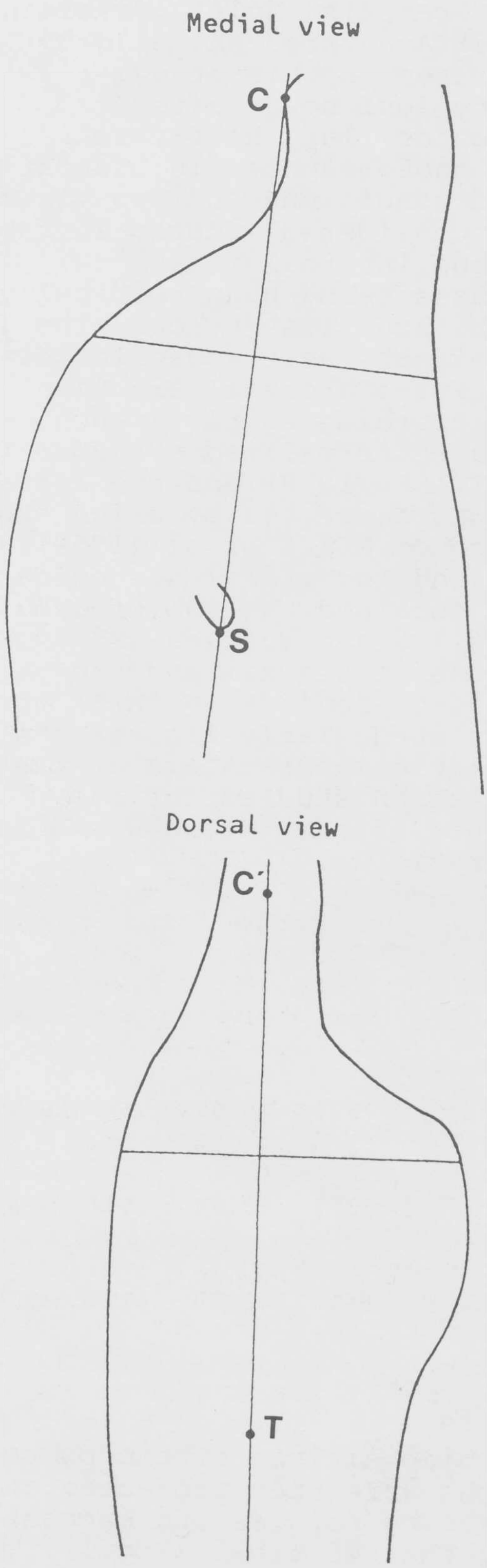

Figure 1

Then the dorsal view was projected without changing the conditions and again the outline of the ham was drawn. The apparent calcaneum tuber in that view (C') was also positioned and the vertical hanging axis of the carcase passing through C' was drawn. On that axis the point T such as C'T=25 cm was located.

On the drawings of the two views the width of hams was obtained by measuring the transverse apparent diameters (TAD), at right angles to the two reference axes, CS and C'T respectively. Twenty six measurements (M0, M1...M25) were thus made from the TAD passing through C(M0) to the TAD at the level of S (M25), each TAD being equally distant along CS.The same procedure was followed for the dorsal view, for which 26 measurements were also considered from C' (D0) to T (D25). The TAD which has been drawn in Fig 1 refers to the levels M12 and D12.

The statistical treatment involved the calculation of mean and standard deviation of the different widths and their correlations with M/B ratio. Using the multivariate analysis of centered data (LEFEBVRE, 1976) the interrelations between variables were studied to find the most discriminating widths as M/B ratio differences were concerned. At last a multiple regression analysis was performed to set the part of variation of the M/B ratio explained by various combinations of the most interesting variables.

RESULTS

The mean and coefficient of variation of the width measurements are given in Table 2 where are also shown the values of the correlation coefficients between the M/B ratio and the different widths.

One can see that the variation of width is larger in dorsal

Table 2

level	TAD mean	TAD c.v.%	r with M/B
M0	7.18	6.72	0.147
M1	7.42	6.01	0.184
M2	7.42	5.55	0.201
M3	7.38	5.69	0.205
M4	7.45	5.71	0.181
M5	7.66	5.69	0.309
M6	8.19	8.30	0.512
M7	9.24	11.61	0.568
M8	10.60	11.63	0.670
M9	11.86	11.77	0.726
M10	13.08	11.81	0.743
M11	14.24	11.39	0.749
M12	15.33	10.56	0.757
M13	16.36	9.56	0.757
M14	17.34	8.60	0.734
M15	18.22	8.05	0.705
M16	19.01	7.74	0.672
M17	19.62	7.49	0.625
M18	19.99	7.23	0.576
M19	20.13	7.02	0.519
M20	20.18	6.91	0.429
M21	20.49	6.38	0.236
M22	21.08	5.94	0.064
M23	21.50	5.95	0.034
M24	21.84	6.53	0.026
M25	21.98	6.97	0.035
D0	4.66	9.36	0.167
D1	4.80	9.48	0.218
D2	4.95	9.42	0.218
D3	5.18	9.59	0.229
D4	5.50	10.99	0.301
D5	5.99	12.91	0.393
D6	6.66	16.63	0.494
D7	7.83	21.77	0.619
D8	9.32	22.52	0.695
D9	10.70	21.08	0.739
D10	11.90	18.27	0.768
D11	12.88	15.74	0.779
D12	13.67	13.46	0.783
D13	14.28	11.92	0.796
D14	14.70	10.82	0.809
D15	14.88	10.51	0.824
D16	15.03	10.39	0.816
D17	15.09	9.92	0.800
D18	15.01	9.74	0.782
D19	14.73	9.99	0.754
D20	14.33	10.37	0.747
D21	13.98	10.26	0.719
D22	13.59	10.15	0.689
D23	13.31	9.77	0.669
D24	13.13	9.40	0.648
D25	12.97	9.36	0.623

view and also that it is very different along the two reference axes. It is maximum for D between D7 and D10 an for M between M9 and M12.

The relationships with the M/B ratio are also different from one view to the other and vary largely according the levels. Correlations are > 0,6 from D7 to D25, with a maximum (r⩾ 0.80) between D14 and D17. But in medial position correlations > 0.6 are restricted to a short area of the ham (M8 to M17) and the maximum (D12) is only 0.757.

The analysis of the centered data of the 26 widths in relation with the M/B ratio is shown in Fig 2 and 3 where are projected the variables in the plane defined by the two first axes, respectively for the dorsal and medial views. In Fig. 2 the widths of TAD at the different levels (D0,D1,...D25) are represented by a,b,...z. In Fig. 3 the different widths (M0,M1...M25) are represented by A,B,...Z. For D view, where the two first axes explained respectivly 58.58 and 26.01 per cent of the variation it is clear that it exists a strong opposition between some groups of variables, on one hand, along the first axis, between variables D7,D8,D9 and all the others,and along the second axis, between the widths of the distal part and those of the proximal part of the ham.

M/B ratio is not asociated with the separation of the other variables along the first axis, but it is a major variable of the second axis. This suggests, particularly, that M/B ratio is determined by the opposition between the variables of the proximal and distal parts of ham and that its variation is specially associated with that of the ratios of some widths, as D10/D3 ratio.

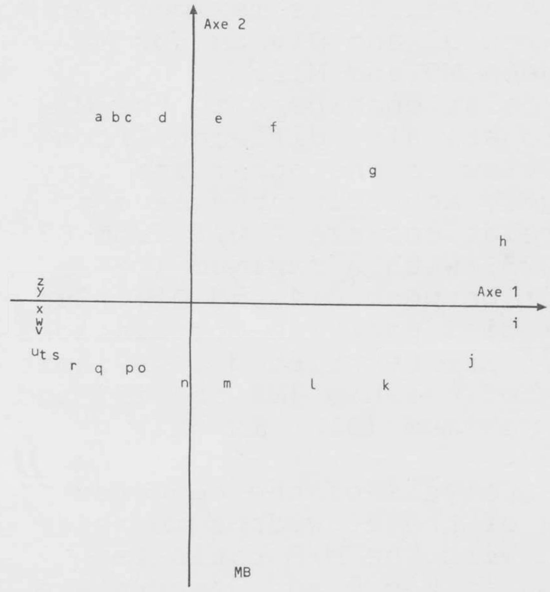

Figure 2

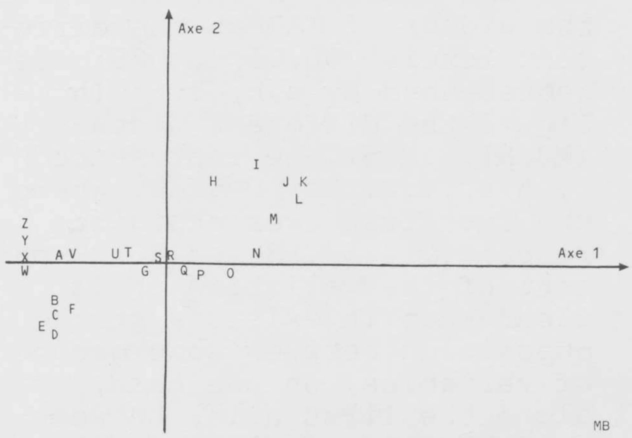

Figure 3

Looking at M view (Fig 3) it is clear that M/B ratio acts as a major discriminant variable along the two axes, but mainly along the first one (63.4 p cent of explanation), and at a lesser extent along the second one (11.27 p cent explanation). In these conditions, one must hope that the ratios of the widths at M9, M10, M11 to the widths the most distant along the axes are strongly correlated with M/B ratio. One find, in fact, that among the nine possible ratios the values of the correlation coefficient are all ⩾ 0.84, the higher correlation being found with the ratio M9/M24.

From these observations one may calculate which type of associations between variables could be suggested to obtain the best estimation of the M/B ratio. Table 3 gives thus for some individual variables and their association the percentage of the variation of the M/B ratio they explained.

Table 3

Variables	% explanation
M12	0.573
D15	0.678
D15,D12	0.691
D15, (D10/D3)	0.753
(M9/M24)	0.762
M12, (M9/M24)	0.768
(M9/M24) (D10/D3)	0.831
D15,M12, (D10/D3), (M9/M24)	0.846
(M9/M24), (D10/D3), D15	0.846

DISCUSSION

The measurement of transversal apparent diameters of the ham considered at a constant length as it was suggested by previous work for the dorsal view (DUMONT *et al*, 1980) provides a simple and objective method to study the variation of its morphology and to analyze the observed variability existing between animals.

It appears that this variation is not uniform at the different

anatomical levels (from the distal to the proximal parts of the ham) and, thus, one cannot pass, from one ham into another, only by a simple mathematical transformation (like a similarity, e.g.).
It is also very important to note that the levels of variation of TAD which corresponds to the best measurements of the "conformation" (i.e. from M7 to M11 and from D7 to D9) are located at the third distal part of the ham and do not absolutely correspond to those levels for which the correlation with the M/B ratio is maximum. One may thus consider that conformation and fleshiness are not strictly dependent and, then, must be measured and assessed by independent methods.
From the projection of the individuals - which is not presented here for lack of space - one may also conclude that the hams differ by many of the ratios of their TAD at different levels. Thus the differences in ham morphology are very subtle and, in the sample considered here, could be probably explained by the differences due to both breed and sex. The possibility of identification of sex (or breed) through the values of the ratios of TAD might then be considered in further studies.
The best estimation of M/B ratio is given by the following equation :

16.087 (M9/M24)+1.363(D10/D3) +0.236 D15-6.959

which explains 84.6 p.100 of the variation of the M/B ratio (F=111.444).
This equation could be used to select groups of hams on the basis of their expected M/B ratios, especially in the case of carcase evaluation in any progeny-test programme in selection scheme in breeding.

CONCLUSION
This study shows the interest of considering the variation of the relative morphology at various anatomical levels. It is thus suggested that further studies might consider other planes of examination and the different types of transverse diameters, from the proximal to the distal part of the hindlimb. One can suppose, in effect, that the complete scanning of ham in three dimensions could be easily assessed in the future by video-systems on the slaughter line and thus be used to classify pork carcasses, both for conformation and for fleshiness. The interest given to M/B ratio is justified not only because it is one of the determinant of the percentage of muscles in ham - and thus varies greatly between animals (DUMONT, 1989) - but also because its variation is closely related to muscle biochemical characteristics and, from that, to the variation of meat quality (BOUSSET and DUMONT, 1983). *

REFERENCES
Bousset, J. & Dumont, B.L. (1983):
Interrelations entre quelques caractères physico-chimiques de muscles de porcs Piétrain de conformation différente. Journées Rech. Porcine en France, 15, 225-232.

Dumont, B.L. (1989) :
Note sur la variation du rapport muscle/os du jambon de porc. Journées Rech. Porcine en France, 21, 387-392.

Dumont, B.L., Schmitt, O, Boulleau, T. (1980) :
Proposition d'une méthode de mesure objective de la conformation du jambon de porc. Journées Rech. Porcine en France, 133-138.

Lefebvre, J. (1976) :
Introduction aux analyses statistiques multidimensionnelles, Masson édit. Paris, 219 pp.

Meslé, L., Giron, J., Dumont, B.L.(1959) :
Anatomie et composition chimique du jambon. 5ème Réunion des Instituts de Recherches sur les Viandes. Paris, 19 pp.

Ollivier, L.(1970) :
L'épreuve de la descendance chez le porc Large-White français de 1953 à 1966. I-Analyse de la variation. Ann. Génét. Sél. anim., 2, 311-324.

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