Challenges and opportunities of genetic improvement in alpacas and llamas in Peru

G. Gutierrez[1], J.P. Gutierrez[2], T. Huanca[3] & M. Wurzinger[4]

[1] Universidad Nacional Agraria La Molina, Av. La Molina, Lima, Peru
gustavogr@lamolina.edu.pe (Corresponding Author)
[2] Universidad Complutense de Madrid, Avda. de Séneca, 28040 Madrid, Spain
[3] INIA-Instituto Nacional de Innovación Agraria, Av. La Molina 1981, Lima, Peru
[4]BOKU-University of Natural Resources and Life Sciences, Gregor-Mendel-Strasse 33, 1180 Vienna, Austria

Summary

Alpacas and llamas play an important role in the livelihood of many rural families in the High Andes of Peru. The census of 2012 indicates a population of 3 million alpacas and 746,269 llamas. Both species are kept in extensive, low-input, pasture-based systems in altitudes between 3800 m and up to 5000 meters above sea level. Smallholders keep mixed herds of sheep, alpaca and llamas as a mitigation strategy against fluctuating market prices.

Since 1997 the Peruvian Ministry of Agriculture manages a genealogy registry for alpacas and llamas, but so far the up-take rate by farmers and inscription rate of animals is low. The national research organisation INIA (Instituto Nacional de Innovación Agaria) runs an ex-situ in-vivo conservation program for coloured alpacas (21 different colours) and llamas. INIA is also doing research in the area of embryo transfer, artificial insemination and controlled mating.

There is no national breeding program for alpacas, but all individual initiatives from private companies, NGOs and farmers´ cooperatives aim to improve fibre quality by reducing fibre diameter. At the moment these various local programs are not connected. There is also no national breeding program in place for llamas. Little attempts have been made to set up functional breeding programs for this species.

Furthermore, there is no a national conservation plan in place. However, INIA have just started the formulation phase of a National Bank for Agrobiodiversity Conservation that include ex situ in vitro conservation of SACs.

The Peruvian Ministry of agriculture prioritizes in the recently launched national livestock development plan for 2017 – 2027 alpacas and llamas. Support for the development of breeding plans is mentioned as one action line to increase productivity in both species.

Keywords: alpacas, conservation, llamas, genetic improvement, Peru

Introduction

Both domesticated South American Camelid (SAC) species, namely alpacas and llamas, play an important role in the livelihoods of many rural families in the High Andes of Peru. The area of production overlaps with high incidences of rural poverty. The figures from 2017 indicate that 34% of all alpaca farmers are considered as poor and 12% as extreme poor (MINAGRI, 2017a).

SAC provide fibre, skins, meat and manure for agricultural production, are a cornerstone of cultural heritage and llamas are still, but with declining importance used as

pack animals. Alpacas are mainly kept for fibre production and meat is a secondary product, whereas for llamas it is the other way around and meat is the predominant product.

Peru hosts about 85% of the worldwide alpaca population, whereas 65% of the llama population is located in the neighbouring country Bolivia. The last national census of 2011 reported 3.0 million alpacas and 746,269 llamas. This means an increase of 1 million alpacas, but at the same time a decline of about 300,000 llamas since the last census in the year 1994 (INEI, 1994; INEI, 2012). 80% of alpacas belong to Huacaya type, 12% are Suris and 8% are intermediate (MINAGRI, 2017a) and about 70% of llamas are considered as a more wooly type (called Lanudo or Ch'aku) and 30% are more meat oriented type (called Pelado or K´ara). The distribution of llama types varies according to region, where more Lanudos are found in the South of the country (Puno district) at the boarder to Bolivia and K´ara more in the central Highlands.

SAC contribute to the regional economy and alpaca fiber is in high demand by the textile industry. Since 2001 the alpaca fiber production increased annually by 1.79%, which is mainly a result of an increase in number of animals. In 2015 the fiber production reached 4,478t at national level, of which 90% was for export market and 10% for the national market (mainly for handicraft). Main destinations are Italy, China, South Korea and Taiwan. In 2016 the export volume of tops was 51 million US $ with an average price of 14.6 US $/kg (MINAGRI, 2017a).

The aim of this paper is to present advances in research, but also development initiatives related to genetic improvement in alpacas and llamas in Peru. The authors do not claim to provide a complete picture of all research and development activities as they are sometimes scattered and isolated and not well documented, but compiled to their best knowledge relevant information at hand for Huacaya alpacas and K´ara llamas. The paper presents more data on alpacas as there is more information available. This reflects also the economic importance of these animals.

Production systems

Alpacas and llamas inhabit the Andean highlands and are kept at altitudes between 3800 and up to 5000 meters above sea level. Although both species are very closely related, they have different demands on their respective habitat and therefore occupy different ecological niches. Llamas can better cope with arid conditions and low quality feed resources (Flores, 1991; Flores and Gutierrez, 1995). Therefore, llamas are more concentrated in the drier highlands in southern Peru.

Both species are kept in extensive, low-input, pasture-based systems. Differences in ownership patterns can be observed between alpacas and llamas (Table 1). On average, an alpaca farmer has 50 animals and 30% of the total alpaca population is raised by farmers, who own less than 5 ha of land (MINAGRI, 2017a). 76% of the Peruvian llama population is kept on farms with less than 50 ha and 41.5% of llamas are found on farms with less than 3 ha (Fernandez-Baca, 2005). A study from the Central Andes in the department of Cerro de Pasco indicates an average number of 36 llamas per farmer (Gutierrez et al., 2012).

Table 1. Different ownership patterns for alpacas and llamas in Peruvian Central Highlands

Type	Communal	Communal	Association	Individual	Private

	cooperative	farm		farmers	companies
Main livestock	Sheep alpaca llama	Sheep Alpaca	sheep alpaca	sheep alpaca llama	alpaca
Land owner	Community	community	community	community	Company
Member	Community members	A community	Group of individuals – families	Individual	company
Main destination of profit	Members	Community investments / services	Members	Individuals	Company

Radolf et al. (2014) documented that farmers like to keep mixed herds of sheep, alpaca and llamas as a risk mitigation strategy and to increase resilience towards fluctuating prices for different products. This study also showed that farmers perceive climate change as a possible threat for their livestock production. They favour llamas over alpacas as they are considered to be better able to cope with an increasingly stressful environment. The forecast for the Central and Southern Andes predicts a decline in annual precipitation, which translates directly in declined pasture productivity, but also in a change in fodder plants (SENAMHI, 2009). Pizarro et al. (2015) modelled different possible scenarios under climate change and demonstrated that llamas might be more relevant as an adaptation strategy in the near future.

Current situation of genetic improvement

Government initiatives

In 1997 the Peruvian Ministry of Agriculture established the genealogy registry for alpacas and llamas. The objective of this registry was to identify and record all animals which are phenotypically according to the set standards. Animals only with a score with 75 or higher (maximum 100 points) are allowed to enter the registry. The up-take rate of this system is very low and only a very small number of animals are actually recorded in this system. One of the problems is the extremely strict standard to include animals in the registry, another one is that farmers do not see a benefit of having animals registered.

At the research farm Quimsachata in the department of Puno in Southern Peru the national research organisation INIA (Instituto Nacional de Innovación Agaria) runs an ex-situ in-vivo conservation program for coloured alpacas (21 different colours) and llamas (Huanca et al, 2007). The low number of females in the program, low fertility rates and high mortality rates of young animals are stated as limiting factors for genetic improvement (MINAGRI, 2017a).

INIA also execute the national program for innovation in camelids (Programa Nacional de Innovación Agraria en Camélidos-PNIA) with its aim of establishing controlled mating and use of good breeding males. INIA is also doing research in the area of embryo transfer, artificial insemination and controlled mating.

In 2017 a livestock department (Dirección General de Ganadería) within the Ministry of Agriculture was re-established. This department prepared the national livestock development plan for 2017 – 2027. The Ministry set as goals the increase of the export

volume up to 3,426t and 67 mio US$ by the year 2027. For the same year an increased production of 5,900t of greasy fibre and 2.3 kg/alpaca/year is envisaged (MINAGRI, 2017b). This should be achieved through different strategies such as strengthened farmers´ cooperatives, dynamic information system for alpaca and llama value chains, quality certification of camelid meat, improved access to credits and better linkages between private and public stakeholders. The design and implementation of a national breeding program for SACs, gene banks and production centres of breeding males are explicitly mentioned as genetic improvement strategies.

Regional governments (e.g. Puno, Cusco) provide funds for development projects in alpaca production system, but not for llamas. They emphasize farmers´ training in management and trading, they also organized breeding male centers to share males with farmers, but this strategy did not work well because of the lack of a genetic evaluation system and genetic structure of the alpaca population at smallholder level.

Alpacas

Genetic parameters

Several studies were carried out to estimate genetic parameters for fibre, growth and reproductive traits in Peruvian alpaca population. Average fibre diameter (FD), standard deviation of FD (SDFD), coefficient of variation of FD (CVFD) and comfort factor (CF), defined as % fibres less than 30 microns, have shown from moderate to high heritability (Cervantes et al., 2010; Paredes et al., 2011; Gutiérrez et al., 2014). Heritability estimates for fleece weight ranged from low to high values (Gutiérrez et al., 2009; Paredes et al., 2011; More et al., 2017). Growth and reproductive traits ranged from low to moderate respectively (Cruz et al, 2015, 2017). Genetic correlations between FD and SDFD was positive and high and between FD (Cervantes et al., 2010; Paredes et al., 2011; Gutiérrez et al., 2014; More et al., 2017) and CF were negative and high (Cervantes et al., 2010; Gutiérrez et al., 2014). In contrast, the genetic correlations between FD and FW ranged from low to moderate (Gutiérrez et al., 2009, Paredes et al., 2011; More et al., 2017), FD and reproductive traits were very low (Cruz et al, 2015). Genetic correlations between FD with growth traits were positive and moderate (Cruz et al, 2017). It is also plausible to reduce the FD variability across age (Gutierrez et al 2011). Research has been conducted to estimate heritability for medullation fibres, preliminary results indicate a moderate heritability.

Breeding goals and selection criteria

Although there is no a national breeding plan, the main goal in alpacas is to reduce FD and its variability across the fleece. Currently, many institutions have OFDA equipment to offer FD related measurements to alpaca breeders in Cusco and Puno. Some breeders want to increase FW, but it is not recorded routinely in most farms. Moreover, Pacomarca farm included the reduction of the prickle factor as a breeding goal, but it is not clear what will be the appropriate selection criterion (% of medullated fibres, SDFD, etc.)

Breeding programs

Isolated initiatives to implement breeding programs have been started by different actors like Pacomarca (farm of textile company), Mallkini (farm of textile company), INIA

(national research organization), Pasco (group of farmers), DESCO (NGO), UNSAAC (university) or Rural Allianza (farmers enterprise) (e.g. Mueller 2007). Some of these initiatives run a genetic evaluation using BLUP. The problem is that these breeding programs are isolated and farms are therefore not genetically connected. Some alpaca farms achieved a significant amount of genetic improvement, thus a decreasing in FD from 22.5 to 18.4 microns in about 10 years was reported at Pacomarca farm (Gutierrez JP, personal communication).

Smallholders sometimes buy animals from the initiatives mentioned above where animals are registered and performance records are kept, but there is no follow-up after these purchases on animals. There is currently no breeding program run for or with smallholder farmers, who own the majority of the alpaca population.

Reproduction technologies

Artificial insemination, embryo transfer, in-vitro fertilization, semen and embryo freezing have been investigated for several years. However only embryo transfer has been applied routinely for genetic improvement in some herds (e.g. Morante et al 2009)

Llamas

Genetic parameters

Few studies were carried out for estimating genetic parameters for growth and reproductive traits llamas in Peru but results were not conclusive (eg Mamani-Cato et al 2014).

Breeding goals and selection criteria

Compared to alpacas, initiatives and projects working on genetic improvement in llamas are very limited. From 2011-2013 and from 2014-2017 two small research for development projects were implemented by UNALM-Universidad Nacional Agaria La Molina together with farmers in Cerro de Pasco region, Central Andes. The first project aimed at the design and implementation of a community-based breeding program. In a multi-stakeholder process different options were developed and farmers formed officially the PROLLAMA association (Wurzinger and Gutierrez, 2017). In the second one recording mechanisms, performance testing of young males, alternative feeding and meat processing strategies were evaluated (Gomez at al., 2015, Gutierrez et al., 2017). In the scope of an FAO-supported project, which was jointly executed with Bolivia, an online database for llama recording was designed and capacity development for farmers and young scientists in the field of animal science were carried out. The breeding program is still not fully operational, but there are currently discussions between the Ministry, the local government and farmers how this program could be supported for the coming years.

Gutierrez et al. (2012) revealed in a study from the Central Andes that the most important selection criteria for males and females are body size, conformation, color and pedigree. Information on pedigree does not mean that farmers have written information about the ancestors of each individual animal. This only means that farmers can identify the dam and in some rare cases the sire of their llamas (Gutierrez et al., 2012). In a ranking experiment where farmers were asked to rank young breeding males, the three most important

characteristics out of a total number of eleven, were strong cannon bone, chest width and height at withers (Wurzinger et al., 2017). All these criteria indicate the importance for meat production in llamas.

Conservation strategies in alpacas and llamas

Although a germplasm bank for alpacas and lamas was implemented already in 1983 in Quimsachata research unit, there is no a national conservation plan in place. However, INIA have just started the formulation phase of a National Bank for Agrobiodiversity Conservation that include ex situ in vitro conservation of SACs.

Genomic tools

A test for parentage verification using microsatellite markers was set up for many researchers in Peru (Rodriguez et al 2004, Agapito et al 2008, Yalta et al 2014; Moron et al 2015). Some studies to associate molecular markers with FD was conducted (Paredes et al 2014), but more research is needed to confirm the results. Studies have recently started to identify and allocate SNP markers in alpacas, preliminary results reported a number from about 50,000 to 60,000 SNP by using a High Density Bovine Beadchip (Bertolini et al 2016).

Conclusions

Alpacas and llamas are important animal genetic resources in Peru and contribute to the national economy and support the livelihoods of many rural families in the Andes.

Over the last years research, especially in alpacas, has shown some advances, but implementation of fully functional breeding programs including a large number of animals remains a challenge to be solved. As there is an interesting international market for especially fine fibre there is an incentive for farmers to work towards this goal. A possible solution would be the establishment of a sire-reference scheme between already existing initiatives, support by the Ministry of Agriculture.

The situation remains still more challenging for the llama sector. The advantages of llamas, especially under changing climate conditions, are not yet fully recognised and the development of a market for these products still has to be developed. In addition, further research is needed to know the genetic structure of the llama populations for a design of sustainable breeding programs.

A positive development is that the Ministry of Agriculture recognises in its development plan the importance of both species. It still has to be proven that the new plan will be implemented in the coming years and enough budget will be allocated to all required activities.

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