IJAS Iranian Journal of Applied Animal Science

Area of Origin, But Not Farm or Sex, Predicts Horse Carcass Weight as a Main Effect

Short Communication

P.M. Pares Casanova[1*]

[1] Department of Animal Production, University of Lleida, Av. Alcalde Rovira Roure, 191 25700 Lleida, Catalunya, Spain

Received on: 10 May 2013
Revised on: 1 Jun 2013
Accepted on: 15 Jun 2013
Online Published on: Jun 2014

*Correspondence E-mail: peremiquelp@prodan.udl.cat

Online version is available on: www.ijas.ir

ABSTRACT

The aim of this study was to evaluate the differences between cold carcass weights (CCW) for the Catalan Pyrenean horse (*Cavall pirinenc català*) breed according to different variables: area of origin, farm, gender and age. Linear regression models were applied using a generalized linear model (GLM) procedure for CCW of 397 animals (217 males and 180 females) slaughtered in a commercial abattoir. Fixed effects GLMs included age, gender, farm and area of origin, and their interactions. The best model for explaining CCW included area of origin only ($ß_{origin}$=0.02541, W_i=0.67, R^2=0.0518) thus indicating that sex and farm were not important explanatory variables, as might have been expected. This information may be useful for obtaining better estimates of carcass weight of this breed for carcasses from specific breeding areas.

KEY WORDS abattoir effect, Catalan Pyrenean horse, *Cavall pirinenc català*, multicollinearity.

INTRODUCTION

Currently, horse meat consumption is commonplace in some parts of Spain. In other European countries including Italy, Belgium, France and Netherlands, horse meat is also included in the diet and even has to be imported in order to meet demand. Meat obtained from horses was historically obtained from horses that were slaughtered at the end of their productive life (Tateo *et al.* 2008). However, in the Spanish Pyrenees, the meat is produced from animals raised for human consumption from meat breeds. In fact, several horse breeds are found in both slopes of the Pyrenees and Pre-Pyrenees including the Burguete, *Caballo de monte del país vasco*, Merens and Pottoka. One breed that is found exclusively in Catalunya (north eastern Spain) is the so called Catalan Pyrenean horse (*Cavall pirinenc català*) that is well adapted to the harsh Pyrenean environmental conditions and is managed in small-scale organized distributions. The Catalan Pyrenean horse is nowadays raised almost exclusively for meat and is widely distributed throughout large areas of the Catalan Pyrenean and Pre-Pyrenean territory, where weather and orographic conditions allow the exploitation of highland grass during the summer. Animals thrive outdoors, including during winter. Management of the breed is quite extensive, with no controlled mating (one or more stallions live all year round with a group of mares) and sudden weaning of foals between the ages of 5 and 8 months. The fattening system uses indoor pens and is based on hay and concentrates *ad libitum*, with rations and concentrate formulation differing between farmers. The breed is characterized by its rusticity and low stamina. Males are never castrated. During recent decades, the population has gradually declined, with the last official census giving an estimate of 4000 mares and 475 stallions distributed among less than 500 breeders. At the present time, the regions in which the breed is native, known as “comarques” (typical minor regions in Catalunya; similar to counties, clearly differentiated by both natural and traditional social borders)

are: Val d'Aran, Alta Ribagorça, Pallars Jussà, Alt Urgell, Pallars Sobirà, Cerdanya and Ripollès. More than two thirds of total population and breeders are concentrated in the latter three regions.

As with all domestic animal species, information on correlations among pre- and post-slaughter traits is important in meat breeding. Carcass weight (CW) is an example of a variable that can indicate the value of a meat foal for commercial purposes. Performance testing, which would form the basis for improvement of fattening work, is difficult to conduct in the case of the Catalan Pyrenean horse, for which no value parameters are registered. CW is normally the only variable related to meat collected at the abattoir. However, analysis of other variables than can be obtained from the abattoir and that can predict the foal CW should address the interdependence among the predictors (multicollinearity). The problem in the analysis of management and CW data is the difficulty in knowing which the most useful management variables are for predicting CW. For the Catalan Pyrenean horse, the estimation of CW from variables related to management using factor analysis has not been studied. Therefore, the aim of this study was to evaluate the differences between CW for this breed according to different variables: area of origin, farm, gender and age.

As the first study to date to use a generalized linear model (GLM) to predict CW in this breed, this study will further aid the selection and breeding programs of meat foal in the Catalan Pyrenean and Pre-Pyrenean environment.

MATERIALS AND METHODS

The studied breed was the Catalan Pyrenean horse. To assess the cold carcass weight (CCW), a set of independent GLMs was fitted. CCW was obtained as the total carcass weight minus blood loss and all organs in the thoracic, abdominal, and pelvic cavities, at 24 h / 3 ˚C, taken to the nearest centigram. The GLM is a flexible generalization of ordinary linear regression that allows for response variables that have a non-normal distribution. It generalizes linear regression by allowing the linear model to be related to the response variable via a link function and by allowing the magnitude of the variance of each measurement to be a function of its predicted value. Several models comprising fixed effects were tested: age, gender, area of origin (county), farm before finishing to market ("fattener"), as well as some two-way interactions.

Area of origin was included since different morphological typologies between animals are observed in each of these areas. The following natural counties were considered: Pallars (Pallars Sobirà and Pallars Jussà were treated jointly, n=160), Alt Urgell (n=109), Cerdanya (n=75) and Solsonès (n=5). Andorra (n=48), a small country in the middle of the Central Pyrenees, bordering both Spain and France, was also considered, as although it is politically a different country, its animals are morphologically identical to Pyrenean horses and are not currently officially recognized as a separate breed. Live weight could not be considered because no data were available. Animals with incomplete individual information were removed from the study, which left 397 animals (217 males and 180 females) with complete final information for inclusion in the statistical analyses, with an age range between 129 and 598 days which is the typical market age range for foal consumption for this breed.

Records were obtained from a commercial abattoir. No practice involving manipulation of animals was performed to obtain records. Animals were transported to the abattoir the same day or previous day of the slaughter, rarely mixing foals from different fattening areas of origin, and trying to minimize the stress of the animals. Some animals were reared on farms situated a considerable distance from the slaughter plant, but careful loading, transportation and unloading conditions were maintained. The distance to the abattoir was always less than 150 km. Average body condition was good for all animals.

At the abattoir, foals were processed in an identical manner, which consisted of two parts: stunning and exsanguinations (bleeding). Animals were rendered insensible by stunning with a captive bolt and were then killed by bleeding according to current EU regulations (council directive of the European Union 95/221 EC). The carcass was then hung by the hind legs using a pulley. The head was removed at the atlanto-occipital joint and the fore and hind feet at the carpal and tarsal joints respectively. Immediately after skinning, evisceration was carried out. Carcasses were then split along the mid line and chilled for 24 h in a conventional room at a temperature of 2 ˚C and 98% relative humidity.

All registered carcasses were suitable for human consumption (non-edible carcasses were excluded from the study). Data for the analysis were gathered over a period of five years (November 2009 to January 2013). In order to minimize the possible effects of breed or crossing, only data for the Catalan Pyrenean Foal (or those from Andorra) non-reproductive animals were considered.

For all statistical models, a model selection procedure based on the information-theoretic approach was carried out. Data were processed using the GLM procedure according to the following linear model:

$$Y_{ijk} = M + a_i + b_i + (a \times b)_{ij} + E_{ijk}$$

Where:
Y_{ij}: dependent variables.
M: overall mean.
a_i: variable 1.

Iranian Journal of Applied Animal Science (2014) 4(2), 429-432

b_j: variable 2.
$(a \times b)_{ij}$: binary interaction between both variables.
E_{ijk}: error term.

Because the interaction between area of origin and other factors could not influence the parameters investigated, it was decided to delete these terms from the statistical model. The fit of the models to the data was assessed using Akaike's information criterion (AIC) (Akaike, 1973) corrected for small sample size and Akaike weights (Burnham and Anderson 2002; Johnson, 2002). AIC_c is defined as:

$$AIC_c = AIC + [(2(K+1) \times (K+2) / (N-K-2)]$$

Where:
K: the number of parameters.
N: the number of records.

AIC_c was preferred over the standard AIC in this study because of the small data set, as suggested by Littell *et al.* (2006). Competing models were ranked in relation to the difference between their Akaike scores with the score of the best model (D_i) having the lowest AICc. Models with $D_i <$ 2 units have substantial support for explaining the observed variability in the variable of interest. Subsequently, the Akaike weight (W_i), defined as the relative probability that a given model is the best model among those being compared, was estimated. In short, a model that fits the data, compared to other models, has a small AIC_c and an Akaike weight closer to one. Data were analyzed using statistical packages R version 2.15.2 (2012-10-26) and PAST (Palaeontological statistics) version 2.12 (2012-10-26). Each animal was considered as an experimental unit.

RESULTS AND DISCUSSION

The CCWs were in the range of 122.3-305.2 kg (mean 215.9 kg). Mean values in males and females were 218.9 ± 35.83 and 212.8 ± 39.90 kg respectively, with no difference between them (F=1.24, P=0.006). CCW data fit a normal distribution (W=0.993, P=0.07) but age did not (W=9.978, P<0.001), although these variables were highly correlated (r_s=0.639, P<0.0001).

In Table 1 there is a biological model selection for explaining CCW in the Pyrenean foal. The best model for explaining CCW (D_i=0) included area of origin only ($ß_{origin}$=0.02541, W_i=0.67, R^2=0.0518). CCWs were especially high in animals originating from Alt Urgell and Solsonès, which curiously are the less high mountain areas (Figure 1). In Table 2 there are the ANOVA results for CCW according to area of origin (F=4.77, P<0.01). Significant differences appeared between animals from Cerdanya and Andorra, and those from Alt Urgell and Pallars.

Table 1 Biological model selection for explaining cold carcass weight in Pyrenean foals

Biological models	K	AICc	Di	Wi
Area of origin	6	460.81	0.00	0.67907
Gender	3	458.52	2.14	0.23339
Gender + age	4	456.56	4.13	0.08610
Null	2	447.69	12.93	0.00106
Age	3	445.69	14.96	0.00038
Farm	55	453.56	25.09	0.00000
Farm + origin	58	452.28	28.56	0.00000

K: number of parameters; AIC_c: Akaike's information criterion corrected for small sample sizes; D_i: difference of AIC_c with respect to the best model and W_i: Akaike weight.
The best model for explaining CCW (D_i=0) included area of origin only ($ß_{origin}$= 0.02541; W_i= 0.679; R^2= 0.0518).

Table 2 ANOVA results for cold carcass weight according to area of origin (F=4.77, P<0.01)

Origin	Solsones	Pallars	Cerdanya	Andorra	Alt Urglle
CCW (Mean±SD)	216.7 ±24.67	134.8 ±37.05	206.0 ±43.04	204.4 ±32.16	226.4 ±34.6
Solsones	-	-	-	-	-
Pallars	0.946	-	-	-	-
Cerdanya	0.600	0.026**	-	-	-
Andorra	0.409	0.025**	0.825	-	-
Alt Urglle	0.538	0.060	0.0006***	0.0004***	-

CCW: cold carcass weight.
** P<0.05 and *** P<0.001.

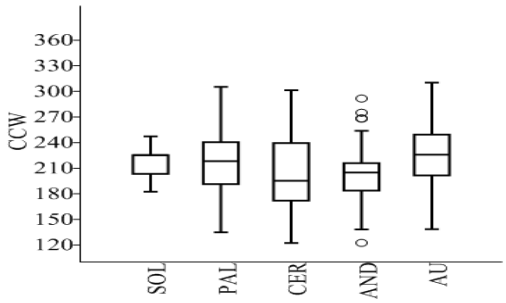

Figure 1 Box plot of cold carcass weight (CCW, in kg) per area of origin
Circles correspond to outliers
Y-axis: cold carcass weight (kg) and X-axis: area of origin ("comarques")
SOL: Solsonès; PAL: Pallars; CER: Cerdanya; AND: Andorra; AU: Alt Urgell

It is not unexpected that Cerdanya and Andorra showed similar results (206.0±43.04 and 204.4±32.16 kg respectively), since they share common spring and summer grazing areas and thus, stallions can mount alien mares. The second model with substantial support (Table 1, D_i>2, W_i=0.23) was not selected due to the principle of parsimony. Thus no interactions could be determined. No significant effects of sex and age on the slaughter value indicators of the carcass were observed.

Farming systems, feeding programs and especially area of origin are likely to contribute significantly to the meat

quality of the Pyrenean Catalan Horse. Farming systems and feeding programs are not commonly registered at abattoirs for this breed, so it is suggested that data on these traits should be collected. Maternal effects (both genetic and non-genetic) would be also useful to evaluate.

CONCLUSION

Factors such as breed, sex, live weight, environment, diet, degree of fatness and their interactions have been shown to affect carcass and meat quality, as well as fat deposition and fatty acid composition (De Smet *et al*. 2004; Wood *et al*. 2004). In this context, genetic effects on those traits have been widely reported in several species (De Smet *et al*. 2004; Wood *et al*. 2004, Wood *et al*. 2008). However, the effects on horse carcass for the Pyrenean Catalan Horse had to be clarified. Therefore, the objectives of the present work were to study the effects of area of origin, farm and sex on the weight trait of the carcass of this breed reared following the same traditional production system. Our results show significant deviations in carcass weight according to the area of animal origin, so fattening management seems to be less important in "finishing" foals before their slaughtering. This could suggest a certain genetic difference between populations, as they are geographically separated. However, whether these differences are due to fat deposition and fatty acid composition cannot be assumed, as these data have not been recorded in the abattoir. The application of independent GLMs in this study has shown that this statistical method is a suitable tool for supplementary assessment in foal carcass yield, and could be applied to further analyses, taking into account additional variables such as conformation, fatness, meat and fat color. Equine producers must produce horse meat more consistently to meet the consumer's expectations. This starts with livestock management. Frequently, animals are not raised appropriately according to their maximum genetic capacity. For instance, males are removed before the end of their total mating life. Meatiness and genealogic data are also not collected. Selection and improvement requires reliable and easy-to-apply methods for estimating the performance and breeding value of a foal.

ACKNOWLEDGMENTS

We express our gratitude to the MAFRISEU SA abattoir for kindly providing all required data.

REFERENCES

Akaike H. (1973). Information theory and an extension of the maximum likelihood principle. Pp 267-281 in Proc 2nd Int. Symp. Budapest, Hungary.

Burnham K.P. and Anderson D.R. (2002). Model Selection and Multimodel Inference: A Aractical Information-Theoretic Approach. New York: Springer-Verlag.

De Smet S., Raes K. and Demeyer D. (2004). Meat fatty acid composition as affected by fatness and genetic factors: a review. *Ann. Res.* **53,** 81-98.

Johnson D.H. (2002). The role of hypothesis testing in wildlife science. *J. Wildl. Manage.* **66,** 272-276.

Littell R.C., Milliken G.A., Stroup W.W., Wolfinger R.D. and Schabenberger O. (2006). SAS for Mixed Models. Cary (NC): SAS Institute Inc. USA.

Tateo A., De Palo A., Ceci E. and Centoducati P. (2008). Physico-chemical properties of meat of Italian Heavy Draft horses slaughtered at the age of eleven months. *J. Anim. Sci.* **86(5),** 1205-1214.

Wood J.D., Enser M., Fisher A.V., Nute G.R., Sheard P.R. and Richardson R.I. (2008). Fat deposition, fatty acid composition and meat quality: a review. *Meat Sci.* **78,** 343-358.

Wood J.D., Nute G.R., Richardson R.I., Whittington F.M., Southwood O. and Plastow G. (2004). Effects of breed, diet and muscle on fat deposition and eating quality in pigs. *Meat Sci.* **67,** 651-667.