# Towards a Sustainable Breeding Goal for Llamas in Bolivia: WTP Estimates for Selection Traits

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## Introduction

Llamas form a crucial part of highland farming systems in Bolivia fulfilling multiple functions in the subsistence-oriented smallholdings. A considerable number of the traditional functions being perceived as most important by herders (Markemann et al. (2009)), like wealth accumulation by maintaining or increasing herd size and the close integration of the animals as pack animals in a mixed crop-livestock farming system, do not relate to production traits and hence their consideration in the breeding objective is not straightforward. Llamas in Bolivia have not been subject to a genetic improvement programme up to now (Stemmer and Valle Zárate (2006)). In order to premise sustainability of a breeding programme, the involvement of farmers and their knowledge, as well as the consideration of non-production traits or intangible benefits derived from the animals has been postulated (e.g. Sölkner et al. (1998); Kosgey et al. (2004)). Despite research has been undertaken recently towards defining sustainable breeding goals for low-input low-output systems, the derivation of economic values for traits that cannot be described by profit equations, remains a major challenge for animal breeders. In Bolivia, the majority of functions and products derived from llama production are home-consumed (Nürnberg (2005)). Hence, detailed information on local market transactions is non-existent, posing considerable difficulties on breeding objective setting even for tradable factors. The present research work aims to support the formalisation of a breeding objective for llamas in Bolivia by evaluating important indigenous traits of llama breeding males with choice experiment (CE) data.

## Material and Methods

The study was carried out in the province of Ayopaya, located in the north-western part of the Cochabamba department in Bolivia. Data was collected from March to May 2006 and July to October 2007 comprising a total of 159 llama breeders from seven farming communities. Based on previous results (Delgado (2003); Markemann and Valle Zárate (2010)), five llama traits (attributes) were selected for the design of choice cards, each card combining different levels of the given attributes. The following traits and respective levels were selected: fibre diameter (17, 21, 25 and 29µm), fleece colour (single-coloured – spotted), body conformation ('square appearance' with straight legs, neck and back – straight neck and legs, bend back – straight neck and back, crooked legs – straight back and legs, aquiline neck), height at withers (120, 100 and 80cm) and testicle conformation (big and

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even – big and unequal – small). The price of an adult llama based on a range of informal market prices at the time of the study was added to each alternative as a sixth attribute.
The total number of possible trait-level-combinations was reduced to a fractional factorial design (based on D-efficiency criterion) using the SAS macro described in Kuhfeld (2005). The procedure yielded 32 llama profiles. The resulting 16 choice sets comprising two profiles were further grouped into two blocks of eight choice sets, which were presented to each of the respondents. The respondents were required to choose a llama profile that they would prefer to buy from the two profiles. If neither of the two were found satisfactory, the respondents were allowed to choose an opt-out (or "zero") option.
The data was analyzed with LIMDEP 8.0 NLOGIT 3.0 (Greene (2002)) applying a mixed logit model (MXL). Based on the coefficients resulting from the MXL model, the willingness to pay (WTP), or compensation demanded (WTA) for the llama attributes were calculated following the approach presented by Thiene and Scarpa (2009).

## Results and Discussion

The estimated random coefficients of all attributes show the expected signs and are statistically significant, except for the attribute '80cm height at withers' (Table 1).

**Table 1: Estimation Results from Mixed Logit (MXL) Model[a]**

| Variable | Mean Coefficient (s.e.) | | St.Dev. Random Coefficient (s.e.) | |
|---|---|---|---|---|
| 17µm fibre diameter | 0.539*** | (0.093) | 0.182 | (0.119) |
| 21µm fibre diameter | 0.190* | (0.104) | 0.242* | (0.134) |
| 25µm fibre diameter | 0.405*** | (0.090) | 0.186 | (0.130) |
| Single-coloured fleece | 0.377*** | (0.090) | 0.439*** | (0.088) |
| Straight neck and legs, bend back | -0.287*** | (0.072) | 0.160 | (0.133) |
| Straight neck and back, crooked legs | -0.668*** | (0.094) | 0.342** | (0.115) |
| Straight legs and back, aquiline neck | -0.314*** | (0.095) | 0.112 | (0.226) |
| 80cm height at withers | -0.125 | (0.084) | 0.165 | (0.184) |
| 120cm height at withers | 0.183** | (0.072) | 0.270*** | (0.094) |
| Big and unequal testicles | -0.908*** | (0.099) | 0.495*** | (0.099) |
| Small and even testicles | -0.690*** | (0.086) | 0.389*** | (0.089) |
| N_Price[b] | -6.381*** | (0.381) | 1.013*** | (0.329) |
| Log-likelihood function | -1408.545 | | | |
| Adjusted Pseudo-$R^2$ | 0.15 | | | |

Notes: No. of observations=1520; s.e. = standard error; st.dev. = standard deviation; ***1% significance level, **5% significance level, *10% significance level; [a]Simulation based on 500 Halton draws; [b]Variable name 'N_Price' reflects the opposite of the original price variable.

The standard deviations of the random parameters indicate significant taste heterogeneity for the attributes 'fleece colour', '120cm height at withers', 'big and unequal testicles', 'small and even testicles', 'price' ($p$<0.001), 'straight neck and back, crooked legs' (significant at the 5% level) and '21µm fibre diameter' ($p$<0.1). Insignificant estimates for derived standard deviations suggest that all information in the distribution is captured within the mean

(Hensher et al. (2005)), as is e.g. the case for the mean coefficients '17µm fibre diameter' and '25µm fibre diameter'.

The fibre diameter is the most important quality attribute for the textile industry. The outstanding fibre quality of Ayopayan llamas has been previously described (Delgado (2003)). Proven effects on fibre diameter are age and type (Wurzinger et al. (2006)), secondary effects are assumed to be high altitude and seasonal low quality nutrition (Braga et al. (2007)). In this context, the regional preference of herders for a deliberate selection of high fibre quality males should also be taken into consideration.

The random coefficients for fleece colour and 120cm height at withers indicate a general preference of farmers for single-coloured animals of high stature. The estimated standard deviations of the parameters, however, show significant taste heterogeneity for the attributes. Thus, it is very likely that sub-populations of farmers in Ayopaya have preferences divergent from the general population and prefer llamas of medium size and a spotted fleece. Such indications have to be verified and taken into consideration in the setting up of breeding goals. Gizaw et al. (2010) already pointed out that breeding objectives need to be tailored to the specific needs of different groups of farmers.

The magnitude of the other estimates shows that small and particularly unequal testicles are strongly disliked. Crooked legs also have a high negative coefficient and are much less acceptable than other deficiencies in body conformation, i.e. a bend back or an aquiline neck. Highest simulated WTP values are observed for very fine fibre animals of 17µm with 300Bs, followed by an improvement of the fibre fineness from 29 to 25µm with 220Bs (Table 2).

**Table 2: Median WTP/WTA for llama attributes**

| Attribute[a] | WTP/WTA[b] | |
|---|---|---|
| | Median | (percentile 25,75) |
| 17µm fibre diameter*** | 303.33 | (142.11, 628.76) |
| 21µm fibre diameter* | 84.38 | (9.28, 248.44) |
| 25µm fibre diameter*** | 219.07 | (96.37, 475.20) |
| Single-coloured fleece*** | 170.16 | (26.56, 480.84) |
| Straight neck and legs; bend back*** | -144.55 | (-60.40, -327.05) |
| Straight neck and back, crooked legs*** | -342.02 | (-148.18, -758.82) |
| Straight back and legs, aquiline neck*** | -171.66 | (-81.14, -356.07) |
| 80cm height at withers | n.s. | |
| 120cm height at withers** | 79.97 | (0.28, 247.19) |
| Big and unequal testicles*** | -458.27 | (-193.77, -1034.39) |
| Small and even testicles*** | -346.13 | (-144.18, -786.08) |

[a]significance levels from MXL model, ***1% significance level, **5% significance level, *10% significance level; [b]simulations based on $10^4$ replications, WTP/WTA values in Bs = Bolivian Boliviano (1 US Dollar = 8.32 Bs.; exchange rate on April 15, 2006; 1 US Dollar = 7.91 Bs.; exchange rate on August 31, 2007) (OANDA, 2009).

This relates to an average economic value of 40Bs (4.93USD) per unit µm in fibre diameter. A llama with a single-coloured fleece is valued at 170Bs more than a spotted one, and an animal reaching 120cm height at withers averages 80Bs more than one with a moderate height at withers of 100cm. The 25$^{th}$ and 75$^{th}$ percentiles reflect considerable taste variation in the population. The body and testicle conformation traits receive a negative value, typically denominated willingness to accept (WTA) compensation. Highest aversion of breeders is expressed towards animals with unequal testicles (WTA of 460Bs), followed by small testicles and crooked legs (WTA of 346Bs and 342Bs, respectively).

## Conclusions

The results show that the selection of male llamas in the Ayopaya region is done on the basis of well-determined and clear-cut phenotypic traits that most likely assure to fulfil the functions that farmers expect from their animals. It appears that price relevant quality criteria for the processing textile industry are already considered in the selection decisions of smallholder llama-keepers, providing a promising basis for fibre marketing. The WTP estimates are the first presented for this species and might contribute to the formalisation of a breeding objective for llamas in Bolivia. In addition to still open questions on how to measure components of adaptation, such as transportation capacity, more research is however needed on the integration of such estimates in selection index calculations, combining market-derived economic weights and livestock breeders' preferences for traits.

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