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Assessment of grazing selectivity in relation to land cover: a comparison between sheep and goats

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La tâche du berger serait bien plus dure sans l'amour de ses moutons

De *Anne Barratin*

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Abstract

Portugal's Northeast production of sheep and goats are based on the exploitation of landscape by-products such as spontaneous native vegetation and agriculture leftovers. Shepherds tend the flocks throughout grazing itineraries every day, crossing a mosaic of patches of varied land uses. During the journey, the shepherd acts together with the sheep and goats to select each patch in creating an ordered sequence of land uses.

The focus of the research is on the land-use composition of the grazing itineraries; determinate how they depend on the patterns of the landscape mosaic. It is utilized a data set of 26 monthly herd's itineraries, 13 of sheep and 13 of goats, to investigate the relationship of the land uses crossed by the flocks and the land uses of the landscape, evaluating the land-use preferences and selectivity of the sheep and goats.

It is utilized the divergences in the time spent and distance travelled by the herds and the area of the land uses in the landscape, the chi-square test to relate the preferred land used and the season, and the discriminate analysis to distinguish the preferences and the selectivity of the herd of sheep and the herd of goats.

The herds of the sheep and the goats presented different land-use preferences over the seasons and the discriminant analysis shows that they have different landscape preferences. The herd of sheep has the highest selectivity indexes for the *annual irrigated crops*, the *agricultural complex systems* and the *agroforestry* land uses. The highest selectivity indexes for the herd of goats were found for the *deciduous forest*, the *agriculture with natural and semi-natural spaces* and the *shrublands* land uses. It was concluded that the landscape management for sheep and goats herding has to be different: the agricultural land uses are essential to the flocks of sheep and the forest land uses are decisive to the flocks of goats.

Keywords: small ruminants, grazing circuits, land-uses preferences, land-use selectivity index, Portugal

Resumo

No Nordeste de Portugal, a produção de pequenos ruminantes baseia-se na exploração de recursos espontâneos e subprodutos da agricultura. Os rebanhos acompanhados do pastor, percorrem diariamente um mosaico de diferentes usos do solo. Ao longo dos percursos de pastoreio, o pastor e o rebanho interagem na selecção das superfícies forrageiras, criando uma sequência ordenada de usos do solo.

Este estudo centra-se na composição de usos da solo observada nos percursos de pastoreio para perceber a sua dependência relativamente ao padrão da paisagem. Utilizou-se uma base de dados com 26 itinerários mensais, 13 de ovinos e 13 de caprinos, para investigar a relação entre os usos do solo utilizados pelos rebanhos e os usos do solo na paisagem, avaliando a preferência de utilização dos usos do solo e a sua selectividade pelos ovinos e caprinos.

Foram utilizadas as diferenças no tempo despendido e na distância atravessada pelos rebanhos e a área dos usos do solo na paisagem, o teste de qui-quadrado para relacionar os usos do solo preferidos e a estação e a análise discriminante para distinguir as preferências e a selectividade dos rebanhos de ovinos e caprinos.

Os rebanhos de ovinos e caprinos evidenciaram preferências diferentes pelos usos do solo ao longo das estações e a análise discriminante mostrou que existem diferenças nas preferências pela paisagem. No caso dos ovinos, os índices de selectividade mais elevados estão associados às Culturas temporárias de regadio, Sistemas culturais e parcelares complexos e Sistemas agro-florestais. Os índices de selectividade mais elevados para caprinos foram encontrados para os usos do solo Florestas de folhosas, Agricultura com espaços naturais e seminaturais e Matos. Conclui-se que a gestão da paisagem para a produção de ovinos e caprinos tem de ser diferente: os usos agrícolas são essenciais para o rebanho de ovinos e as áreas florestais fundamentais para os rebanhos de cabras.

Palavras – chave: pequenos ruminantes, percursos de pastoreio, preferência de usos do solo, índice de selectividade de usos do solo, Portugal.

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Chapter 1. Introduction

There are different interpretations and multiple meanings to the word « landscape »; as a consequence, the ways of dealing with it differ depending on the needs and the purposes. According to Haber (2004 quoted by Farina, 2006), the landscape is "a piece of land which we perceive comprehensively around us, without looking closely at single components, and which looks familiar to us". The landscape is not fixed and static; in fact, it experiments changes over time and it is characterized by a continuous dynamic. Marginal regions, such as the mountainous areas, have been significantly affected by landscape changes (Moreira et al., 2011). Effectively, it is the case of Northeastern Portugal where the landscape has become more aggregated and less diverse because of the strong decrease in agriculture and a regular increase in forests and shrublands, during last half century (Moreira et al., 2011).

These changes affect livestock and the grazing activity, any modification in the configuration and the composition of the landscape can reduce or increase the availability of vegetation, in terms of area and preferred species for sheep and goats. Locals still recur to grazing as living activity and rangelands are main sources of income to shepherds (Harris, 2000 quoted by Papanastasis, 2009). However, this type of lands is subject to degradation, the reason why urgent measures of management should be implemented (Papanastasis, 2009).

Silvopastoral systems are very important particularly in mountains areas. They play a major role in the functioning and structure of the landscape mainly the conservation of its components. Fire is one of the disturbances that operate radical changes at landscape levels. An adequate managed livestock grazing aids to decrease fire hazards (Bary et al., 2015). The grazing reduces the density of shrubs and potential fuel and modifies their distribution in a healthy way for the environment. In another hand, grazing can enable the reduction and the non-competition of non-native species to allow the regeneration of the other desirable ones. Bary et al. (2015) deduced also that grazing enhance and maintain habitats for grassland plants and animals.

From an economical point of view, the livestock represents an important activity for the Mediterranean regions, and grazing is a good alternative to increase the production and reduce costs (Enne et al., 2004), it plays a crucial role in providing food. In another side, livestock contributes to improving the ecosystem services by providing many goods and services such as food and fertilization.

According to Castro et al. (2004), sheep and goats have different strategies for the use of the territory, the first are quite attached to agricultural activities while the latter is deeply linked to the forest matrix. Consequently, the landscape changes will influence these strategies depending on its tendency either towards the increase of forest matrix or the agricultural matrix.

In the Northeastern Portugal, the traditional landscape of Terra Fria is a mosaic of very small patches of annual and perennial agriculture, shrubs, and woodlands. The landscape of this mountainous area is characterized by a high level of biodiversity and the patches are diverse in terms of composition and configuration. Furthermore, the traditional livestock systems are based on grazing itineraries on this landscape mosaic that provides different functions: grazing, browsing, resting and refugee among others. This agroforestry system which integrates forest, agriculture, and livestock, in the same place can be regarded as a sustainable landscape management.

The production systems of small ruminant – sheep and goats – are greatly based on the extensive exploitation of landscape by-products such as agriculture leftovers and spontaneous native vegetation. The herds are conducted by their shepherd over grazing itineraries crossing a mosaic several land uses patches on a daily basis. The choice of the itinerary is not totally controlled by the shepherd. Actually, the shepherd and the animal together select the grazing paths depending on the resource availability which varies according to opportunities of the season. Grazing itineraries must be considered as an ordered sequence of land uses where the flock and the shepherd influence the resources selection at different temporal and spatial scales.

The organization of the grazing process, each patch selection and consequently the itinerary delineation, is conditioned by the attributes of the landscape such as land cover and land use patterns, topography, water points, among others. Grazing selectivity by sheep and goats, and shepherds, can be evaluated by very simple ratios between the existing land uses area and the land uses selected by the herds.

Considering that landscape composition and configuration have a major role in supporting the traditional silvopastoral systems, and that their sustainability can be threatened by strong changes in the landscape pattern, the key objective of this study is to understand how that pattern – composition and configuration– could influence the grazing activities, and furthermore, to recognize those land uses selected for grazing and those ones important to guarantee the connectivity in the itineraries of herds.

As specific objectives, this study aims:

- Firstly, to recognize the land cover composition of silvopastoral areas in the studied villages: Rebordainhos and Freixedelo.
- Secondly, to relate this composition with those of the grazing itineraries of sheep flock (Rebordainhos) and goats flock (Freixedelo).
- And finally, to describe the functions and services provided by the silvopastoral mosaic associated with the grazing system of sheep and goats itineraries.

The thesis is organized comprising:

- An introduction;
- An overview of the agroforestry, the silvopastoral systems as well as the circuits of pastures;
- The presentation of the study area and the data set;
- A description of the methods utilized;
- The interpretation of the obtained results;
- The discussion and the conclusions of this study.

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Chapter 2. The context of the research

2.1. The agroforestry and the silvopastoral systems

2.1.1. Agroforestry

The history of agroforestry as a science is short, it was during the 1990's which research has gradually been transformed from a collection of largely descriptive and empirical studies into more scientific approaches, based on process-oriented research (Zulberti, 1990). However, agroforestry is only a new term for age-old practices of integrated land-use in almost all parts of the world.

Many definitions of agroforestry have been proposed (Nair 1985 (quoted by Somariba et al., 1998), ICRAF 1993), which have in common that agroforestry involves combinations of different components on the same land surface. Nair (1993) pointed out, that in agroforestry systems there are three basic sets of elements or components which are managed by the land user, namely, the tree or woody perennial, the herb (agricultural crops including pasture species), and the animal. Also, Sommariba (1992, as cited in McAdam et al., 2009) argued that agroforestry systems satisfy three basic conditions:

- There are at least two species that interact biologically,
- At least one of the species is a woody perennial,
- At least one of the plant species is managed for forage, annual or perennial crop production,

In addition to this biophysical common denominator, agroforestry is often linked to sustainability and smallholder agriculture (van Zanten et al., 2013). For instance, the World Agroforestry Centre describes Agroforestry as a "… a dynamic, ecologically based on a natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels" (ICRAF, 1998).

On the other hand, agroforestry could be perceived as science or practice. Then, it can be considered that Agroforestry is the science that study agroforestry systems and simultaneously it is a land use practice combining trees, crops and/or livestock on the same area of land in all special or temporal arrangements (Nair, 1993; Silva-Pando and Rozados-Lorenzo, 2002; Mosquera-Losada et al., 2009)

Recently, den Herder et al. (2015) have defined agroforestry as the practice of "deliberately integrating woody vegetation (trees or shrubs) with crop and/or livestock production systems

to benefit from the resulting ecological and economic interactions". The need for ecological and economic interactions was present in the definition from Lundgren and Raintree (1982) adopted by the World Agroforestry Centre (ICRAF) and Food and Agriculture Organization of the United Nations (FAO), that agroforestry is "a collective name for a land use systems and technologies where woody perennials are deliberately used on the same land-management unit as agricultural crops and/or animals, in some form of spatial and temporal arrangement".

Agroforestry practices or systems can be categorized according to (i) components, (ii) predominant land use, (iii) spatial and temporal structure, (iv) agroecological zone, (v) socio-economic status, or (vi) function (McDam et al., 2009). In relation to components Nair (1993) proposed three basic forms of agroforestry, these are Agrosylviculture (crops and trees), Silvopastoral systems (pasture/animals and trees) and Agrosilvopastoral systems (crops, pasture/animal, and trees)

2.1.2. Silvopastoral systems

Silvopastoral systems can be defined as complex management systems that integrate tree, pasture, and animals in a concrete edaphoclimatic context (Nair 1993, Etienne, 1996). Several authors (Nair, 1993; Etienne, 1996; Papanastasis, 1996; San Miguel, 2003) agree that silvopastoral systems have four main components: trees (woody vegetation), sward, animals and man, in other words, it is recognized the shepherd's role in resources exploitation. Several criteria are used to classify the silvopastoral systems, among such criteria it is possible to identify the systems according to spatial and temporal arrangement (Rois-Díaz et al., 2006). For instance, Mosquera-Losada et al. (2001) identified two clusters with subclasses:

1. Silvopastoral systems within the same area and time-scale;

i) Pure silvopastoral systems or grazing in the forest; ii) Ligniculture on sward, iii) Silvopastoral systems in lines

2. Silvopastoral systems in the same time-scale but not in area;

i) Forestry in livestock farm

Etienne (1996) taking account the distribution of woody and herbaceous vegetation and animals has elaborated a classification of Mediterranean European silvopastoral systems as it is shown in **Table *1***.

Table 1. Classification of Mediterranean silvopastoral systems, according to Etienne (1996, quoted by San-Miguel 2004).

Grazing and browsing in shrublands or forests	Shrublands	Natural shrublands		Marquis Garrigue Legume shrublands Xerophytic shrublands Saline & Nitrophilous shrublands Other
		Fodder shrub plantation		*Atriplex sp.* *Medicago arborea* *Opuntia sp.* Other
	Forests	Coppices		Usually *Quercus sp.*
		High forests	Conifers	Some wild junipers provide forage for livestock and wildlife
			Broadleaved	Usually, provide browse and sometimes fruits for livestock and wildlife
Scattered trees (or shrubs) on swards	Wild trees	Fodder trees (browse, fruits)		Dehesas & montados Other
		Non-fodder trees		Xerophytic conifer Woodlands
	Plantation (usually agricultural trees)			Olive (*Olea europaea*) Almond (Prunus *dulcis*) *Pinus pinea* Leguminous fodder trees (*Ceratonia, Robinia, Gleditsia*…) Other
Mosaic of different land uses with one management unit	Two or more of the following land user; forest, woodlands, shrubland, rangeland, cropland			

2.1.3. Mediterranean region and silvopastoral systems

The Mediterranean region has a long history of human utilization (L'Houerou, 1981; quoted by San-Miguel, 2004). The agriculture and livestock emerged due to the Neolithic revolution almost 10,000-12,000 years ago. These long intensive human activities have as a result the disappearance of the vast majority of primitive forest around the Mediterranean basin which means that the whole territory may be considered as an immense agroforestry system. In this interactive process, the human-induced transformations shaped the landscape, modifying plant and animal communities, the genetic makeup of individuals, races and ecotypes (San-Miguel, 2004). Human adaptation leads to differentiated land use systems and forms of resource exploitation. Among these, multi-purpose uses like agroforestry occupy a place of major importance in this region (Castro, 2009).

Most of the Mediterranean landscape and their biodiversity depend on human activities and are closely related to them. For this reason, it is necessary for this area, to consider the traditional agropastoral practices such productive activities as well as essential conservation tools. (Bland and Auclair, 1996; Redecker et al., 2002; San Miguel, 2003).

The socio-economic progress which has occurred in Europe around the 1960's was given rise to profound changes in the structure and management of silvopastoral systems (San Miguel, 2004). As a consequence, shepherding and transhumance which were common in the Mediterranean European area until the 1960s (Beaufoy, 1994) has known an abundance in the current time (San Miguel, 2004). These changes have also influenced the Montado system where it occurred the substitution of transhumance sheep by sedentary cattle (Montero et al., 2000).

In the Mediterranean, the trees and the shrubs represent an important feeding resource for livestock and wildlife because of their sclerophyllous evergreen nature. In fact, they contribute to the mitigation of hunger period (summer and winter) for extensive livestock in Mediterranean Europe (Papanastasis, 1999; San Miguel et al., 1999). Since that sclerophyllous trees have a low wood productivity, the non-timber products such as cork, fungus, honey, fodder, and fruits are generally more interesting than the timber products (San Miguel, 2004).

Most of the Mediterranean swards consist in therophytes, perennial and summer-senescing herbs whose growth is reduced in winter because of the cold (San Miguel, 2004). That's why the majority of Mediterranean silvopastoral systems know two periods of lack of green herbage;

summer and winter. Livestock and wildlife have responded to these conditions by adopting transhumance or shorter herd movements and looking for another nutrients source that is usually represented by woody perennials (San Miguel, 2004). Legumes are a key component of Mediterranean silvopastoral systems swards. In fact, they supply protein-rich fruits and seeds as well as they permit enrichment of soil in nitrogen. That's why those silvopastoral sward systems adopt many pastoral regimes trying raising plenty of legumes in natural and artificial swards (San Miguel, 2004).

In Europe, Mediterranean swards are characterized by their high level of biodiversity (Pineda et al., 1991; Beaufoy, 1994) what becomes important within the silvopastoral system. This biodiversity is due to the seeds contained in the soil which provides more persistent green swards in spite of the high variability of Mediterranean climate (San Miguel, 2004).

The Mediterranean ecosystems are unique also by a high diversity of livestock too, including livestock species that are known by their particular breeds and their seasonal movements; transhumance. However, the role of livestock and wildlife was affected by the socio-economic changes that Europe has known in the 1960s which can be summarized by partial substitution of extensive and low-intensive grazing for mini-intensive management systems; intense decrease of transhumance and shorter seasonal movements; partial substitution of traditional breeds by industrial crossing and that of sheep by cattle (San Miguel, 2004).

Portugal has a high diversity of agroforestry systems. This is the result of the Mediterranean climate, the great variability of bioclimatic conditions, a long history of land use, and a marked variation in land tenure between north and south of the country (Castro, 2009). Then, the main types identified in Etienne's classification which can be seen in Portugal are:

1) Grazing and browsing in shrublands or forests- type natural shrublands and coppices are the most widespread system in Portugal.
2) Mosaic of different land uses within one management unit is one of the most representative systems in mountainous areas of the North of the country and it is the system studied in our thesis.
3) Scattered trees on swards-type agricultural trees are depicted by olives in Mediterranean areas and by chestnuts for fruit in mountain areas of the North.
4) Scattered trees on swards-type wild trees are represented by montado of cork or green oak (dehesa, in Spanish).

2.2. Extensive livestock systems based on grazing circuits

Extensive livestock systems based on pastoral resources are widespread worldwide, and they are one of the key production in the world's mountain areas. Pastoral resources include several vegetation types such as natural grasslands, shrublands, woodlands, forestlands, etc., which are invariably called grasslands or rangelands. Often, these resources are integrated into feeding systems with crop by-products (Castro et al., 2004; Castro, 2009, Papanastasis, 2009).

Grazing systems are biological structures that arise from the interactions between natural resources and human behavior (Salis, 2010). Therefore, they show different features depending on the region where they have been shaped. However, all pastoral systems have flexible and opportunistic character. Grazing systems are primarily found in the more marginal areas which are uncultivable for cropping because of topography, low temperature or low rainfall (Steinfeld el al. 2006).

Pastoral systems are defined as systems in which more than 90% of the dry matter to feed the animals comes from natural pastures and forages, rangelands, and foodstuffs and in which annual average stocking rates are less than ten livestock units per hectare of agricultural land (Seré and Steiner, 1995). The mixed farming systems are a type of livestock systems in which more than 10% of the dry matter fed to animals comes from crop by-products such as stubble, or where more than 10% of the total value of production comes from non-livestock farming activities (Slorach, 2006).

According to the basic classification of Etienne (1996), the livestock system of small ruminants (sheep and goats) of the Northeast of Portugal can be classified as a Mosaic of different land uses within one management unit. According to Blench (2001) it can be classified as an agropastoral system and according to Seré and Steiner (1995) it is a mixed farming system.

2.2.1. The pastoral system of Trás-os-Montes region

In Trás-os Montes, the landscape is a patchy set of different land uses class, mainly annual and perennial crops, pastures, woodlands, shrublands, forestlands. These different patches of land uses are utilized by a silvopastoral system of sheep and goat flocks based on daily grazing itineraries (Castro et al., 2016). Additionally, some agriculture by-products complement the feeding needs, mainly in the case of sheep. In this landscape, each land use class has a specific role within the grazing pattern. Among them, the coppices of oak pyreanean (*Quercus pyrenaica* wild.), the chestnut, and olive orchards are the most remarkable.

Sheep and goats are raised by landless farmers and smallholders. The herds are always guided by the shepherd and return every day to sheds (Castro, 2004). According to Castro et al. (2015) the management of grazing circuits in order to promote extensive livestock welfare, sheep herds have longer journeys than goat' ones, going out earlier in the morning.

Usually, sheep flocks go into meadows and forages areas around the homestead firstly, while goats prefer the remote woodlands far away from the hamlet (Castro et al., 2016). The grazing circuits take place across all the non-fenced and the unploughed fields in which the shepherd and the animals adopt strategies to adapt to and to avoid the natural resources constraints (Castro et al., 2016). As a result, grazing circuits, food resources and animals' diet varies throughout the year and throughout the territory.

In these pastoral systems, the shepherd plays a key role in the patch and land use selection (Baumont et al., 2000). As rangelands are patchy environments, herds cross extremely diverse vegetation, so the shepherds have to organize each grazing circuit as the succession of grazing circumstances and moments on different patches in order to optimize the animal's feeding behavior (Baumont et al, 2000).

In the other hand, in this pastoral system, the land use management, the rules on the itineraries, the husbandry techniques, and their adaptation to the environmental conditions and to the social relationships are based on a long-established local knowledge and practices. The whole village territory is a potential grazing area, vital for feeding sheep, which make use of all the natural resources available in the territory. As the flocks move along over the local territory, this itinerary grazing must be accepted and regulated by land owners (Barbosa and Portela, 2005).

According to Barbosa and Portela (2005), sheep farms depend on external feed and social actors to create conditions for a so complex farming system. Their essential components are constantly under interaction. The grazing itinerary is the main feature of the system and it determines the sheep husbandry techniques as well as other components. It occurs over the local parish, including commons and private plots: untilled land and fallow fields, oak- and cork oak groves, as well as vegetation under tree canopies (e.g. olive groves, almond and chestnut trees). Farming by-products as cereals, horticulture, vineyards and others, are also used as food resources. Thus, sheep utilizes these resources that otherwise would be useless.

These social rules originated from old practices are informal and unwritten. They take in account that the animals can't cross the cultivated land before harvest and other plots marked

with " balizas" (a specific sign that is in stick form bearing a small flag) that sign that the owner refuses the access to the plots. The second type of rules is represented by rules established by local authorities and/or farmer's organizations (in Southern Trás-os-Montes). These more formal rules concern essentially the grazing, sheep herding and housing and damage compensation. In this type of grazing circuits, land use is based on the exchange relations and social regulations of the land. Shepherds are interested in establishing good relationships with landowners because their herds benefit from these resources plots. Some shepherd strategies utilize the exchange of herd services and products. (Barbosa and Portela, 2005).

2.2.2. The particular role of the land uses on the pastoral system

As stated before, this pastoral system is based on several land use types; some them can be considered as ecological indicators of the regional conditions, particularly coppices of the pyrenean oak coppices (*Quercus pyrenaica* Wild), the chestnut orchards and olive groves.

The pyrenean oak coppices provide forage and enhance welfare to small ruminants (Castro et al., 2000 a,b). They are characterized by close tree layer of 400 and 1100 stems ha^{-1} depending on the intensity of use and age. The understory is dominated by oak regeneration and shrubs species as *Cytisus* sp. pl., *Erica* sp. pl. and *Genista falcata* Brot., and the herbaceous layer is scarce due to leaf fall and tree shading. The herbage production reaches values of 570-2500 kg DM ha^{-1} $year^{-1}$ (Castro, 2004b). During the leaf period (May – October), sheep flocks cross these woodlands mainly searching for shelter and to the midday rest. Resting time takes place mainly inside the woods, and it represents between 20 and 30% of sheep and goat flocks itineraries duration, respectively (Castro et al., 2004). Oak leaves are eaten mainly by goats. Consumption increases through the season, becoming very high in August and September when the other resources become are scarce and less quality. Castro et al. (2004) state a goat's diet in summer containing about 25% of oak leaves and only 2.5% for sheep. The oak acorns are eaten by sheep and goat from late September and to early November. In winter time, pyrenean oak woodlands use by sheep herds is quite insignificant, less than 1%, but they are about 10% of goat flocks itineraries. In these no-leaf periods, the flocks cross the woodlands searching for shrubs and grass (Castro, 2009).

Castanea sativa is a multipurpose species that can be cultivated for timber, nut production, or both, and also for tannin production (Monteiro, 2000). Additionally, a large number of by-products products are available. Among them, mushrooms have been the most valued for both fresh consumption and the food industry (Scarascia-Mugnozza et al., 2000). Chestnut

ecosystems also represent an important component in small ruminants' husbandry of the mountain regions.

In Portugal, the chestnut orchards, locally named *soutos*, are generally grazed only by sheep utilization; the *soutos* owners do not allow goats to enter since they can damage the bark of the trees. The chestnut orchards are frequently intercropped with cereal cultivated to feed sheep direct in the place. A low plantation density (of 70-100 stems ha^{-1}; 12 x 12 or 10 x 10 meters spacing) allows the cereal crop.

Traditionally, the sheep appreciates the nuts left over on the ground after the owners' harvest. According to Pereira-Lorenzo et al. (2006), the nut composition varies with the cultivar and region. This author describes the composition of a large number of samples, characterized by higher starch content - between 45 and 60% of dry matter, and higher total sugars – from 13 to 20% (data refers to dry matter). The fibrous fraction is very low, with neutral detergent fiber varying between 16% and 18% of dry matter, acid detergent fiber between 2.7 and 3.5% and crude fiber between 2.5 and 2.9%, fat compounds varying between 2.8 and 3.2% and crude protein from 5.8 to 6.3%. According to De La Montana Míguelez et al. (2004), chestnut cultivated over schist soils contains higher protein than those over granite-based soils.

Alibes and Tisserand (1990) describe seasonal variations on nutritious value of chestnut leaves, from spring to autumn: crude protein 12.4 to 14.5%, NDF 33.3 to 37.5 %, ADF 24.7 to 26.3 % and crude fiber 18.9 to 20.9%. On the other hand, shrubs and other understory plant resources can be used by the flocks of chestnut coppices.

The orchards intercropped with cereals for direct animal feed are locally named *ferrã*, and grazing by sheep occurs during winter and part of the spring. When intercropping is absent, the understory species are consumed if the soil is less frequently plowed.

The olive orchards constitute a continuous landscape in many parts of southern Europe sometimes intercropped with cereals (Eichhorn et al., 2006). According to Papanastasis (2004), the olive tree (*Olea europaea* L.) is the most important cultivated evergreen species of the Mediterranean agrosilvopastoral systems. In Portugal, the olive orchards cover about 340,000 ha, with 62,000 ha in northeast Portugal (Monteiro 1999, quoted by Castro, 2009).

The olives groves by-products, mainly the olive leaves, has been part of the tradition animal food in the Mediterranean basin countries (Sansoucy, 1985). These systems where animals cohabit with crops, the remains of pruning provide a useful additional foodstuff, reducing the

cost of animal feeds. According to Delgado-Pertíñez et al. (2000) the olive leaves at the moment of pruning shows an interesting forage value, by means of about 12% for Crude Protein and 43% for Digestible Organic Material. After the main olive collecting (December), sheep and goat flocks can eat the remaining left over on the ground. The understory species are grazed mainly in spring.

2.3. Ecosystem Services

Nowadays, the pastoral systems are recognized not only for the economic aspects but also for the services they provide. The concept of ecosystem services is rooted in the simple notion of humanity's dependence on its natural environment (Hoffmann et al., 2014). Conceptually it describes how biophysical systems provide a variety of important benefits to human well-being (MA, 2005). It defined human well-being comprising multiple constituents, including the basic material for a good life, health, good social relations, security, and freedom of choice and action. The ecosystem services framework has become the most widely adopted integrated structure to study the relations between ecosystem and people (Fagerholm et al., 2016)

According to Costanza et al. (1997), ecosystem functions refer to the habitat, the biological or system properties or processes of ecosystems, and the ecosystem goods (e.g. foods) and services (e.g. climate regulation) which benefits the human populations, directly or indirectly derived from the ecosystems. In a simple manner, authors refer indifferently as ecosystem services.

The Millennium Ecosystem Assessment (MA) was called for by the United Nations Secretary-General Kofi Annan in 2000. The objective of the MA was to assess the consequences of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to human well-being (MA, 2005).

Ecosystem services was largely developed and treated by the MA which distinguished four groups of ecosystem services: (1) **provisioning services** are the products supplied by ecosystems, such as food, fuel, fiber, fresh water, and genetic resources;(2) **regulating services** are the benefits obtained by from the regulation of ecosystem processes, including climate regulation, erosion control, air quality maintenance, regulation of human diseases, and water purification; (3) **supporting services** are the key services for the production of all other ecosystem services, including the primary production, soil formation, and production of oxygen

(4) **cultural services**, referring to non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences

Ecosystem services can also be divided into those that can be converted into and marketed as private goods (e.g. provisioning services and to some extent cultural services) and those that underpin the production of these, but are of a non-market public good nature (e.g. regulating, supporting and most cultural services). This distinction allows for the evaluation of different livestock production systems in terms of their contribution to the production of private goods, as well as underpinning public goods, and as such, of their overall and long-term contribution to human well-being.

Animal genetic resources are defined as those animal species that are used, or may be used, for the production of food and agriculture, and the populations within each of them (Hoffmann et al, .2014). Livestock species and breeds which are key components of agroecosystems have a close connection with natural ecosystems and consequently play an important role in the provision of ecosystem services (Hoffmann et al, .2014). Like other genetic resources for food and agriculture, livestock breeds are both providers of ecosystem services and, in themselves, an ecosystem service arising from, and dependent on, other ecosystem functions (Hoffmann et al, .2014).

Also, many traditional livestock systems have a close connection with cultural aspects and Intangible Cultural Heritage, providing many cultural services. Many traditional livestock farmers follow a strategy of using multi-species and multi-breed herds and flocks, in order to maintain high diversity in on-farm niches and to reduce the impact of climatic and economic adversities (Hoffmann et al,.2014). The more the breeds and species are different the more the contribution to livelihoods is different, through the provision of food, fertilizer, fiber, transportation, draft power and cash income (Hoffmann et al,.2014).

Hoffman et al. (2014) point out the three characteristics of livestock that determine their specific roles in ecosystems:

- livestock's unique ability to convert non-human edible feed and organic waste into useful products, through their digestive tracts;
- Livestock has a direct interaction with ecosystems by means of trampling, grazing and browsing beside the production of urine and dung;

- their mobility and resulting ability to respond to temporal and spatial fluctuations of ecosystems in resource availability

In recent years, livestock and other agricultural systems have received global attention for its positive contribution to ecosystem services. They have been described in the following way shown in **Table *2***.

Table 2. Type of Ecosystem services provided by livestock (after MA, 2005; TEEB, 2010; Oteros-Rozas et al., 2013).

Provisioning services: products obtained from ecosystems	
Food	Meat, milk, eggs, honey
Fiber, skins and related products	Wool, fiber, leather, hides, skins, wax
Fertilizer	Manure and urine for fertilizer
Fuel	Manure and methane for energy, biogas from manure slaughterhouses etc. Power
Power	Draught power
Genetic resources	Basis for breed improvement and medicinal purposes
Biotechnical/Medicinal resources	Laboratory animals, test-organisms, biochemical products
Regulating services: benefits obtained from the regulation of ecosystem processes	
Waste recycling and conversion of nonhuman edible feed	Recycling of crop residues, household waste, swill, and primary vegetation consumption
Land degradation and erosion prevention	Maintenance of vegetation cover
Water quality regulation/purification	Water purification/filtering in soils
Regulation of water flows	Natural drainage and drought prevention, influence of vegetation on rainfall, timing, and magnitude of runoff and flooding
Climate regulation	Soil carbon sequestration, Greenhouse Gas (GHG) mitigation
Regulating services: benefits obtained from the regulation of ecosystem processes	
Moderation of extreme events	Avalanche and fire control
Pollination	Yield and seed quality of crops and natural vegetation; genetic diversity
Biological control and animal/human disease regulation	Destruction of habitats of pest and disease vectors; yields (for example, consumption of pest insects by poultry)
Supporting services: ecosystem services that are necessary for the production of all other ecosystem services	
Maintenance of soil structure and fertility	Nutrient cycling on farm and across landscapes, soil formation
Primary production	Improving vegetation growth/cover
Habitat services	
Maintenance of life cycles of species	Habitat for species, esp. migratory species

Habitat connectivity	Seed dispersal in guts and coats
Maintenance of genetic diversity	Gene pools protection and conservation
Cultural services: nonmaterial benefits people obtain from ecosystems	
Opportunities for recreation	Eco/agro-tourism, sports, shows and other recreational activities involving specific animal breeds
Knowledge systems and educational values	Traditional and formal knowledge about the breed, the grazing and socio-cultural systems of the area, information for cognitive development, scientific discovery
Cultural and historic heritage	Presence of the breed in the area helps to maintain elements of the local and/or culture that are valued as part of the heritage of the region; cultural identity, esp. for indigenous peoples
Inspiration for culture, art and design	Traditional art and handicraft; fashion; cultural, intellectual and spiritual enrichment and inspiration; pet animals, advertising
Natural (Landscape) heritage	Values associated with the landscape as shaped by the animals themselves or as a part of the landscape, e.g. aesthetic values, sense of place, inspiration
Spiritual and religious experience	Values related to religious rituals, human life-cycle such as religious ceremonies, funerals or weddings

Chapter 3. Study area, data, and methods

3.1. Study Area and Data

The study areas are in Trás-os-Montes, Northeastern of Portugal, in two small parishes of Bragança municipality: Rebordainhos and Freixedelo.

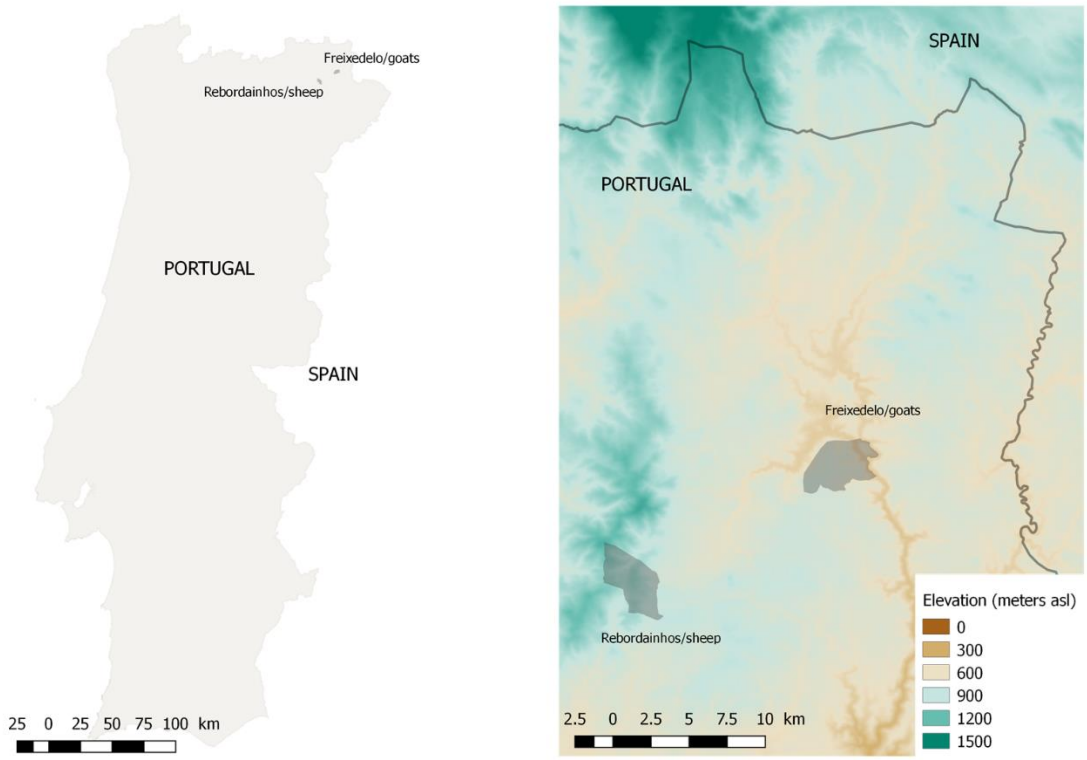

Figure 1. Location map of the study areas.

Trás-os-Montes is one of the most disfavored regions of Portugal. It is an agrarian region which is composed of several various plateaus and mountains reaching an elevation that varies between 700m and 1300m. The deep valley of Douro River and its tributaries flows through these plateaus (Taborda, 1987). This nomination is due to the mountainous geology and climate of the area. Two natural zones can be distinguished: a first zone has a cold prolonged winter and brief hot summer – Terra Fria, and a second one has a warm dry summer and soft winter – Terra Quente (Ribeiro, 1995).

Freixedelo and Rebordainhos are located near Bragança in the Northeast of Trás-os-Montes: 41°43'N6°42'W; 682m a.s.l. and 41°40'N6°52'W, 933m a.s.l. They differ because of the physiography, the first between 650 and 750 meters of elevation, corresponding to the extension

of the Iberian central plateau (meseta) – Freixedelo, and the base of a mountain slope – Rebordainhos).

3.1.1 Climate, Relief, and Soils

The climate is Supra-Mediterranean sub-humid type except for the character Meso-Mediterranean Sabor river valley in the Eastern end of the border village of Freixedelo, and the wet nature of the peaks of the Serra de Nogueira on the northwestern border of Rebordainhos.

Due to the absence of climatic data for both study locations, we present the precipitation and temperature data for the city of Bragança, measured by Synoptic station; Number: 575; Local: Lat.: 41º48'N; Lon. 06º44'W; Hig.: 690m. Bragança is located far from Freixedelo by 12.7 km and from Rebordainhos by 25.7 km.

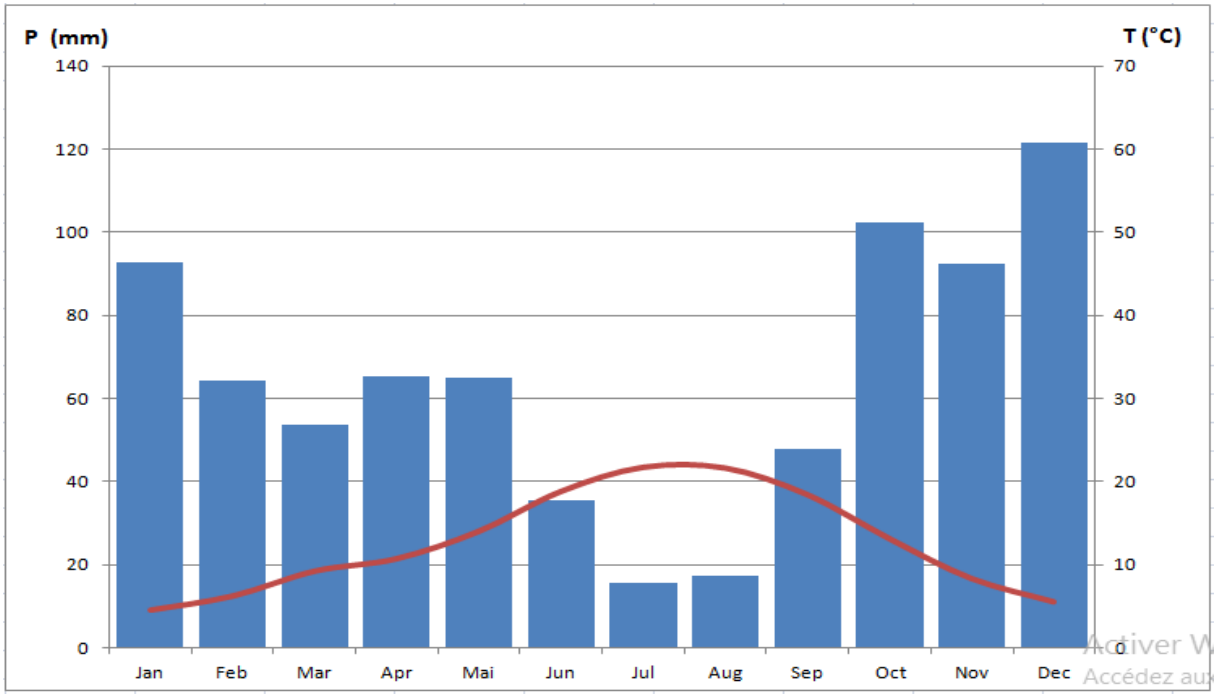

Figure 2. Climate graph Bragança 1981-2010 (www.ipma.pt).

The average annual temperature is 12.67°C with amplitude of 17.2°C (the difference between the lowest temperature and the highest of the year), several factors influencing the thermal amplitude of a climate region: insolation, cloud cover, the average humidity, terrain, proximity to the sea and the relative duration of day and night.

The warmest month is July when the temperature reaches 21.7°C. The coldest one is January when the temperature gets at 4.5°C.

In Bragança region, the soils are derived from schist or granite and are mainly characterized by their acidity and low productive capacity. The most dominant soils are umbric leptosols and dystric leptosols (Castro, 2004).

The relief of the Trás-os-Montes represents a succession of Supra-Temperate or Supra-Mediterranean (Terra-Fria) granitic plateaus with an altitude of more than 650-700 m, the fragments of an ancient peneplain crossed by Meso-Mediterranean (Terra-Quente) deep valleys (Gutiérrez Elorza 1994; Cabral 1995).

3.1.2. Social System

Trás-os-Montes are one of the least favored and depopulated areas of Portugal. Since the 60's the region has known a decrease of population. Trás-os-Montes represent 5% of the total Portuguese population with a density of 36 inhabitants/km2, while the national average is around 110 inhabitants/km2. The area has 3% of the Portuguese GDP (Gross Domestic Product), with a per capita GDP of about two-thirds of the national value. Agriculture plays an important role in the economy of the region and the agricultural population which is around 196 960 inhabitants, corresponds to 44% of the local population.

The census 2011 recorded that Rebordainhos and Freixedelo villages have small populations as it is presented in the **Erreur ! Source du renvoi introuvable.** and *4* below.

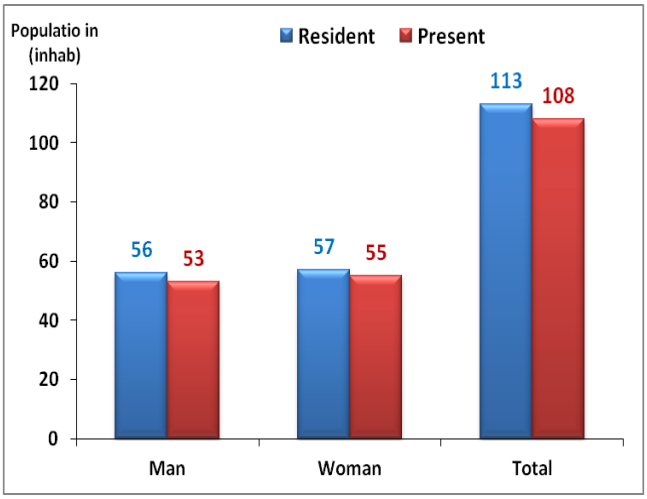

Figure 4. Number of Freixedelo population.

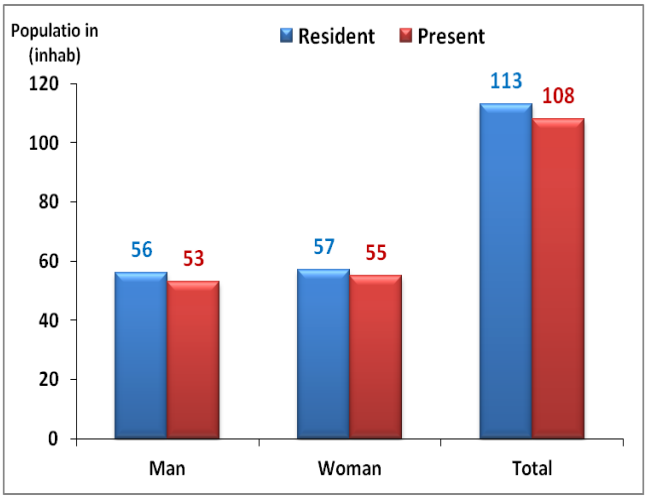

Figure 3. Number of Rebordainhos population

Obviously, both villages have a very small population with the almost equal number of male and female.

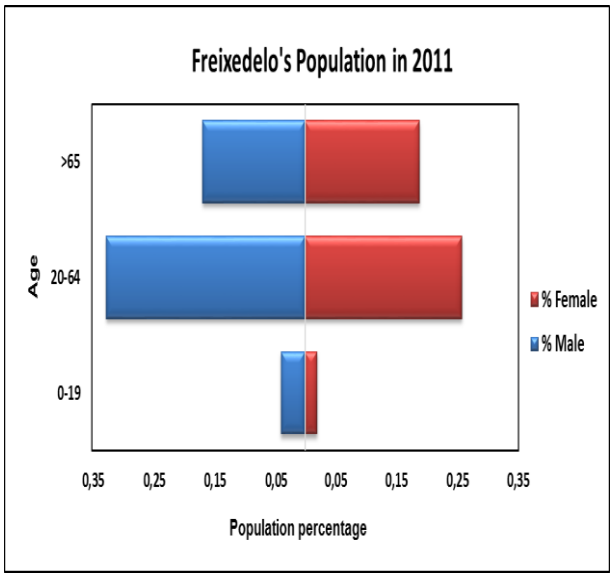

Figure 5. Population pyramid of Freixedelo village.

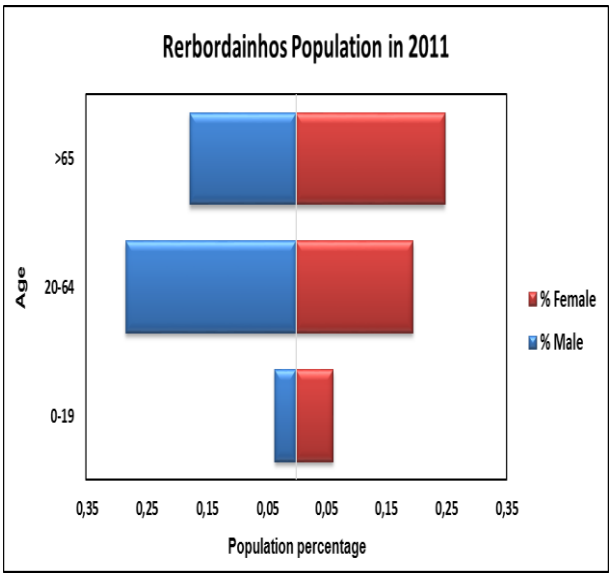

Figure 6. Population pyramid of Rebordainhos village.

Table 3. Percentage of individuals working in primary, secondary and tertiary sectors.

	Percentage of workforce	
Sector	**Freixedelo**	**Rebordainhos**
Primary	24%	19%
Secondary	36%	38%
Tertiary	40%	42%

Population pyramid represents the distribution of population where population age is divided by sex into female (right) and male (left). In the case of Freixedelo village (**Figure *5***), the pyramid has a mushroom shape, in fact, the base is very narrow while the summit is wide which means that the population is aged with a low fertility rate. It is observed that the reproductive category (20-64) is the most important category which significates that the population is active, and has a major economic role. This category represents a symmetry between men and women, indeed they have almost the same percentages. In another hand, the post-reproductive category is also an important population percentage, with symmetry between men and women, but the proportion of men is less than women. This category is composed of old retired individuals up of 65 years, the majority of them are former farmers, this explains the low percentage of individuals working in the primary sector as it is shown in the table above. However secondary and tertiary sectors have values much important.

The pyramid, in the case if Rebordainhos (**Figure *6***) population is relatively mushroom shaped with a narrow base and wide summit, which means that the population has a low birth rate and a high proportion of elderly people and this will lead to the extinction of the population in the future. The graph shows an asymmetry between men and women, in fact, it is observed that the percentage of women is higher than men for the category of persons whose age exceeds 65 years, while it is lower than men percentage for the category of persons whom age is comprised between 20 and 64 years. Like in Freixedelo village, the proportion of individual working in the primary sector is lower than other sectors because this category is consisting of old retired farmers.

3.1.3. Natural vegetation, land cover, and land uses

According to Costa et al. (1998), the land use in northeastern Portugal is strongly linked to bioclimate and implicitly correlated to vegetation belts. Terra-Fria lies in the field of the sub-continental *Quercus pyrenaica* (Fagaceae) woodlands which are, nowadays, largely substituted by chestnut groves, arable land, heathlands dominated by *Erica australis* (Ericaceae) or broom (Cytisus sp.pl., Fabaceae) shrublands. The area consists also of mixed forests *Q. robur*-*Q. pyrenaica*, riparian woodlands with *Betula celtiberica* (Betulaceae) and *Pterospartum tridentatum subsp* and scrublands with *Ulex* minor (Fabaceae). *cantabricum* (Fabaceae) constitute the main components of the vegetal landscape of the western Trás-os-Montes supratemperate peneplains. Both Terra-Fria et Terra-Quente are rich in hay-meadows species like herbaceous perennial or biennial oligotrophic pastures dominated by oligotrophic grasses like *Agrostis curtisii*, *A. x fouilladei* [*A. castellana* x *A. capillaris*], *A. truncatula* subsp. *commista, Arrhenatherum elatius subsp. bulbosum, Pseudarrhenatherum longifolium* or *Nardus stricta* (Asensi et al., 2011).

The agricultural system in the Terra Quente region is basically formed by the archetypal Mediterranean cultivated plants: the olive tree, almond tree and vineyards. The area of olive tree cultivation is growing which is due to the expansion of crop to the detriment of wheat or rye cultivated in high altitudes. In contrast, a remarkable abundance touched the almond and olive shepherds especially those that exist in an inaccessible land with a slope. Until 1986 (The entry of Portugal to the European Community), wheat was the main component of the agriculture systems of Terra-Quente. Since this time large extent of cereal, land has been substituted by shrub vegetation which is extensively grazed by small ruminants (sheep and

goats). In Terra-Quente cork oak (*Quercus suber*, Fagaceae) "montado" represents a considerable source of returned (Asensi et al., 2011).

In the Terra-Fria, where soil water deficits and the temperature integrals are smaller than the Terra-Quente, the wheat crop is substituted by rye, while the chestnuts replaced the olive trees and the vineyards. The mountain agricultural systems of Terra Fria consist mainly by communal shrublands and hay meadows. Recently there was plantations of cherry tree (*Prunus avium*, Rosaceae), *Fraxinus* sp.pl. or chestnut trees on agricultural lands which were abandoned (Asensi et al., 2011).

The study area consists of two villages (Rebordainhos and Freixedelo) which are composed by different land uses presented in the charts below, as well as the area by hectare occupied by each land use.

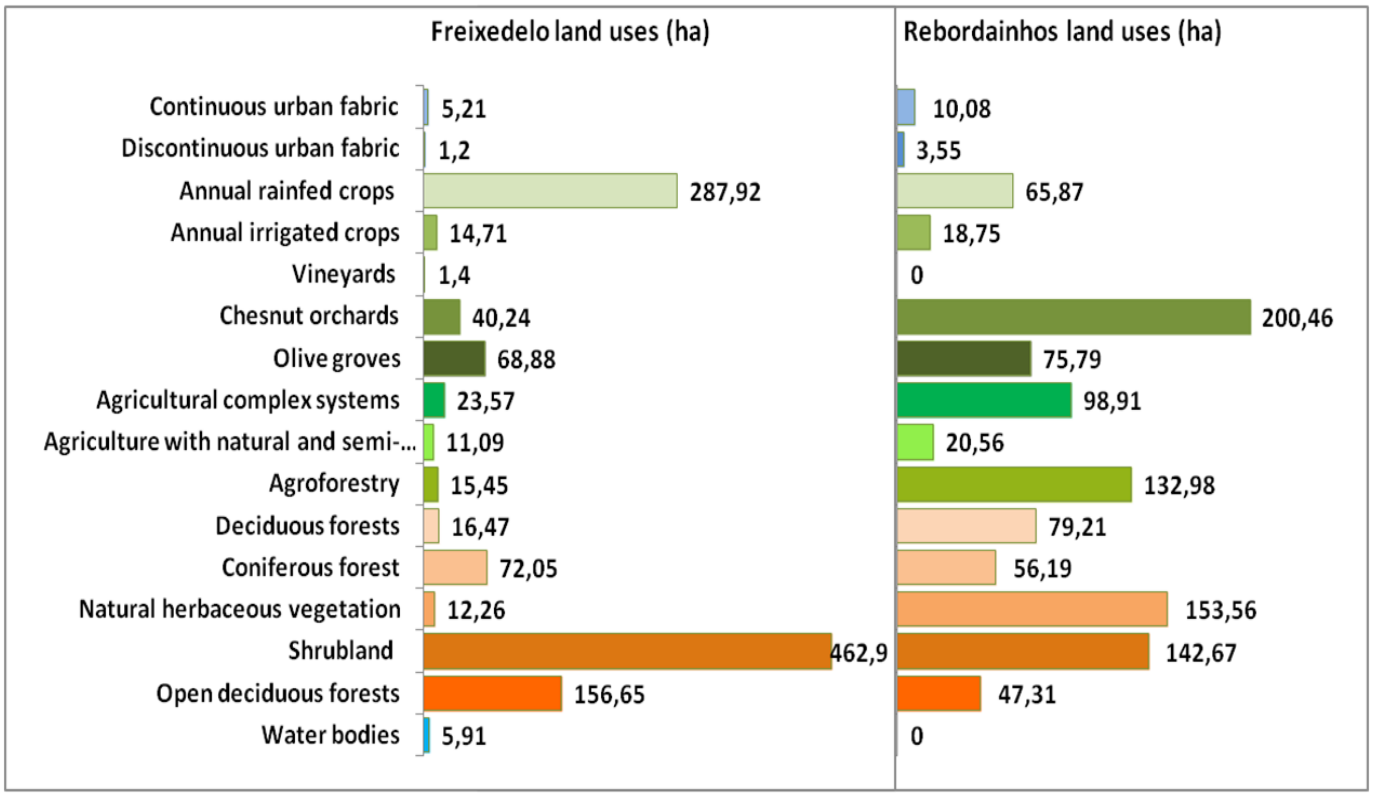

Figure 7. The area in hectares of different land uses of Freixedelo and Rebordainhos.

From charts, it can be seen that the contribution of the same land use in the total area of territory differs between the two villages. Chestnut orchards, for instance, have a more important area in Rebordainhos village than in Freixedelo village. Oppositely, the area of annual rainfed crops is less great in Rebordainhos village than in Freixedelo village.

The study deals with eleven most important land uses;

Annual rainfed crops or non-irrigated arable lands are lands for cereal production.

Annual irrigated crops or permanently irrigated land, in general, are consisting in our case of legume orchards whose production is for itself consumption, they are dominated by potato and tomato crops, as well as fodder corn. this last is mainly intended for herd grazing.

Chestnut orchards, locally named soutos, are traditionally used by sheep in flocks to eat the chestnuts left over on the ground after the harvest.

An agricultural complex system which refers to complex cultivation patterns that are a juxtaposition of small parcels of diverse annual crops, pasture and or/ permanent crops somewhere with scattered houses.

Agriculture with natural and semi-natural spaces is areas principally occupied by agriculture, interspersed with significant natural areas; including wetlands and water bodies, outcrops.

Agroforestry areas are annual crops or grazing land under the wooded cover of forestry species.

Deciduous forest or broad-leaved forest are vegetation formation composed principally of trees, including shrub and bush understory, where broad-leaved species (Oak in our case) predominate.

Natural herbaceous vegetation or natural grasslands are areas where herbaceous vegetation consisting of gramineous species with maximum height is 1500 cm, covers at least 75 % of the surface covered by vegetation.

Coniferous forests are made up mainly of cone-bearing or coniferous trees with leaves either small and needle-like or scale-like. In the study area, these forests are principally consisting of pines species.

Shrublands, more generally moors and heathland are vegetation with low and closed cover, dominated by bushes, shrub, and herbaceous plants.

The open deciduous forest is part of transitional woodland-shrub which is consisting of bushy or herbaceous vegetation with scattered trees

Land uses pictures

(1)

(2)

(3)

(4)

(5)

(6)

(7)

(8)

1, 2, 3 = Meadows

4, 5 = Olive groves

6 = Oak forest

7, 8 = Fallow

(9)

(10)

(11)

(12)

(13)

(14)

(15)

(16)

9, 10, 11 = Shrublands **13, 14 = Chestnut orchards**

12 = Open deciduous forest **15 = Over roads**

16 = Riparian woods

The distribution of different land uses composing the study territories is shown by both maps in the (figure 10) and (figure 11) below.

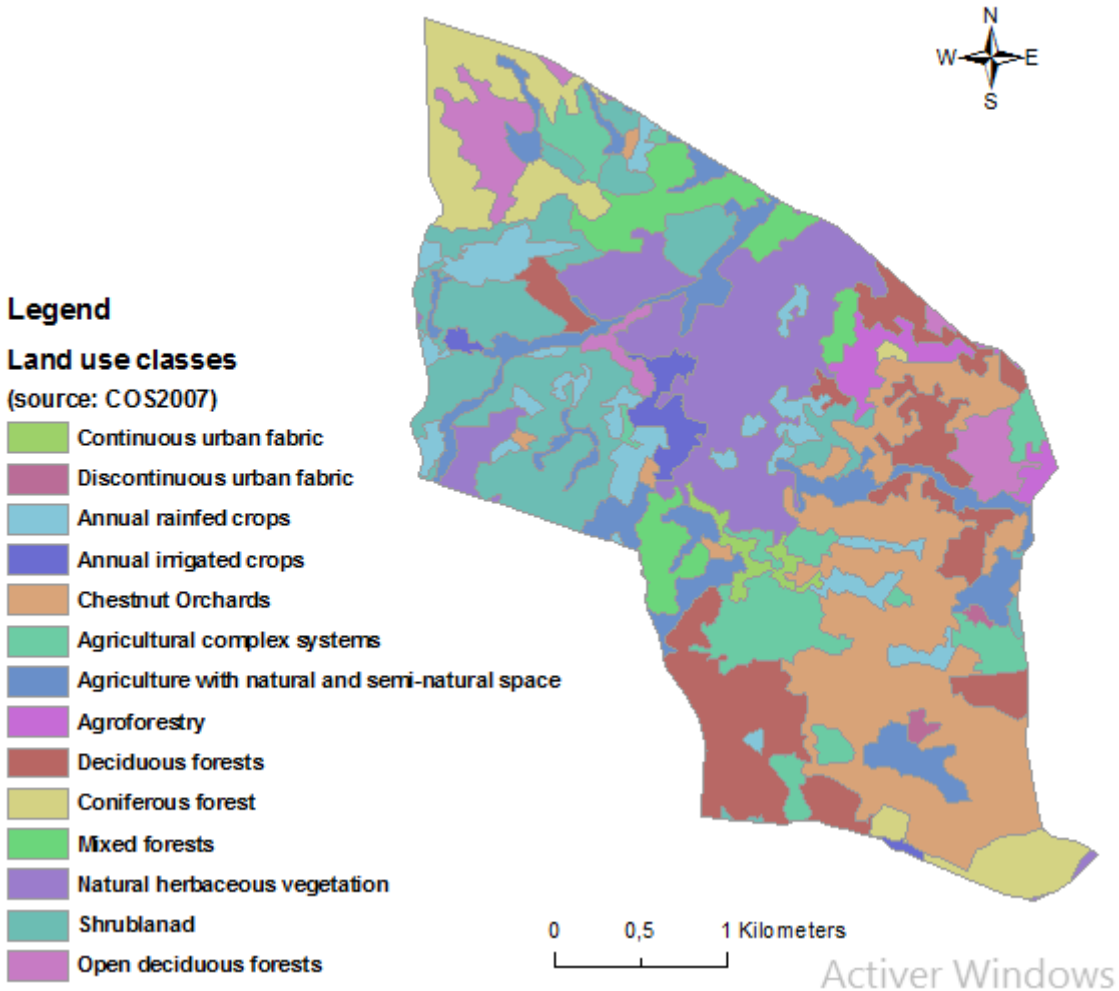

Figure 8. Land uses map of Rebordainhos village.

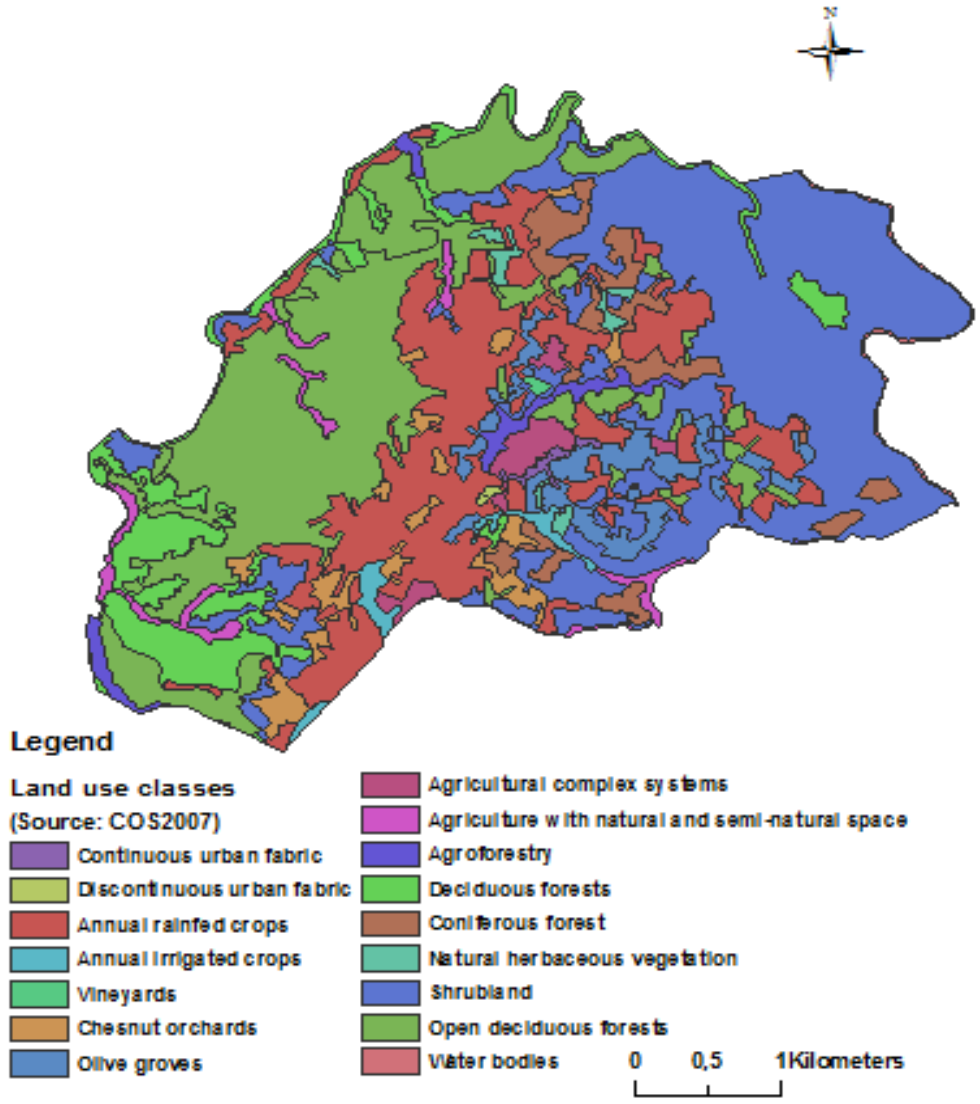

Figure 9. Land uses map of Freixedelo village.

3.1.4. Livestock farms and the traditional breeds of sheep and goats

According to Tibério, et al. (2014), In Portugal about 52,000 sheep farms and a total number of 2.2 million animals have been identified (**Appendix *1***), and about 32,000 goat farms and 420,000 animals. Both sheep and goat production are mainly oriented to meat production. The average size of sheep farms is less than 50 animals per farm (**Appendix *2***); in fact, in Trás-os-Montes region, medium-sized herds (having between 10 and 49 animals) are the most dominated with an average size of 13 animals per farm for a goat farm. In the regions of Entre Douro e Minho (North Portugal), generally, milk farms tend to have an average size greater than the meat farms for sheep farms, whereas the average size of dairy goat farms is not representative since it represents a greatly small number of farms.

In the period between 1999 and 2009, sheep and goat production was faced a deep decrease in all the territory of Portugal. The herd reduction rate was successively of 24% and 22%.

Portugal has important reserves of genetic resources, Tiberio (2014) states that forty-five indigenous breeds have been officially recognized; among these breeds, we find fifteen sheep and five goats (see **Appendix *3***).

There are six sheep local breeds in this region where the main ones are; Churra da Terra Quente, Churra Galega Bragança, Churra Galega Mirandesa, and Churra Badana. For goats, Bravia and Serrana are the most common breeds in the region, indeed Serrana breed represents around 50% of the national herd of indigenous goats (Tiberio, 2014) (see **Appendix *4*** and **Appendix *5***).

3.1.4.1. Characteristics of breeds

The livestock is raised for meat production and the management is considered to be extensive. In Freixedelo, the flock of goats is composed about 140 animals of *Serrana* race and in Reboraínhos, it is composed about 200 sheep of *Merina Mondeguiera* breed. The live weight of goats and sheep ranged from 25 to 40 kg and 55 to 60 kg, respectively.

- Sheep breed; Merina Mondegueira

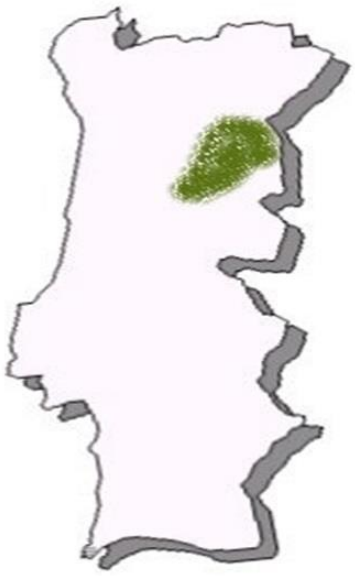

Figure 10. Ram of Merina Mondegueira breed and its geographical distribution.

This breed appeared in the Beira Alta region specifically in the region of Upper Mondego. Due to the livestock development policy which promoted the intersection of Mondegueira race with other exotic breeds to end maximize milk production through; there was a decrease in numbers of the breed. Currently, there is recourse to a program of breed improvement, made by the Association of sheep producers, with a number of around 7,000 animals, including 3,200 registered in the book of the breed (Mendes dos Santos,1997/98).

The ancestral characters that manifest and differentiate it from other breeds are; conformation; temperament and hardiness (breed standards in **Appendix *6***).

- Goats breed; Serrana

Figure 11. Goat of Serrana breed and its geographical distribution.

The origin of the Serrana goat is unknown, but thanks to the study of fossils of animal skeletons, archaeologists believe that this race has dated about 3 million years (see **Appendix *7*** and **Appendix *8***) for the phenotypic characteristics as well as reproduction and production parameters). In fact, the authors say it appears that the Portuguese goat breeds have originated in the Quaternary period. According to Barreto (1959) (Mendes dos Santos,1997/98), in the fifties, the number of Serrana breed animals was estimated at 43% of a total number of Portuguese goats. After about two decades (seventy) this race seems to have maintained its proportion (45% for mountainous areas) (Tropa et al., 1967, reported by Almendra, 1996).

3.2. Methods

The study was based on the calculation of time spent as well as the distance traversed by animals in each land use of the territory, using a dataset collected by Castro (2004), which also permits to know the location of animals on the territory using the land use map gotten from COS2007.

3.2.1 Data collection

A dataset recorded from May 1999 to May 2000 in two villages of Bragança municipality was used (Castro,2004): Freixedelo for goats and Rebordaínhos for sheep. During this period, the two flocks were monitored once a month during one year with a hand rover Trimble GPS (Global Positioning System), accompanying their shepherd. The herds were monitored for a full day, from setting out to pasture in the morning to its stable return in the afternoon. The shepherding journey last from 6 and 16 hours as a function of season and species. The grazing circuits change during the year in function to the availability of resources (Castro et al., 2004).

The total data includes the time and geographical position of each location for 26 herd's itineraries, 13 for each species. The GPS was programmed to record the location of the herd every minute: longitude and latitude and altitude. Each monthly itinerary represents a sample that was used to calculate the time and space of the herd spent in each land use type.

The information provided by the GPS are added as a table to the ArcGIS software, as well as the land uses map of our study territory (the two villages). With the tool "Spatial join" of "Arc Toolbox Window", we have created a table that joins the GPS data to the data from the land uses map. This operation allowed us to know the type of land use for each point recorded by the GPS. The land use map was gotten from COS2007 (http://www.igeo.pt) which is a thematic mapping, established in the framework of a project done by The Portuguese Geographic Institute (IGP) for the production of a Land Use and Land Cover (LULC) map, that characterize in great detail the occupation / land use of Portugal in 2007. This mapping was produced based on visual interpretation of orthorectified aerial images, high spatial resolution (50 cm). The information acquired is in vector format and has a cartographic minimum unit of 1 ha. in this framework, the Portuguese Geographic Institute (IGP) decide to classify the land use and land cover into 5 levels. the level 1 which is the most general has 5 classes: urban areas; agricultural and agroforestry areas; forests and natural and semi-natural areas; wetlands; and water bodies (Caetano, 2009).

The new table that contains all information was exported to Excel, then it was calculated the duration and the distance, the key variables of this study. The duration is calculated using the data of time measured by GPS, each point of the circuit has its time. Considering, for instance, a circuit of three points as is shown in figure 10 below; we calculated the duration that animals spent in minute in the three points using the following formulas:

The duration in the first point is $T1 = (t_2 - t_1) / 2$

The duration in the second point is $T2 = (t_2 - t_1) / 2 + (t_3 - t_2) / 2$

The duration in the last point is $T3 = (t_3 - t_2) / 2$

Where t_1, t_2, t_3 are the time (hour, minute) in the point1, point2 and point3 respectively.

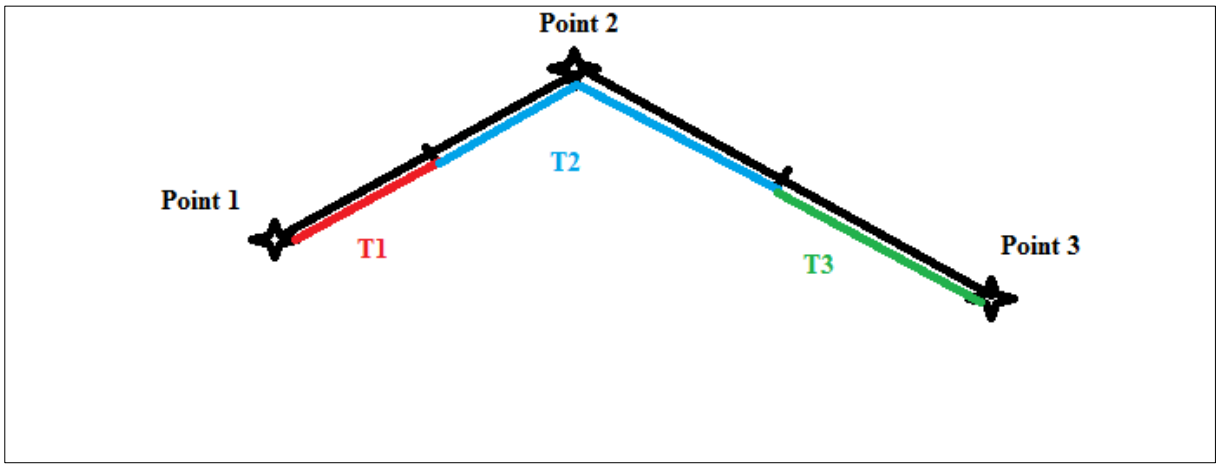

Figure 12.Example of calculating percentage of time spent for each circuit point.

The choice of this formula is explained by the fact that the classic one used to calculate the duration (T_{i+1}-T_i) does not allow calculating the duration of the last point. In order not to have a null value for this point, we thought of following this principle by assigning half the time for the first point and the half for the last, and doing the sum of two halves for the other points. That is to reduce the margin of error and to maintain accuracy values.

By adopting the same principle applied for the duration, we calculated the distance traversed by the animals between two points in a given land use based on its longitude and its latitude. The **Figure 13** below represents an example of three points of a circuit. The distance traveled between this points are calculated as following;

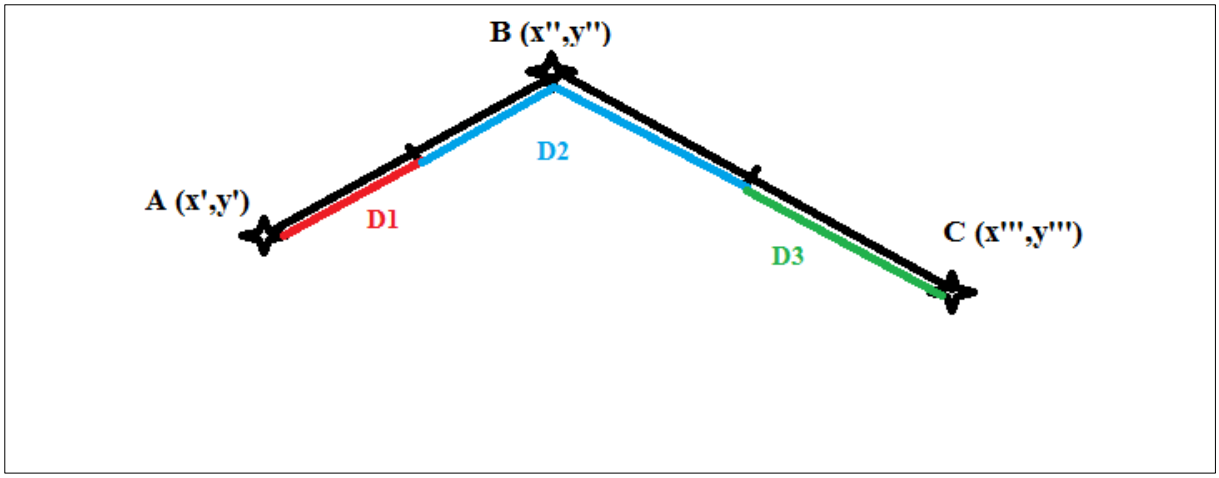

Figure 13. An example of calculating the distance traveled for each circuit point.

The first distance D1 = $(((x'-x)^2 + ((y'-y)^2)^{0.5})) / 2$

The second distance D2 = $(((x''-x')^2 + ((y''-y')^2)^{0.5})) + ((x'''-x'')^2 + ((y'''-y'')^2)^{0.5})) / 2$

The last distance D3 = $(((x'''-x'')^2 + ((y'''-y'')^2)^{0.5})) / 2$

The time spent and the distance traveled by animals in a given land use are the key variables of our study.

3.2.2. Preferences and selectivity evaluation

The comparison between the proportion of usage of the different land uses with their respective availabilities in the landscape provides an assessment of land use utilization by the flocks, as well as a display about the preference or selectivity shown by animals.

It was calculated the difference between the proportion of usage of the land uses (GPS localization of flock's) with their respective availability in the landscape, in terms of time and space for every month.

i) $(ti / T) – (a_i / A)$

ii) $(d_i / D) – (a_i / A)$

Where (a_{i}) is the area of a given land use (i) in the territory and $A = \sum a_i$

The proportion of usage of the land use in the circuit is expressed firstly in the percentage of time spent by animals in that land use compared to the total time spent in all circuits (t_i / T where t_i is the time that the herd spent in a given land use (i) and $T = \sum t_i$). Secondly, the use proportion of the land use in the circuit is expressed in percentage of distance that animals

traveled in that land use in relation to the total distances traveled in all circuits (di / D where d_i is the distance traveled in a given land use (i) and D = $\sum d_i$). These operations have been done for both sheep and goat.

Additionally, it was performed a chi-square test that allowed to know if the availability proportions of each land use in the landscape are the same for each grazing circuit, in terms of time and length crossed.

The null hypothesis (H_0)**,** states that the proportion of each land use in the grazing circuit are the same of those in the landscape, and the alternative hypothesis (H_1) states that these proportions are different, in other words, the animals don't use indifferently each type of land use.

The formula for calculating chi-square X^2 is:

$$X^2 = \sum_{i=1}^{k} (o_i - e_i)^2 / e_i$$

Where o_i observed variable is the total number of minutes spent in each land use of each circuit or the total, it corresponds to the observed proportion of usage of the particular land use.

e_i: expected variable, is the duration of grazing circuit (in minutes) multiplied by the proportion of that land use in the landscape, it corresponds to the expected proportion, of usage of the particular land use.

While in the case of distance traveled:

o_i observed variable is the total number of meters traveled in each land use of each circuit or the total, it corresponds to the observed proportion of usage of the particular land use.

e_i: expected variable, is the distance traveled in grazing circuit (in meters) multiplied by the proportion of that land use in the landscape, it corresponds to the expected proportion, of usage of the particular land use.

The chi-square distribution has a degree of freedom (DF) equal to:

DF = (number of rows – 1) *(number of columns– 1)

In this study number of rows corresponds to number of land uses groups and number of columns corresponds to number of circuits (months).

Then, DF = (8 – 1) *(13 – 1) = 84

The chi-square critical value is calculated considering the significance level $p = 0.05$ and DF = 84. Hence, H_0 is accepted if chi-square critical value is higher than chi-square value and rejected if chi-square critical value is lower than chi-square value.

As follows, an example of how chi-square values were calculated for an itinerary of two land uses (annual rainfed crops and annual irrigated crops) and two circuits (May and June-99):

		Time spent	
Land use	% of land use area	May-99	Jun-99
Annual rainfed crops	0,06	0,05	0,03
Annual irrigated crops	0,02	0,16	0,02
	Total time	0,22	0,05

Then,

$$X^2 = (0.05 – (0.22*0.06))^2 + (0.03 – (0.05*0.06))^2 + (0.16 – (0.22*0.02))^2 + (0.02 – (0.05*0.02))^2$$

The last approach used to relate landscape composition and grazing activity was based on resource selection function which is a function such that its value for a resource unit is proportional to the probability of that unit being used. This function can be determined from an index of selection; the selection ratio. The selection ratio (w_i) for a given resource (in this case land use type) is calculated by:

$$wi = oi/\pi i$$ (Manly et al., 1993),

Where o_i is the proportion of land uses utilization in each grazing circuit, in our case it is estimated from the percentage of time spent by sheep and goats in a given land use. And π_i is the proportion of availability of land uses in the landscape, in this study, calculated from the percentage of each land use in the territory of Rebordaínhos or Freixedelo villages.

The selection ration (w_i) serves as the foundation for analyzing of this selectivity; for each land cover type, (w_i) is calculated by dividing percentage (%) of land cover of grazing circuit by percentage (%) of available land cover type. When the value of SR equals 1; that's mean that land cover type is used in a random way, when the value is lower than 1, the result shows that land cover type is rejected by animals, and at a value greater than 1; the result means that the land cover type is preferred.

3.2.3. Statistical analysis

The results obtained from the calculation of selectivity index were subsequently subjected to statistical analysis. An analysis of variance (ANOVA) with type I and type II sums of squares was performed using the SYSTAT software version 12.

The selectivity index of different land uses was analyzed via ANOVA (one-factor) with the objective to compare the means between species (sheep and goats). Additionally, the grazing circuits were grouped in two clusters: summer and winter and for each one, it was studied if the index selectivity was different between species. The level of statistical significance being set at $p < 0.05$.

In the case of sheep, summer starts from April to August, while winter is from September to March. For goats, summer is from November to May, and winter from June to October.

In addition, a classical discriminant analysis (DA) was used as a technique to discriminate and separate between sheep and goat animals in term of land uses selected by each one, and to classify the land uses according to its characters. In another word, affecting the land use to a group or to other, sheep or goat, taking into account its characteristics.

The discriminant analysis (DA) is a statistical technique that allows the user to assess the differences between multiple groups of objects using several variables. It is both predictive and descriptive method. In the first case, it is sought to produce a ranking system that lets to assign a group to an individual depending on its characteristics. The second case is called discriminant analysis. The aim is to produce a synthetic representation system where we can better distinguish the groups, providing the elements of interpretation to understand what can gather them or differentiate between them. In our case, the population is divided into two groups (sheep and goat) and it is described by a series of eleven characters (land uses) quantitative. The aim purpose of this method is to highlight the land uses that permit to better distinguish between goat and sheep. Furthermore, it facilitates the classification of new land use (affect it to a specific group) regarding its characteristics.

Chapter 4. Results

The usage of land use types by the sheep herd differs monthly, from circuit to circuit all year around. In fact, the herds of sheep and goats deal differently with land use classes, preferring ones and avoiding others depending on the availability of feeding resources and land cover composition. (Figure 14, Figure 15, Figure 16, Figure 17) show how sheep and goats use the land uses throughout the year in term of time spent and distance traveled.

4.1. The time spent and the distance crossed by sheep

The largest positive values, those where herds remain most of the time, are noted for agricultural complex systems with a 90% of difference between percentage of time spent and that of land use area during March, 44% in May and 27% in November, followed by natural herbaceous vegetation with a difference of 62% during August and 53% in July, and by chestnut orchards with a difference of 56% and 42% during December and June, respectively. Finally, the annual irrigated crops with a difference of 47% in September and agriculture with natural and semi-natural spaces with a difference of 36% during February.

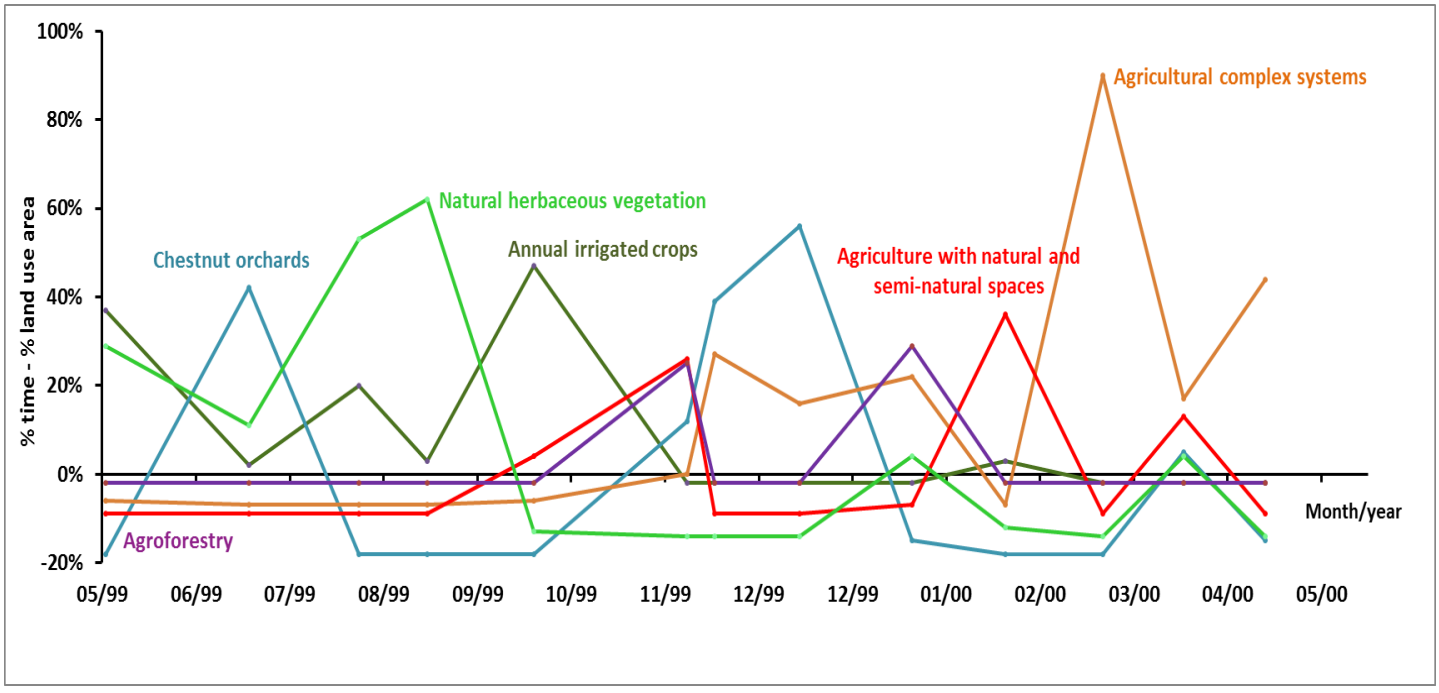

Figure 14. Differences between time spent (%) and area of land use class (%) to the monthly circuits of sheep herd.

The lowest values found in agroforestry land use, almost through all the year, are null.

Regarding the highest negative values, those land uses avoided by the herd, they are found in the chestnut orchard land use with -18% of the difference between the percentage of time spent and that of land use area over February, May, March, July, August, and September. In the case of chestnut orchards, it is noted that they have high positive and negative values throughout the year, which means that the usage of this land use varies by season.

It is observed that sheep during their itineraries prefer cultural complex system land use, natural herbaceous vegetation, orchard, and annual irrigated crops since they spent a lot of time in these land use.

During the summer, sheep spent a large part of the grazing time in natural herbaceous vegetation, followed by orchards and annual irrigated crops. In autumn, sheep spent more time in the annual irrigated crops, agriculture with natural and semi-natural spaces and agroforestry land-use classes. Over winter, it was remarked that the sheep herd preferred to spend time in chestnut orchards and agricultural complex systems. Also, it was observed that the main land use chosen by sheep during the spring season is represented by agricultural complex systems and some agriculture with natural and semi-natural spaces.

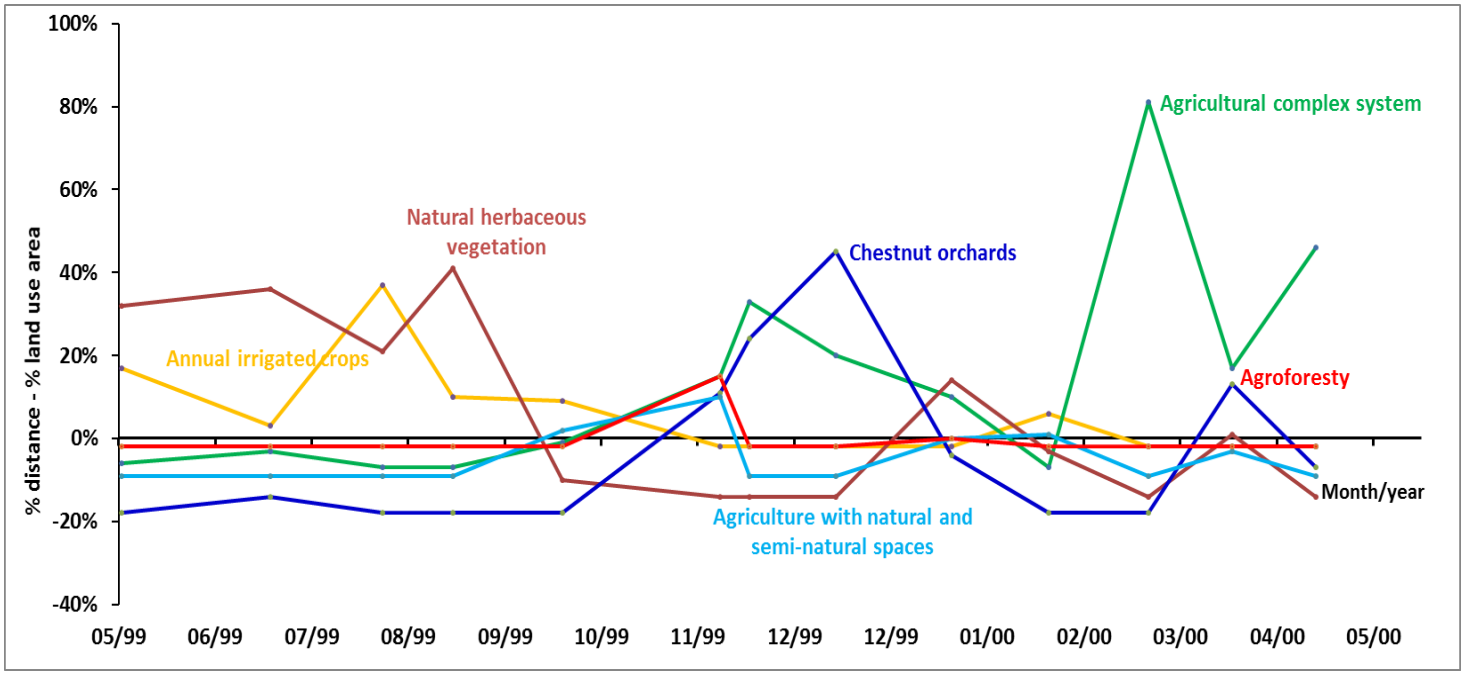

Figure 15. Differences between distance traveled (%) and area of land use class (%) according to monthly circuits (month) for sheep herd.

Observing the graph in **Figure 15**, it is found that the most important land uses in terms of distance traveled are represented by agricultural complex systems; in fact, it has 81% difference between the percentage of distance crossed and land use area, during March and 33% in

November. Followed by chestnut orchards with a 45% of difference observed in December, and natural herbaceous vegetation with 41% over August, 36% during May and June. Finally, annual irrigated crops have 37% of difference during July.

Regarding agriculture with natural and semi-natural spaces, it represents low values of difference comprise between 10% and -10%.

Comparing the distances crossed by sheep in terms of the season, we note that during summer the most important distances are found in natural herbaceous vegetation and somewhat? in annual irrigated crops. In autumn, they mainly used natural herbaceous vegetation and annual irrigated crops. Regarding winter, it is found that sheep traveled great distances in chestnut orchards and agricultural complex systems; this last represents the principal land use in the spring season.

A comparison between the variables related to land-use intensity from time or space (difference of time spent or difference of length crossed) showed in the **Figure 15**, it is observed that during summer season, chestnut orchards appear in the time spent graph and not in that of the distance crossed which means that sheep spend large periods grazing on this land use crossing short distances. Over autumn, natural herbaceous vegetation figures out only in crossed distance graph, so sheep crossed important distances in this land use but in very short time. During winter the land uses presented by the two graphs are almost the same which means that chestnut orchards and agricultural complex systems are important for sheep in term of both time spent and distance crossed. The same happens in the spring suggesting that the agricultural complex systems are of huge importance regarding the distance traveled by the herds and the time spent on it.

4.2. The time spent and the distance crossed by goats

In the **Figure 16**, it was showed the monthly variation of land-use intensity by goat herd, performed by the difference between the proportion of usage of the main land uses classes with their respective availability.

Coniferous land-use class is important in June and July; they represent successively 54% and 38% of the difference between the percentage of time spent and that of the land use area. However, their values are insignificant during the rest of the year.

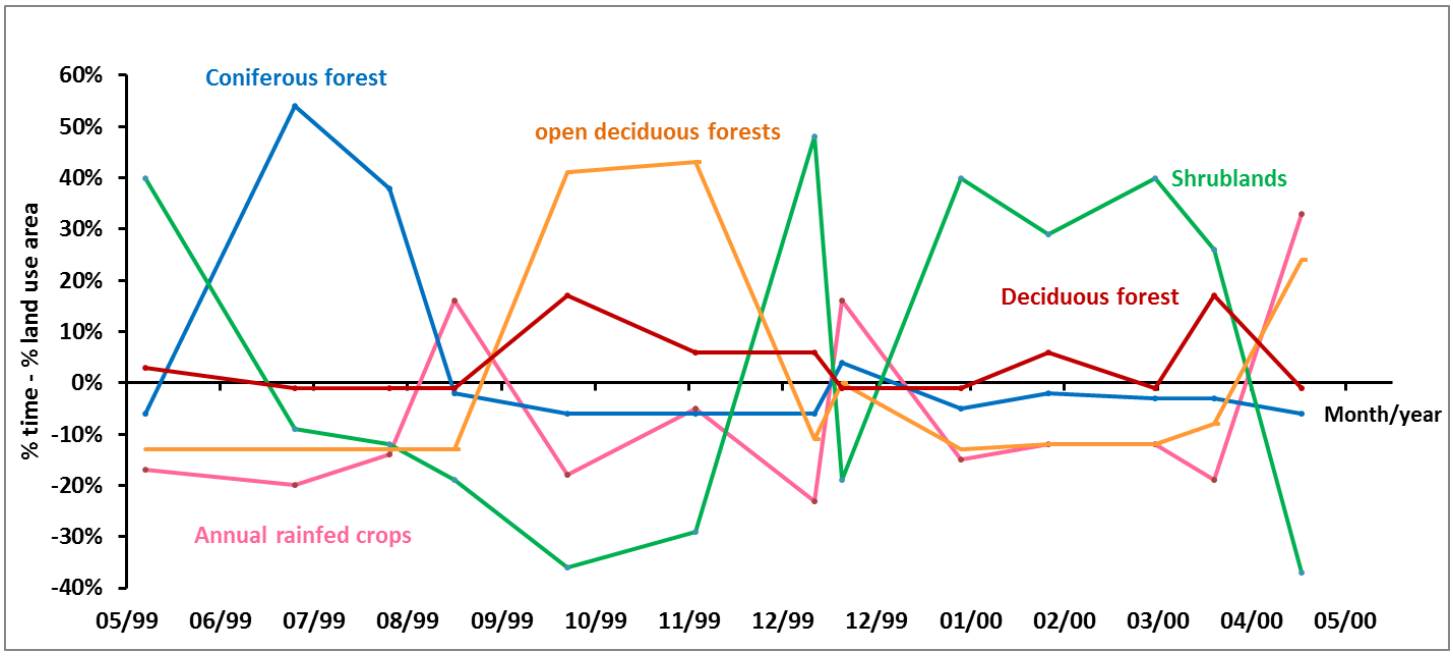

Figure 16. Differences between time spent (%) and area of land use class (%) according to the monthly circuits of goats flock.

Open deciduous forests are used with a 41% difference in September and 43% in November. For other periods, the values vary in a negative interval from -13% to 0.

Shrublands represent significant variations; in fact, they have considerable positive and negative values. 48% is noted in December and 40% in May, March, and January. Also -36% is found in September, -29% in November and -19% in December.

Annual irrigated crops vary along the year, actually the values of the difference between the percentage of time spent and that of the land use area, range between -23% and 16%.

Regarding deciduous forests, they represent low values which vary around 0.

Relying on the season as a criterion for comparison, it is found that goats stayed mainly in the coniferous forest during summer, while in autumn they spent most of their time in the open deciduous forest and deciduous forest in a lower degree. Shrublands are the principal land use frequented during winter. In addition to shrublands, goats used to a lesser extent deciduous forest.

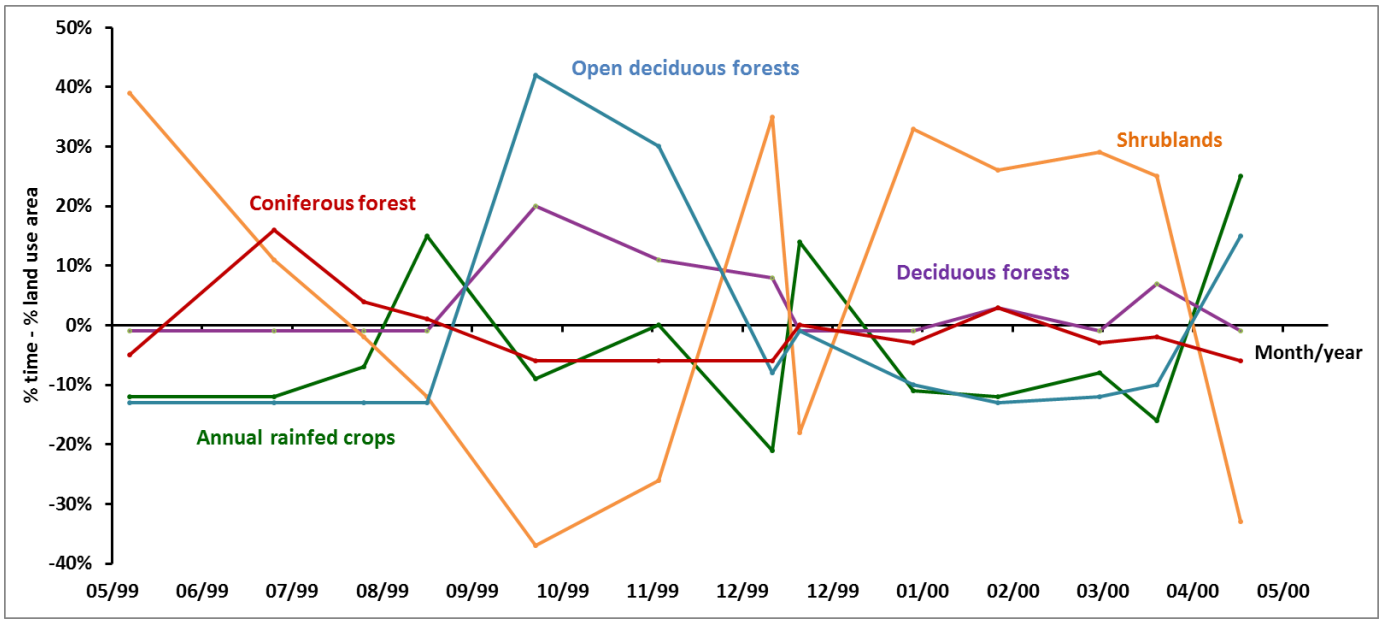

Figure 17. Differences between distance traveled (%) and area of land use class (%) according to the monthly circuits of goats flock.

The **Figure 17** shows that the highest positive values for the difference between the percentage of distance crossed and percentage of land use area, are observed for the open deciduous forest in September with a value of 42% and 30% in November. For the others months, the values are between -13% and 0. Followed by shrublands which represent a difference of 39%, 35% and 30% during May, December, and January. In the other hand, this land use has the highest negative values: -37% and -26% in September and November, respectively. Deciduous forests reached the value of 20% in September while presenting negligible values for the rest of the year. As to annual irrigated crops and coniferous forest, they fluctuated for the first case in the range -21 to 14 and closely near to 0 for the second case.

In terms of the season, it is observed that goat herd traveled considerable distances in shrublands and coniferous forest, during summer, and in annual irrigated crops as well as open deciduous forest in autumn. Regarding winter, goats crossed relatively small distances in annual irrigated crops and in some points of shrublands. In spring, great distances are crossed essentially in shrublands.

The comparison between both graphics (time spent and distance crossed graphics) depending on the season, enabled us to have the following results; during summer goats roam great distances in shrublands in a short amount of time. The same holds for the case of annual

irrigated crops in autumn and winter. However, during spring, goats spent a lot of their time in deciduous forest crossing small distances.

4.3. The land use throughout the year

The Chi-square (X^2) test is intended to test how likely it is that an observed distribution is due to chance. In our case, it was tested if the proportion of the land-use classes, by sheep or goats, is similar to their proportion in the territory. Then:

H_0 (null hypothesis): states that the proportion of land-use usage by the herds is similar to their availability, in other words, the herds utilize the landscape indifferently

And the

H_1 (alternative hypothesis): states that these proportions are different and in other words the herds have a strategy of landscape usage or there is a pastoral landscape.

In order to facilitate the study, it was regrouped the land uses classes with similar characteristics, as follows, for sheep:

- Urban areas class (UAC): urban fabric and discontinuous urban fabric;
- Agroforestry class (AF): agroforestry and agriculture with natural and semi-natural spaces;
- Forest class (Fo): coniferous forest, deciduous forest, and mixte forest;
- Shrublands class (Sh): natural herbaceous vegetation, shrublands, and open deciduous forest;

The other land-use types (annual rainfed crops (ARC), annual irrigated crops (AIC) and chestnut orchards (CO)) are kept as originally were.

And as follows, for goats:

- Urban areas class (UAC): urban fabric and discontinuous urban fabric;
- Agroforestry class (AF): agroforestry and agriculture with natural and semi-natural spaces;
- Forest class (Fo): coniferous forest and deciduous forest;
- Shrublands class (Sh): natural herbaceous vegetation, shrublands, open deciduous forest and water bodies;
- Perennial crops class (PC): chestnut and olive orchards and vineyards;

The other land-use types (annual rainfed crops, annual irrigated crops, and agricultural complex system) are kept as originally were.

In the following (**Table *4***, **Table *5***, **Table *6***, **Table *7***) it is shown the values of Chi-square for each land-use class and for each grazing circuit, time spent in (**Table *4***) (sheep) and (**Table *6***) (goats) and distance in (**Table *5***) (sheep) and (**Table *7***) (goats). Cells with green color represent the case where the difference between the observed and the expectet values is high, the yallow for the intermidiate values of difference, and the orange for the low values of difference.

We reject the null hypothesis and we admit that the land uses grazed are not randomly chosen by sheep either for time and distance ($\chi^2_{tab} > 106.69$). In other words, it was concluded that the herds don't use the land-use types indifrently. Furthermore, it can be seen that this steategy change along the season and between sheep and goats.

The (**Table *4***), shows that observed χ^2 of the main land uses are higher than the expected for time spent in sheep, namely the case of annual irrigated crops during September, May and July and the case of agricultural complex systems during March and May.

Concerning the distance crossed (**Table *5***), three land uses have a higher proportion than their proportion of the territory, namely the annual irrigated crops in June and May, the agricultural complex system during March and May and the urban area mainly in February and May (***Table 6***) shows that the main land uses have an observed χ^2 highest than the expected to the time spent by goats, such as the case of forests during June and July and agroforestry in September. (***Table 7***) shows that goats crossed mainly agroforestry patches during May, July and December, and forests during June and September, as well as agricultural complex system in July.

Since χ^2 is higher than the critical value, we reject the null hypothesis and we conclude that the time spent and the distance traveled for particular land uses are related to animal selectivity and preference.

Table 4. $\chi 2$ values based on time spent by sheep herd.

	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Nov-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00	
Urban areas	65,844	11,586	11,968	11,035	8,736	2,200	3,705	0,147	16,534	126,955	8,030	11,767	1,047	
Annual rainfed crops	39,907	5,117	33,127	207,931	48,815	22,954	28,309	24,429	18,473	32,970	26,844	3,995	889,710	
Annual irrigated crops	5014,895	24,089	2343,707	46,271	9485,595	7,656	8,058	6,954	7,466	38,457	7,641	8,090	9,897	
Chestnut Orchards	109,285	897,982	176,021	162,296	128,484	7,888	391,046	697,856	53,182	92,364	81,693	6,224	69,970	
Agricultural complex systems	33,585	57,554	66,550	61,361	37,523	1,124	512,692	159,671	302,135	34,921	5377,974	204,927	1640,691	
Agroforestry	65,132	101,558	104,905	96,725	3,382	1454,354	51,345	44,307	192,838	541,625	48,688	58,076	63,061	
Forest	146,313	228,142	235,661	217,286	172,017	109,591	58,404	86,024	26,766	123,659	109,373	112,002	55,909	
Shrublandd	27,369	0,238	648,931	624,883	10,114	140,282	147,645	127,406	20,246	0,000	140,003	8,487	181,334	
														36620

Table 5. $\chi 2$ values based on distance crossed by sheep herd.

	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Nov-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00	
Urban areas	17746,070	52,156	41,201	39,343	56,992	451,915	11,761	1,116	4658,694	25272,482	1941,379	4524,944	74,383	
Annual rainfed crops	275,812	944,402	7,911	1341,313	1449,487	11,019	222,607	230,157	58,232	976,797	119,132	12,703	1,646	
Annual irrigated crops	9350,624	371,123	27388,273	1907,558	2228,981	56,235	63,366	65,514	92,896	1222,497	33,911	85,280	59,841	
Chestnut orchards	935,656	480,484	605,949	578,633	838,203	229,884	1198,925	4349,835	47,596	918,661	362,552	477,219	105,932	
Agricultural complex syste	217,578	61,927	229,098	218,770	6,110	1074,830	5857,129	2397,021	802,397	347,328	19137,003	2182,907	10970,865	
Agroforestry	557,632	457,156	361,133	344,853	0,241	1982,696	403,748	417,441	0,033	1,524	216,073	119,245	381,289	
Forest	1252,676	1026,965	811,258	774,686	1122,204	804,919	98,317	431,395	544,658	1229,922	485,392	1047,036	10,178	
Shrublands	365,009	2011,985	683,388	1287,593	696,915	1030,337	1160,992	1200,365	22,063	102,268	621,326	176,178	1096,409	
														183421

Table 6. $\chi 2$ values based on time spent by goat herd.

	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Nov-99	Dec-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00	
Urban areas	1,624	0,640	0,292	2,170	3,319	2,789	2,128	2,212	0,535	0,960	3,079	3,142	3,440	
Annual rainfed crops	77,672	130,824	58,997	79,273	80,492	4,943	90,187	43,556	42,211	24,997	31,689	83,841	281,807	
Annual irrigated crops	7,627	1,196	4,884	0,311	7,616	6,401	4,883	5,076	5,658	6,066	7,066	7,210	7,894	
Perenes crops	44,099	22,350	19,284	350,674	38,806	10,087	30,933	19,763	6,116	11,716	37,365	34,432	59,307	
Agricultural complex syste	12,220	14,786	89,356	8,746	12,204	10,256	7,824	6,256	9,065	9,719	11,322	6,784	12,648	
Agroforestry	3,884	12,948	22,734	4,908	592,410	1,022	8,810	53,293	5,820	1,633	3,195	9,064	8,001	
Forest	7,738	2815,230	1357,775	10,872	97,751	0,680	0,009	3,810	22,747	6,415	16,458	144,488	41,069	
Shrublands	128,686	76,162	98,387	148,858	1,553	16,682	105,803	14,655	75,298	49,849	88,920	33,841	24,669	
														8141

Table 7. $\chi 2$ values based on distance crossed by goats herd.

	May-99	Jun-99	Jul-99	Aug-99	Sep-99	Nov-99	Dec-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00	
Urban areas	0,611	8,677	661,420	2,310	37,701	32,082	29,698	34,905	14,831	3,972	45,084	51,053	38,559	
Annual rainfed crops	494,885	452,007	133,788	748,298	242,547	0,443	1013,987	543,059	425,531	430,602	254,115	980,384	1904,234	
Annual irrigated crops	101,360	237,792	65,187	263,295	86,518	73,624	68,152	80,103	95,569	85,828	103,460	117,159	88,488	
Perenes crops	285,602	3,029	6,808	254,577	200,363	23,457	229,731	146,851	140,417	380,298	98,691	115,305	470,954	
Agricultural complex syste	162,411	148,998	1652,791	3,025	138,628	117,969	109,201	48,035	153,131	137,523	165,776	1,708	141,786	
Agroforestry	168,350	10,956	3784,154	1313,719	0,127	7,890	122,961	2474,084	24,159	21,012	10,504	44,475	6000,539	
Forest	425,714	2271,766	58,843	0,782	1802,927	151,933	17,871	15,900	192,926	230,850	210,463	327,559	532,493	
Shrublands	956,292	14,534	330,132	1160,434	24,030	5,777	1036,991	255,711	809,348	373,532	589,707	517,016	536,006	
														42221

4.4. Differences between the sheep and the goats herds

The differences in selectivity of land use between sheep and goat were assessed using a discriminant analysis. Actually, the dataset of selectivity index was analyzed via this model, with to compare the means between this land uses and determine whether any of those means are significantly different from each other. The output of this study is represented by (**Figure 18**) where; CF: coniferous forest, DF: deciduous forest, ODF: open deciduous forest, Sh: shrublands, CO: chestnut orchards, ANSNS: agriculture with natural and semi-natural spaces, ACS: agricultural complex system, ARC: annual rainfed crops, NHV: natural herbaceous vegetation, AF: agroforestry, AIC: annual irrigated crops.

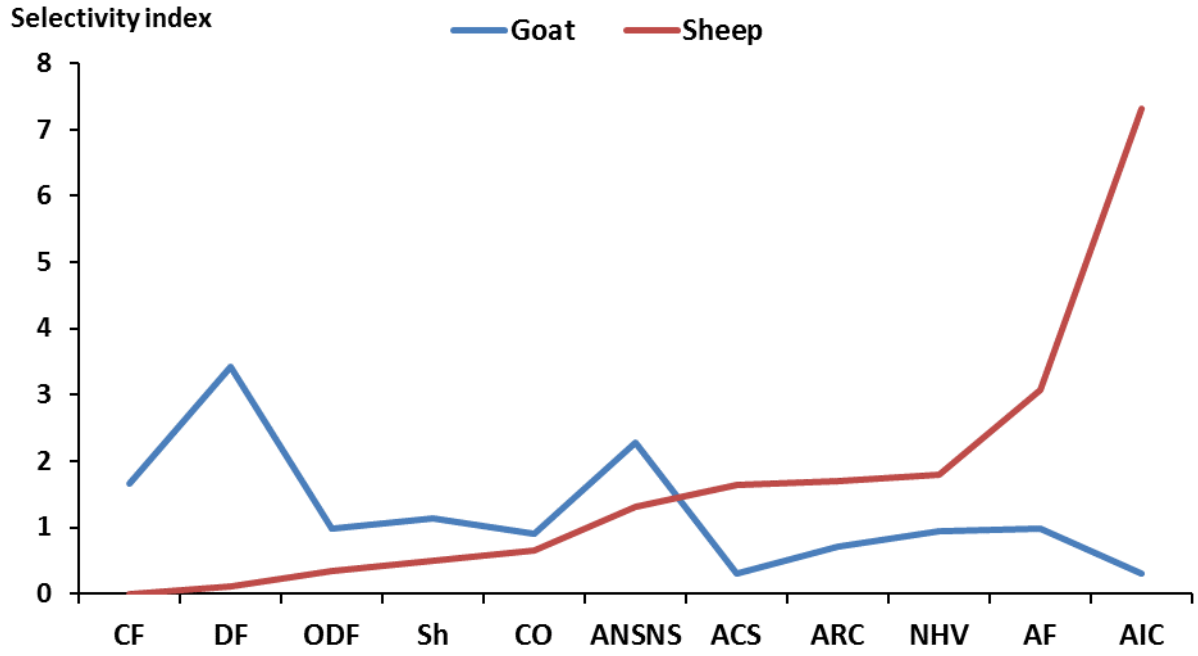

Figure 18. Land uses and their main selectivity index per group.

The chart shows the different land uses that sheep herd and goat flock select in their grazing itineraries. The Y-axis represents the land-use index of selectivity for goats (blue) and sheep (red). It is obvious that annual rainfed crops, natural herbaceous vegetation, agroforestry, and annual irrigated crops are more selected by sheep than goats. On the other hand, it is observed that goats prefer coniferous forest, deciduous forest, open deciduous forest, shrublands, chestnut orchards, agriculture with natural and semi-natural patches. Both curves intersect in the land use agricultural complex system, which means that this land use is equally selected by both, goat and sheep.

Wilks' Lambda (0.255) is a privileged indicator for statistical evaluation model. The closer to 0 Lambda is, the more the variables contribute to the discriminant function. The null hypothesis is rejected when the p-value is lower than 5%. In our case, it is noted that Wilks's Lambda is greatly close to 0 than to 1, in addition, p-value (0.045) is less than 0.05; hence the model used is suitable.

One of the powerful points of discriminant analysis that it establishes classification functions, that are used to define which observation, in our case the type of land use, are more likely to belong to goats or sheep circuits. The observation is classified in the group with the highest value. It can be seen from (figure.19) below that annual irrigated crops, agricultural complex system and agriculture with natural and semi-natural spaces belong to sheep group. While the other land uses (annual rainfed crops, chestnut orchards, agroforestry, deciduous forest, coniferous forest, natural herbaceous vegetation, shrublands, and open deciduous forest) are classified in goat group.

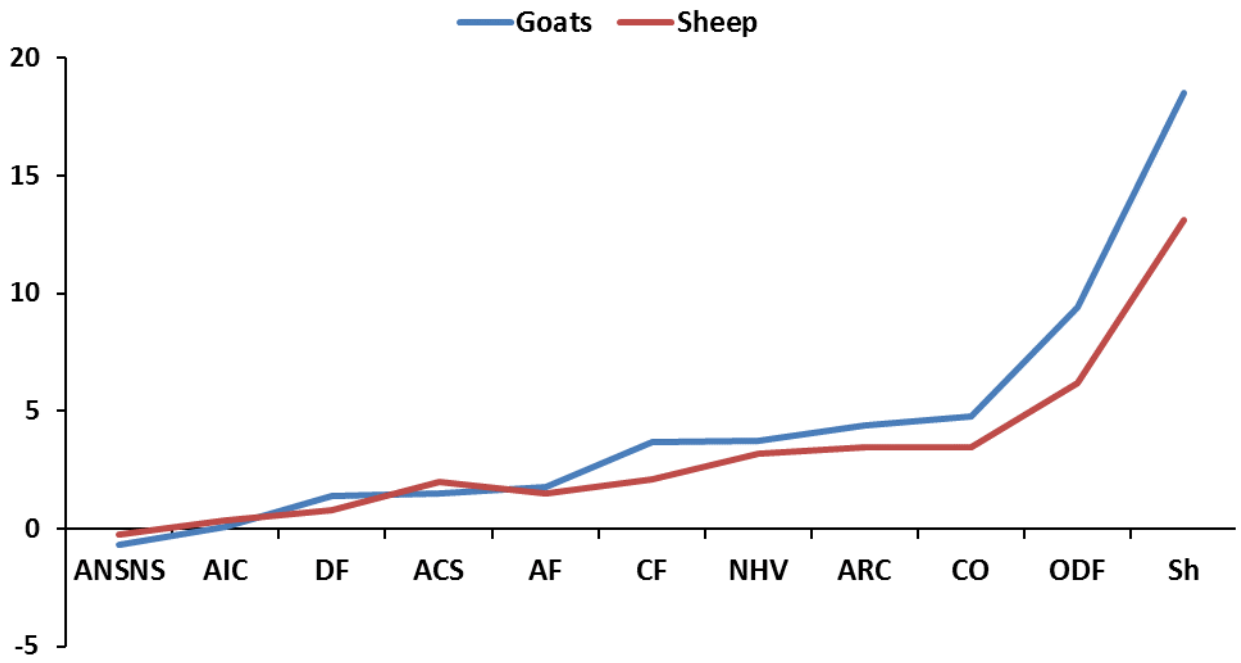

Figure 19. Classification functions for the groups of sheep and goats circuits.

Besides, the descriptive method of discriminant analysis permits to establish the canonical discriminant functions, which will be used to produce a synthetic representation system where we can better distinguish the groups (sheep and goats) as it is given in (figure.17) below.

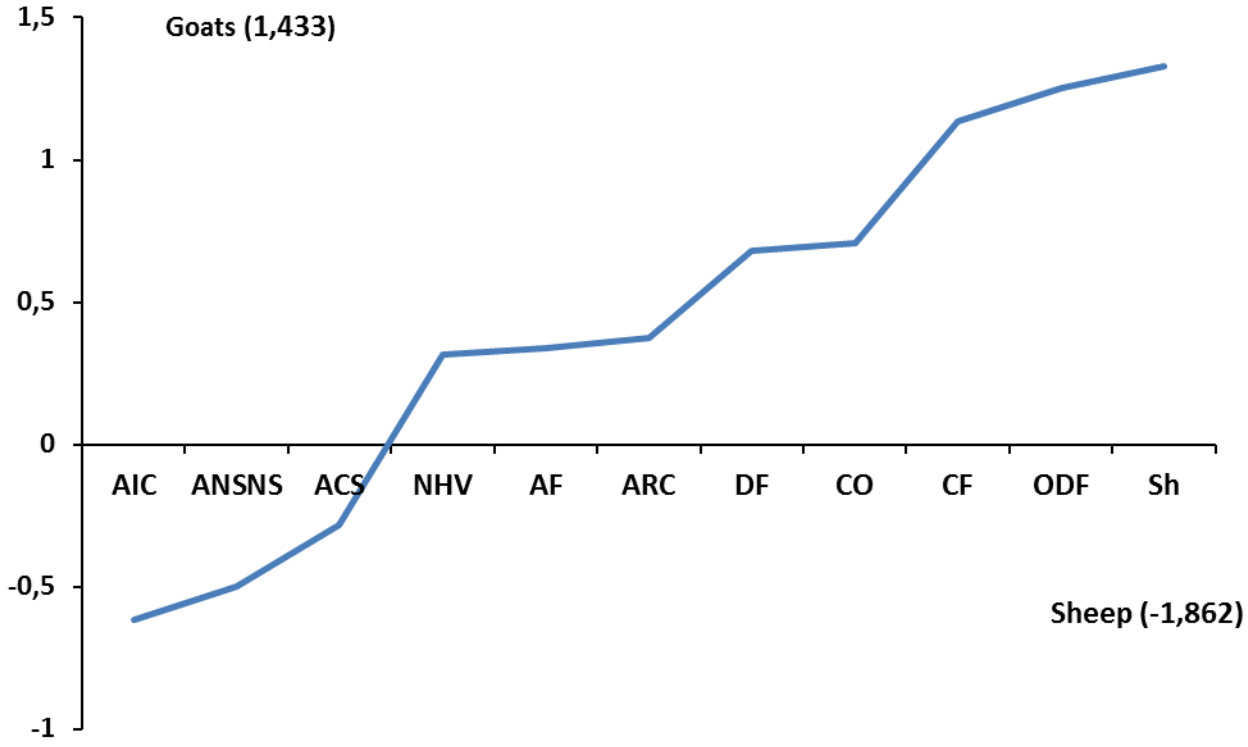

Figure 20. Canonical discriminant functions.

The chart exhibits the coefficients of canonical discriminant functions. The negative values refer to the land uses significantly used by sheep, while the positive values correspond to the land uses more using by the goats. Hence, sheep selected annual irrigated crops, agricultural complex system, and agriculture with natural and semi-natural spaces, and goats utilized agroforestry, annual rainfed crops, deciduous forest, chestnut orchards, coniferous forest, open deciduous forest, and shrublands.

4.5. The selectivity index

Sheep and goat selectivity was analyzed using the analysis of variance (ANOVA II). The **Table 8** below compares the selectivity index for each land use between sheep and goats, different letters indicate significant differences ($p<0.05$).

Table 8. Selectivity index of each land use for sheep and goats.

Selectivity index	Sheep	Goat
Annual Rainfed Crops	1.310[a]	0.713[a]
Annual Irrigated Crops	5.635[a]	0.300[b]
Chestnut orchards	1.059[a]	0.910[a]
Agricultural Complex Systems	2.993[a]	0.311[b]
Agriculture with Natural and Semi-Natural Spaces	1.007[a]	2.280[a]
Agroforestry	2.368[a]	0.981[a]
Deciduous Forest	0.146 [a]	3.415 [b]
Coniferous Forest	0.000[a]	1.660[b]
Natural Herbaceous Vegetation	1.383[a]	0.941[a]
Shrublands	0.375[a]	1.132[b]
Open Deciduous Forest	0.266[a]	0.987[a]

A selectivity index higher than 1 means that the land use is preferred by the animal, while selectivity indexes lower than 1 refers to land use avoided by the herd. Hence, it is seen from the (**Table 8**) above that annual irrigated crops are greatly preferred by sheep and very selected comparing to goats. In addition, agricultural complex systems and agroforestry are of very importance for sheep than for goats. Sheep also prefer each of Natural Herbaceous Vegetation, annual rainfed crops, chestnut orchards and agriculture with natural and semi-natural spaces.

In another hand, deciduous forest is highly preferred by goats, indeed this land use is very selected by goats comparing to sheep. Additionally, goats tend much to select agriculture with natural and semi-natural spaces than sheep. Besides, they prefer coniferous forest as well as shrublands.

The results of analysis of variance about sheep/goat factor are not significant, which means that the effect of the season on the selection of land uses by herds of sheep or goats is not enough pronounced. But seen that there are some values very close to be significant, as well as the interaction between season and sheep/goat is significant in some cases, we proceeded to another analysis of variance (ANOVA II) on two factors (sheep/goat and season). This second test considers just two seasons (summer and winter) because of the fact that with fewer factor levels, the analysis is more general which permits to have significant results.

Effectively, the effect of the season is substantial in the case of agricultural complex systems, which is more selected by sheep in winter (p = 0.029). In another hand, sheep select natural herbaceous vegetation more than the goats in summer (p = 0.035), while goats tend to select coniferous forest during summer more than sheep (p = 0.05).

4.6. Land-use availability and land-use selectivity

The comparison results between land uses selection versus land uses rejection by goats and sheep can be seen in (**Figure 21** and **Figure 22**) The use is expressed in percentage of time and the availability refers to the percentage of land use area.

The red line in the graphics below corresponds to points where the utilization of land uses by the herds is equal to their available area. The points above the red line represent the land use where the use by herds is higher than its availability in term of the area meanwhile the points below the red line refer to the land use where the use is lower than its availability.

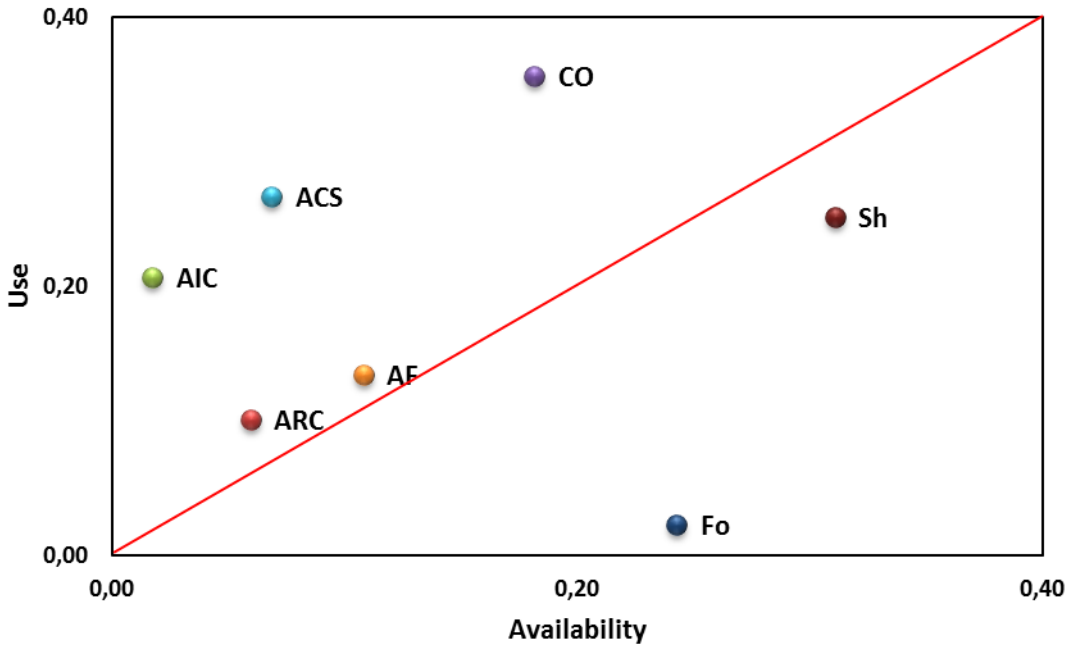

Figure 21. Land uses selection vs. Rejection by sheep herds during the year.

The graph separates the land uses groups into three different categories:

- The most preferred but not available: Chestnut orchards (CO), agricultural complex system (ACS), and annual irrigated crops (AIC).

- Concerning the land use: annual rainfed crops (ARC), agroforestry (AF), and shrublands (Sh) they are near to boundary line where the availability is equal to the use, which means that the area of these three land uses is enough for the sheep use.
- The most available but not very preferred by sheep: mainly forests (Fo)

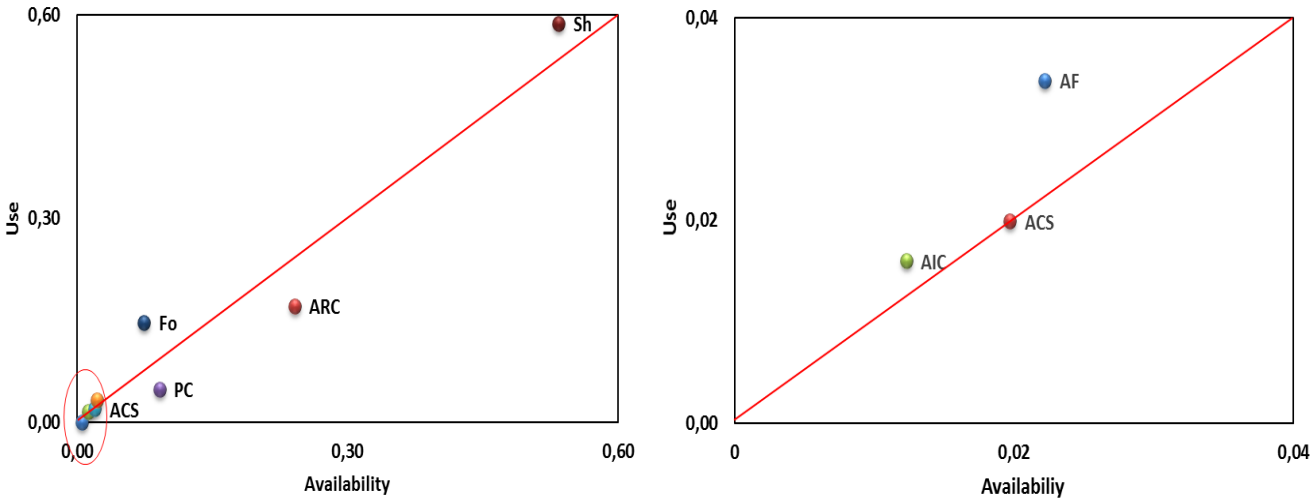

Figure 22. Land uses selection vs. Rejection by goats during the year (the graph on the right is to clarify the distribution of the circled points in the first one).

Regarding goats, the graph shows the selection of land uses groups:

- The most preferred and available are shrublands (Sh).
- The preferred but not available are forests (Fo) and agroforestry (AF).
- The agricultural complex system (ACS), as well as annual irrigated crops (AIC) availability, is equal to its use.
- The available but not very preferred: Annual rainfed crops (ARC) and perennial crops (PC).

Chapter 5. Discussion

The main purpose of this study is determinate the land uses preference for sheep and goats and to establish the relation between land use availability and usage by herds, in order to evaluate if sheep and goats use indifferently the landscape, or contrariwise they show a strategy in dealing with it. It was also of a great importance to analyze how annual variation influence the usage of land use by animals.

Our approach is based on the relation of land use availability in the landscape and the time spent or distance crossed by herds in each land use. The starting hypothesis is if the herds use the landscape differently of its composition, then there is a grazing strategy dependent on its composition. In order to assess this hypothesis, it was performed:

- A graphic analysis from the difference of the percentage of each land use (time or distance) in the grazing circuits and of the percentage of each land use in territory;
- A X2 test to evaluate if the proportion of land-use usage by the herds is similar or different to their availability;
- An Index selectivity for each land-use from the ration of observed proportions and the available proportion (computed by time);
- A discriminate analysis in order to understand the preference of landscape by the sheep and goats.

According to the results, sheep spent long time in May and July in annual irrigated crops (AIC) due to the residues of potatoes that are left in the field as forage for the animals. They spend also long period in this (AIC) in July which is the season of the fodder corn harvesting, thus sheep feed on the stubbles left in the field. However, still the availability of this land use lower than the use of sheep.

Concerning agriculture complex system (ACS), it is very used by sheep in March and May by spending both long time and long distances in this land use. That can be explained by the fact that this class is consisting of several sub-classes characterized by high diversity (cereals, crops, grasslands), hence sheep have many opportunities to graze. Also this can be justified by the fact that agricultural complex systems are often around the village, thereby sheep start their grazing itineraries by these systems. It was also reported that sheep preferred travel small distances comparing to goats (Castro personal communication). This explain the high selectivity of sheep to the ACS.

Sheep spend long time (9h per day) in chestnut orchard during June but a small distances (160m) which means they are using this land use for resting. These orchards provide shade with low temperatures in a very hot month like June. As it is known, sheep are particularly sensitive to high temperatures and solar mediation (Marai et al., 2007), for this reason they rest in this orchards during the hot hours of the day, while the grazing occurred early in the morning and at night (Castro et al., 2016). This land use is also exploited in November and December as a source of alimentation by providing chestnut left over on the ground after the harvest. Some chestnut orchards are intercropped with cereals, in these cases sheep eat crops residues such as stubble as previously reported in a study of Castro (2009), and in the opposite case they graze on understory plants.

Sheep spend a long period and great distances in shrublands during July and August comparing to the rest of the year. Shrublands regroups natural herbaceous vegetation, shrub land and open deciduous forest. The most consumed class is the natural herbaceous vegetation which is dominated by gramineous species with high palatability.

The forest (coniferous forest and deciduous forest) is used for crossing to other land use since the time spend in this category is much lower comparing to the distance traveled. Also this land use is expanded in large area compared to it use by the sheep. Consequently, we can consider forests as a corridor in the territory exploited by sheep. They use it to reach other land uses more preferred for grazing.

Annual rainfed crops are more available than irrigated crops, but less used by sheep. This lasts spent long duration in rainfed crops in May, grazing cereal stubbles.

Based on the results of our study, goats graze mainly on shrublands all year around with an average of (325 min/circuit), crossing big distances, hence we can conclude that goats used this land use for browsing and feeding as previously reported by (Castro et al., 2016) which states that the percentage of shrubs and tree species in the diet of goats was significantly higher. Indeed, this land use represents the largest area in whole territory of goats (53%), which explains its high availability. Goats also used forests (mostly oak and pin species) and annual rainfed crops as the principal feeding resources. Despite the fact that forests have small area comparing to other land uses (7% of the territory), goats tend to spend long duration exploiting this land use especially during June and July. A study done by (Schlecht et al., 2009) corroborates our results reporting that trees leaves are preferably grazed by goat.

Agroforestry (Agrof) as well as the perennial crops (PC) are not much used, also they are not available in terms of area representing both 2% of the goats territory. The category of PC is consisting of chestnut and olive orchards, the fact that the owners of chestnut orchards most of the time prohibit the access of goats to their land seen that these animals damage trees bark (Castro, 2009), can explain the low used of this land use by goats. Regarding annual irrigated crops (AIC) which has the smallest area in whole the territory, is used by goats for crossing to other land uses since they traveled more a less important distances in very short time. Therefore, AIC can be seen as path allowing access to other land uses more preferred and selected by goats.

Concerning selectivity of each land use, there are marked differences between sheep and goats. Annual irrigated crops (AIC), agricultural complex system (ACS) and agroforestry (AF) shown a strong preference by sheep herds while deciduous forest (DF), and agriculture with natural and semi-natural spaces (ANSNS) are preferred by goats herds. Also, coniferous forest and shrublands are positively selected by goats and negatively selected by sheep. That can be explained by the fact that goats tend to use the forest territory more than sheep.

The grazing activity is strongly influenced by the climatic conditions of the year, hence these conditions affect the availability of feeding resources and consequently the selection of land uses by the animals. The effect of season is clear in the case of agricultural complex systems; in fact, this land use is more selected by sheep in winter. In the other hand another hand, sheep select natural herbaceous vegetation more than goat in summer ($p = 0.035$), while goats tend to select coniferous forest during summer more than sheep ($p = 0.05$).

The results obtained by the different methods used in our study, are consistent each other, except the analysis of selectivity index. These selectivity analyses show sometimes results inconsistent with the results from other methods that analyze the usage of land use by animals. For instance, according to the analysis of variance, agriculture with natural and semi-natural spaces is more selected by goats than sheep, which is in contrast with other results indicating that this land use is rather used by sheep. This contradiction can be due to the great area of agriculture with natural and semi-natural spaces in the territory of sheep compared to that of goats. Since the analysis of variance is applied on selectivity index, and this latter is calculated by dividing the percentage of time by the area of the land use, consequently the highest is the area the lower is the selectivity index.

The discriminant analysis has shown that annual irrigated crops, agricultural complex system and agriculture with natural and semi-natural spaces are more related to sheep, while deciduous forest, coniferous forest, shrublands and open deciduous forest are more liked to goats.

Comparing land uses exploited by sheep and those used by goats, it can be concluded that sheep tend to use agricultural matrix throughout the year, whereas goats have forestry matrix trend. It was also reported by Castro et al. (2004) that sheep and goats follow different strategies dealing with land uses from one to other; sheep are highly dependent on agricultural activities while goats are profoundly bound to the space with forest vocation.

Sheep and goat are small ruminants genetically different, even they are often spoken about in the same breath (Beaver et al., 2016). These differences influence their foraging behavior and diet selection. Indeed, goats are natural browsers that can stand on their hind legs to reach vegetation and tops of plants. Sheep are grazers, preferring to graze close to the soil surface (Jonsson, 2010; Castro et al., 2016). That can explain the results of our study. Regarding shrublands which regroups natural herbaceous vegetation, shrublands and open deciduous forests, the results show that this land use is important even for goats and sheep. In fact, the analysis of variance points out that sheep tend to use natural herbaceous vegetation while goats have tendency to exploit shrublands and open deciduous forests.

As claimed by our results, there is no overlap in the use of grazing territory between sheep and goats since the former usually prefer graze in lands of importance for farming activity, while the latter tend to use the forestry matrix. This result is consistent with that of (Castro et al., 2004; Castro, 2009). Hence, competition for the same feed resources is low between both sheep and goats, since they differ in land uses exploited.

Chapter 6. Conclusion

The results of these two case studies – Rebordaínhos and Freixedelo – contribute to knowledge about the traditional shepherding systems of sheep and goats in the Northeastern's Portugal. Sheep and goats don't use the landscape in a random way, it seems they put rationality in their use since the proportion of each land use in the circuit is different from its proportion in the territory.

Results show that sheep prefer *Annual irrigated crops*, *Agricultural complex system*, *Natural herbaceous vegetation*, *Chestnut orchards* and *Agriculture with natural and semi-natural spaces* land-uses. While goats tend to prefer *Shrublands*, *Coniferous forest*, *Deciduous forest* and *Open deciduous forest* land-uses.

The herd of sheep has the highest selectivity indexes for the *Annual Irrigated Crops*, the *Agricultural Complex Systems* and the *Agroforestry* land uses. The highest selectivity indexes for the herd of goats were found for the *Deciduous Forest*, the *Agriculture with Natural and Semi-Natural Spaces* and the *Shrublands* land uses. The herd of sheep has the lowest selectivity indexes for the *Coniferous forest*, *Deciduous forest*, and *Open deciduous forest* land-uses. The lowest selectivity indexes for the herd of goats were found for *Annual irrigated crops* and *Agricultural complex systems* land-uses.

The discriminant analysis distinguishes the two herds – the sheep and the goats - in terms of landscape composition for grazing. The flock of sheep is related to *Annual irrigated crops*, *Agricultural complex system* and *Agriculture with natural and semi-natural spaces*. And the flock of goat is related to, *Chestnut orchards*, *Agroforestry fields*, *Deciduous forest*, *Coniferous forest*, *Shrublands* and *Open deciduous forest*.

An important relationship exists between landscape and the pastoral system studied. The landscape influences the grazing system through its composition and configuration and this one pastoral system valorizes and conserves the landscape as has been noted by several authors.

It was concluded that the landscape management for the sheep or for the goats herding has to be different: the agricultural land uses are essential to the flocks of sheep and the forest land uses are decisive to the flocks of goats. Despite these interesting conclusions, it should be highlighted that this study was applied on only one herd of sheep and one herd of goats. Then in the future, this study needs to be applied to more herds and territories.

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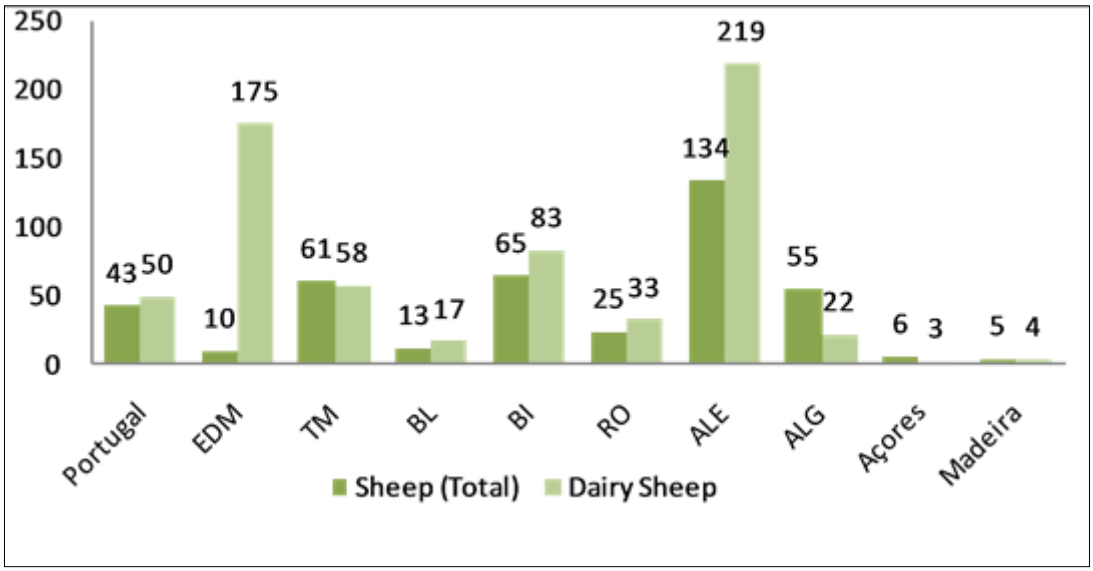
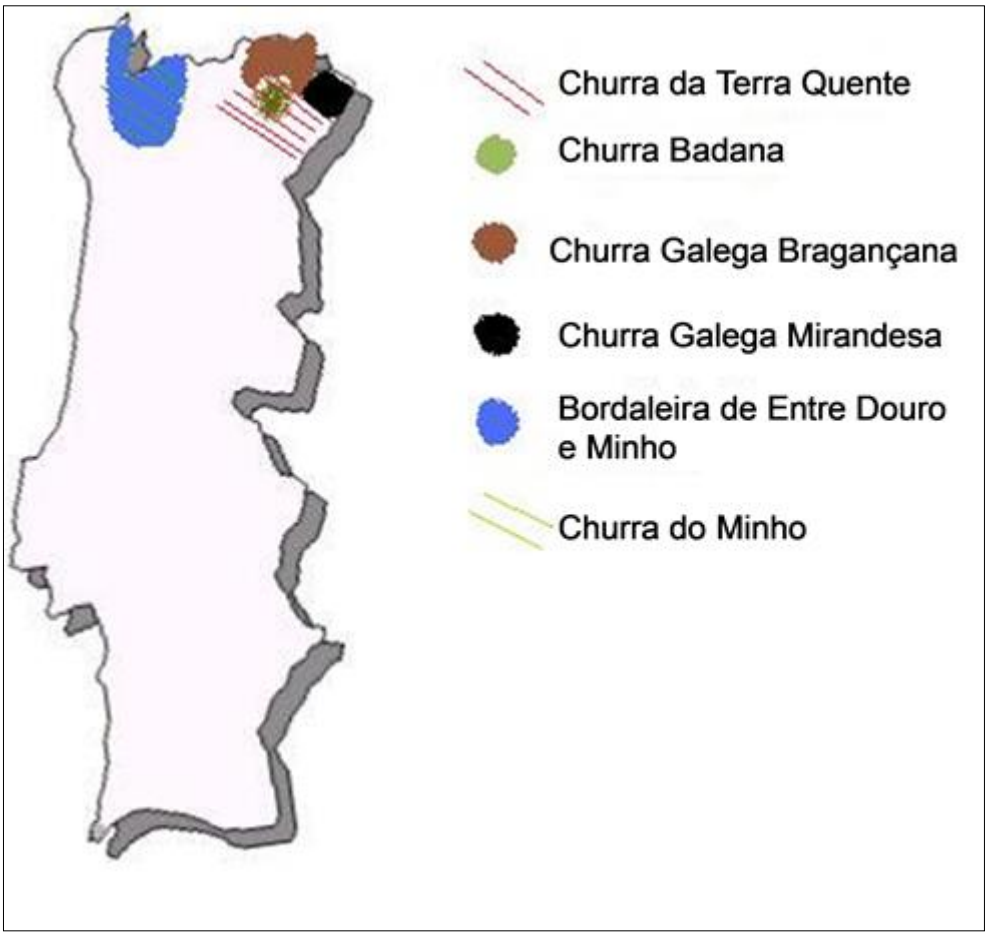
Appendix

Sheep Population per region								
Regions	Sheep (Total)				Dairy Sheep			
	Farmers (nº)	(%)	Nº	(%)	Farmers (nº)	(%)	Nº	(%)
Portugal	51,787	100	2,219,639	100	8,551	100	424,448	100
EDM	12,721	25	129,148	6	2	0	350	0
TM	4436	9	269,726	12	889	10	51,609	12
BL	11,464	22	143,866	6	2987	35	50,301	12
BI	5550	11	359,200	16	2695	32	224,305	53
RO	7082	14	173,803	8	1227	14	39,964	9
ALE	8133	16	1,090,421	49	248	3	54,239	13
ALG	811	2	45,009	2	97	1	2171	1
Açores	638	1	3850	0	148	2	436	0
Madeira	952	2	4616	0	258	3	1,073	0

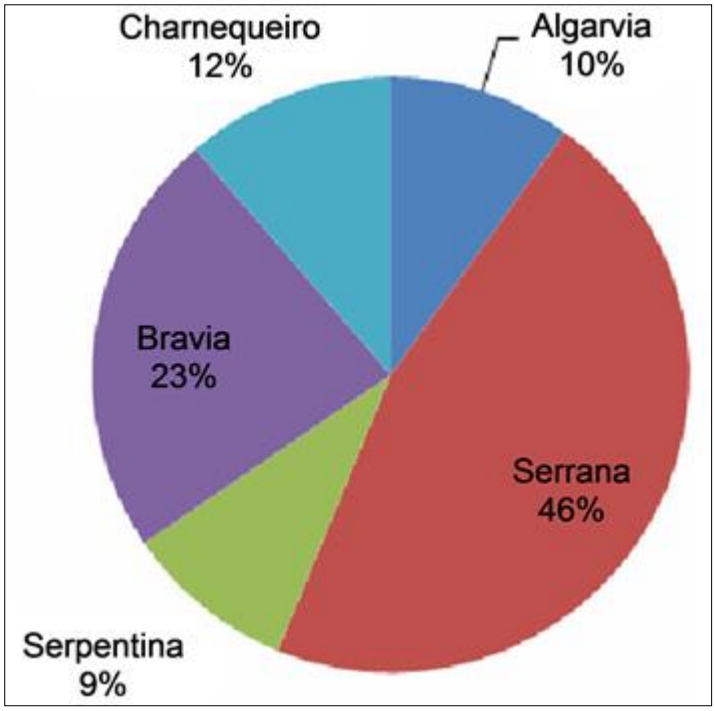
Appendix 1. Farmers and number of sheep in production



Appendix 2. The average size of sheep farms in Portugal



Appendix 3. Distribution of Local sheep breeds from the North



Appendix 4. Goat local breeds

General aspect	Average height and white
Skin, fleece and wool	Thin and oily skin, usually white, sometimes with pigmentation around the eyes, the ears and the limbs
Head	Medium volume, slightly convex conical head especially for males, horizontal ears of medium length; horns in both sexes, in the form of open spiral, rough and triangular section; large mouth, thick lips, sometimes pigmented black or brown; big eyes.
Neck	Narrow, triangular in shape and coated wool; without dewlap or wrinkles; regular connection to the trunk.
Trunk	Relatively narrow chest, with slightly sprung ribs;
Udder	Globes, good volume, coated with a thin elastic skin, with obvious median groove; good ceilings generally well established.
members	Thin but strong; buttock undeveloped; rigid nails.
adult body weight	Females: 40 - 50 kg; Males: 50 - 60 kg.

Appendix 5. Merina Mondegueira Breed Standard

General aspect	Medium height, predominantly dairy fitness. It is a goat with a height of 64 cm at the withers
Skin, fleece and wool	The coat can be black, brown and may have yellow color in some regions, the only native goats bred for long.
Head	Head: large, long, wide front and slightly arched; triangular face; thin muzzle; small mouth and thin lips; relatively short and horizontal ears, triangular section of horns, rough, driven back a saber.
Neck	Long, more muscular, straight edges with or without earrings
Trunk	Midline almost straight or slightly oblique, dorsal and fleshless and rectilinear kidneys; croup drooping, short and upturned tail. Trunk slightly arched; abdomen developed;
Udder	Udder well developed, globular, sometimes pending fornix; and small conical caps directed forward and slightly to the side.
members	Members: thin, resistant, with small and hard nails.
adult body weight	Males - 35-50 kg; Females - 25 to 40 kg.

Appendix 6. Serrana Breed Standard

Reproductive parameters	
Fertility rate	90-95%
Prolificacy rate	170-180%
Fertility Rate	150 - 160%
Age at 1st calving	15-18 months
Age at Puberty	8 -12 months

Appendix 7. Reproduction parameters of Serrana breed

Meat Production	
Birth Weight	2.2 - 3.0 kg
Weight 30-40 days	6.0 - 8.0 kg
Weight at 60 days	11.0 kg
extensive GMD	120 g / day
Traditional slaughtering weight	6 - 8 kg
Traditional slaughtering age	30 - 40 days
Main time of slaughter	Christmas and Easter

Appendix 8. Serrana breed production