



## Technology Transfer from Academia to Rural Communities: The Case of Caprines in vitro Fecundation and Local Livestock Market in Tamarugal Province in Chile

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### Abstract

The following article shows a case study of the caprine industry in the Tamarugal province (Chile) and includes a comparison with the data previously retrieved by governmental agencies and a local survey performed in this work. It aims to identify the objectives of the Center for Animal Reproduction of Universidad de los Lagos (CRAULA) to fulfill the needs of the local goat producers, in order to switch the economic basis of the region to more sustainable sources than the used nowadays. The center develops in vitro fecundation process to manage genetic improvement in goats. The technology transfer strategy includes a close monitoring of the production in a climatic extreme condition such as the north of Chile. Our results retrieve an updated snapshot of the goat production in the province, the economic projections and the producer's demands for assessment and technology support, where a stronger interaction between University and industry is suggested.

**Keywords:** technology transfer, developing countries, livestock, rural communities, in vitro fecundation, quantitative prospection.

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## Introduction

### Caprine livestock industry in Tamarugal province

Tamarugal province is located in the 1st of the Chilean regions, at the very north of the country, with an extensive area of 39,390.5 Km<sup>2</sup>, representing the 5.21% of the Chilean territory, its population consists in 22,532 inhabitants which of them the 47.3% live in rural areas (INE, 2007a). In economic terms contributes to the Chilean GDP in a 3.5%, based mainly in the mining area revenues. Due to its desertical climate and the poor quality of water resources, the land used with agricultural and livestock purposes is just 8.35% of the regional area (INE, 2007b). The lack of innovative disruption in this province during the last decade, caused that the contribution to the regional and the national GDP in agricultural and livestock sector have a downward trend (FIA, 2009a). Particularly in the livestock industry the main product belongs to the camelid, where llamas (*Lama glama*) and alpacas (*Vicugna pacos*) are the main species employed for the exploitation (INE, 2007b). The caprine species on the other hand belong to a resource produced in a very low level due mainly to the use of "criolla" mixed races (creole goat), which have a very limited fodder access (FIA, 2009b; Mujica, 2005). These rustic races come from years of uncontrolled breeding and natural selection, and are highly adaptable to extreme geographical and climatic conditions (Dubeuf and Boyazoglu, 2009; Gunia et al., 2010). The case of the Chilean "criolla" race have been highly influenced by the introduction of races Anglo Nubian and Saanen which had been translated in a wide variety of traits and is considered a multipurpose race. Under mediterranean climate conditions adult females (does) weigh in a range of 32 to 78 Kg and males (bucks) reach between 50 to 90 Kg, and the milk production (mechanical extraction) is 78,6 Kg at the 176th day of lactation (Mujica, 2005).

The local caprine production depends mostly on familiar small producers from Aymara communities spread in a huge area (FIA, 2009a). The lack of precision in the prospecting executed so far in the province and the limited existence of slaughterhouses (SAG, 2010) that provide statistics of the local productions and their needs consists in a major breakthrough to correct. Nonetheless, it has been identified by governmental entities that improvement in the handling practices aimed to the production, the health and nutrition of the livestock is needed, remarking specially the adaptation of potential breeders objectives to the extreme climate conditions of Tarapacá and particularly to Tamarugal province, having as main projection the meat production, taking in account that is a highly demanded product during holidays period (FIA, 2000, 2009a). A proper supporting

breeding program in order to improve the production and the sustainability of these communities becomes a potential solution to establish direct contact with the producers communities, make precise prospecting, identify the needs and develop a pipeline to introduce controlled breeding to increase local sustainability.

### Caprine In vitro technology

Existence of In vitro fertilization (IVF) in caprines is documented since first viable kids were obtained from In vitro capacitated spermatozooids (Song and Iritani, 1981) plus In vivo capacitated oocytes (Hanada, 1985) and In vitro capacitated oocytes (Crozet et al., 1995). In the following years several improvements to the technique have been developed aimed principally to the impact as a biotechnological tool, remarking the use of frozen embryos and the split possibility in order to minimize the use of goats for improving programs (Amoah and Gelaye, 1997).

The IVF embryo production can greatly benefit breeding and genetic improvement schemes. With this technique it is possible to increase the genetic progress through selection of males with better fitness and increased number of embryos obtained from a single seminal sample. Also the offspring generation time is reduced, allowing the quick production of new genotypes with high production value. The cryopreservation of embryos allows the storage and conservation of genetic traits that otherwise will disappear with the individual. It also offers greater health safeguards against transmission of infectious agents, facilitating the international trade.

### Technology transfer bridging strategy

Considering that the relevance of the scientific knowledge has into the development of local economies aiming to look for the avoidance of "locking-in inferior technological solutions" (Delvenne and Hendrickx, 2013) the need for effective translational results is imperative in order to develop sustainable solutions for communities such as the case of the caprine industry in Tamarugal province. Taking in account that the stakeholders within the productive system in caprine industry at Tamarugal province includes producers, consumers, policy makers, regulatory entities and scientific knowledge institutions, which consists of the different actors that can be affected, create value or be benefit from the developed technology (Ezezika et al., 2009) the identification of them, and a dynamic overview of them becomes mandatory in order to design solutions aimed to correct the breakthroughs mentioned above. The creation of the Center for Animal Reproduction of Universidad de los Lagos (CRAULA) in the Tamarugal province aims to fulfill these gaps and to improve the local industry with effective technology transfer based on the observation of the local goat livestock industry.

## Methods

### Bibliographic analysis

Existing data from agricultural and livestock censuses within the last 20 years were analyzed performed by the National Statistics Institute (INE). These censuses by definition consist in a measuring of the total agricultural and livestock exploitation within the country. Is performed each 10 years and shows the evolution of the Chilean agricultural and livestock evolution. As well was included in the analysis the data retrieved from the livestock breeders' census, which is performed by the Agricultural and Livestock Service (SAG). Since the information from this survey is not publicly available, it was retrieved by direct communication with a SAG agent.

### Tamarugal province livestock industry field survey

In order to generate a report with precise data, a survey was designed including production parameters such as specie, race, age, sex, and amount. The survey was delimited the geographic area of Pozo Almonte, where local goat producers were interviewed.

## Results

Data from four sources were gathered, including Agricultural and livestock census from years 1997 and 2007-which is a survey applied each 10 years in Chile by INE- and livestock census from years 2010, 2011 and 2012- which is performed by SAG- The first census is applied at national level, and second one has a voluntary nature. Regarding to the sample (Figure 1a) it can be observed that the obligatory nature of the national census impacts directly in the amount of informers considered within it having around 4 fold the informers considered in the one performed by SAG agency. Considering that the livestock census lacks samples in mulars but has a weak incidence in the total livestock amount reported since the SAG reports have just 25% of the reporters that national survey has. It can be remarked that from the data retrieved in the national survey to the data retrieved by the SAG reports of the total livestock resource (Figure 1b) shows a drop of the 20% between years 2007 and 2010, inferring a 10 years tendency. From data in total livestock amount between years 2007 and 2010 exist a 35% difference despite the 75% difference in the amount of informers for the same period, which statistically can imply: Lack of consistency of the censuses due to sampling issue due to a "cherry picking" tendency to select reporters that have higher resources, or simply an exponential growth in this industry within the province. Between years 2010 and 2011 it can be observed a tendency similar to the observed between 1997 and 2007 with a 20% drop in the livestock ac-

tivity showing an accelerated decrease of the livestock in the region, which also can be associated to the sampling methodology or the ratio of resources to number of informers. The last census performed in 2012 shows an increase of 100% in reference to the one performed in year 2010 considering the same amount of informers, the data retrieved from 2012 is similar to the data obtained in year 2007 but considering just a 25% of the informers, implying the following assumptions:

- Inconsistency in some of the surveys performed
- Explosive growth within a year
- Huge resource transference in 5 years period
- Hidden sample not considered in previous surveys

Regarding to the evolution of the caprine livestock resource (Figure 1c) shows a significant drop in the period 1997-2007 (74% decrease). The amount of caprines of 2010 is 35% higher than the reported in 2007 considering that the amount of informers gathered were less, and reports lacks a marked tendency since data from year breaks it showing a new decrease in the activity, which is replenished by the measuring made in year 2012. These data reveals a big chasm between the caprine livestock resource and the census capacities to sense it.

The evolution of the carpine resource compared to the total livestock reported (Figure 1d) reflects congruence issues within the sample, remarking the results retrieved in years 2007 and 2011, since such a decrease can affect the whole population of the province, and none by the considering increase of the activity in other livestock resources can explain such a drop.

The significant differences between livestock resource reported and the informer considered in these surveys evidence possible breakthroughs in the surveying methodology needed to be fixed. It can be remarked a "ghost" resource information not retrieved yet due to geographical, cultural and economic-political issues proper of this province rich in rural areas with difficult access. This implies the need of a "tailor made" methodology to sense in a more accurate way the real state of the industry in the area and the needs according to the market where it points that can be improved by effective technology transfer. Considering this the methodology designed for included a marked delimitation of parameters such as sex and purpose of the caprine resource. From the performed survey we detect that with a limited amount of reporters gathered in a delimited area (Pozo Almonte) can inform a significant amount of livestock, which quantified and taking as reference the previous reports (Figure 1c) consider this a relevant sample for study the geographic region. If is considered that in the Tamarugal province exist an estimated amount of 20.000 livestock individuals

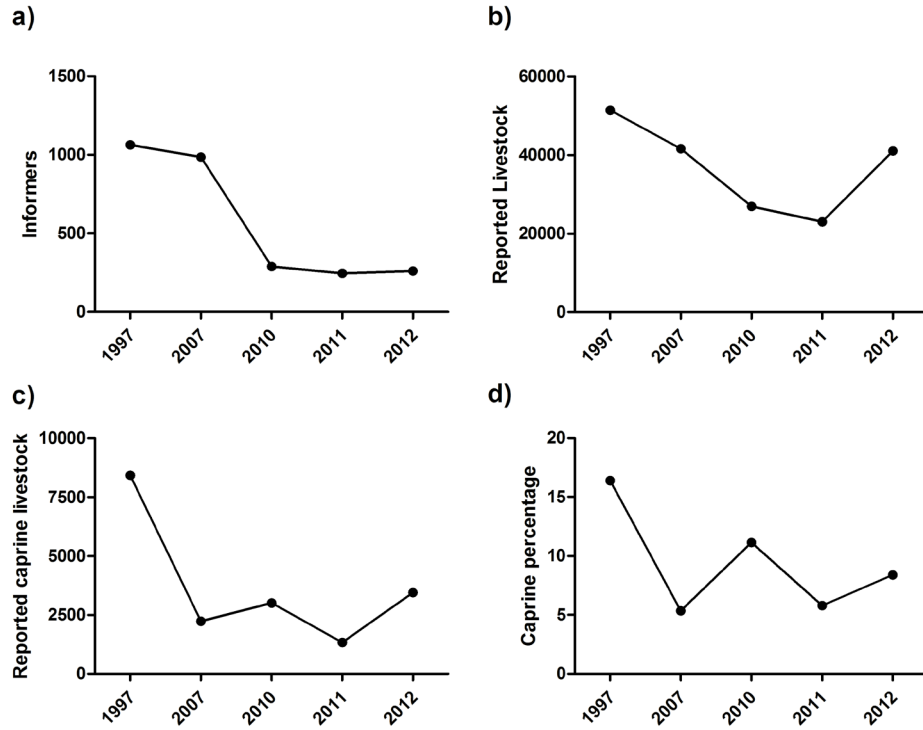


Figure 1: Data retrieved by from previous censuses shows the amount of surveyed informers in each event (a) the total livestock in amount of animals (b) the amount of goat population (c) and the percentage of the total livestock population that caprine livestock consists (d).

Reporter ID	Sex and age group		
	Males	Females	Kids
10001	4	350	100
10003	0	70	80
10004	1	5	0
10005	4	70	30
10006	2	38	0
10007	1	70	60
10008	2	60	10
10009	3	47	0
10011	2	48	0
10012	0	140	48
10013	4	91	0
10014	2	90	48
10015	1	50	20
10017	2	73	0
10018	1	49	0
Total	29	1251	396

Table I: Livestock sex and age groups surveyed.

Product	Feeding source	Amount	% Consumption
Meat	Alfalfa	761	31,48%
	Tamarugo	745	30,80%
	Algarrobo	258	10,67%
	Quillaja	48	1,98%
	Shepherding	570	23,58%
	Atriplex	36	1,49%
	<b>Total</b>		<b>2418</b>
Milk	Alfalfa	19	13,94%
	Tamarugo	92	66,93%
	Algarrobo	26	19,12%
	<b>Total</b>		<b>137</b>
Total	Alfalfa	780	30,54%
	Tamarugo	836	32,74%
	Algarrobo	284	11,13%
	Quillaja	48	1,87%
	Shepherding	570	22,31%
	Atriplex	36	1,41%
<b>Total</b>		<b>2555</b>	<b>100,00%</b>

Table II: Feeding source consumption per product with caprine livestock.

the total sample taken (1679 caprine individuals) has a 95% confidence interval, a 5% margin of error and 1% precision.

The population observed showed a considerably bigger amount of female individuals (Table I) which preliminary can indicate that the population is employed for the sustainability of the livestock and/or production of renewable products such as milk or wool. Nonetheless the results observed in the feeding questions (Table II) shows that the main activity is associated with meat production and within this group the principal source of feeding is alfalfa and tamarugo. As well the indicators of meat production shows that the overall yield per animal despite the race employed is 53%, remarking with these measurements that Boer race has the higher yield (65%) a 15% higher than the observed in the Criollo livestock.

Taking in account the fertility rate of the population (Table IV) under non assisted conditions it was observed that the value is close to the 40%, considering that close to one event per year is performed.

Considering the opinion of the producers according to their position about establish collaboration with the environment the results were mainly positive to the willing to establish collaboration with external assistance (Figure 2a) in any form as well with all the indicators employed to measure the actual participation of the goat producers shows that at the present day half of the producers surveyed take proper action with their environment in order to associate and improve their production, in form of peer association (Figures 2b and 2c) and within organizations (Figure 2d).

Race	Age/Sex		Weight (Kg)	Meat (Kg)	Yield	N
Criollo	Kid	Mean	31,17	15,67	0,50	6
		SD	7,083	3,615	0,028	
Anglo	Kid	Mean	35,00	15,00	0,43	1
		SD	.	.	.	
Boer	Male	Mean	60,00	35,00	0,58	1
		SD	.	.	.	
	Old Male	Mean	60,00	40,00	0,67	1
		SD	.	.	.	
	Old Female	Mean	50,00	35,00	0,70	1
		SD	.	.	.	
	Total	Mean	56,67	36,67	0,65	3
		SD	5,774	2,887	0,060	
Somalia	Male	Mean	100,00	50,00	0,50	1
		SD	.	.	.	
	Female	Mean	70,00	35,00	0,50	1
		SD	.	.	.	
Total	Male	Mean	80,00	42,50	0,54	2
		SD	28,284	10,607	0,059	
	Female	Mean	70,00	35,00	0,50	1
		SD	.	.	.	
	Kid	Mean	31,71	15,57	0,49	7
		SD	6,626	3,309	0,038	
	Old Male	Mean	60,00	40,00	0,67	1
		SD	.	.	.	
	Old Female	Mean	50,00	35,00	0,70	1
		SD	.	.	.	
	Total	Mean	46,83	25,33	0,53	12
		SD	22,530	12,922	0,080	

Table III: Meat yield per goat race.

In reference to the needs reported by the goat producers community is evidenced that two main topics are remarked as immediate by the surveyed sample, and include the assistantship with projects that can improve the entrepreneurship instances within the industry (Figure 3a) and the assistance in animal health and management (Figure 3b), topic in which assisted fertilization is included.

**Discussion**

The existing data allowed us to have a snapshot of the tendency of the livestock in the region. Nevertheless, due mainly to geographic, technical and cultural factors the data retrieved show gaps and lack specificity. With these antecedents we delimited a manageable geographic limit which included the city of Pozo Almonte, where a considerably

Reporter ID	Total livestock	Kids	Cross events	Fertility rate
10001	354	100	1,5	19%
10003	70	60	1,0	86%
10005	74	30	1,0	41%
10007	71	60	1,5	56%
10008	62	15	1,0	24%
10012	140	50	1,0	36%
10015	51	20	1,0	39%
<b>Total</b>	<b>822</b>	<b>335</b>	<b>1,143</b>	<b>36%</b>

Table IV: Fertility rate of caprines in Pozo Almonte goat population.

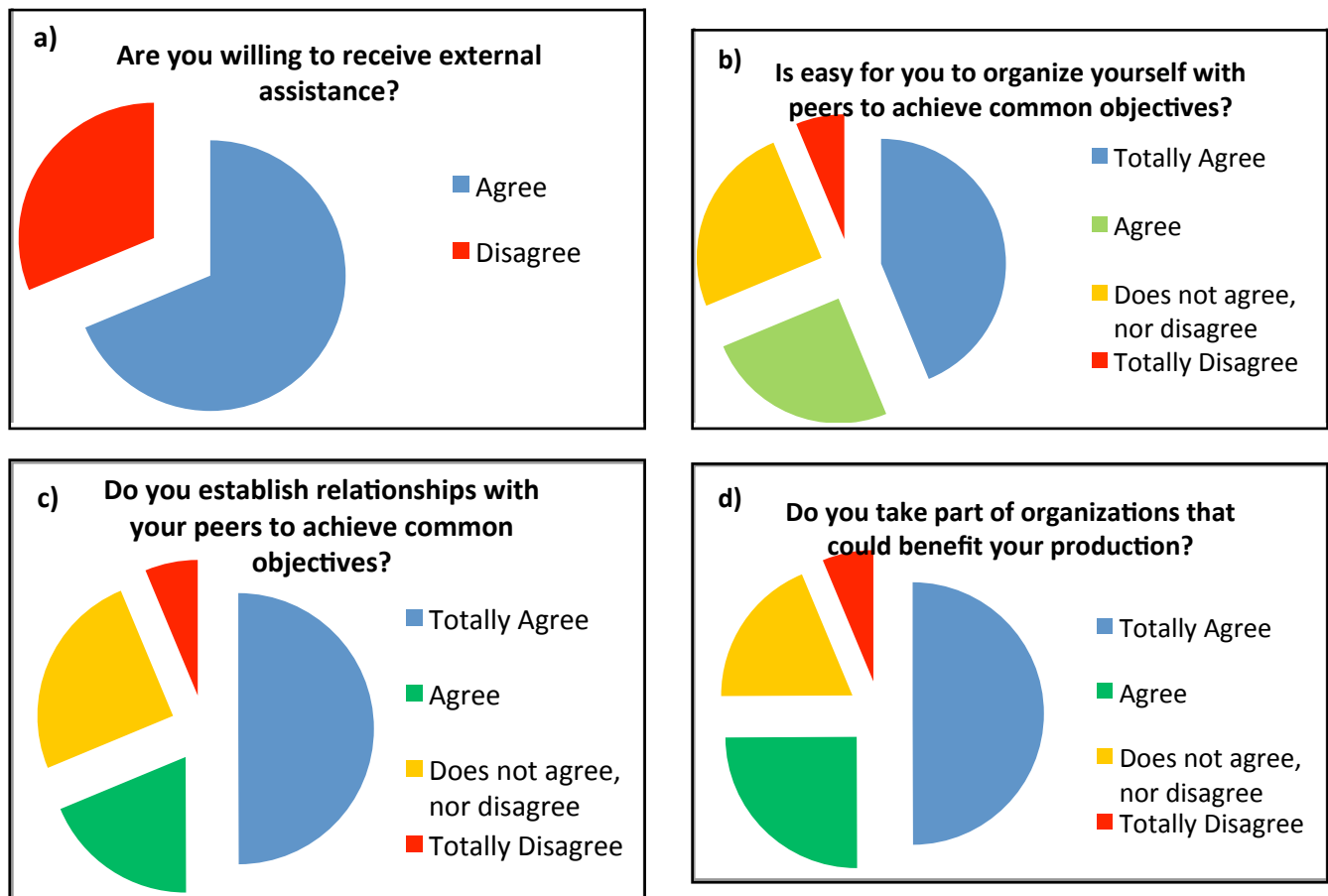


Figure 2: Goat producer's survey according to their association potential.

significant amount of livestock and producers that manage it are situated, and taking in consideration the previous reports made by national agencies. Our delimited sample can in a controlled way give a precise perception of the goat livestock industry. The results demonstrate that despite the potential of this resource, a relevant lack of targeting for the local production is evidenced, considering that a high aim for meat production despite the yield of the livestock managed is done. Within this a window of genetic improvement assisted by FIV is evidenced, taking in account of the main race “Criollo” employed in the production and overlapping this results with the optimal meat yield presented by the race Boer, which shows as well an important factor that is the adaptation to the extreme conditions of the Tamarugal province.

**Technology strategy and selection of races for genetic improvement**

Taking in account that the “Criollo” goat livestock is a mixture of races that are highly adapted to the extreme climatic conditions (Mujica, 2005) as well as one of the most commonly used goat for the producers in the province, is considered as a potential basis for the livestock improvement. Under the yield results observed within “Criollo” race in our study and having in mind that the main purpose of the livestock is for meat production, we consider that carcass improvement in “Criollo” goat consists in one of the most important objectives of the Center for Animal Reproduction of Universidad de los Lagos (CRAULA) in the Tamarugal province. Previous studies reported that “Criollo” livestock yield under slaughterhouse conditions up to 26% of the total weight in adults (Owen et al., 1983) with no reduction of this value within kids (Nunez Gonzalez et al., 1983). On the other hand, the evidence observed of a successful adapta-

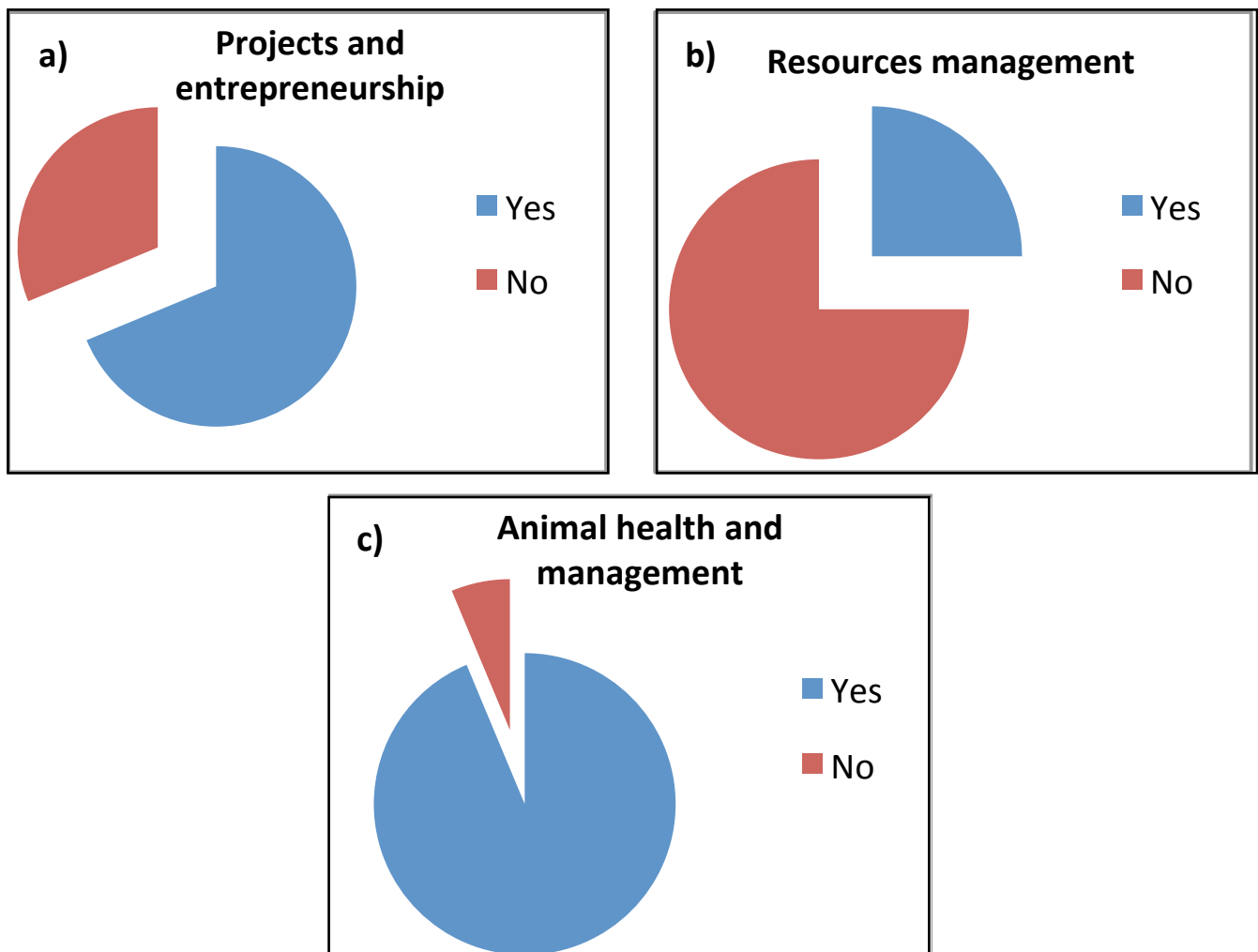


Figure 3: Goat producer's survey according to their needs for external assistance

tion of Boer livestock in the area, as well as the carcass yield measured suggests that for improvement this race can be the target for hybridization and enrichment of the "Criollo" background in Tamarugal province. Boer consists in a highly fertile race with a high reported carcass yield conformed by a lean meat that also has traits such as a good milk production- which is associated to the animal growth (Malan, 2000). Despite this, is very important to consider the relevance of the livestock fodder, since a very close assessment is suggested for genetic improvement programs with Boer race in several genetic backgrounds (Saanen and Toggenburg) included in the "Criollo" race (Almeida et al., 2006; Browning et al., 2012; Oman et al., 1999), which includes a relevant feedstock assessment role towards the local industry of CRAULA. Taking in account that as well has been reported that Boer goat has been adapted to several extreme climatic conditions, as well to present significative disease tolerance (Erasmus, 2000; Pellerin and Browning, 2012). Improvement of milk and multipurpose livestock with enhanced meat yield races is projected this way as the main objective of CRAULA within the province.

The inclusion of such a research center in an isolated geographic location, and considering the willing of the goat producers in the zone prospects implies the opportunity to move an economy based in the exploitation of nonrenewable resources to an improved exploitation of highly renewable one. The transference from a methodology developed in the university such as the FIV has to point to the before mentioned races in order to observe in the forthcoming years these results in the field, always taking in account the constant monitoring of the main issues to improve the sustainability of the local producers, such as the animal health assessment, and fodder management.

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