BONE MINERALIZATION AND BODY COMPOSITION OF NEWBORN CROSSBRED AND PUREBRED CALVES USING DUAL ENERGY X-RAY ABSORPTIOMETRY (DXA)

A. Scholz[2], S. Nüske[2], P. Soffner[1] and M. Förster[1]

Ludwig-Maximilians-University Munich, Veterinary Faculty,
[1]Institute of Animal Breeding, Veterinärstr. 13, 80539 Munich, Germany
[2]Experimental Farm Oberschleißheim, Hubertusstr. 12, 85764 Oberschleißheim, Germany

INTRODUCTION

This study was performed in the context of a crossbreeding program with cattle of the dairy breed German Holsteins and the two-purpose breed (milk and meat) German Fleckvieh (Simmental) at the Experimental Farm Oberschleissheim of the University Munich. Since German Fleckvieh cows are more robust and have less health problems (udder and legs) than German Holsteins in an automatic milking system with free cow traffic (Scholz *et al.*, 2001a, b), one question was, if already the newborn F1 crossbred calves of these two breeds would show an advantage in bone stability (and body composition for meat production) over their parent breeds. The data were acquired by using dual energy x-ray absorptiometry (DXA), which is a relatively new method for the measurement of bone mineralization and body composition in livestock (Mitchell and Scholz, 2001). The principle of DXA is based on the different x-ray attenuation of different body tissues. Thus, the whole body or body regions (claws: Nüske *et al.*, 2002) can be analyzed for bone mineral content (BMC, g or %), bone mineral density (BMD, g/cm²), and for the content of fat tissue (DXA Fat, g or %) or lean tissue (DXA Lean, g or %). In this study the bone mineralization and composition of the whole body of female and male calves was compared among the four different breeding types: [German Holsteins -- DH], [German Holsteins | x German Fleckvieh ~ -- DH-FV], [German Fleckvieh | x German Holsteins ~ -- FV-DH], and [German Fleckvieh -- FV] during growth from birth (≥ 4th day of life) until 50th day of life. In addition, the study was aimed at the assessment of DXA for the measurement of early bone mineralization and body composition under the aspect of genetic evaluation of different breeding lines in cattle.

MATERIAL AND METHODS

Beginning at day 4 post partum, we performed three DXA scans using a GE LUNAR DPX-IQ® scanner (Fig. 1) with a three week interval. Totally, 31 male (m) and 32 female (w) calves from the two breeds DH and FV, and of the two F1 sublines DH|FV~ or FV|DH~ were analyzed under light sedation with Xylazin (Rompun® 2 %) [1.5-2.5 ml/100 kg body weight -- BW, i.m.] (Tab. 1). The calves originate from the matings of 4 DH sires and 5 FV sires with totally 29 DH and 25 FV cows or heifers (1st–6th lactation; 1 FV cow with 1 calf in 4th and twins in 5th parity). Among all calves were 12 twins (from 6 twin births), and 3 calves originated from a triple birth. With exception of one twin birth, all multiple births originated from FV cows. Up to the 7th day of life, all calves were fed individually colostrum (4 – 6 l) and housed in single calf boxes on straw mats under outside conditions. From day 8, calves were housed in groups on straw in a cold stall. They received -- age-dependent -- milk replacer over an automatic milk feeder (Westfalia®). In addition, they received (*ad lib.*) hay, corn (whole kernels) and on-farm produced concentrate (pelleted) consisting of 28.7 % winter wheat, 42.3 % oat, 28 % soybean meal and 1 % mineral mix (~0.25 kg/calf and day).

Table 1. Number of calves within measurement, genetic origin and gender

	Measurement 1 (MEAS1: ~6 days p.p.)	Measurement 2 (MEAS2: ~28 days p.p.)	Measurement 3 (MEAS3: ~50 days p.p.)
DH:	12	9	5
DH| FV~ :	22	19	9
FV:	11	9	7
FV| DH~ :	18	15	10
male	31	24	15
female	32	28	16

Data analysis was performed using the GE LUNAR® DPX-IQ software (vers. 4.7c) and the following General Linear Model (Proc GLM, SAS 8.1):

$$Y_{ijklmn} = O_i + G_j + M_k + L_l + B_m + e_{ijklmn}$$

Y_{ijklmn} = Observation
O_i = Genetic Origin (i=1-4)
G_j = Gender (j=1-2)
M_k = Number of Measurement (k=1-3)
L_l = Number of Lactation (l=1-5)
B_m = Multiple Birth (m=1-2)
e_{ijklmn} = Error.

Alone whole body results were considered in this analysis. Lactation numbers 5 and 6 form one joint class. The fixed effect "Multiple Birth" was divided into two classes "twin or triple" and "single". Figures 2-7 contain Least Squares Means and corresponding Standard Errors. The significance level was set for $p \leq 0.05$.

RESULTS AND DISCUSSION

Generally, the absolute DXA Fat (%) differences are small among the calves of different breeding lines shortly after birth (until 50th day of life). Though, the F1 crossbred calves show higher body fat percentages -- "energy reserves" -- (with DH|FV~ > FV|DH~) than purebreds (Fig. 3). Correspondingly, there consist differences in bone mineral density (BMD, g/cm²). DH calves have a significantly lower BMD than DH|FV~ and the purebred FV calves. The difference to FV|DH~ is not significant (p=0.077, Fig. 2). Since the average BMD (0.955 g/cm²) of the F1 calves (DH|FV~ and FV|DH~) is higher than the average BMD (0.928 g/cm²) of their parent lines, a small heterosis effect (+0.027 g/cm², +2.8 %) for this trait seems likely. In addition, there is an indication for a position effect in the crossbreeding program. The mating of DH sires with FV cows results -- in tendency (p=0.084) -- in a higher BMD than the reciprocal mating (FV| with DH~). Generally, F1 calves reach at least the bone mineralization of FV calves -- with slight disadvantages for F1 calves from DH mothers.

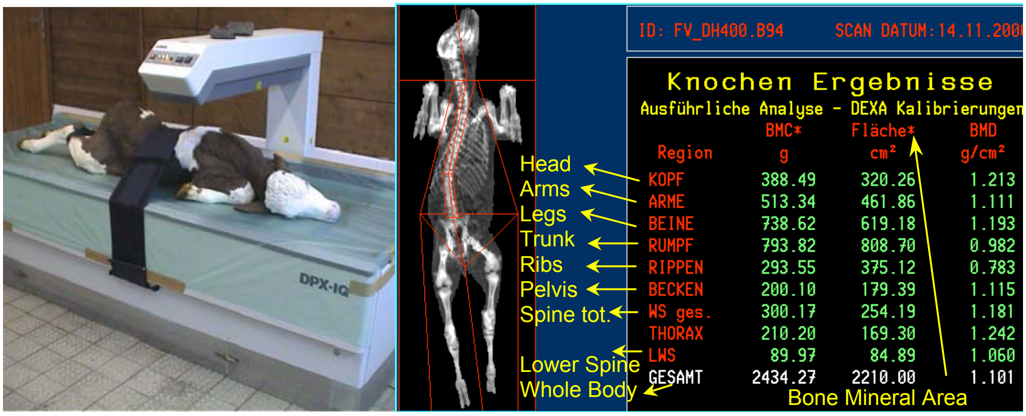
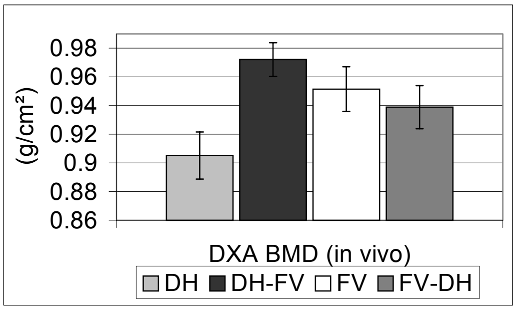


Figure 1. Example for the positioning of a calf on the DXA table (left) and bone mineralization results (right)



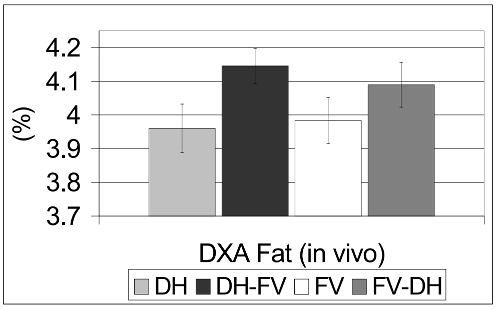
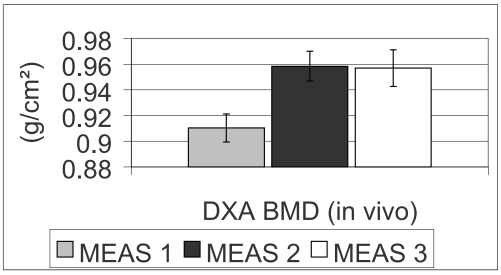


Figure 2. BMD in different calf genotypes **Figure 3. DXA Fat in different calf genotypes**

[∅ Body weight - BW (kg): German Holsteins - DH=52.28; DH | x German Fleckvieh ~ - DH-FV=52.98; FV=54.77; FV-DH=54.74; ∅ Age (days): 27.6 – 27.9 – 27.9 – 27.4]

While body fat (%) slightly (MEAS1 = 4.13 ± 0.05 %; MEAS2 = 3.97 ± 0.05 %; MEAS3 = 4.03 ± 0.06 %) and BMC (MEAS1 = 3.83 ± 0.05 %; MEAS2 = 3.78 ± 0.05 %; MEAS3 = 3.56 ± 0.06 %) significantly decreases, DXA lean (%) and BMD (g/cm²) increase with higher body weights between 4 and 50 days of age. However, there is no further increase in BMD between second and third measurement (Fig. 4 and 5). Between male and female calves exists only a significant difference in BMC (%). Female calves contain -- at lower body weights and similar age -- a higher BMC (%) and slightly higher BMD than male calves (Fig. 6 and 7). In comparison to calves from a single birth (S), calves from a multiple birth (twins or triples = M) are -- besides lower body weights (M: 49.18 ± 1.26 kg to S: 58.20 ± 0.68 kg) -- significantly disadvantaged in regard to BMD (M: 0.90 ± 0.02 g/cm² to S: 0.98 ± 0.01 g/cm²) and BMC (M: 3.61 ± 0.07 % to S: 3.83 ± 0.04 %). Therefore *multiples* show -- unexpectedly -- a significantly higher DXA fat content (M: 4.14 ± 0.07 % to S: 3.95 ± 0.04 %).



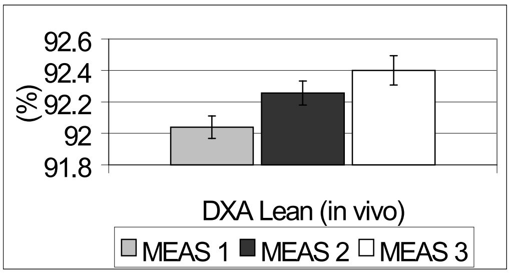
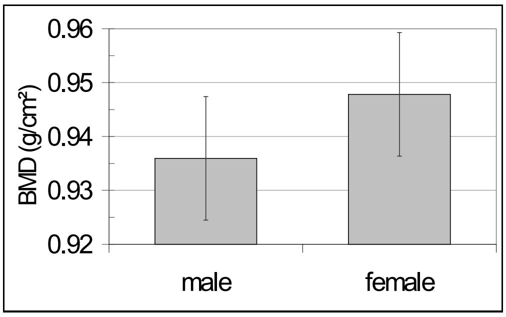


Figure 4. Development of BMD (g/cm²) **Figure 5. Development of DXA Lean (%)**
[Ø BW (kg): MEAS1=45.1; MEAS2=54.8; MEAS3=61.2; Ø Age (days): 5.8 – 27.8 – 49.5]



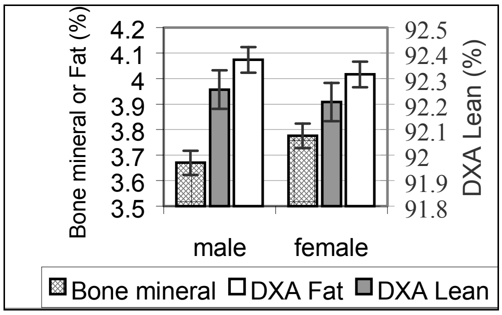


Figure 6. BMD (g/cm²) in both genders **Figure 7. Body composition in both genders**
Ø Body weight (kg): male = 55.7 and female = 51.7; Ø Age: 27.4 and 28.0 days]

DXA proves as a suitable method to measure differences in body composition and bone mineralization also for calves of different genetic origin, though the body fat content of the calves surpassed just slightly the lower measurement limit (≥3.8%) for the DPX-IQ scanner. DH|FV~ crossbred calves exceed their parent lines in bone stability (BMD).

REFERENCES

Mitchell, A.D. and A.M. Scholz (2001) In « Swine Nutrition 2nd Edition », p. 917-960, Editors A.J. Lewis and L. Lee Southern, CRC Press, Boca Raton, FL, USA.

Nüske, S., A. Scholz, M. Förster (2002) Proc 12th International Symposium on Lameness in Ruminants, Orlando, Florida, January 9-13: 199-201.

Scholz, A., U. Neuhaus, S. Nüske, G. Kragenings, M. Förster (2001 a, b) *Züchtungskunde* **73**: 12-22 and 23-32.