

weaning and at approximately 16 months. Weaning and yearling weight (WW and YW) were adjusted to 240 and 450 days respectively.

**Sample collection and DNA extraction.** Semen straws were used to obtain DNA from bulls by deproteinization with organic solvents. For the steers, DNA extractions were performed from 5 ml blood by a salting out method.

**Genotypic data.** The SNP (C/T) in intron 9 of the *PPARGC1A* gene (Weikard *et al.* (2005)) and the SNP (A/G) in exon 2 of the *FABP4* gene (Cho *et al.* (2008)) were genotyped by PCR-RFLP method, using restriction enzymes *BsuRI* and *NmuCI*, respectively. The microsatellite IGF-1 (Bishop *et al.* (1994)) was genotyped by capillary electrophoresis.

**Statistical Analysis.** A mixed model was used to evaluate the influence of markers on BFT and REA. Fixed effects were contemporary group composed by birth place, site of feedlot and genotypes, in addition to the random effect of bull. The age of the animal at the time of measurement was included as a covariate. For FG the model included fixed effects of site of feedlot and genotypes besides the random effect of bull. For WW and YW the model was fitted for fixed effects of birth place and genotypes, the age of the animal at measurement as covariate and the random effect of bull. The analysis was made by the maximum likelihood method using the procedure PROC MIXED of the Statistical Analysis System (SAS Institute Inc. (2003)). Genotypic means were calculated by the GLM procedure of SAS for the markers that had significant ( $P < 0.05$ ) or suggestive effect ( $P < 0.10$ ) on any trait evaluated. A Tukey test was applied to confirm difference between means. Allele substitution effects were calculated for significant maker-trait associations by replacing the effect of marker genotype in the statistical model by covariates representing each allele in the genotype.

## Results and Discussion

The reference families were segregating for the three marker loci studied. Allelic and genotypic frequencies are presented in Table 1.

**Table 1. Allele and genotypic frequencies of *PPARGC1A*, *FABP4* and *IGF-1* polymorphisms.**

GENE	FREQUENCY (%)				
	ALLELIC		GENOTYPIC		
<i>PPARGC1A</i>	C	T	CC	CT	TT
	85.40	14.60	72.20	26.36	1.44
<i>FABP4</i>	A	G	AA	AG	GG
	17.51	82.49	1.80	31.41	66.79
<i>IGF-1</i>	225	229	225/225	225/229	229/229
	73.55	26.45	54.34	38.41	7.25

*PPARGC1A* (peroxisome proliferative active receptor gamma coactivator 1 A); *FABP4* (fatty acid binding protein 4); *IGF-1* (insulin-like growth factor)

In the analysis of association (Table 2) *FABP4* genotypes were significantly associated ( $P < 0.05$ ) to BFT and suggestively associated ( $P < 0.10$ ) to FG.

Table 2. Results of the association between the marker and the characteristics evaluated

Markers	P values by trait						
	BFT1	BFT2	FG	REA1	REA2	WW	YW
<i>PPARGC1A</i>	0.499	0.737	0.548	0.570	0.412	0.285	0.774
<i>FABP4</i>	0.369	0.040	0.093	0.156	0.871	0.763	0.522
<i>IGF-1</i>	0.503	0.644	0.740	0.770	0.440	0.559	0.071

*PPARGC1A* (peroxisome proliferative active receptor gamma coactivator 1 A); *FABP4* (fatty acid binding protein 4); *IGF-1* (insulin-like growth factor); BFT1 and REA1= Backfat and Rib Eye Area at the first ultrasound measure, respectively; BFT2 and REA2= Backfat and Rib Eye Area at the second ultrasound measure, respectively

Polymorphisms in *FABP4* have been associated to BFT (Michall *et al.* (2006); Cho *et al.* (2008)), marbling (Michall *et al.* (2006)) and composition of palmitoleic and linoleic acid in the intramuscular fat (Hoashi *et al.* (2008)). In this work, despite no association was observed between *FABP4* and the first measure of BFT we found a significant effect of this marker on the second measure of BFT (BFT2) and suggestive effect on FG. The difference between the two analyses may reflect the low exposure of the genetic potential of the animals for fat deposition in the first measure, which was taken under pasture.

Significant difference between the means of genotypes AA and AG ( $P = 0.003$ ) and AA and GG ( $P = 0.001$ ) of *FABP4* gene were found for BFT2. There was no significant difference between AG and GG genotypes ( $P = 0.735$ ), suggesting a dominant gene action. For FG, a suggestive difference between the means of AA and AG ( $P = 0.053$ ) was found, significant difference between the means of AA and GG ( $P = 0.041$ ) and no significant difference between the means of AG and GG genotypes ( $P = 0.793$ ), consistent with the dominant effect observed for BFT2.

There was no significant association between *FABP4* and REA in this population of Nellore cattle, agreeing with other studies (Hoashi *et al.* (2008); Rezende *et al.* (2008)). No effect of *FABP4* polymorphism on growth traits WW and YW was observed. There was no significant effect of *FABP4* allele substitution on either BFT2 or FG. Since allele substitution is a measure of the additive effect of a *locus*, these results reinforce the dominant nature of the association between *FABP4* and BFT2.

Suggestive association was also found between YW and *IGF-1* gene (Table 2). Significant difference was not found between the means of genotypes of *IGF-1* gene for YW, but a significant effect of allele substitution for the *IGF-1* and YW ( $P=0.017$ ). The mean allele substitution effect was 6.9 kilogram, with the 229 allele associated to reduced YW in this population of Nellore. The *IGF-1* gene has an essential role in the metabolism and growth of animals. Associations of this *IGF-1* polymorphism with growth traits (Ge *et al.* (2001); Pereira *et al.* (2005)) and residual feed intake (Wood *et al.* (2004)) have been described in cattle. Furthermore, Islam *et al.* (2009)) associated a SNP in the promoter region of *IGF-1* gene with BFT and other carcass traits. The microsatellite used in this study is also in the promoter region of *IGF-1* gene, than there is a high probability of being in linkage

disequilibrium with this SNP and behave as an indirect marker. We did not find significant effect of the microsatellite in the *IGF-1* gene on any carcass trait. However, for the growth traits we found a suggestive effect on YW and no effect was found for WW.

Although *PPARGC1A* is associated with energy metabolism and production traits and has been associated to fat deposition in the milk (Weikard *et al.* (2005); Schennink *et al.* (2009)) in the present work we did not find significant association with the traits studied, agreeing with other results obtained for carcass traits in cattle (White *et al.* (2006); Soria *et al.* (2009); Tizioto *et al.* (2009)).

## Conclusion

*FABP4* significantly affected BFT measured after 55 days on feedlot and had a suggestive effect on fat gain. In addition, a suggestive association between the *IGF-1* gene and YW was found in this population of Nellore breed. Extending this investigation to the next two years of progeny evaluation may allow for more accurate estimate of marker effect and application on breeding programs.

## References

- Anualpec (2008). *Anuário da pecuária brasileira*. FNP Institue, 380 pages.
- Bishop, M.D.; Kappes, S.M.; Keele, J.W. *et al.* (1994). *Genetics*. 136:619-639.
- Cho, S., Park, T.S., Cheong, H.S. *et al.* (2008). *BMB Rep.* 41(1): 29-34.
- Ge, W., Davis, E., Hines, H.C. *et al.* (2001). *J. Anim. Sci.* 79:1757-1762.
- Hoashi, S., Hinenoya, T., Tanaka, A. *et al.* (2008). *BMC Genetics*. 9:2156-2159.
- Islan, K.K., Vinsky, M., Crews, R.E. *et al.* (2009). *Animal Genetics*. 40:766-769.
- Michall, J.J., Zhang, Z.W., Gaskins, C.T. *et al.* (2006). *Animal Genetics*. 37:400-402.
- Pereira, A.P., Alencar, M.M., Oliveira, H.N. *et al.* (2005). *Genet. Mol. Biol.* 28(2): 230-236.
- Rezende, F.M., Ferraz, J.B.S., Silva, S.L. *et al.* (2008). In *VII SBMA*.
- SAS Institue Inc. *SAS procedures guide*. (2000) Cary, 8<sup>th</sup>.
- Schennink, A., Bovenhuis, H., Léon – Kloosterziel, K.M. *et al.* (2009) *Animal Genetic* 40(6):909-916.
- Soria, L.A., Corva, P.M., Branda Sica, A. *et al.* (2009). *Molecular and Cellular Probe* 23(6): 304:308.
- Tizioto, P.C., Veneroni, G.B., Meirelles, S.L. *et al.* (2009). In *Workshop da Rede Genômica Animal*.
- Weikard, R., Kuhn, C., Goldammer, T. *et al.* (2005). *Physiological Genomics*. 21:1-13.
- White, S.N., Casas, E., Allan, M.F. *et al.* (2006). *Anim. Sci.* 85:1-10.
- Wood, B.J., Archer, J.A. and Van Der Werf, J.H.J. (2004). *Livestock Production Scienc* 91: 69-81.