



Pattern and function of woody features on the grazing itineraries of Terra Fria, Trás-os-Montes - Portugal

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*“I’ve been the subject of my own investigation.
To believe when no reason pushes to faith,
To stand where no reason pushes to sustain,
To sight when reasons push to see,
And only Ambition shepherds my track.”*

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– *Gratitude is aging fast, but remains the Memory of the Heart*

Abstract

The trees, hedgerows and woods are current configuration of the tree network in several ecological regions of the world. In Trás-os-Montes region, Northeast of Portugal, they are a traditional component of Terra fria landscape and they could be seen in several forms: scatter trees, fencerows, small woodlots, riparian buffer strips, among others.

The extensive livestock systems in this region are based on a set of circuits across the landscape. In this practice, flocks interacts with these structures using them for different functions inducing an influence on the itineraries. Our purpose will be focused on the woody features of landscape regarding their configurations, abundance and spacial distribution; in order to examine how the grazing systems depends on the currency of these formations; particularly how species flocks behaviors are related on.

Depending on spatial data, The investigation attain to compare the tree network within the agriculture matrix, to the grazed territory crossed by flocks. From the other side, the importance of spatial data on interpreting the issue by suggesting different parameter that may influence the circuits.

The recognition of the pressure exerciced by the occurence of the woody structures on the grazed circuits is possible. We believe that the role of these woody structures features in supporting the tradicional silvopastoral systems has been sufficiently strong for change their distribution pattern.

Keywords: Woody feature, GPS tracking, Grazing itineraries, Small ruminants, herd management, Grazing behavior.

Resumo

Árvores, sebes e pequenos bosques são elementos recorrentes na configuração das paisagens agrícolas. Em Trás-os-Montes, Nordeste de Portugal, estes são componentes importantes da paisagem da Terra Fria, assumindo várias formas como árvores dispersas, cortinas arbóreas, matas, galerias ripícolas, entre outras.

Por outro lado, os sistemas tradicionais de produção animal, nomeadamente no caso das raças autóctones de pequenos ruminantes, estão baseados na exploração de um conjunto de circuitos de pastoreio utilizados pelos rebanhos. Nesta prática, os rebanhos interagem com essas estruturas arbóreas, usando-as para diferentes fins, e seleccionam os seus itinerários em função da sua distribuição. O objectivo deste trabalho centra-se nestes componentes lenhosos da paisagem agrícola, com a sua particular configuração, abundância e distribuição espacial, a fim de averiguar a forma como os sistemas de pastoreio dependem de seus padrões, no caso particular, o comportamento dos rebanhos de ovinos e caprinos.

Nesta investigação recorre-se à análise de informação geográfica para comparar o território atravessado por rebanhos com a composição da matriz agrícola em termos da configuração das suas estruturas lenhosas. A interpretação dos resultados obtidos sugere que a sua ocorrência influencia os circuitos de pastoreio, identificando as estruturas que podem condicionar os percursos dos rebanhos de ovelhas e cabras. Em conclusão, a função destas estruturas lenhosas na sustentação dos sistemas silvopastoris tradicionais em Trás-os-Montes é suficientemente forte para justificar uma gestão activa na conservação dessas paisagens.

Palavras-chave : estrutura arborea, Sistema de Posicionamento Global, pequenos ruminantes, gestão do rebanho, comportamento em pastoreio.

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1. Introduction

The “Terra Fria” (cold land) refers to a particular landscape of north–eastern Portugal, sharing common traits with the traditional landscapes of the north–western Iberian Peninsula. Despite the agriculture preponderance that fragments the region into multiple agriculture matrixes, the diversity of woody features within the Terra Fria consists into a pervasive element of the landscape (Castro, 2004). The tree has been "domesticated" by man: selected, cultivated, cut, pruned, exploited and valued for the resources it provided, resulting in diversity of configuration among the territory. The tree network remains nowadays the witness of ancestral practices of the region, but it also becomes the object of new uses for products and various functions. They are represented as isolated trees in meadows, planted in alignment along the roads, located along the river or limit plots in hedges, or aggregated in patches within the agrarian matrix. In most cases, the woody features was kept deliberately, planted and maintained to ensure one or more functions, one or more uses.

The man influence translated into traditional use and functions towards the tree network has been a vital factor in the network dynamics. The herd management being a component of the traditional use has resulted in a close relationship within this dynamic. Therefore, preserving the local breeds and the livestock practice in the region is slightly linked to the conservation of the WF component of the landscape.

The extensive livestock system is an ancient activity based on the interaction between men, herd and territory. This interaction between the shepherd, the animals, the landscape, and the existence of different management objectives, results in high levels of complexity of this system (Balent and Landais, 1995). In Northeastern Portugal, the small ruminant production systems are mainly based on the extensive exploitation of the spontaneous vegetation. The local breeds of the region have been adapted to the historical practice of this extensive exploitation. The shepherds direct their flocks on grazing itineraries across different land cover patches (Barbosa and Portela 2000; Castro et al. 2010). As in the so–called “Alpine systems”, the small ruminants browses on common land during a part of the year, or goes to the commons on a daily basis (Moreira, 2010). They use a set of itineraries that change depending on the geography, the season, the weather and a set of other variables, tracking the variation of feed resources in time and space.

The animal behavior has been defined as any organism's attitude that involves action and response to stimulation. The response of an individual, group or species to a whole variety of factors constituting its environment induces the behavior (Anderson and Estell, 2009). For an experienced shepherd, the animal behavior is partially predictable (Savini et al, 1995), the uncertain part of these behavior remains to the weather variation. In the so-called silvopastoral system, the herds and the shepherd are the only features able to move and browse the components of this system. It is largely recognized that the mobility and the seasonal migration of pastoral flocks have to be sustained to maintain and improve the efficiency of the livestock within these systems (Niamir–Fuller, 1999). Therefore, the interaction between the ruminant behavior and the shepherd – combined into a set of tracks – is a primordial attribute to be investigated. Thus, to understand how the use of the territory operates.

1.1. Problem

The Mediterranean European silvopastoral landscape has four major components: Tree, Pastures, Animal and Man. This study stands for the importance of woody features (WF) within the landscape by investigating into the extensive livestock practice, a representative activity of the silvopastoral system. This daily practice – resulting from the interaction of animal and man– generates its own landscape represented by the grazing itineraries areas. The previous empirical observation suggests that the WF network strongly affects the decision of shepherd and animals browsing their itineraries throughout the mountain system. On the other hand, our interest converged into the capacity of spatial data on describing behaviors, structures and tracks. Thus, this research deals with the sheep and goat behavior and the spatiality of the tracks in order to analyze the issue. Starting from basic information as location and time, the coincidence of sheep and goats' flocks and the WF network are investigated in order to understand how important it is to preserve and to promote the functions of the rural landscape.

1.2. Objectives

This investigation aims to study the WF properties that influence the grazing journey, clarifying how the itineraries are delineated throughout the space considering two perspectives: the landscape and the herd behavior.

Browsing the landscape, the extensive livestock system looks over different architectures of lands. The animal behavior isn't the only factor conditioning the use of the landscape; a shepherd leading the herds takes part on how the mountain is managed. The interaction of these two actors results in the grazing track, a strategical daily decision adapted to the animal behavior and the environment conditions. The approaches attempt to clarify the interaction looking throughout different entities that may contribute into shaping the circuit from a landscape point of view.

The specific objectives:

- Identify the importance of WF on influencing the grazing itineraries of sheep and goat in Trás-os-Montes.
- Recognize the importance of WF on defining the grazing area.
- Identify the affinity between speeds and ruminant behavior
- Determine the relationship between the WF structures and the ruminant behavior.

2. Related works: The animal behavior and the woody features

The pastoral systems are systems using pasture areas and require the livestock practice (Savini et al., 1995). These systems are extremely diversified in close relationship on the diversity and the heterogeneity of the landscape exploited (Pastures, Meadows, Forestlands, Crop lands...). It is common to a pastoral landscape counting – in variable proportion – the agriculture matrix surrounding the villages. Beaufoy et al (1994) used the term of “low-intensity farming systems” referring to these systems with a low amount of external inputs as fertilizers and agrochemicals, distinguishing them from the intensive ones. The term “extensive farming” has been used in a similar sense, applied precisely to a particular type of low-intensity farming which, in addition to a poor use of external inputs, suggests the exploitation of the landscape at a large scale.

In order to achieve a range of socio-economic goals, the large use of the territory falls within the enhancement and the development of agronomical practice relying on a strong adaptation to the environment conditions. Lecrivain et al (1995) mentioned the livestock as an important feature of the pastoral landscape. At the opposite of the reliefs and the type covers, it is the only feature able to move and browse the landscape; letting the extensive livestock practice a good example of the use of the landscape at a large scale.

The extensive livestock practice remains a system relatively referring to small ruminants' herds – commonly sheep and goat – performing migration patterns; depending on the distance of this pattern, Moreira (2010) denominated two practices: “Transhumance” performing long migration and “Transtermitance”: short migration pattern between private land and the common of free access areas (usually mountain areas) with relatively intensive livestock breeding. In the both practices, the livestock needs the presence of shepherd to lead the migration. In order to understand the exploitation of the territory, “The Landscape” and “Shepherd Livestock Interaction” comprise the principal originality of the pastoral system (Savini et al, 1995).

2.1. Organization of the grazing circuits

2.1.1. Basic concepts

The extensive livestock system deal with what Landais (1991) called “La configuration de l’alpage” roughly translated by the mountain configuration: defined as the organization and the management process of putting a herd in altitude pasture. This system is characterized by a spatial and temporal diversity of use, conditioned by the availability and the heterogeneity of the fodder resources (Balent, 1987). Three basic concepts have been studied by Savini et al (1995) in order to answer to the exploitation of mountain system: Sector, Section and the grazing circuit.

2.1.1.1. *The Sector*

The sector is a subdivision of the pastoral territory, fenced by the spatial behavior of the herds and their grazing attitude due to a physic unit characterizing the sector. The fragmentation of the landscape into sectors is distinguished in term of accessibility, vegetation, area and intern heterogeneity. The limitation of the sectors is based on the geomorphologic characteristic of the mountain, naturally by rivers, gulches, physic obstacles and land covers. The shift during one sector to another is followed by the adoption of a behavior change by the herds. Nevertheless, the sectors are used individually from the other ones, which means that the flocks cannot “be” and “use” more than one sector at the time.

2.1.1.2. *The Section*

The section is a calendar of the mountain use. According to the authors, it represents a group of sectors grazed at the days of summer. The precocity of the grass growth explains this functional division which determine the season when the grazing on land is available. By the practice of the extensive live stock system during years and decades, the sections of the landscape are known by the local shepherds and can be changed, adapted or conditioned to the pastoral planning entities (Sheds, water point, parks, pathways...). The number of section can't exceed the number of seasons. Therefore, two, three, or four sections can be distinguished on the mountain. The main sections are retained according to the snow thaw, an indicator of the fodder availability:

- The Spring section: the lowest part of the mountain, where the snow thaw the soonest

- The Summer section: the higher part of the mountain, where the snow thaw the last

More sections can be distinguished depending on the calendar of the fodder availability and precocity. Some of them as the autumn section can designate a strategical section for the reuse of the vegetation.

2.1.1.3. *The grazing circuit*

The grazing circuit is the itinerary shaped by the flocks led by the shepherd among the landscape during a day period. The herd browses different landcovers corresponding to different sectors and sections. According to the authors, a landscape exploited by the extensive livestock system can hold from ten till fifteen itineraries; depending on the configuration and the environment condition of the landscape. Obviously, the grazing circuit doesn't change daily. It is based on the seasons, the availability of the fodder and other parameters that the shepherd pictures strategically into the circuits; in order to get the optimum use of the land while managing the animal behavior. When the herds visit the same sectors several times, the variation of the behavior starts to be noticeable from a day to another. However, the grazing circuit is characterized by a seasonal and annual rigidity on its design; the tracks rarely change along the years.

2.1.2. The grazing behavior

2.1.2.1. *The shapes of the flock*

Lecrivain et al, (1995) characterized the different shapes that the herd can adapt during the daily grazing. Many authors tried to explain how the shapes of the animals appear during grazing, concluding that the pattern depends on many factors. The shapes result from the distribution, the dispersion and the cohesion of the herd. The cohesion of the entire herd leans on: the density of the vegetation cover (Leclerc et Lécivain, 1979); the usual driving mode and the number of livestock groups comprising the herds (Favres, 1979). The dispersion is more related to age classes that the herd contains, its social composition and its sanitary conditions (Squires, 1975; Favre, 1979), plus the number of animals constituting the flock (Landais E. et al, 1989). In addition to the relief – And precisely slopes – influencing the distribution (Ganskopp and Vavra 1987).

Lecrivain et al, (1995) agreed on the following shapes. The authors distinguish between “persistent” forms and “transition” ones. The persistent forms are characterized by a slow

dynamic in time; they can last for several minutes due to its stability. At the opposite of the transition one, induced by a sudden change of activity. The fact that the transition forms last for few minutes or less, results on its high dynamic. Only the persistent forms are described for the purpose of this work:

According to the author, three structures emanate from the persistent forms: Shifting, Grazing and Rest form.

▪ **The shapes of shifting:**

- Prolonged form with lanes: All the animals mold a stringy lane following each other. The shape appears during a high speed shifting without a grazing activity obliging the animals to move without lowering the head to graze.

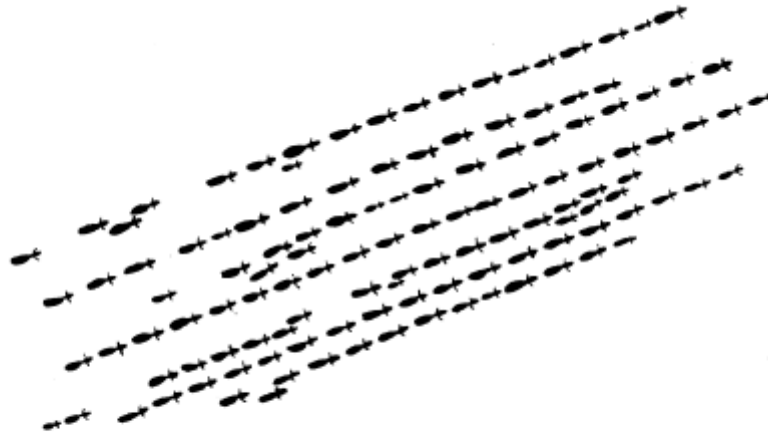


Figure 1.1 Herd during shift : The animal follows each other in lanes without lowering the head to graze (Drawing of André Leroy, in Landais and Deffontaine, 1988)

- Ovoid form without lanes: The form emerges when both activities of shifting and grazing alternate inducing the animals to lower their head to graze. The speed during this form decrease but the shifting remains the main motion letting the animals more outspread, and breaking the lane shape.

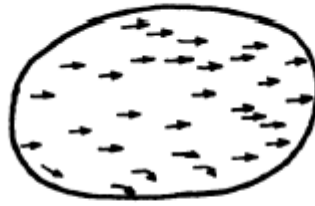


Figure 1.2 Ovoid form without lanes, unidirectional shift with lower speed inducing the break of the lanes (E. Lécivain et al., 1995)

▪ **The shapes of grazing:**

- Forehead mobile form: Opposed to the Ovoid form without lanes, the main activity is grazing, with a low speed of shifting. The animals shape a grazing front where they browse the vegetation cover in line. This movement is similar to a translation: the forehead animals graze linearly without a specific selectivity of the vegetation; described as a mower by Lecler and Lécivain (1979). The animal in the center and the rear have a more scattered dispersion than the forehead, alternating shifting and grazing, their movement are less rectilinear considering their selectivity of the vegetation cover. This particular form is differentiated by its hierarchical structure: Quick selectivity at the front, slow one at back. Nevertheless, the flock keeps its principal direction despite the different animal behaviors noticed within the same herd.

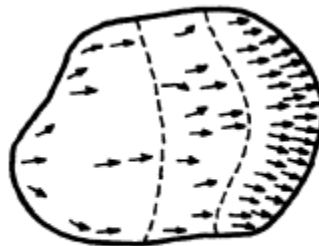


Figure 1.3 Forehead mobile form, the hierarchical structure of the "mower shift" (E. Lécivain et al., 1995)

- Circular standstill form: This stationary shape appear when the grazing activity is the most intense. The flock displays an immobile structure, exception made for individual small shifting. The animals shape a spread circular silhouette where they adopt different standing direction, without getting far from the herd.

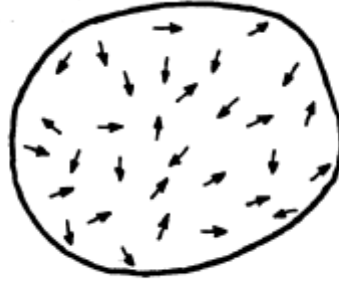


Figure 1.4 Circular standstill form, the spread multidirectional structure (E. Lécivain et al., 1995)

▪ **The shape of rest**

Considering the diurnal resting, this form is commonly appears in an aggregated form. After the grazing and leveying the main part of their diet, the major part of the herd gathers in multiple small clusters which will merge step by step for the resting purpose.



Figure 1.5 Diurnal rest form: Aggregated resting shape (E. Lécivain et al. 1995)

2.1.2.2. The dynamic of the herd during the journey

The shapes described in the previous paragraph answer to the different behavior periods that the flocks adapt during their daily itinerary. Animal activities (grazing, resting and walking) are affected by landscape attributes (Ganskopp and Bohnert 2009). However, the proportion of time spent dedicated to the shifting across land covers isn't related to the animal behavior (Barbossa, Portela 2000). The principle food intake period is splitted between multiple episodes of uneven importance, according to Dudzinski et al. (1978), episodes segregated by shifting reducing the appetite. The types of activity that define behavioral episodes are directly affected at the herd level. Savini et al (1995) retained the following behaviors that define the rhythm of the herd activity:

- The pure shifting : When the flocks register the highest speed of browsing, no grazing is considered

- The Shift – Grazing: Intense shifting but influenced by small “munching” activity
- The Grazing–Shift: The episode where the grazing takes over the shifting, activity favored by the shepherd reducing the movement speed of the animals
- The Stagnant Grazing: a pure grazing activity where the animals are immobile and oriented in all directions. Small individual shift may be noticed. This period correspond to the main food intake by the herds
- The Rumination rest: diurnal and nocturnal.

2.2. The circuit: GPS tracking process

For more than 22 years, domesticated animals studies and precisely extensive livestock systems has been the subject of little high–resolution data collect using spatial analysis (Buerkert, 2009). In all animal ecology fields, researchers attempt to understand the interaction applied between the animals and their environment (Homburger et al, 2014). An environment characterized by seasonal variation, specifically in pastoral drylands systems. The key approach that many researches adopted in order to face the environmental variation falls within “the mobility” of the flocks (Adriansen, 2008). As mentioned before, the animal are the only feature of the silvopastoral system which is identified by its motion through the landscape. As a result of the spatial and the temporal availability of the pastoral resources, shepherds have developed herding strategies for the safeguard of the livelihood, strategies that has been mentally modeled and established into one motional feature of the landscape: The grazing itinerary (Vetter, 2005).

To be able to understand the spatial distribution pattern of the circuit in term of temporal basis, researches from different field converge to GPS tracking adopting several perspectives: Performance of GPS collar to monitor grazing itineraries (Buerkert and Schlecht, 2009); Determination of behavioral states of grazing livestock from high–frequency position data alone (Homburger et al, 2014); Evaluation of spatio–temporal differences in grazing patterns and land use preferences of livestock through GPS trajectories analysis (Schlecht, 2006; Feldt & Schlecht, 2016). These kinds of studies suggest three major steps for their achievement: Data collection, GPS data analysis and statistical analysis.

2.2.1. Data collection

The grazing behavior and resting time of domestic grazers are the major features taken in account to study the efficient resource use, productivity, and impacts on ecosystem functioning (Milchunas and Lauenroth, 1993). However, essential difficulties are held during the data collection about animal behavior: Bad weather condition or nighttime constitute constraint to this purpose, even more when the study requires a continuous observation over space and time; in addition to the alteration of the animal behavior due to human presence (Homburger et al, 2014). According to the objectives of each research, several studies apprehend the spatial behavior resulting on multiple methods for the purpose of the data collection. The methods depended on the time accorded for the collection, the type of the GPS tracking and obviously the objective of the research.

The study carried out by Schlecht et al. (2009) on the grazing itineraries and forage selection of goats in the Al Jabal al Akhdar Mountain (Oman) attempted to delight the seasonal variation of the grazing circuits. Thus, two period of the year were considered: February–April and November–December 2005. Before the onset of the study, the GPS collar was tested on individual goats in order to check if the grazing behavior is affected. Thenceforth, the goats' herds were set out for pasture with a lightweight GPS collar fixed around the neck of one animal and was switched on to record the goats' position every 5–30 seconds.

The periods dedicated for the data collection are mainly conditioned by the feature studied. The periods in which the performance of the GPS collar are tested last for a range of months: 10 days during February and March of 2008 (Trotter, 2009), October to March (Buerkert and Schlecht, 2009). At the opposite of investigations converging on the grazing circuits where the periods were extended following different data collect approaches: three consecutive days every 5–6 weeks throughout January–December 1998 (Schlecht, 2006); three consecutive days at bi-monthly intervals between November 2011 and November 2013 in which more flocks and villages were considered (Feldt and Schlecht, 2016); and throughout a sampled year recording the tracks each time they are changed (Castro et al., 2010).

The GPS collar in the studies mentioned before are equipped directly on the animals. From other perspectives, as a reason for not disturbing the animal behavior, the tracking methods suggested that the GPS collar is held by an observer. The observer follows the herd at a distance ensuring that the animals behave undisturbed (Castro et al, 2004). The same instruction is imposed for the visual observation which is mainly combined with the GPS

tracking. The observer monitors the flocks activities each range of minutes and describes a range of behaviors as walking, grazing and resting.

2.2.2. Collection of spatial data and analysis

The study of behavioral episodes is a challenging subject considering the movement as a slow and complex pattern. For sheep and goats, the behavioral activities are characterized by frequent changes within a small space, making their identification difficult (Ungar et al,2005). The exactitude of behavioral classification depends on range of factors: The performance of the remote tracking device and its precision (Patterson et al, 2010); the interval period considered during data monitoring between two successive GPS measurements on the field (Postlethwaite & Dennis, 2013); The variation of behavioral activities within individuals of the flock (Case when the constitution of the flock carries more than one specie) (Bailey et al, 2006); and the statistical approach used for the classification of the behavioral activities (Schlecht et al, 2004). Nevertheless, many studies have presented approaches to these classifications of grazing livestock activities basing on GPS data. Only the approaches related to the purpose of our study are mentioned in the following paragraph.

“The speed” is the main function considered by the authors to clarify the flock behavior (Schlecht et al, 2006; Castro et al, 2004; Homburer, 2014). “The speed” considered does not refer to the actual speed of the flocks. It is a parameter referring to the proportion of time spent during the interval of two successive GPS sampling which can include a certain behaviors during the shift. The authors calculate it through dividing the distance covered by the duration elapsed between two successive position loggings using different equations depending on the projected coordinate system used on the study location. The simplest form of the equation consist into calculating the distance from a meters coordinate system: $D = ((x_1 - x_2)^2 + (y_1 - y_2)^2)^{1/2}$ (Schlecht et al., 2006). The profile of the daily activities of the herds were computed by Schlecht et al. (2009) based on the speed of movement during 1-min intervals (Shift average); taken as an indicator of the animals' behavior at the pasture. The following categorization was suggested: Speed movements at $v < 0.2\text{m/s}$ were allocated as resting or stagnant grazing on the spot. Speed movements at $0.2 < v < 0.7\text{ m/s}$ were classified as the continuum of short term-grazing and subsequent shifts to a nearby feeding station influenced by grazing or munching, while speeds at $v > 0.7\text{ m/s}$ were interpreted as directional walking uninterrupted by feeding.

In order to realize further spatial data collection, other approaches were taken in consideration applying geospatial processing programs as ArcGis Software Package (ESRI Corp, Redlands, CA, USA). Using the GPS data, the investigations attempt to achieve a delimitation of the grazing areas through buffers created around the grazing itineraries. The accuracy of the buffers was arbitrary suggested by the authors. Schlecht et al. (2009) created buffers of 15 meters width to the both sides of individual tracks on each itinerary, all buffers were then merged and the external borderline of the merged tracks was proposed to delimit the grazing area of the flocks. On another investigation of the same author (Schlecht, 2006) buffers width were calculated by a radius equal to the actual itinerary length divided by π . A theoretical grazing area was also proposed by Samuels et al, (2007) considering width of 50 meters, used also by Schlecht et al. (2009).

Beyond the buffers, the Near Analysis tool was coupled to the grazing tracks in order to determine the nearest feature to the circuit. As an example, this geoprocessing tool has been applied to calculate the distance between the itineraries and water points to depict seasonal variation in water availability (Feldt & Schlecht, 2016). Castro et al. (2010) applied the same function to determine the landcovers crossed by the animals; and combined with the speeds, shows the preference index values for four principal activities and the principal landcovers.

2.2.3. Statistical analysis:

Each itineraries sampled were considered as an independent observation crossed by a range of variables. Statistical analyses are meant to determine the effect of site, season, species, itinerary characteristics (as the itinerary length and the maximum distance browsed), daily time on pasture, and activity patterns (Feldt & Schlecht, 2016). According to the study carried, statistical analyses were suggested as approaches.

The analysis of variance was tested for example on the effects of location (particularly, the grazing pressure) on herbaceous mass (Schlecht et al., 2009). Data residuals of individual tracks of goats and sheep were realized for checking the normal distribution, and then tested for an independent t-test and one-way ANOVA with Tukey post hoc test for normal distribution data sets – when two or more independent variables were crossed (Feldt & E. Schlecht, 2016). Multivariate analysis of variance (Proc GLM) was carried out to determine the effect of grazers species (cattle, goats, sheep) and seasons on different dependent variables; then for the comparison of means, the Student–Newman–Keuls multiple range test was applied in order to determine the correlation between the variables' level.

2.3. The woody features of the agrarian matrix:

Nowadays, Agroforestry systems contain pasture, livestock and trees: fruit or nut trees interplant with vegetable or grain crop; windbreaks and shelterbelts; multispecific riparian buffer strips; and forest farming systems for special crops (Long, 1999). The tree is constantly present in agrarian matrix with a great diversity of species, structures and uses (Pointereau, 2006). The woody features – referring to all ligneous vegetation from shrubs and trees – has been studied through different discipline perspectives, starting from arboriculture and forest farming as a production pattern till Silvopastoralism and Agroforestry as a components for management. In the Mediterranean silvopastoral systems, trees represent one of the major features among the pastures, human activities and livestock. The function, type and configuration of the woody features depend strongly on the diversity of the Mediterranean climate: Cold winters and drought summers (San Miguel–Ayanz, 2003). An unpredictable factor that the same discipline cited before develop practical approaches to clarify a sustainable way for facing this issue.

2.3.1. Woody feature structures

In the FAO report dedicated to the tree outside forests (FAO, 2004), the difficulties in defining traditional models of tree network of the cultural landscape are highlighted. However, no real typology of tree structures is proposed. The diversity of landscape forms, uses and trees management methods largely explain this lack of universal typology. Considering their spatial organization, many authors as Guillerme et al (2009), Castro (2004) and Pointereau et al. (2002) organize the arrangement of the tree network based on the dimension of the canopy connectivity. The connection of the trees' crown in the agrarian matrix results in the following forms: linear forms (one–dimensional connectivity), polygonal (bidimensional connectivity) and punctual forms (no canopy connection). This structural typology is very usual in analyzes of the landscape for its importance on the agrarian matrices. Castro (2004) pointed their utility as environmental indicators for: ecological stability; information value about old productive agricultural processes and current ecological processes; and ecological contrast and ecotones which can promote wildlife richness in humanized ecosystems.

2.3.1.1. *The Punctual structure: Scatter trees*

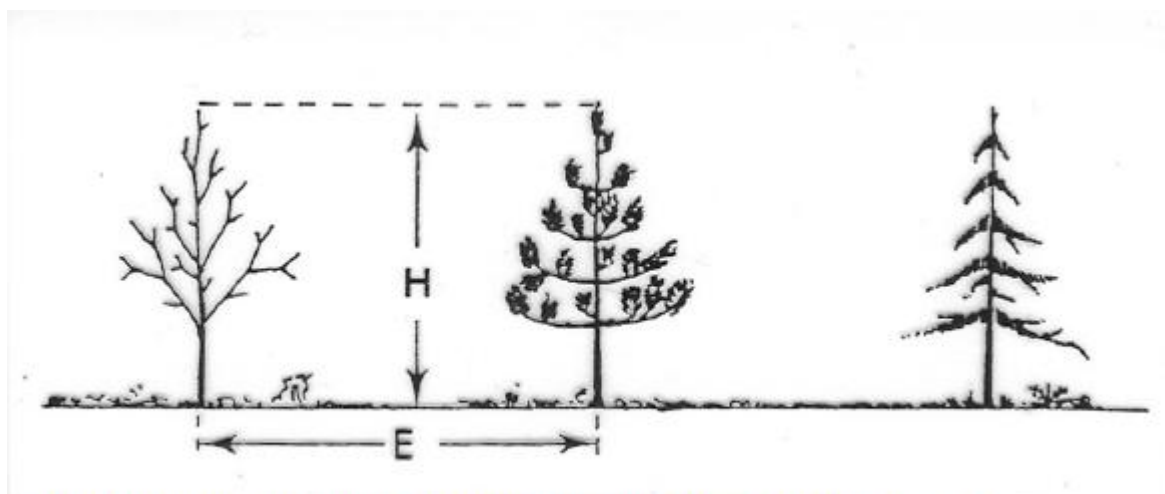


Figure 1.6 Characterization parameters for isolated trees (M. Hubert & R. Courraud, 1994).

According to the definition given by Hubert and Courraud (1994), a single tree – commonly called scatter or isolated tree – is a tree scattered from other ligneous vegetation by a distance E superior at its height H (Figure 1.6). The single trees are punctual elements that may have many various significations. They remain the source of the landscape diversity (Castro, 2004). Isolated trees usually occur in orchards and pastures, and more sparsely in the shrub pastures and dry land; their frequency depends on the circumstances of the farm to which it belongs. They stand for a productive complementary role of the plot where they are located, with function of livening up the atmosphere of the site (Castro, 2004).

In silvo–agro–pastoral systems, their function concern mainly the influence of the microclimate under the sub canopy by providing shades to the cultures impacting the soil temperature around (Dancette & Poulain, 1969). The effects of single tree consist into a greater biomass production, which beyond the supply of organic material, induced by the reduction of evapotranspiration and the enhancement of the relative humidity (Amundson et al., 1995). Experiments carried out in Australia by Wilson et al. (1986), showed that a light reduction of 37% increased twice the grass production and the nitrogen intake below the crown zone.

2.3.1.2. *The linear shapes: Hedgerows*

Since nature rarely designs perfect geometrical forms, the linear woody structures are mainly man–made. These structures refers to many structural approach: Road verges (Cousins & Erikson 2002), Tree row (Antrop 1998), Verges (Hinsley & Bellamy 2000), Riparian buffer

strips (Long 1999) Fencerows (Demers et al. 1995) and Hedgerows network (Schmucki et al. 2002). The main linear forms within the tree network are Hedgerows, fences and riparian buffer strips (Guillerme et al, 2009). According to the definition given by the Northern Ireland Environment Agency (NIEA, 2015) a hedgerow is defined as “any boundary line of trees or shrubs over 20m long and less than 5m wide, and where any gaps between the trees or shrub species are less than 20m wide”. Once used to limit parcels in the agrarian matrix and to provide wood fuel (Liagre, 2006), their importance nowadays doesn't converge on their boundaries or fences' functions, they have been the purpose of researches on different perspective from several fields.

Considering an agroforestry approach, these structures play a role on modifying the micro climate inside the agricultural fields mainly by their function of windbreaks and their benefits regarding the erosion protection and runoff control (Earnshaw, 2004). From a nature conservation perspective, they constitute habitat and food source for many different species: Invertebrates, mammals and birds, some of high conservation status (Brown & Fisher , 2014) enhancing the connectivity between different habitat – concept from Landscape Ecology – by forming ecological corridors for wildlife and also vegetation within the agrarian matrix (Liguare, 2006). Nevertheless, managing livestock systems is slightly linked to those ecosystem services. Following Van Der Horst et al. (2014), the linear woody structures represent a provision for fodder and fences to keep animals away from agricultural corps. Daget & Poissonet (2010) reported that as well for isolated trees, the presence of hedgerows increase the livestock performance by providing to the animals a level of comfort through affording shelter from strong winds or shadows during the warm hours of the grazing journey. However, a formation of trampled non-productive rest areas is noticed when the same structures are reused.

The cultural significance of hedgerows has been widely recognized (Oreszcyn and Lane 2000). Thus, the recognition of their importance isn't just about biodiversity (Environmental Resource Management, 1999), they are listed as a key indicator of the landscape character areas.

2.3.1.3. *The Polygonal: Woods*

The practice of grazing inside woods is ancient issue (Brun et al., 2003). In the Mediterranean region, the woods are characterized of being the fields where the Silvopastoralism recognize

its first steps (Legéard et al, 1997). In order to apprehend the concept of polygonal woodlots, the FAO (FRA, 2010) conceptualizes two notions referring to this woody structure: “The Forest” and “Other wooded lands”. According to the description given : *the forest is a land whose area is greater than 0.5 hectares, with trees’ height greater than 5 meters and a canopy cover of more than 10%, or trees able to reach these thresholds in situ*. While the Other Wooded lands are considered as *lands not within the "forest" category, spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of 5–10%, or trees able to reach these thresholds in situ, or a mixed shrub cover, shrubs and trees greater than 10%*. However, these technical definitions do not comprise the concept of woodlots’ structure.

During the last decades, the introduction of the livestock inside woods represented the creed of the modern silviculture – due to economic and social reasons linked to the environment – grazing into forest became a exploitable research area leading to several reflections about wildfire protection and sustainability of the forest (Simiane, 1987). Studies have shown that the introduction of animals and particularly small ruminants isn’t limited to the grazing purpose. An example of a research carried out by Etienne et al. (1985) equilibrates forestry and pastoral objectives. The investigation had for goal the exploitation of the woods by goats for pastoral objectives while the grazing contributes to the establishment of firebreaks by the flocks. Nevertheless, other studies proved the concern of woods into the grazing systems depending on the breeds and the kind of exploitation. Farrie (1979) investigated the contribution of the forest resources into the livestock practice, resulting – as a demonstration – that the woodlots supply 63% of grazing resources against 23% of pasture for milk production sheep’ flocks in the Landes forest region located on south–west of France.

2.3.2. The woody landscape on animal behavior

Beyond the ecological value of the woody features: specific effect of scattered trees in Mediterranean silvopastoral systems on reduction of climatic stress and improvement of soil moisture levels (Joffre et al. 1991, 1999); conservation, maintenance and protection of water and soil (Nair, 1984); The woody features tend to influence on the animal behavior. Browsing the daily itinerary, the flocks can use the woods for different purposes. Castro (2010) reported that the woods area could have other functions than grazing and browsing; activities as resting and sheltering were recorded within this type of lands.

During the study of Schlecht et al. (2009) on the mountainous region of Jabal Al Akhdar (Oman), The proportion of grazing time spend in spring period was 70% on the tree–shrubs

layer for goats against 39% in Autumn, explained by the fodder availability (Flower and Leaves) afforded by *Euphorbia Larica* and *Pteropyrum scoparim* during spring on the slopes surrounding Masayrat. Gordon and Iason (1989) pointed the difference of diet selection between small ruminants: sheeps and goats. Castro et al. (2004) agreed on the same result while investigating the use of black oak woods by the small ruminants in the northeast of Portugal where the flocks adopt different behavior toward the black oak: a low feeding intake was noticed for the sheep while the resting activity was more correlated to the woodlots area, in contrast with goats in which black oak forage compose almost the quarter (22.5%) of their food consumption during summer period.

Regarding the use of tree leaves as fodder, the exploitation of “Fodder trees” has been considered as an old tradition by Ramana et al. (2000), a tradition that yet is rarely used in modern agronomy in developed countries. This traditional practice proves its importance on animal nutrition in extreme and unstable climatic regions, an example mentioned by M. Mulas and G. Mulas (2004) for the use of *Atriplex* and *Optunia*. These fodder shrubs were introduced both in many region of north Africa and west Asia with the goal of closing the nutrition gap of livestock and improve the protein content of the diet; in addition to their great adaptation to saline soils and their high efficiency in the use of water. Araba et al. (2009) determinate the nutrition value of the *Optunia* rackets as “maintenance fodder” during the dry period, affording to the ruminants energy and water. Moreover, the small grazing animals as sheep are able to survive using the *Optunia* rackets without drinking water for 525 days (Araba et al, 2009). Other specific studies have demonstrated the great ability of the *Atriplex* to absorb nitrogen from the substrate and to partially benefit the action of nitrogen fixing organisms (Ismaili et al., 2000).

3. Materials and methods

3.1. Framework

The first approach based on the seasonal variability relies on the comparison of the woody structures' "concentrations" inside and outside the land used. The first constraint faced consists into defining the area of the exploited surface. Therefore, the approach used the seasonal variability and the amount of the woody structure of each itinerary to determine an approximation of the buffering distance to delimit the grazed surface; at the same time, the importance of the structure according to the seasons.

The second approach tends to apprehend more a physiognomy of the itineraries from a day period. We suggested a range of variables that may influence the daily tracks. Some of those variables act as behavioral indicators of the flocks while the other has been proposed for being landscape factors. The variables were tested and collected in order to build a second data set for statistical analysis.

3.2. Study areas

The experiment was conducted in the region of Trás-os-Montes– Northeast of Portugal, in the two rural districts – freguesias – of Bragança municipality (41°46'N latitude and 6°45'W longitude): Rebordãos (200 inhabitants, 1105 ha) and Freixedelo (221 inhabitants, 1134 ha). They are two mountainous areas registering an altitude going from 500 to 1000 meters above sea level.

“Nove meses de inverno, três meses do inferno”, this local dictum tells a lot about the humid Mediterranean climate imposed to the region. Roughly translated as “Nine month of winter, three months of hell”, it refers to cold winters and dry summers; a characteristic of the Mediterranean climate (San Miguel–Ayanz, 2004). The average temperature during the year record 11.6°C and a precipitation of 972.1 mm, which mainly arise from October until May (INMG 1991). The dominant soils are umbric leptosols and dystric leptosols, depending on the land use.

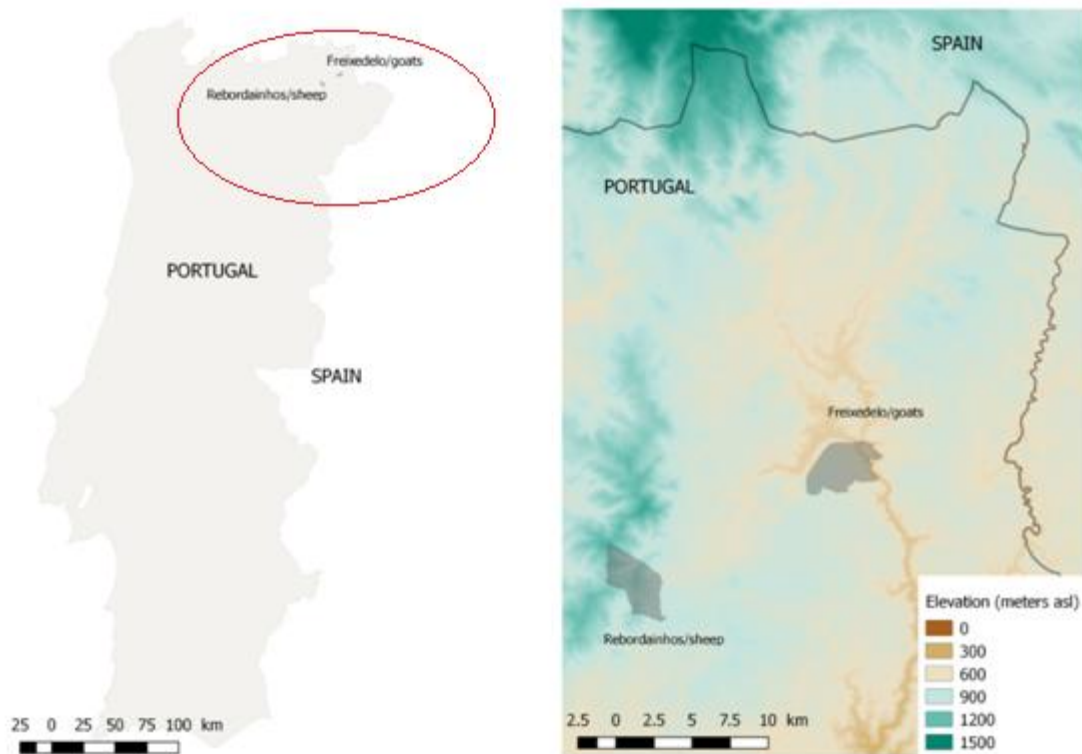


Figure 2.1 Location of the study area: Rebordainhos (Sheep) and Freixedelo (Goats) - Portugal.

Two flocks – one of sheep (Rebordainhos) and one of goats (Freixedelo) – were monitored each month from May 1999 to May 2000 resulting on 13 tracks of grazing for each species/village, 26 tracks in total (Castro, 2004). Both of the flocks are raised for meat production, with the local breeds “Serrana” for goat and “Mondegueira” for sheep. The size of the herds varied along the experiment ranging from 100 to 200 individual each, depending on business opportunities. The animals were monitored during their journey outside sheepfold, being followed by an observer carrying a GPS (Global Position System) to get the geographical position and type of land use. The GPS was set to record the geographical position each minute, as well as the date, time and altitude.

The circuits were sampled every time the grazing tracks changed according to the season and weather. Tracks can stay unchanged for more than one month or less, resulting sometimes on more than one different circuit per month. The time spent for the journey varies between 6 and 16 hours depending on the animal species, weather and season.

The woody features (WF) – punctual, linear or polygonal – were monitored from aerial orthophotos (2000) using the Esri's ArcGIS software; then, geoprocessed in shapefiles. The structures have been distinguished on their canopy connectivity. The WF are discerned as

hedgerows when the trees presents a one–dimensional connectivity of the crown (Alignment of trees). In the case of a bidimensional connectivity, the aggregated trees are allocated to woodlots. The scatter trees are characterized when the crown presents no connection.

3.3. Methods

3.3.1. Woody features density

3.3.1.1. *Geoprocessing*

The geoprocessing software ArcMap 10.1 is retained for our investigation. As it is known as a geospatial processing programs, ArcMap is primarily made for creating and modifying set of data into the form of geographical information organized into layers. The software allows the user to explore data and carry out a wide range of GIS tasks (ArcGis 10.1, 2015). For the purpose of this study, the software is used for data analysis and collection on the study area. The manipulation of data was applied on the WF structure and the tracks. In order to process to more specify data analysis, three major geoprocessing tools were used: buffer, intersect and near geoprocessing tool.

The buffer is geoprocessing tool of the proximity analysis, allows the creation of polygons around the input features with a specific distance, the input feature can be punctual, linear or polygons. The polygons layer created by the buffer is circular arc segments, exception made for the punctual features where the outputs are circular arcs. The use of the *dissolve type* in the geoprocessing tool has been used in this study to avoid overlapping polygons, dissolving the overlapped ones into a single feature.

The buffer module has been applied to the grazing circuits of goats and sheep considering each recorded location as a punctual feature of each itinerary studied; the output consists in a polygon layer representing the exploited surface of the landscape for each track. We studied five buffer distances – 10 m, 20 m, 50 m, 100 m and 200 m – to recognize the WF that have been potentially used by the herds. The buffer distances had been suggested empirically by the observation of the area exploited by the goats and sheep flocks. This approach is an attempt to define simultaneously an optimal buffer distance to relate the exploited area by the sheep and goats' herds and the WF network, in recognizing the importance of WF structures on the daily itineraries.

The intersect module is an overlay analysis tool to perform geometric intersections of shapefiles. The intersection performed results in a combination of shapefiles of different geometrical types, point, multipoint, lines or polygons. The output geometry is the same as the lowest dimension geometry of the input features types. On this study, it was performed an intersection of each track buffer and the WF – single trees, hedgerows and woodlots – to the two study areas.

The data set obtained display the WF variability exploited by the herds on the different tracks as well as how it changes considering different buffer distances. The outputs are points shapefiles for the single trees, linear shapefiles for hedgerows and polygonal shapefiles for woodlots. Each track buffer is described by the number of single trees, meters of hedgerows and hectares of woodlots. These quantities have been reported to the hectare unit using the area of each track buffer resulting in densities of trees per hectare, meters of hedgerows per hectare and covered surface (ha) of woods per hectare. These results has been compared and related to the level of trees, hedgerows and woods of the landscape of each study area. The data was organized by buffer distance, WF type and date.

3.3.1.2. Statistical analysis

Since the approach adopted wasn't applied by other authors before, a basic presentation of the data has been applied. The data collected on the woody features has been organized and represented in linear charts considering the amount of WF for the different buffer distances (y axis) according to the date/tracks (x axis) throughout the sampled year. The data was organized considering each track as a sample containing the three types of WF: trees, hedgerows and woodlots; on the five buffers suggested.

Ahead from the data exploration, the software SYSTAT 12 has been admitted to carry the statistical analysis on the data. In order to define the signification of the ranges and woody structures and interpret their variations explicitly, the study performed the factorial analysis as an ordination method. The factorial analysis is tested with Equamax option considering the amounts of WF by buffer distances as model variables. The rotation mode has been chosen for being a “weighted mixture” of Varimax and Quartimax and assumes that the factors in the analysis are uncorrelated (Gorsuch, 1983). The flock tracks – 13 for goats and 13 for sheep – were classified separately using the Hierarchical Cluster Analysis (HCA). This divisive method start with all of the flock tracks in one cluster and then proceeds to hierarchical splits

(partition), resulting into smaller clusters (SAS/STAT 9.2 Users Guide). The classification method is performed to analyze the differences between goats and sheep tracks on a WF basis, identifying categories of herd itineraries.

3.3.2. The flock behavior in function of the woody features

A second dataset was built containing a new set of variables for each flocks' tracking point: the type and the distance to the nearest WF, the flock headway speed of displacement, the positive and negative elevation gain, and the time accumulation. The near geoprocessing tool was used to determinate the type and the distance to the nearest WF of each flock tracking point.

3.3.2.1. *The Near function parameter*

As the name refers to, the Near geoprocessing tool determines the nearest feature with a distance calculation between the input and the features assigned in other layers. The grazing itineraries are spatiotemporal points on the landscape. They contain information on the time and location of the flocks during the journey. The near function being applied on this multipoint layers, display the spatial components influencing the circuit of the flocks. The closet woody feature was assigned to each point of the track, including the variable (NEAR_DIST) referring to the distance of the structure to the point.

3.3.2.2. *The speed classification*

The grazing itineraries are presented as spatiotemporal points (containing time and location informations) browsing the landscape displayed by the geospatial software. On previous studies realized on the same flocks, Castro (2004) used the proportion of time spent on each cover type. In order to analyze and compare the changes that occur in the grazing itinerary, this proportion was calculated by the quotient of time spent on each land cover and the total time spent on the circuit. The time allocated to roads was also considered.

The speeds occurred during the tracks acts as a behavioral indicator: The greater is the ruminant's preference to a land of quality food or WF, the slower is the grazing velocity (Senft et al. 1985). Thus, this parameter attends to describe the elements of the landscape that was taking in consideration to complete the journey: a feature isn't appreciated if high speeds are performed across frequently. The speeds were organized according to the type of the

woody structures crossed, using the Near geoprocessing tool to determine the features (Described in the following paragraphs).

- **Speeds estimation**

The velocity estimation was based on the calculation of distance considered between the successive points of each grazing itinerary and the proportion of time spent during the shift. The two parameters were registered by the GPS collar: the distance has been estimated by the longitude and altitude from the Lisboa Hayford Gauss IgeoE projected coordinate system; and the time spend during each shift of the successive point has been determined by the GPS hour at the moment when the points were recorded. Since the projected coordinate system is metric, the distances were calculated using the equation (1):

$$D = ((x_1 - x_2)^2 + (y_1 - y_2)^2)^{1/2} \quad (1)$$

Due to erroneous position registry by the collar, the speeds of flocks exceeding 3 m within 1 second were deleted from the data set. As Schlecht (2009) performed, this kind of data point may lead to faulty calculation.

- **The speed class orders**

The speeds were estimated during each step (point) of the grazing itineraries. As known and discussed by many authors: Lécivain et al (1995), Schlecht et al (2009), M. Castro and J. Castro (2004); the speeds are linked to the herd activities: High speeds are pure Shifting, low ones are related to grazing and zero speeds can be explained by pure grazing or resting.

The Natural breaks of Jenks is a data classification method based on a natural grouping of the data proposed. This classification method has been set to design the best cluster of values into different classes. An iterative process is required for this optimization method: Different calculations must be repeated using different breaks in the dataset to determine which set of breaks has the smallest in-class variance; the process is done by reducing each class's average deviation from the class' mean, while maximizing each class's deviation from the means of the other groups (Jenks, 1967). In other words, the purpose of the breaks is to get groups with the lowest intern variance while maximizing the extern variance between the groups.

The Natural breaks of Jenks has been applied to the speeds using the ArcMap 10.1 with the objective of obtaining a cluster of speed classes: On each village (or species), Jenks Natural

breaks were applied defining the limits of the speed groups. Three classifications were realized within the sampling year: Classification with one break, two breaks and three breaks; resulting respectively in 2, 3 and 4 speed classes. The limit of each group of breaks was registered. Each flocks' tracking points recorded throughout the itinerary were assigned to speed' classes for each of the classifications (see example below).

Table 2.1 Extract of the dataset for a goat flock itinerary (December, 20) with the classes of headway speed.

OBJECTID *	Date_GPS	Hour_GPS	Longitude_GP	Altitude_GPS	Speeds	Natural Breaks of JENKS		
						CLASS2	CLASS3	CLASS4
1	20/12/1999	10:35:14am	124527	816,044	0	1	1	1
2	20/12/1999	10:36:30am	124603	816,024	0,157203	1	1	1
3	20/12/1999	10:36:47am	124620	815,81	0,440777	1	2	2
4	20/12/1999	10:37:47am	124680	810,46	0,805964	2	3	4
5	20/12/1999	10:38:47am	124740	803,541	1,293178	2	3	4
6	20/12/1999	10:39:47am	124800	797,447	1,162881	2	3	4
7	20/12/1999	10:40:20am	124833	792,758	1,403669	2	3	4
8	20/12/1999	10:40:47am	124860	789,04	1,292976	2	3	4
9	20/12/1999	10:41:48am	124921	778,603	1,057504	2	3	4
10	20/12/1999	10:42:47am	124980	776,062	1,001724	2	3	4
11	20/12/1999	10:43:48am	125041	764,826	1,044571	2	3	4
12	20/12/1999	10:44:47am	125100	765,067	1,111874	2	3	4
13	20/12/1999	10:45:47am	125160	765,499	0,138215	1	1	1
14	20/12/1999	10:46:47am	125220	769,832	0,583596	2	2	3

3.3.2.3. Elevation gain and time accumulation parameters

Ganskopp and Vavra (1987) considered the degree of slopes as a factor influencing the animal behaviors in mountain grazing systems. Mostly used in cycling, hiking and mountaineering, the elevation gain refers to the sum of altitude change between tracking points. The parameter is calculated cumulatively whenever the altitude difference to the starting elevation is positive. The positive and negative elevation gain was calculated using the altitude registered by the GPS throughout the flocks' tracks. The study suggested that the two parameters are influencing the grazing itinerary due to the gravitational potential energy that conditions the strategy and the behavior of the grazing. Savini et al (1995) reported that the summits and the "high land" constrain a continuous attraction on the flocks, especially during the end of the journey. The fact is explained by the localization of land covers preferred by the animals, vegetation quality, and warm days where the flocks try to reach high lands looking for cool air.

The time parameter aims to highlight regularities throughout the journey of goats and sheep flocks. The time accumulation starting from the beginning of the journey, aims to describe the temporal variation on daily basis to the track; commonly the difference that can occur between the beginning and the end of the tracks. The hours recorded by the collar

(Hour_GPS) were transformed in second's unit using the equation (2) to obtain a single unit for the estimation of the parameter. The calculation was then conducted using the equation (3). Supposing that each track contains an N number of sampling points, the calculations were made by the following equations:

$$\text{Transformation: } X_t = \text{Hours (Hour_GPS (t))*3600} + \text{Minutes (Hour_GPS (t))*60} + \text{Seconds (Hour_GPS (t)); } t = \{0,1,2,3,\dots,n\} \quad (2)$$

$$\text{Time_Accumulation} = X_t - X_0 \quad ; t = \{0,1,2,3,\dots,n\} \quad (3)$$

t: Tracks' Point.

3.3.2.4. *Statistical analysis*

The Analysis of variance (ANOVA) was executed to test the significance variation between the features. The velocity is used as a dependent variable, crossed with the species and the woody structures as factors. Pairwise comparisons of means were carried out using the Tukey's Honestly-Significant-Difference and the Student-Newman-Keuls Test in order to determine an affinity between the woody structures factor.

The Correspondence Analysis (CA) has been applied to the woody features crossed independently to the categorical variables CLASS3 (2 Natural Breaks) and CLASS4 (3 Natural Breaks) referring to speeds classes obtained with the natural break of Jenks. The woody features were affected as independent variables. The study retained the two classifications for the similarities that the classes express with the speed classification proposed by the author Schlecht (2009).

All results were specified as least square (LS) mean \pm standard error and their significant level. The box plot is retained for depicting graphically the groups of numerical data. The CA results were indicated through the correspondence plot and the squared correlations with the factors. The factors are graphically exhibited on the correspondence plot using their respective axes: DIM(1) for Factor 1 and DIM(2) for Factor 2.

The woody feature was taken as a factor for the variance analysis. The distance to the nearest woody structure and the parameter "time accumulation" were tested separately as dependent variables. The results were processed first considering the both tracks species for the nearest distance, then independently. For the time accumulation, the variable was tested

independently on sheep and goats. The distances of woody structures exceeding 50 m were removed from the data set as a result of the conclusion made from the first results on buffers.

The Pearson correlation test has been applied crossing the positive and negative elevation gains in order to determine the relation between these two factors. The linear regression was conducted to specify the interaction. The elevations gains were then combined with the time accumulation under the correlation of Pearson analysis. The data has been processed by tracks. The investigation retained four tracks for each species in consideration of the abundance of tracks sampled (26 in total). The tracks monitored during the months of February, May, August and December has been suggested for showing the best results in term of seasonal difference (ANNEX II).

4. Results and discussion

4.1. The woody features among the circuit

4.1.1. The woody features density

▪ *Sheep circuits*

The charts below show the density variation of WF considering the buffering distances suggested: 10 m, 20 m, 50 m, 100 m and 200 m (Figure 3.1, 3.2, 3.3). Their values are compared to the mean of WF density within the study area. The five buffers display almost the same variability trend among the year: The trends are equivalent when the values are lower than the mean; and show different amplitude considering the opposite case. The single trees' density is displayed by the number of trees per hectare with an average of 1,4 trees/ha. The hedgerows density is estimated by meters per hectare with an average of 19,88 m/ha and the woodlots density by covered surface (Hectare) by hectare with an average of 0,89 ha/ha.

Trees and Hedgerows' values demonstrate a similar trend when these features are inferior to the mean during summer and the first months of winter. On the other hand, the buffers display different amplitudes when the two features exceed their averages; during autumn for trees and spring and autumn for hedgerows. The woodlots variation as noticed in the chart is always under the mean. The sheep study area consists into a "forested" agriculture matrix. The woodlot counts for 89% of the area wish may explain the phenomenon.

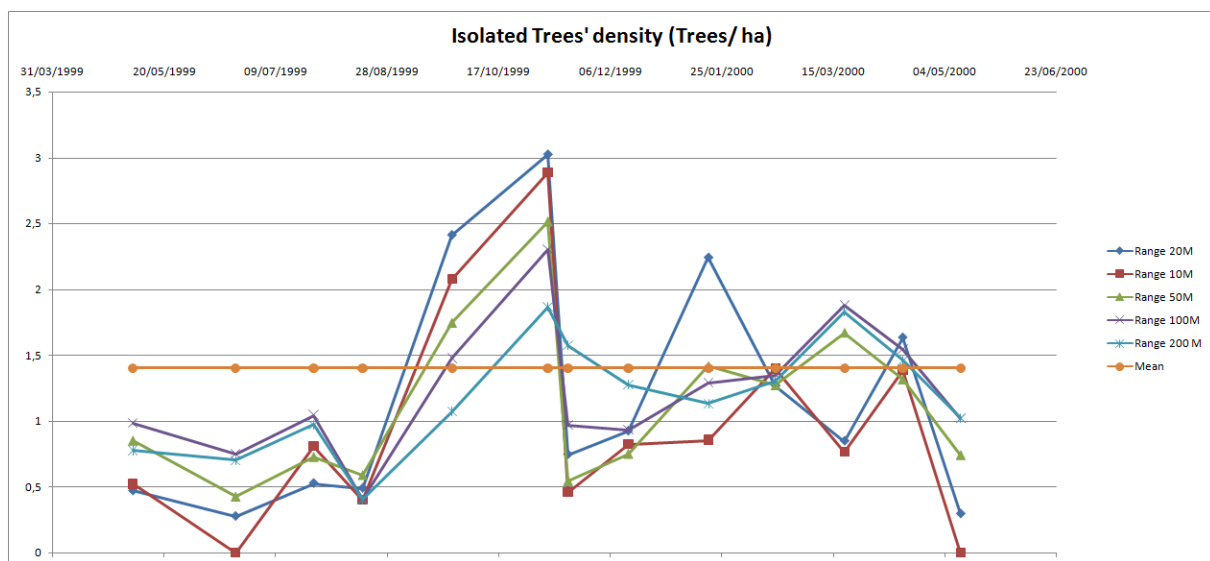


Figure 3.1 Density variation of isolated trees during the year sampled (1999–2000). Case of Sheep.

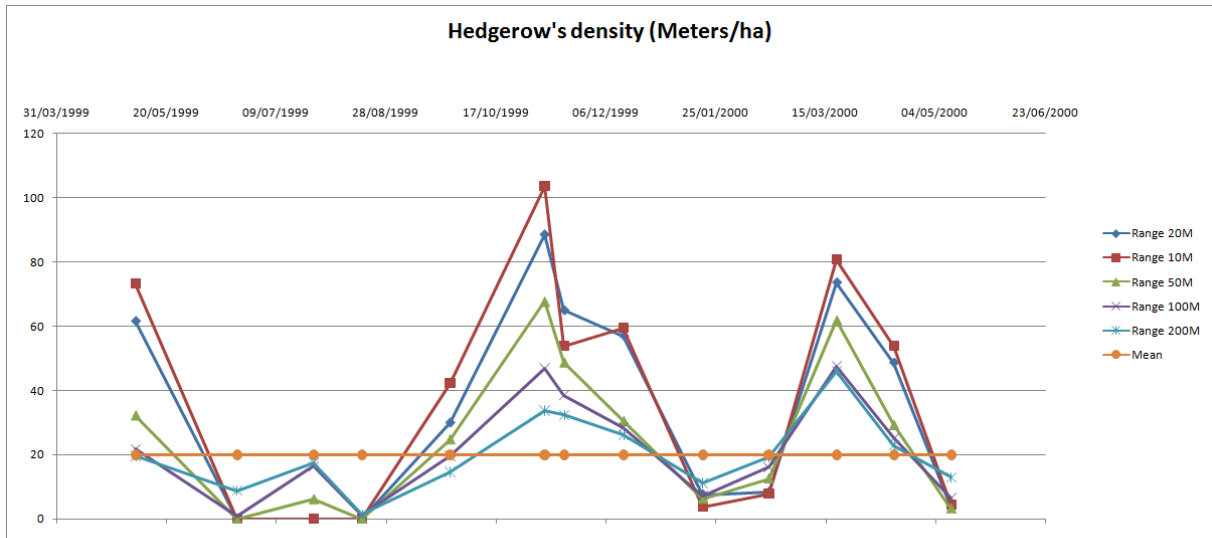


Figure 3.2 Density variation of Hedgerows during the year sampled (1999 – 2000). Case of Sheep.

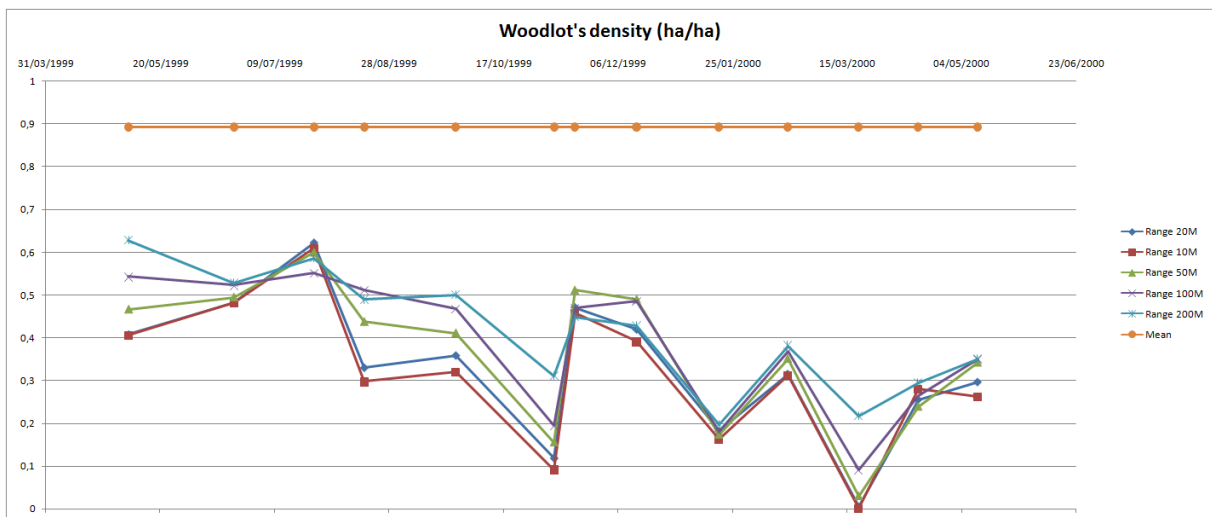


Figure 3.3 Density variation of Woodlots during the year sampled (1999 – 2000). Case of Sheep.

▪ **Goats circuits**

The case of goats' circuits are slightly different (Figure 3.4, 3.5, 3.6), especially considering the hedgerows. The linear woody structure presents different variability among buffers ranges with values higher than the average. Meanwhile the curves drawback to a similar tendency since the amounts goes below the average. At the opposite of sheep, the woodlots in the considered village of goats aren't common, which led to display their concentrations compared to the landscape.

The values of WF show the same pattern of trees and hedgerows in sheep's circuits: decreasing amplitudes according to the augmentation of the buffering distance when these structures are mainly present in the grazing itinerary (summer and winter).

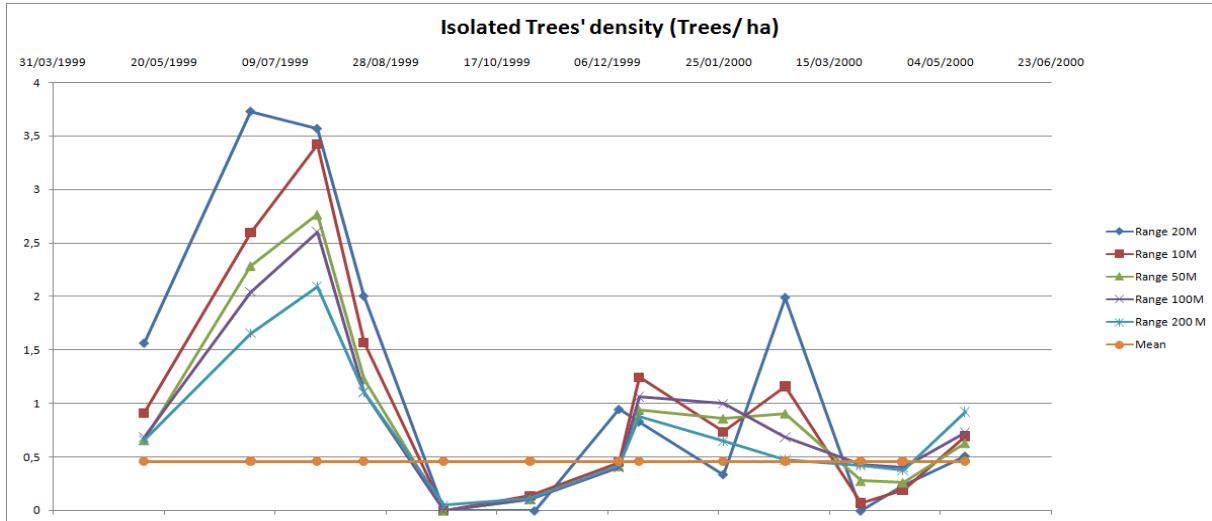


Figure 3.4 Density variation of isolated trees during the year sampled (1999 – 2000). Case of Goats.

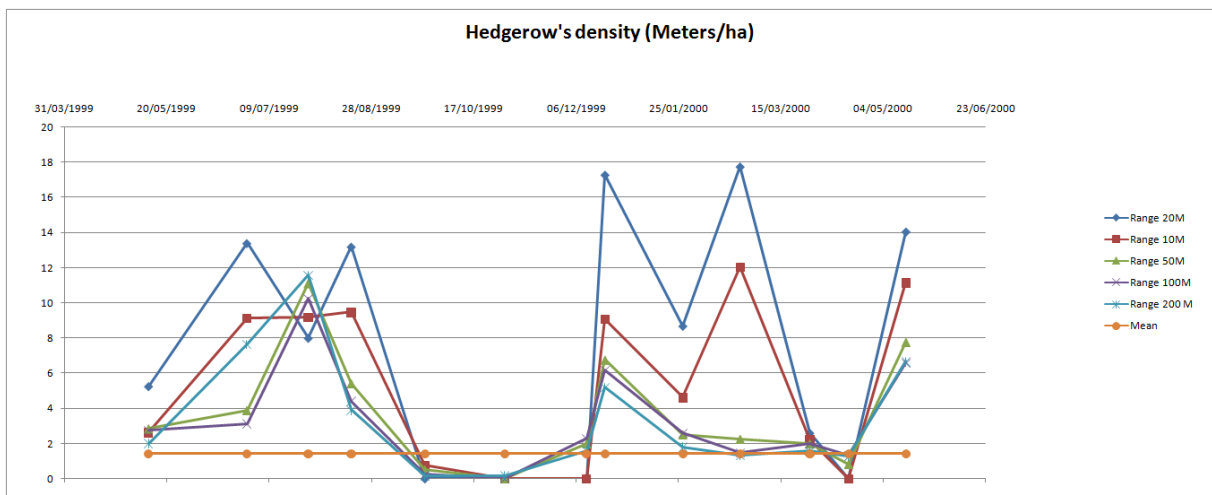


Figure 3.5 Density variation of Hedgerows during the year sampled (1999 – 2000). Case of Goats.

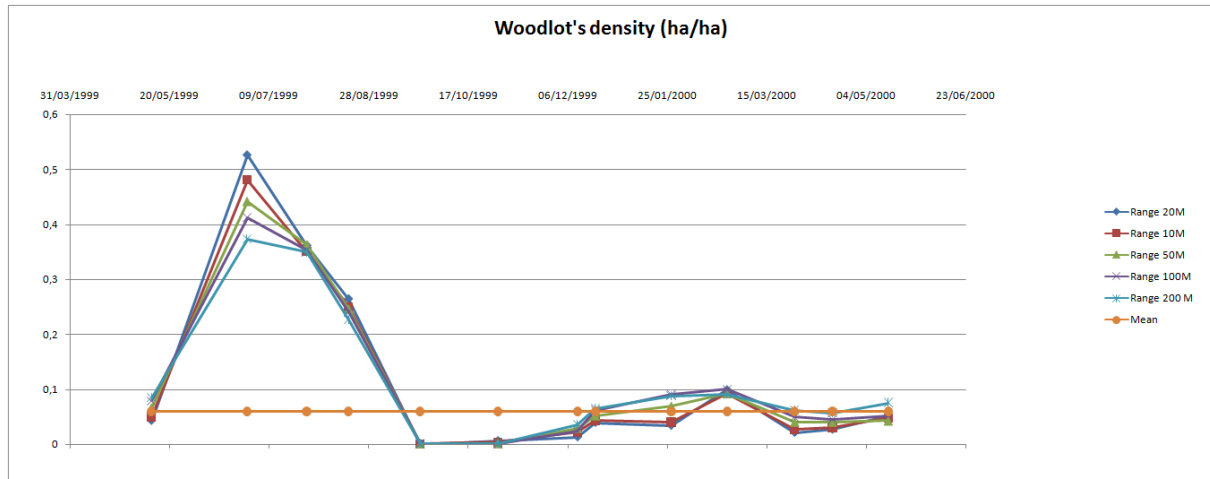


Figure 3.6 Density variation of Woodlots during the year sampled (1999 – 2000). Case of Goats.

4.1.2. The woody structure

The objective of the factor analysis is to determine whether the response variables display patterns of relationships. If two or more variables measure the same quantity then the variables can be combined and considered together rather than separately (Schwartz 1971). As the different buffer ranges measure the same quantities on WF, the factor analysis allows us to reduce the variables in order to understand the interaction of the structures with the grazing tracks.

The Scree Plot (Figure 3.7) displays the number of factors that explain the variability of the tree network among the tracks. The analysis retained 3 factors. The first factor explains the major variability with an eigenvalue equal to 8. The second and the third display also their importance with eigenvalues > 2 .

The first factor analysis was tested without rotation method. The three factors attained to explain 95,016% of the total variance with the following proportions: 52,82% for the first factor, 25,15% for the second and 17,046 % for the third. The variables in the table 3.1 are displayed with a label containing the structure and the buffering distance (Example: WOOD100). The highest correlation was registered by: the single trees at buffer distance of 200 m on the first factor ($r = 0.887$); the woodlots at buffer distance of 20 m on the second factor ($r = -0,766$); and the single trees at a buffer distance of 10 m for the last factor ($r = -0,743$).

The rotation method Equamax was retained for the second factor analysis. The percent of the total variance explained was the same as the first analysis, at the exception of the factors proportion which reached: 33,92% for the first factor, 32,807% for the second and 28.289 % for the third. The loading matrix (Tables 3.2) displayed the hedgerows as the most correlated feature to the factor 1, the woodlots and the trees were respectively correlated to the factor 2 and factor 3. Considering the buffering distances, the buffers of 50 m and 20 m obtained the strongest correlations. The highest correlation was obtained by the buffer distance of 50 m for hedgerows and woodlots. The buffer distance of 20 m was the most correlated to the factor 3 for the single trees (=0.957). Nevertheless, the buffer distance of 50m reached a correlation of 0.944 for this last structure.

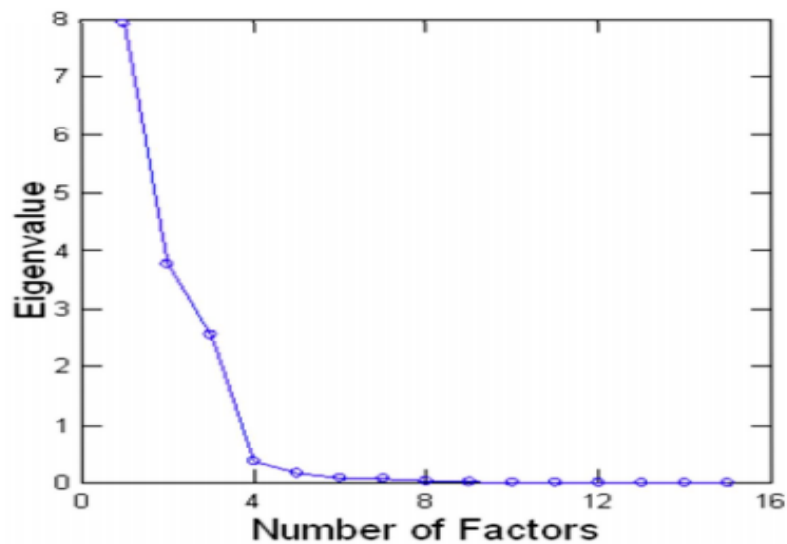


Figure 3.7 Eigenvalue Scree Plot of factors (Factorial Analysis, SYSTAT 12)

Tables 3.1 Correlation Matrix of woody feature and ranges to the factors. (Factorial Analysis, SYSTAT 12)

Component Loadings

	1	2	3
TREES200	0,887	0,195	-0,246
TREES100	0,829	0,215	-0,459
HEDGE200	0,822	0,291	0,409
HEDGES100	0,799	0,402	0,416
HEDGE50	0,763	0,501	0,392
TREES50	0,750	0,238	-0,595
HEDGE20	0,747	0,453	0,434
Hedge10	0,734	0,481	0,381
WOOD200	0,731	-0,614	0,201
WOOD100	0,658	-0,723	0,146
TREES20	0,645	0,203	-0,691
WOOD50	0,640	-0,756	0,109
WOOD20	0,630	-0,766	0,039
WOOD10	0,624	-0,762	-0,002
Trees 10	0,560	0,128	-0,743

Variance Explained by Components

1	2	3
7,923	3,772	2,557

Percent of Total Variance Explained

1	2	3
52,820	25,150	17,046

Tables 3.2 Rotated Correlation Matrix (EQUAMAX) of woody feature and ranges to the factors. (Factorial Analysis, SYSTAT 12)

Rotated Loading Matrix (EQUAMAX, Gamma = 1.500000)

	1	2	3
HEDGE50	0,969	0,042	0,213
HEDGE20	0,959	0,079	0,159
HEDGES100	0,956	0,147	0,192
Hedge10	0,935	0,041	0,201
HEDGE200	0,911	0,251	0,186
TREES200	0,528	0,274	0,729
WOOD50	0,092	0,987	0,102
WOOD20	0,040	0,981	0,151
WOOD100	0,142	0,974	0,090
WOOD10	0,015	0,967	0,182
WOOD200	0,275	0,930	0,109
TREES20	0,120	0,076	0,957
TREES50	0,260	0,116	0,944
Trees 10	-0,002	0,086	0,935
TREES100	0,378	0,196	0,873

"Variance" Explained by Rotated Components

1	2	3
5,088	4,921	4,243

Percent of Total Variance Explained

1	2	3
33,920	32,807	28,289

4.1.3. The circuit categories

The classification method “Cluster tree” (Hierarchical Cluster Analysis) was performed basing on the WF amounts through the circuits. Only the woody structures within a buffer distance of 50 m were considered for performing the classification. Two divisive processes were retained: The first is applied separately to the ruminants’ tracks; the second combined tracks of goat and sheep.

Starting from the cluster trees applied separately on goats and sheep’s tracks (ANNEX I), the cluster distances (Euclidian distance) reveals different scales for both ruminants. The sheep itineraries appear to be more specific towards the WF, with a cluster distance of 40 where the groups’ split started. The classification of sheep tracks obtained 3 clusters with a cluster distance of 15, while the classification of goats’ tracks obtained 2 clusters at a cluster distance of 5. The classification of goats’ tracks started at the distance of 10. The tracks clustered in both species display similarities in seasons (Table 3.3)

The divisive process on the 26 tracks for both species (ANNEX I) reveals the same clustering distance of sheep tracks with a cluster distance of 40. The organization obtained 3 clusters of the circuits at the cluster distance of 15. The two first clusters attained correspond to the Cluster I and Cluster II obtained on the first classification of the sheep tracks. The remaining cluster gathered all the tracks of goats and the Cluster III of sheep circuits.

Table 3.3 Circuit Clusters realized by HCA according to month tracks and season.

Species	Clusters	Month tracks	Season	Species	Clusters	Month tracks	Season	
Sheep	Cluster I	11 May 2000	Spring	Goats	Cluster I	15 May 2000	Spring	
		June 1999	Summer			June 1999	Summer	
		July 1999				July 1999		
	Aug 1999	Winter	Aug 1999			Autumn		
	Jan 2000		Dec 1999					
	Feb 2000	Cluster II	April 2000		Spring	Cluster II	Jan 2000	Winter
	6 May 1999		Autumn		March 2000		Spring	
	Sept 1999				Dec 1999			April 2000
	Dec 1999	Cluster III	08 Nov 1999		Autumn	11 May 1999	Autumn	
17 Nov 1999	Nov 1999							
March 2000	Spring		Dec 1999					

The analysis of sheep tracks’ clusters (Table 3.4) show that the hedgerows were the major feature on which the classification was based on. The amounts of hedgerows are distributed

within intervals of 0 – 15 m for the Cluster I, 20 – 35 m for the Cluster II and 45 – 70 m for the Cluster III. The trees and the woodlots apparently didn't attain an importance for this classification.

Table 3.4 Woody structures' measures at the buffering distance of 50 m (Sheep).

Clusters	Tracks	Trees 50 (Tree/ha)	Hedgerows 50 (m/ha)	Woodlots 50 (ha/ha)
Cluster I	21-Jun-1999	0,43	0,00	0,50
	17-Aug-1999	0,59	0,00	0,44
	11-May-2000	0,74	3,23	0,34
	26-Jul-1999	0,73	6,11	0,60
	19-Jan-2000	1,42	6,23	0,17
	18-Feb-2000	1,27	12,57	0,35
Cluster II	26-Sep-1999	1,75	24,80	0,41
	15-Apr-2000	1,32	29,24	0,24
	14-Dec-1999	0,75	30,49	0,49
	6-May-1999	0,85	32,25	0,47
Cluster III	17-Nov-1999	0,55	48,79	0,51
	20-Mar-2000	1,67	61,96	0,03
	8-Nov-1999	2,51	67,76	0,16

The goats' tracks showed different patterns (Table 3.5). The classification seems to be more opportunistic in term of WF. The quantities of hedgerows display a less importance on the goats tracks (Max (Hedgerows) = 11,11 m). Nevertheless, the results of the HCA clustered the tracks basing on this structure. The Cluster II contains the lowest amounts of the WF, especially for hedgerows and woodlots, while the Cluster I gathered the tracks with the main amount of single trees and hedgerows.

Table 3.5 Woody structures' measures at the buffering distance of 50 m (Goats).

	Weeks	Trees 50 (Tree/ha)	Hedgerows 50 (m/ha)	Woodlots 50 (ha/ha)
Cluster I	28-Jul-99	2,77	11,11	0,36
	28-Jun-99	2,29	3,89	0,44
	18-Aug-99	1,23	5,41	0,25
	15-May-00	0,63	7,77	0,04
	20-Dec-99	0,94	6,76	0,05
Cluster II	24-Feb-99	0,91	2,25	0,09
	27-Jan-00	0,86	2,51	0,07
	1-May-99	0,66	2,84	0,07
	11-Dec-99	0,42	2,00	0,03
	20-Mar-00	0,28	1,98	0,04
	17-Apr-00	0,26	0,83	0,04
	23-Mar-00	0,11	0,00	0,00
	23-Sep-99	0,00	0,51	0,00

4.2. Discussion

In order to compare the area of the grazing itineraries with the landscape, the differences of tree network's pattern within the tracks has been displayed during all study period (13 months) with the average of structures in the landscape. The different amplitudes of WF values recorded by the buffers are interpreted as a "Dilution effect". Explicitly, the dilution effect refers to a decrease of concentration: the values of the structures decreased with the enhancement of the buffering distance. This aspect supports the importance of these structures within the grazing process. During autumn and spring, the tree and the hedgerows are strategical components of the grazed tracks. The similar trend observed on the buffers when trees and hedgerows' values are below the mean, could be interpreted as a disinterest for the WF during the period of summer and first mid-winter. Since the woodlots' density is displayed below the average on the landscape for sheep track, no conclusion can be advanced. We believe that small variation of this structure contributes in influencing the use of trees and hedgerows.

The factorial analysis demonstrated the optimal buffer interval to be retained in order to delimit the grazed area: The buffering distance of 20 m and 50 m were the most correlated ranges to the tracks. More concluding results may be found with a lower resolution of the interval 20 m – 50 m. However, this delimitation is made in term of woody structures. As mentioned in the literature review, the herd adopts different shapes according to their behavior which induce different distributions among the exploited area. Thus, the perpetual variability of the grazing area engenders a complexity concerning the identification of the surface. The WF being a stagnant feature of the landscape contributes its importance for the delimitation of the grazing surface, since the feature is exploited for the pastoral purpose. Among structures, the hedgerows were the principal structure leading first to the identification of the grazed surface, then to the categorification of the tracks through the HCA clustering method. These aspects support the importance of the linear woody structure within the grazed itineraries.

The classification method indicated a selectivity of sheep in term of tree network within a forested agriculture matrix. Reasoning the seasonal exploitation of the woody structures, the clusters reveals a similarity of use during the period of winter and summer; and secondly in autumn and spring. The goats' tracks demonstrated an opportunistic behavior towards the structures considering their classification. Nevertheless, the itineraries were able to be

grouped basing on the hedgerows into two clusters: One containing the main tracks of summer, the other with the main tracks of the remaining seasons. Seasonal similarities or distortions are hardly distinguished for the goats' track.

4.3. Speeds: The behavioral indicators

4.3.1. The classification process

The Natural breaks of Jenks is a classification method with the purpose of getting classes with the lowest intern variance while maximizing the extern variance between these classes. The table 3.6 presents the classification of the speeds during the grazed circuits resulted by the Natural Breaks of Jenks. The speeds are organized by a class order according to the speed limits obtained with Jenks' classification method. The results are compared with the intervals suggested by Schlecht (2009) through a study conducted on goats' itineraries in the Al Jabal al Akhdar mountain range of northern Oman. As mentioned in the previous chapter (Literature review), the following speed classification was suggested by the author: Speed movements at $v < 0.2\text{m/s}$ were allocated as resting or stagnant grazing on the spot. Speed movements at $0.2 < v < 0.7 \text{ m/s}$ were classified as grazing dominating on shifting or short term-grazing dominated by subsequent shifts, while speeds at $v > 0.7 \text{ m/s}$ were interpreted as directional walking uninterrupted by feeding.

Despite of the disparity between the maximum speed registered by the species ($V = 2,52 \text{ m/s}$ for sheep and $V = 1,51 \text{ m/s}$ for goats), the limits registered for each number of natural breaks demonstrate an affinity between goats and sheep: the limits obtained for each class order corresponds in term of species, at the exception of the maximum speeds registered.

Although the difference of the study areas between the two investigations, the resulted limits performed by the natural breaks of Jenks exhibit similarities with the classification proposed by Schlecht (2009). The intervals calculated by the first class obtained with 3 natural breaks and the third class obtained with 2 natural breaks correspond respectively to the first and third class orders suggested by the author. The differences occur within the second class order. However, the results on the second order correspond considering an overlap of the intervals obtained with 2 and 3 natural breaks.

Table 3.6 Speeds Classification using the Natural Breaks of Jenks method.

Species	N° of Natural breaks	N° Class order			
		1	2	3	4
Sheep	1	0 – 0,48	0,48 – 2,52		
	2	0 – 0,31	0,31 – 0,72	0,72 – 2,52	
	3	0 – 0,24	0,24 – 0,54	0,57 – 0,89	0,89 – 2,52
Goat	1	0 – 0,49	0,49 – 1,51		
	2	0 – 0,33	0,33 – 0,71	0,71 – 1,52	
	3	0 – 0,23	0,23 – 0,49	0,49 – 0,79	0,79 – 1,51
Goat (E. Schlecht, 2009)	None	0 – 0,20	0,20 – 0,70	>0,7	

4.3.2. Discussion

The Natural Break of Jenks appears to perform well on delimiting the speed classes. The classification method overcame two factors: The species and the study area. The analysis reveals a common organization of speeds for goats and sheep. Moreover, the classification shows an affinity for the classification proposed by Schlecht, (2009); demonstrating that speeds act as a critical behavioral indicator. Among the natural breaks conducted, the organization considering 2 natural breaks of Jenks corresponds the most with the one proposed. Therefore, the study advanced the following speeds' allocation: the speed movements within the first class order are allocated to stagnant grazing or slow shift strongly affected by grazing with an important feed intake. The second class contains the speeds referring to slow shifts interrupted by munching (trifling feed intake) and the third class is assigned to the pure activity of shifting.

Lécrivain et al, (1995) reported the shapes that the herd adopts during grazing. The persistent forms are characterized by their stability and slow dynamic in time. On the other hand, Savini et al (1995) retained four behaviors defined by the animals' activities, reporting the speeds as the factor conditioning the herd's dynamic. However, the delimitation of the speeds weren't proposed with the authors. Thus, this shapes and dynamics are advanced in the consideration of the class orders obtained. "Pure shift" combined with the "Shift forms" (cited in the Literature review) falls within the last class orders (Class order (3) / 2 Natural Breaks; Class order (4) / 3 Natural breaks). The "rest shape" and "Circular standstill form" are proportioned to the first class orders of each classification. The "Forehead mobile form" and "Ovoid form without lanes" can be approximated with the medium class orders (Class order (2) / 2 Natural Breaks, Class order (2) or (3) / 3 Natural breaks).

4.4. Interaction of speeds with woody features

The variance analysis (ANOVA) was applied considering speeds as a dependent variable, WF and species as factors. The speeds adopted a significant level of $p < 0.01$ within the species (Table 3.7). The goats' circuits present higher speeds with a LS mean of 0.5 m/s while the sheep performs lower speed shift at 0.44 m/s. The interaction with the WF displayed a strong variability with a significant level of $p < 0.001$. The same significant level was registered for the interaction of speeds with the association of the two factors (Species and WF).

On Tukey’s test (Table 3.8), the combination of “Hedgerow–Trees” and “Hedgerows–Woods“ were both significantly relevant with a level of $p < 0.001$, meanwhile the significance level of the last combination “Trees–Woods” obtained a p –value inferior to 0.05. The Student–Newman–Keuls Test (Table 3.9) retained three subgroups for each of the three structures with p –values equal to 1 for the three levels. The subgroups are strongly independent in term of speed. The flocks adopt significant differences of speeds for each of the subgroups.

Table 3.7 Speeds variation, Least Square Means and Standard deviations recorded by Woody features and Species (ANOVA , SYSTAT12).

Analysis of Variance						Least Squares Means				
Source	Type III SS	df	Mean Squares	F-ratio	p-value	Factor	Level	LS Mean	Standard Error	N
SPECIES\$	0.917	1	0.917	8.865	0.003	WF\$	Hedgerows	0.562	0.026	244.000
WF\$	3.818	2	1.909	18.456	0.000	WF\$	Trees	0.445	0.012	1197.000
SPECIES\$*WF\$	3.352	2	1.676	16.203	0.000	WF\$	Woods	0.406	0.008	1767.000
Error	331.184	3202	0.103			Least Squares Means				
						Factor	Level	LS Mean	Standard Error	N
						SPECIES\$	GOATS	0.500	0.016	1948.000
						SPECIES\$	SHEEP	0.442	0.011	1260.000

Table 3.8 Tukey's Honestly-Significant-Difference Test on the woody features (Pairwise Comparison, SYSTAT 12)

Tukey's Honestly-Significant-Difference Test					
WF\$(i)	WF\$(j)	Difference	p-value	95.0% Confidence Interval	
				Lower	Upper
Hedgerows	Trees	0.117	0.000	0.064	0.170
Hedgerows	Woods	0.156	0.000	0.104	0.207
Trees	Woods	0.039	0.015	0.011	0.067

Table 3.9 Student-Newman-Keuls Test on the woody feature (Pairwise Comparison, SYSTAT 12)

Student-Newman-Keuls Test				
SubGroup	WF\$	Group Mean	Group Size	p-value
1	Woods	0.406	244.000	1.000
2	Trees	0.445	1197.000	1.000
3	Hedgerows	0.562	1767.000	1.000

The box plot (Figure 3.8) displays the speed variation around the three structures. Considering this output, the following interpretation is concluded: The sheep flocks perform the lowest speeds when the woodlots are the closest structure to the tracks; the hedgerows for goats consist into the structure when the highest speeds are registered. To avoid any wrong clarifications, further specified analysis on these features is realized on the following paragraph.

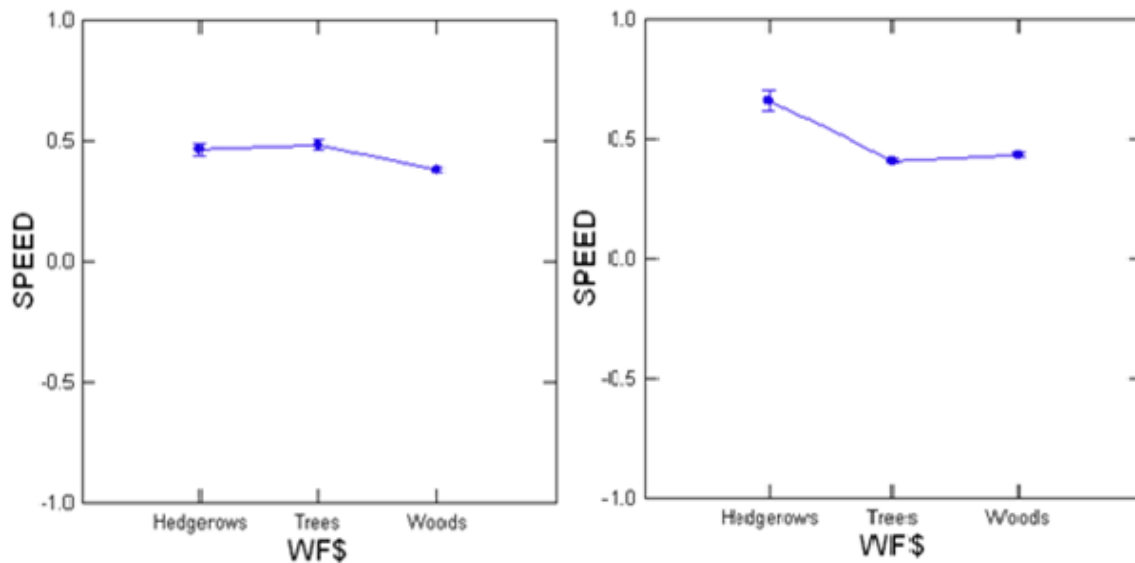


Figure 3.8 Speeds box plot in term of woody structures (ANOVA, SYSTAT 12). Left : Case of Sheep, Right: Case of Goats.

4.4.1. The speed classes

4.4.1.1. The classification with two Natural Breaks

In accordance with the sheep tracks (Table 3.10), the squared correlation through all levels of the categorical variables tested (Class orders for speeds and structures for WF), demonstrated high correlation with the first factor. The correlations with the second factor displayed a less importance. The correspondence plot (Figure 3.9) exhibits the dependency of the speed classes towards the woody structures. High affinity was demonstrated between the class order 1 & 2 and the woodlots through their positive correlation with the first factor; confirming that the sheep adopts low/average speeds while crossing this structure. At the opposite of the two first class orders, the highest class order 3 attained to be negatively correlated to the axe. This last speed order showed a strong dependence approaching the trees and the hedgerows.

Tables 3.10 Woody feature and CLASS3's Squared Correlations with factors (PCA, SYSTAT 12). Case of Sheep.

Row Variable Squared Correlations with Factors		
Name	Factor 1	Factor 2
Hedgerows	0.980	0.020
tree	0.994	0.006
woods	1.000	0.000

Column Variable Squared Correlations with Factors		
Name	Factor 1	Factor 2
1	0.977	0.023
2	0.943	0.057
3	1.000	0.000

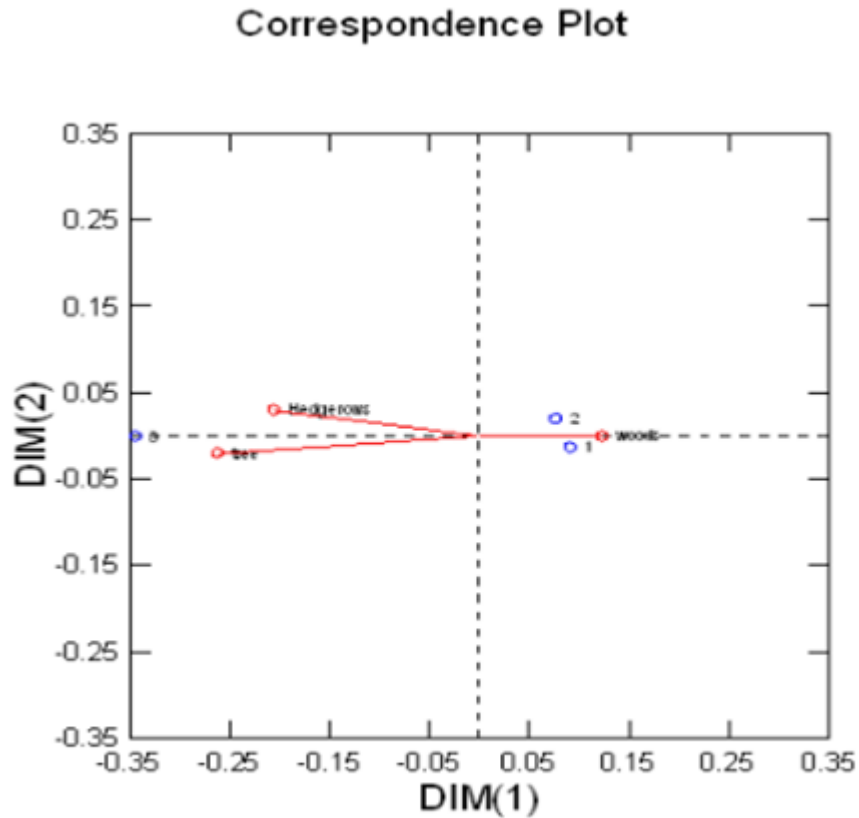


Figure 3.9 Correspondence Plot of Speed Class Order (3) (PCA, SYSTAT 12). Case of Sheep.

The results attained for the goats' tracks did not expose a concrete pattern (Table 3.11, Figure 3.10). Despite of being strongly correlated to the first factor, the distribution of the variables' levels appears to be aggregated beside the correspondence plot's origin. Only the hedgerows and the class order 3 of speeds display a certain correspondence by outstripping the origin and being correlated to the first factor.

Tables 3.11 Woody features and CLASS3's Squared correlations with factors (PCA, SYSTAT 12). Case Of Goats.

Row Variable Squared Correlations with Factors		
Name	Factor 1	Factor 2
hedgerows	0.998	0.002
trees	0.944	0.056
woods	0.678	0.322

Column Variable Squared Correlations with Factors		
Name	Factor 1	Factor 2
1	0.975	0.025
2	0.519	0.481
3	0.999	0.001

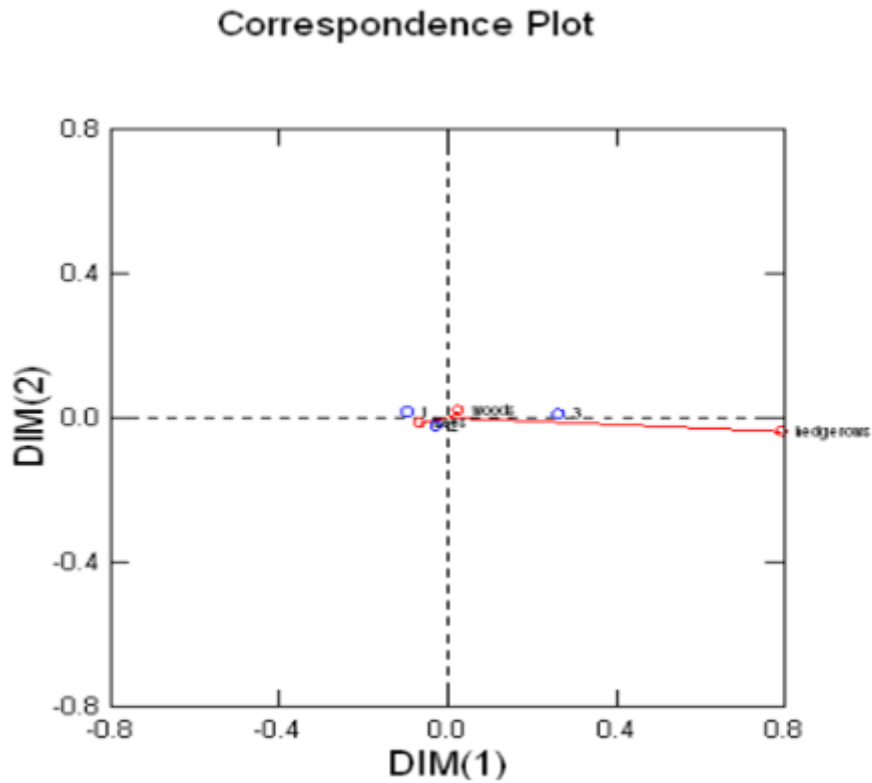


Figure 3.10 Correspondence Plot of Speed Class Order (3) (PCA, SYSTAT 12). Case of Goats.

4.4.1.2. The classification with three Natural Breaks

The CA performed considering the categorical variable of 3 natural breaks (4 Speed classes) showed a greater differentiation on the WF. The correspondence plot (Figure 3.11) of sheep tracks indicated the correlation of the lowest speed classes (1 & 2) across the woodlot structure. The class order 3 was dependent towards the hedgerows. The class order 4 depended on the tree where the highest speeds are recorded. The goats' speeds were less meaningful by displaying the same arrangement of plots seen in the CA with 2 natural breaks of Jenks: the highest class order of speed (4) correspond to the hedgerows structure, the remaining plots persist on their aggregation beside the plots' origin.

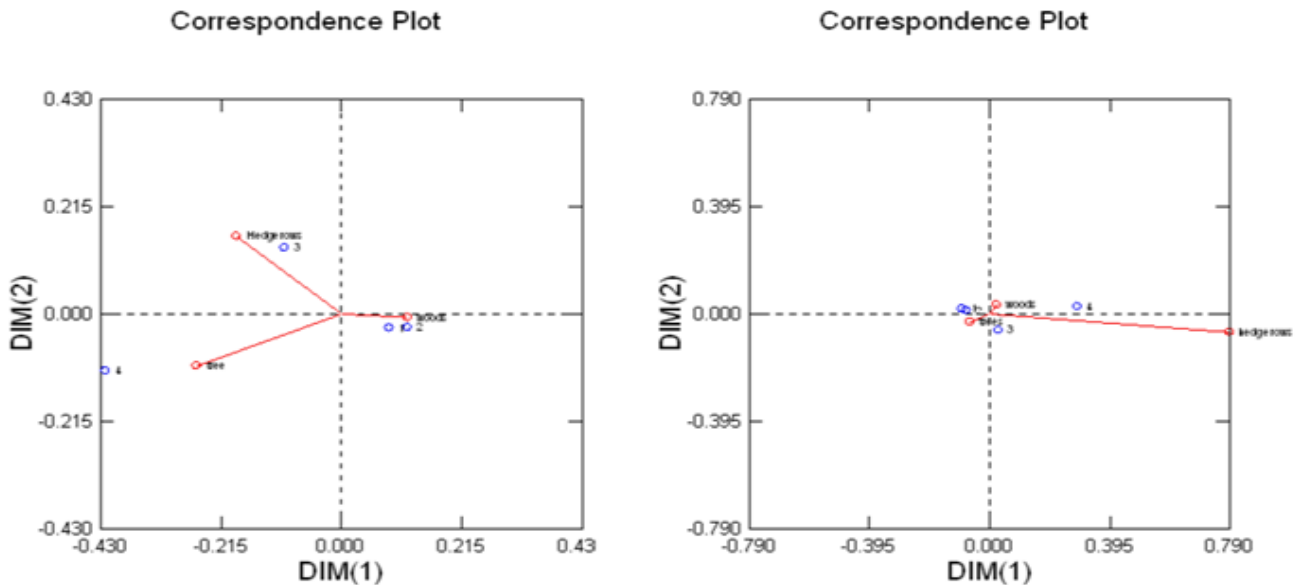


Figure 3.11 Correspondence Plots of Speed Class Order (4) (PCA, SYSTAT 12). Left: Case of Sheep, Right: Case of Goats

4.4.2. Discussion

Tukey's test and Student–Newman–Keuls Test were both performed on the woody structures in order to distinguish a similarity of use on those structures. Both tests confirmed the same results, pointing that the structures don't share any affinity in term of speed. The animals adopt precise behaviors across each type of tree configuration.

The speeds exhibited their influence towards the species and the woody structures. Using the variance analysis, the speed variation displayed to be significant in term of WF. However, the LS means obtained didn't allow the allocation of speeds to behaviors. The classification of the speeds was relevant until the categorification of the variable using the Natural Breaks of Jenks.

As mentioned before, the term “speeds” used in this study doesn't refer to the instant speed of the flocks; it reflects an approximation of the average speed per second. The parameter explains the distance covered during a proportion of time. The time accorded may include more than one behavior occurring within this distance, which affects the real speeds of the flocks. Thus, the use of the continuous values as criterion for the assessment of the speed strikes as being aimless in term of behaviors.

The CA performed approved that the utilization of the parameter into its categorical form attained results on the sheep tracks. The selectivity that the herd adopted highlighted the

exploitation of the ligneous vegetation. The woodlots are crossed with the lowest class speed orders: stagnant grazing and slow shifting are the main behaviors occurring around woods. The hedgerows are identified to the medium/high speeds referring to a quick shifting or shifting affected by grazing. The highest speeds appear frequently near the punctual tree structure. The exploitation of this last feature (isolated trees) holds on a trifling importance. The opportunistic behavior of goats constrained the assignment of speed to the woody structures. The ruminants adopt different behavior towards the trees configuration. Their clusters – on the previous chapter – demonstrated that the seasonal distortion are hardly discerned. Thus, the grazing strategy on goats' tracks depends mainly on the shepherd decision in term of woody structures. Therefore, the importance of the WF is demonstrated by the flocks of sheep; affirming the relationship between structures and behaviors.

4.5. Woody Features: Use among space and time

4.5.1. The Near distance parameter

The relationship between the distance to nearest woody structures and the species were significant with a p-value < 0,01. On the other hand, the distance varied strongly with the type of tree structures (p < 0.001). The woodlots were the closest feature during the tracks sampled for both goat and sheep as shown in the box plot (Figure 3.12) with a LS mean of 8,49 m (Table 3.12). This structure was followed by the hedgerows (12,1 m) and the single trees (22,24 m). Comparing the ruminants' circuits, the goats' tracks display to be closer to the tree network with a LS mean distance of 13 m while the sheep tracks perform longer distance with a LS mean of 15.24 m.

Table 3.12 NEAR_DIST's Least Square Means and Standard deviations recorded by Species and Woody features (ANOVA ,SYSTAT 12)

Least Squares Means

Factor	Level	LS Mean	Standard Error	N
WF\$	Hedgerows	12.072	0.974	240.000
WF\$	Trees	22.242	0.596	411.000
WF\$	Woods	8.487	0.339	1304.000

Least Squares Means

Factor	Level	LS Mean	Standard Error	N
SPECIES\$	GOATS	13.010	0.666	803.000
SPECIES\$	SHEEP	15.524	0.433	1152.000

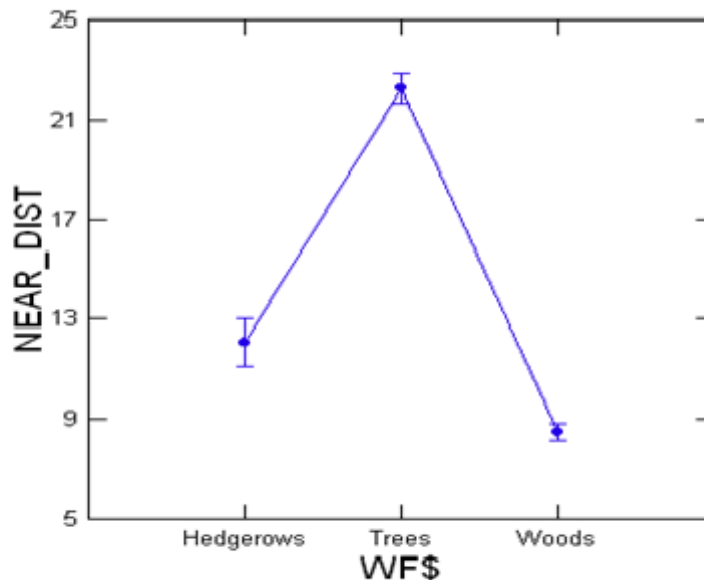


Figure 3.12 NEAR_DIST box plot in term of woody feature (ANOVA, SYSTAT 12). Case of Sheep and Goats

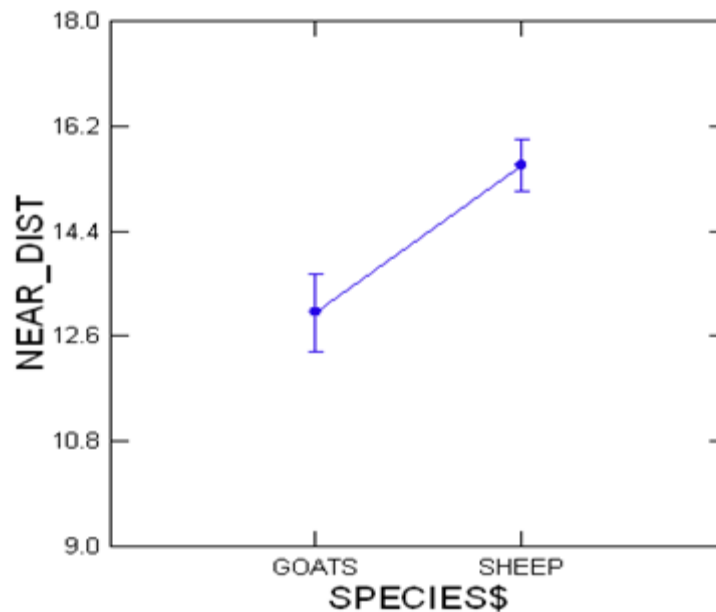


Figure 3.13 NEAR_DIST box plot in term of species (ANOVA, SYSTAT 12)

The variance analysis (Figure 3.14) applied to the species independently didn't influence the succession of the nearest structures (Woodlots < Hedgerows < Trees). The woodlots and the hedgerows' distances are similar regarding the tracks of sheep and goats (Table 3.13), while the single trees outstrip the sheep tracks ($D = 25,29$ m) more than the goat ones ($D = 19,19$ m). The distance to the hedgerows showed a strong variation on the goats' tracks. As mentioned before, the hedgerows registered a maximum of 11,11 m/ha. Nevertheless, comparing to the sheep tracks, the distance to hedgerows displayed a large confidence interval with a standard deviation of 1.74 while the same parameter for sheep tracks recorded a standard deviation of 0.87.

Table 3.13 NEAR_DIST's Least Square Means and Standard deviations recorded by the association of Species and Woody features (ANOVA, SYSTAT 12)

Least Squares Means				
Factor	Level	LS Mean	Standard Error	N
WF\$*SPECIES\$	Hedgerows*GOATS	11.087	1.743	48.000
WF\$*SPECIES\$	Hedgerows*SHEEP	13.057	0.871	192.000
WF\$*SPECIES\$	Trees*GOATS	19.192	0.829	212.000
WF\$*SPECIES\$	Trees*SHEEP	25.293	0.856	199.000
WF\$*SPECIES\$	Woods*GOATS	8.752	0.518	543.000
WF\$*SPECIES\$	Woods*SHEEP	8.222	0.438	761.000

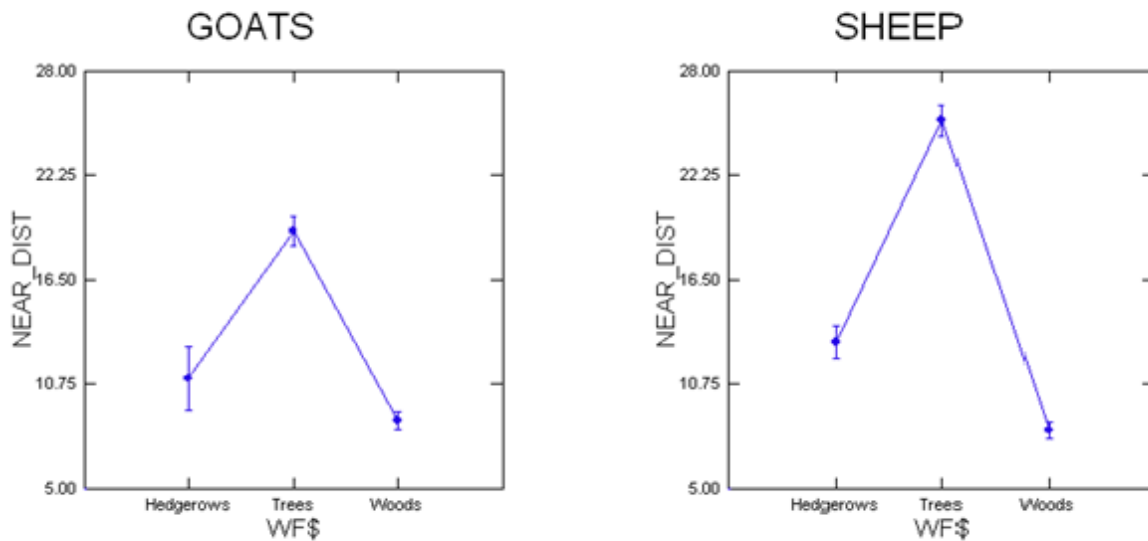


Figure 3.14 NEAR_DIST box plot in term of woody features (ANOVA, SYSTAT 12). Applied to species separately.

4.5.2. The time accumulation parameter

The time accumulation parameter is referring to a parameter distinguishing the temporal variation on daily basis on the track sampled, commonly the difference that can occur between morning and afternoon. The variance analysis applied on the time accumulation crossed by the variable WF manifested a significance level of $p < 0.05$ for sheep (Table 3.14). Thus, the use of the tree structures differs along the day for the ruminant. Looking through the box plot (Figure 3.15), the hedgerows and the woods strikes as being the first structures exploited in term of time. The study suggested by a median calculation the value 13000 (approximately 13h30) as the origin distinguishing between morning and afternoon, this value corresponds to the gaps of the GPS data during the diurnal rest of the flocks. The averages of the woody structures in term of time accumulation occur to have a differentiation after the diurnal rest inducing that the exploitation of the tree network marks an importance especially during afternoons.

Table 3.14 Time Accumulation variations in term of woody feature (ANOVA, SYSTAT12). Case of Sheep

Analysis of Variance

Source	Type III SS	df	Mean Squares	F-ratio	p-value
WF\$	1.594E+009	2	7.972E+008	3.131	0.044
Error	2.925E+011	1149	2.546E+008		

Least Squares Means

Factor	Level	LS Mean	Standard Error	N
WF\$	Hedgerows	17339.703	1151.501	192.000
WF\$	tree	20643.965	1131.067	199.000
WF\$	woods	17592.392	578.393	761.000

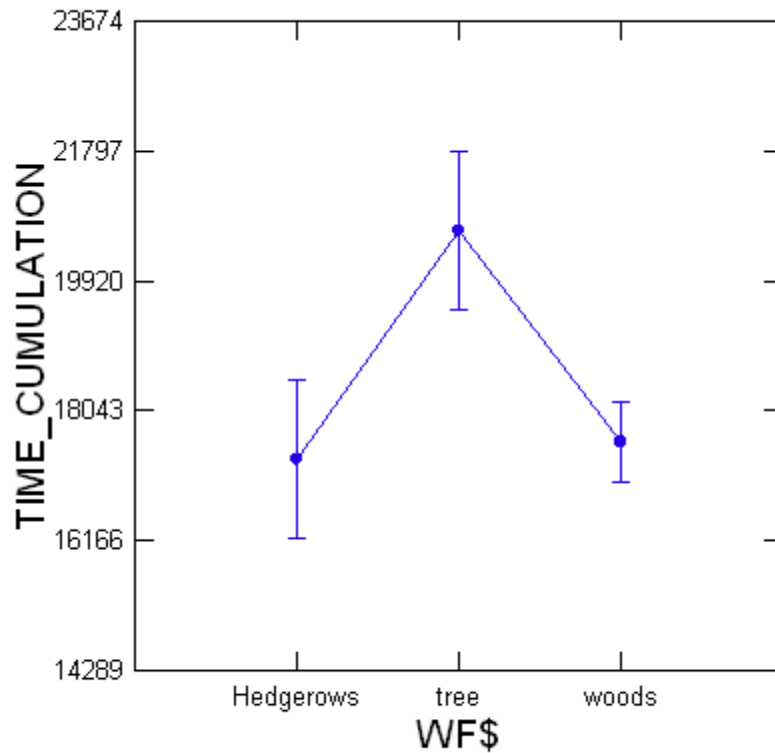


Figure 3.15 Time accumulation box plot in term of Woody features (ANOVA, SYSTAT 12). Case of Sheep.

The ANOVA (Table 3.15 and Figure 3.16) applied on goats’ track reveals the same pattern seen on the sheep analysis with a significance level of $p < 0.001$: The tree structures express a strong variation after the midday rest. The hedgerows and the tree consist into the first exploited structures by the goats’ itineraries. The woodlots display to be the common structure used at the end of the journey.

Table 3.15 Time Accumulation variations in term of woody feature (ANOVA, SYSTAT12). Case of Goats.

Analysis of Variance

Source	Type III SS	df	Mean Squares	F-ratio	p-value
WF\$	4.305E+009	2	2.152E+009	8.825	0.000
Error	1.834E+011	752	2.439E+008		

Least Squares Means

Factor	Level	LS Mean	Standard Error	N
WF\$	hedgerows	16086.024	2409.761	42.000
WF\$	trees	17758.060	1107.062	199.000
WF\$	woods	22530.765	688.838	514.000

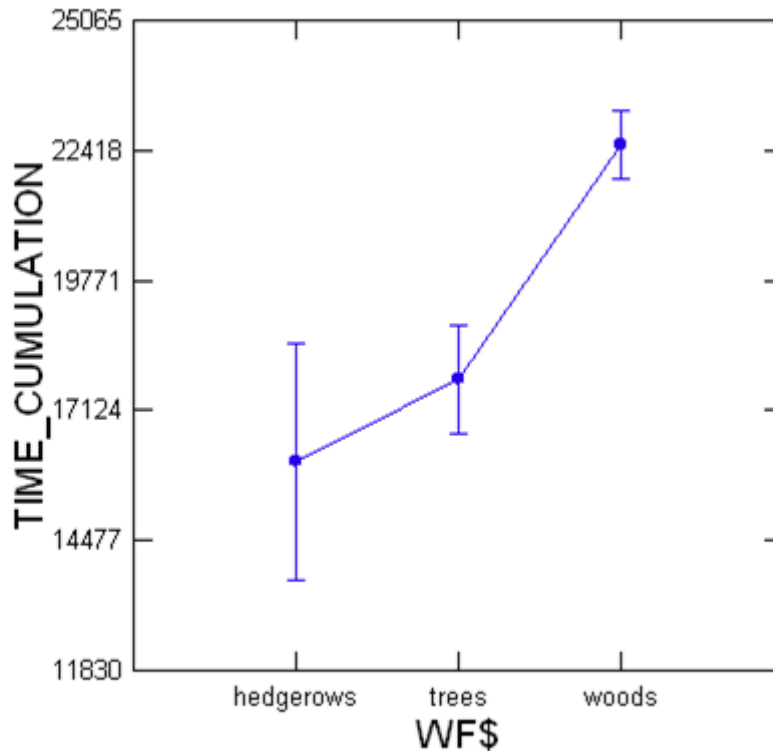


Figure 3.16 Time accumulation box plot in term of Woody features (ANOVA, SYSTAT 12). Case of Goats

4.6. Discussion

The distance analysis attends to display the spatial architecture of the WF around the grazing area. This parameter may lead to errors considering two factors: the dispersion of the flocks during grazing period, and the proximity of the GPS Collar to the animals.

The parameter reached the zero value only for the woodlot structures: Due to the woods' bidimensionnel shape, the flocks are obliged to cross the structure when the exploitation is intended. As discussed before, the trees and the hedgerows are more correlated to high speeds. Concluding that the cohesion of individuals within the herd is maintained next to these woody organizations. Therefore, our analysis supports that errors related to the features' distances are minimized, especially considering the time intervals of the GPS data monitoring (1 minute) and the total number of the data set (3208 points for both tracks).

The opportunistic behavior of goats is demonstrated by comparing the WF distances throughout the tracks. The isolated tree registered the highest distances to sheep and goats' tracks which could be related for being a single point feature on the landscape. However, the high speeds performed across this structure confirm the indifference that the sheep's circuits

carry towards the isolated tree and the same interpretation may be advanced also for goats. Relying on the sheep tracks, the hierarchical order of the WF in term of distance corresponds to the one obtained in term of speeds: The woodlots being the closest structure to the tracks registered the slowest speeds, followed respectively by hedgerows with medium/high speed and single trees with the highest speeds.

In term of value, the time accumulation is not a significant parameter for distinguishing the exploitation between the morning and afternoons. Nevertheless, the utilization of the parameter advances the time relativity between the features used along the journey. Considering the results, hedgerows and woodlots are the earliest structures appreciated by the flocks of sheep. Meanwhile the single tree occurs frequently at the end of the circuits: Probably on the flocks' way back to the sheepfold. The goats' itineraries show preferences to the woodlot structure at the end of the journey, at the opposite of single trees and hedgerows which are used the first. The large confidence interval displayed by the linear structure for goats' circuit demonstrates the recurrence of the structure throughout the circuits.

4.7. The elevation gain parameter

The positive elevation gain was negatively and strongly correlated to the negative elevation gain for both goat and sheep. The correlations recorded values of -0.977 for sheep and -0.947 for goats (Figure 3.17). Moreover, both Scatter Plot Matrix demonstrated a linear trend between the two parameters; approving the similitude of accumulation slopes' use for the small ruminants considered. The linear regression performed on the both species' circuit (Figure 3.18), affirmed the negative linearity trend with the strong significant level of $p < 0.001$: Indicating that the flocks hold on the same behavior towards the altitude, browsing the mountainous landscape within the year sampled.

Reasoning the seasonal factor (ANNEX II), the summer tracks display the largest gaps on the scatter plot matrix. The gaps are linked to the diurnal rest, which affirm that the summer tracks contain the longest periods to the rest activity. The plot distribution show a sinusoidal pattern considering the sheep: The herds' circuit accumulates quick altitudes in the start of the journey and before the diurnal rest, while the flocks browse flat pastures between. The same trend is repeated after the diurnal rest. The goats tracks behave differently within the same period: the elevation gain is accumulating in an exponential trend during mornings. After the diurnal rest, the flocks graze in flat pasture before grazing high lands at the end of the journey.

During the month of February – representing the winter tracks –, the diurnal rest gaps are hardly distinguished. The sheep accomplish a successive sinusoidal tendency: the itinerary performs successional sequences of quick altitude browse and flat pastures during the journey. The goats' itineraries display two main sequences, where the flat areas are exploited in the beginning of the track then riffle the high pastures at the end.

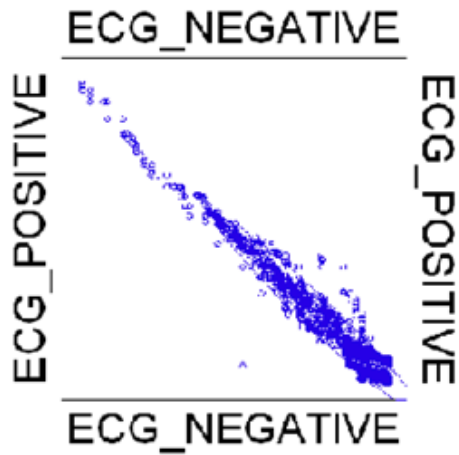
Considering autumn and spring, the goats' tracks display a closely linear trend. The plots expose the sinusoidal tendency with low variability of amplitude, especially noticed in autumn when the negative elevation gain exhibit an asymmetry with the positive one. This distortion supports that the goats mainly climb down the landscape in autumn while the tracks maintain equitable use of high and low pastures in spring. The sheep tracks are more irregular during these two seasons making the interpretation of the two parameters complicated.

Results for SPECIES\$ = SHEEP

Pearson Correlation Matrix

	ECG_NEGATIVE
ECG_POSITIVE	-0.977

Scatter Plot Matrix



Results for SPECIES\$ = GOATS

Pearson Correlation Matrix

	ECG_NEGATIVE
ECG_POSITIVE	-0.947

Scatter Plot Matrix

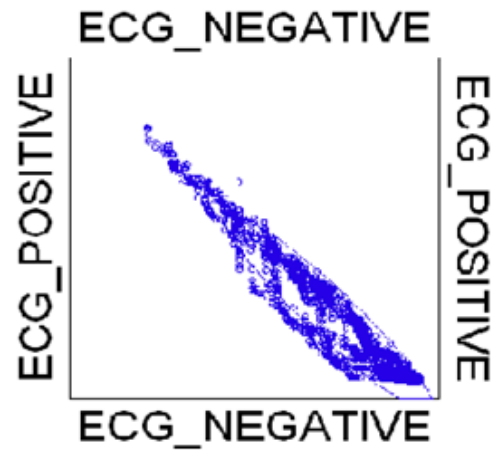


Figure 3.17 Correlation and Scatter Plot Matrix of negative and positive Elevation Gain (Correlation of Pearson, SYSTAT 12). Data by group of specie.

Analysis of Variance

Source	SS	df	Mean Squares	F-ratio	p-value
Regression	1.976E+008	1	1.976E+008	28605.735	0.000
Residual	22149365.553	3206	6908.723		

Confidence Interval and Prediction Interval

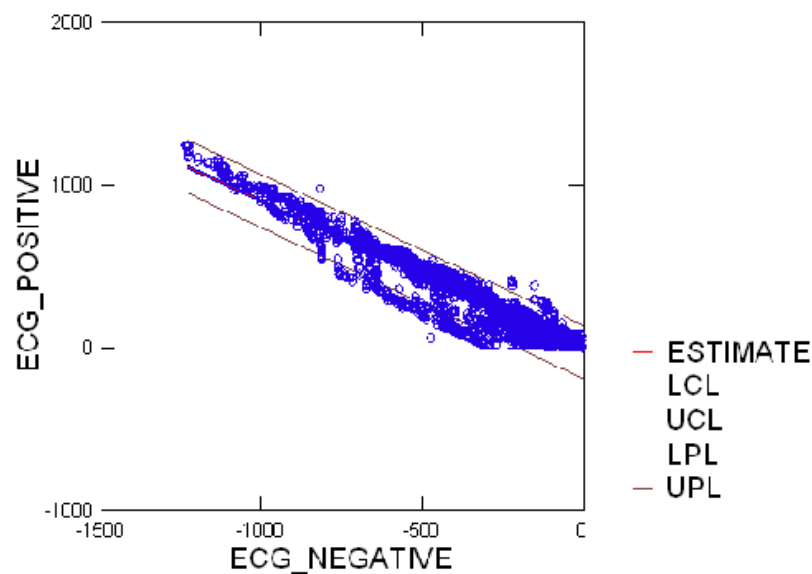


Figure 3.18 Prediction and confidence intervals of the interaction of positive and negative Elevation Gain (Linear Regression, SYSTAT 12).

4.8. Discussion

The correlation of Pearson and the linear regression indicated the use equity between high and low pasture among the year. The negative and positive elevations of gain were significantly relevant to describe the exploitation of the landscape from an altitude perspective. Considering the differences of the landscapes browsed by sheep and goats, the strategical use of the mountains coincides within the two territory and the two species in term of the year. The attention given to the accumulation forms of the parameter allowed the identification of the mountain exploitation. In the case of limiting the variables to their original forms as altitude for the elevation gain, the outcomes would lead to an irregular plot distribution with no significance.

The seasonal factor highlighted strategies of herding among the tracks. As seen in summer, the flocks of sheep performed four major “climb ups”, shared equally between the morning and afternoon period. In the meantime, goats’ tracks dedicated the full morning for their first climb; the second was later achieved at the end of the journey after grazing flat pasture. Winter bring out the behavioral aspect of the species, the goats dedicate their climbing during one sequence of the day (commonly in at the end of the journey); which concur to what Savini et al (1995) reported concerning the pressure exerted by the altitude of lands. Effectively, the high pastures constrain a continuous attraction on the flocks, especially during the end of the journey. The sheep divided their climbing in periodic sequences alternating climb ups and climb down or climb ups and flat fields browse. The same last behavior was manifested by goats in autumn.

5. Conclusion

The importance of the woody structures depended on the approaches directed through this work. The hedgerows were the only structure which answers favorably to the methods conducted. The woods and isolated trees were more related to the behavioral aspects. The woodlots were appreciated by low speeds registered by the sheep, at the same time; they were the closest feature to the tracks. The single tree operated the opposite case: They recorded the farthest distances to the tracks of goats and sheep. The high speed performed by the flocks of sheep across the structure highlighted the trifling role of scatter trees on the grazing itineraries.

The occurrence of the hedgerows on the tracks assisted strongly in order to define the grazed area through the buffers. The ruminants' behavior was recognized by performing medium/high speeds at the proximity of this structure. Moreover, the linear organization tends to be closer to the tracks than the isolated trees. Despite of registering a mediocre maximum average of 11,11m/ha on goats' tracks – Compared to 67.76m/ha on sheep –, the high deviation of hedgerows in term of distance to the track presumes the strong occurrence of this structure in the circuits. Thereby, this structure interferes with several functions and has to be investigated independently.

Using the GPS data, the delimitation of the grazing area consists into a critical step for the matter investigated. The errors generated during gathering data may lead to wrong interpretation due to the "Dilution" effects. The shapes adopted by the flocks resulted into different distribution constraining the definition of the exploited surface. In a scale of 10–200 m, the buffer distance of 50 m maintains a good approximation of this area considering the tree network of the landscape which concord with the suggest of Samuels et al., (2007) . There is a difference between the exploited area and the browsed one. The exploitation refers to a term of use, while browsing is more related to the path transit. Lécivain et al. (1995) discussed the spatial behavior – Not related to the exploitation – while describing what a sector means to small ruminants. The herd behavior is also recognized to the spatial architecture surrounding the herds. The woody features are a part of this architecture and the distribution of this pattern holds on an influence on the grazing animals, especially the flocks of sheep. The selectivity of this specie towards the woody structures supported the analysis conducted.

The velocity of the herd is honest indicator of both behaviors (Spatial behavior and Instant behavior). Nevertheless, the use of this parameter on his continuous form may complex future investigations. The risks of this form may be related to sampling intervals, precision of GPS collar, behavior change or the method conducted during monitoring. On the other hand, the method of classification of this parameter may influence the results considering the categorical form.

The use of Natural Breaks of Jenks proved to be appropriate classification method for the parameter. The organization of speeds into classes overcame two factors: The study area by comparing the classification proposed by E. Schlecht (2009); and the species by applying separately on flocks of sheep and goats. We obtained a common classification despite of the distortion registered for the maximum velocity performed between the species. Therefore, the study attained 3 / 4 classes of speeds referring to the principal behaviors occurring during grazing. Those classes were strongly correlated to the woody features for the case of sheep, and the near distance parameter consolidated the results. The woods being the closest feature to the tracks recorded the slowest speeds classes. The trees, the most distance feature registered the highest ones, while the medium speeds corresponded to the medium distances on the hedgerows.

The opportunistic behavior of goats didn't match with the approach conducted. At the opposite of sheep, the specie holds an adaptive behavior toward the woody features; fact that explains why their tracks were the closest to the features. However, their preferences to the woods at the end of the journey demonstrate that the time parameter could explain their exploitation of woody features when the spatial parameters could not. Thus, the goats' tracks are more linked to the shepherd strategy than their behavior.

The goats and sheep behavior shared an affinity when we considered the elevation gain. Among the year, the exploitation of altitude compensates between the positive and negative elevation gain. The use of high pasture is balanced by the use of low pastures. Though, the seasonal strategies are different. In summer and winter, the sheep browse the altitudes within sequences of going down and going up while the goats show a monodirectional trend of altitude browse.

The herds adopt different behaviors along the journey, and some of those behaviors may depend on the ones adopted before. Thus, the behavior is cumulative processes of activities

conducted during the journey. The cumulative parameters interpret the pattern of exploitation on relative basis; displaying the tendency of use. As discussed, limiting the variables to their original forms as altitude for the elevation gain and the GPS time for time accumulation, would lead to an irregular plot distribution constraining the interpretations of results. Their significance supports an approximation of the exploitation in term of attitude and time.

5.1. Further development

Grazing itinerary is difficult matter to apprehend, and their interaction with woody features can be more investigated. The structures holds specify functions towards the type of grazing ruminant and the type of behavior (Spatial and instant). Thus, several subjects can be developed in the view of this paper work.

The dataset has been build basing on tracks sampled during the year 1999–2000. Radical change can be noticed since then. Therefore, updating the tracks is a primordial fact that should be considered in order to develop further investigation. Moreover, additional flocks' tracks must be taking in account to build strong datasets to highlight the exploitation of the landscape within the region.

The GPS data supports a good basis for this research's field. Nevertheless, the following development has to be coupled considering interviews with the local shepherds to underline their roles in the herding practice. The extracted information gathered from the interviews can support the creation of a map containing grazing sectors and sections, and characterize them in term of WF, landcovers and grazing behavior.

The results pointed the influence of woody structures on the grazing behavior. Hedgerows adopted significant outcomes through the approaches conducted. Thus, Investigating the species, functions, and the composition of woody features' structures would clarify how the exploitation of these feature operates.

Finally, more significant seasonal parameters must be suggested and collected for the purpose of this work. Precipitation, temperature, precocity and availability of vegetation consist into substantial factors for the classification of the tracks on a seasonal basis; in order to understand and detail the tracks' strategies.

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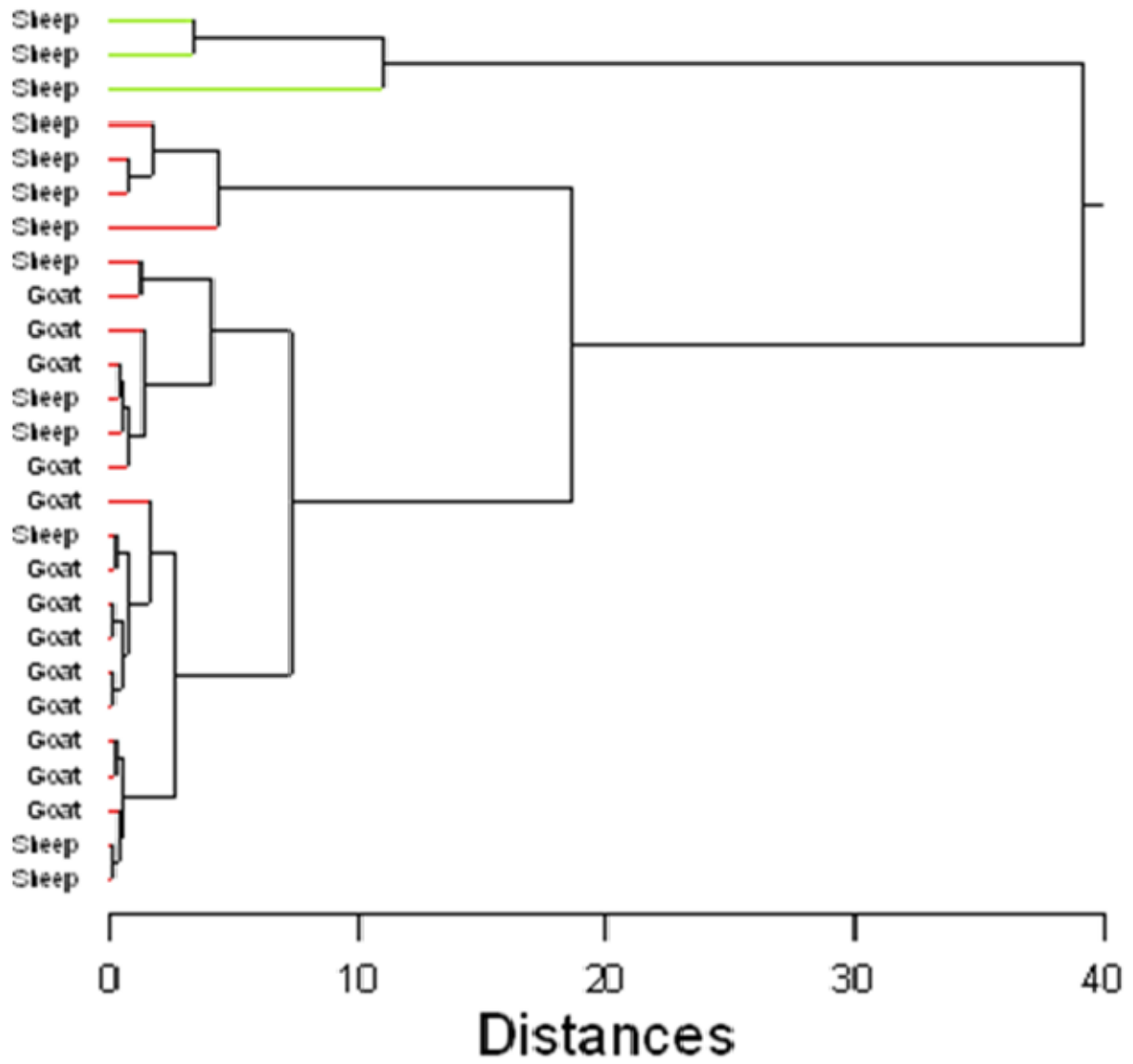
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ANNEX I

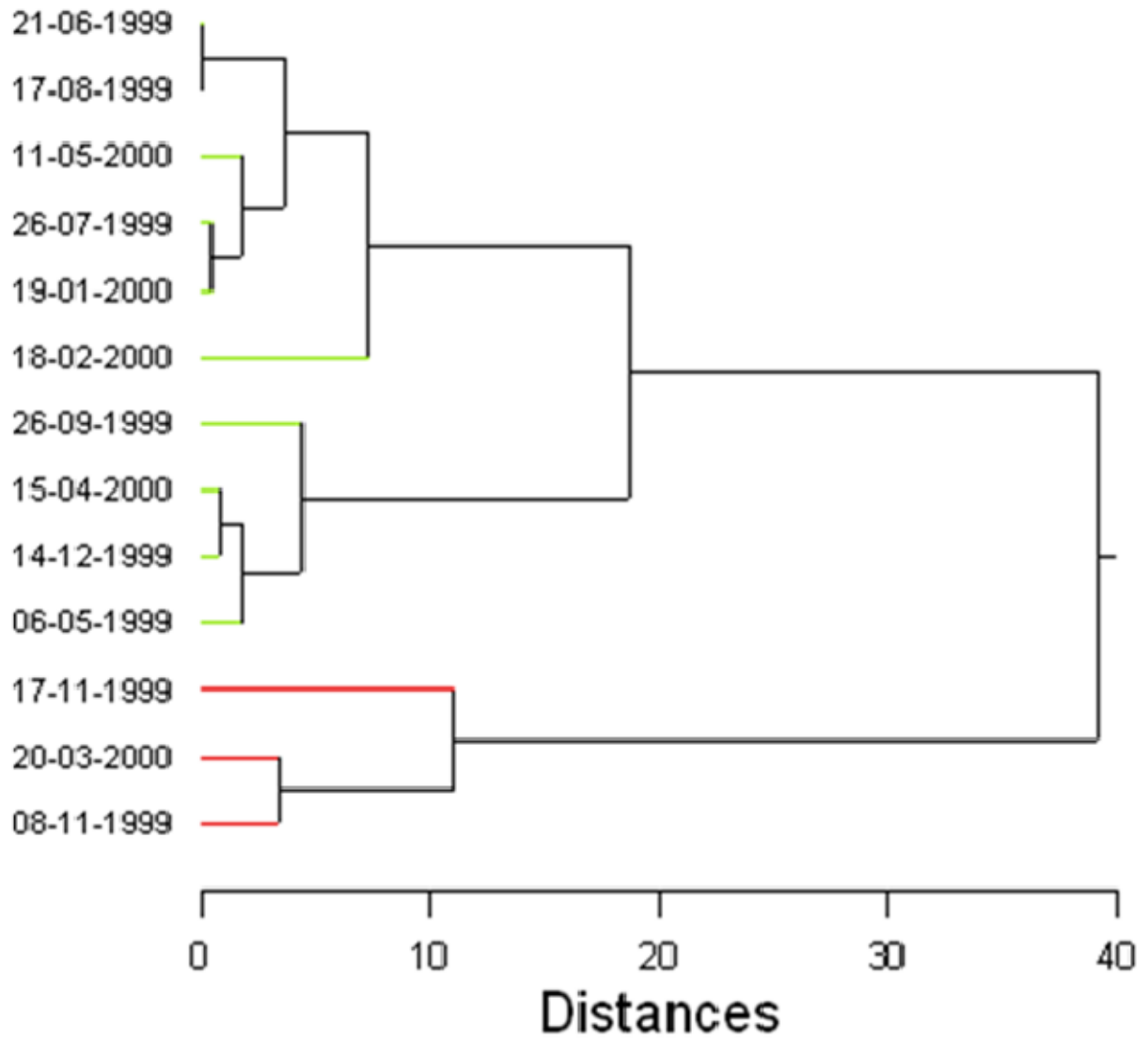
Cluster Tree

Sheep and goats' Track



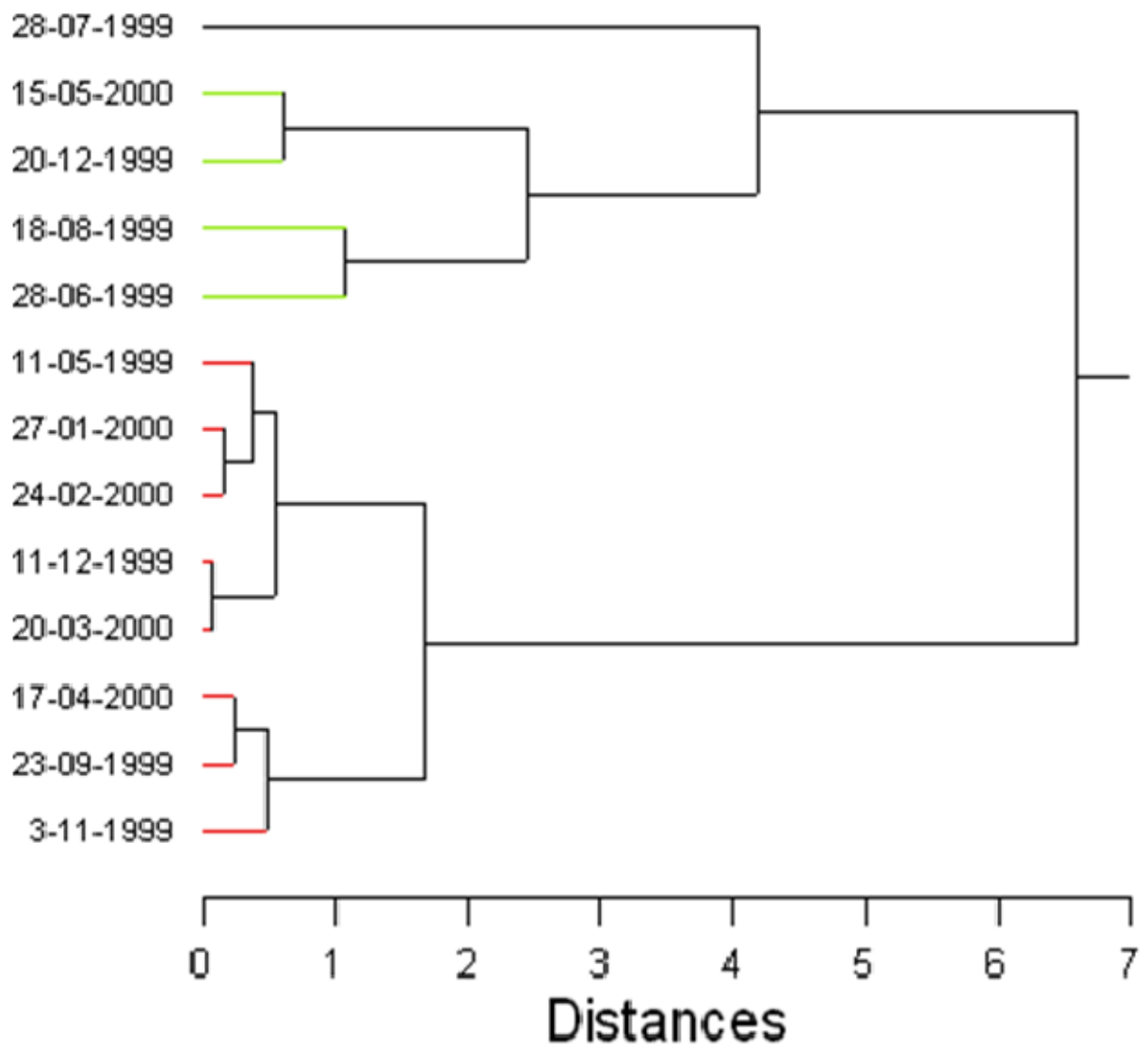
Cluster Tree

Sheep's Track



Cluster Tree

Goats' Tracks



ANNEX II

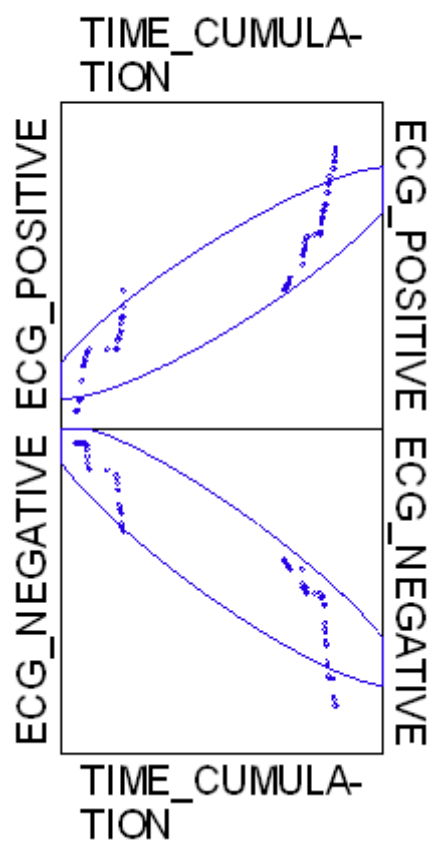
▼ Correlation: Pearson

Results for DATA_GPS = SHEEP AUGUST 1999

Number of Observations: 116

Pearson Correlation Matrix	
	TIME_CUMULATION
ECG_POSITIVE	0.904
ECG_NEGATIVE	-0.913

Scatter Plot Matrix

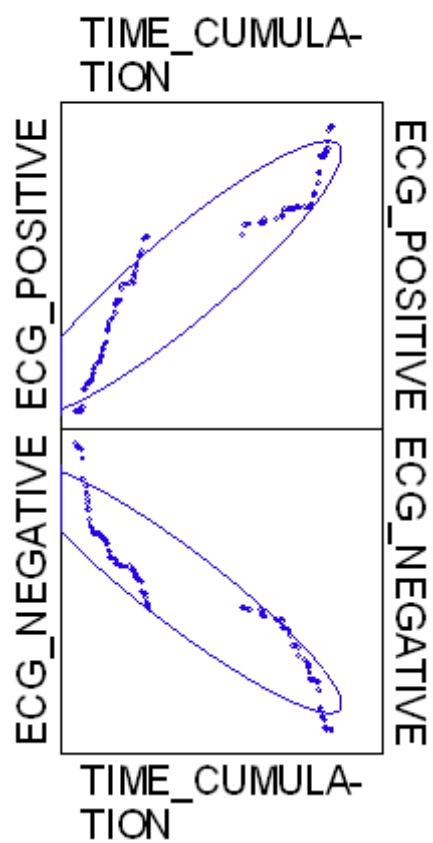


Results for DATA_GPS = GOATS AUGUST 1999

Number of Observations: 157

Pearson Correlation Matrix	
	TIME_CUMULATION
ECG_POSITIVE	0.915
ECG_NEGATIVE	-0.928

Scatter Plot Matrix

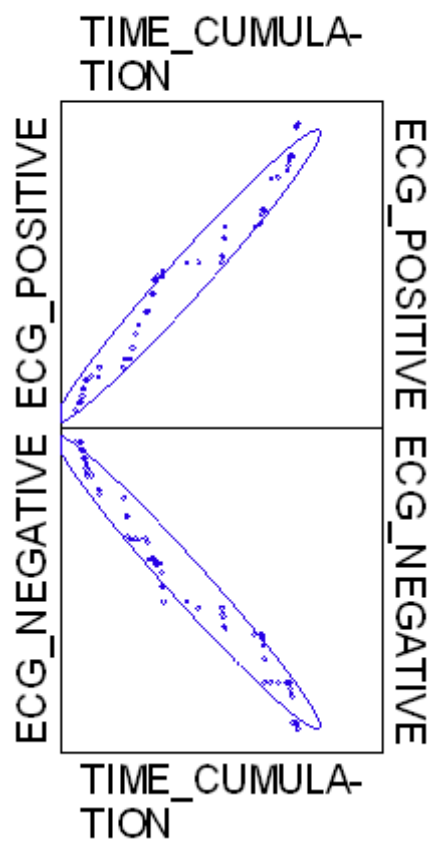


Results for DATA_GPS = SHEEP FEBRUARY 2000

Number of Observations: 78

Pearson Correlation Matrix	
	TIME_CUMULATION
ECG_POSITIVE	0.980
ECG_NEGATIVE	-0.981

Scatter Plot Matrix

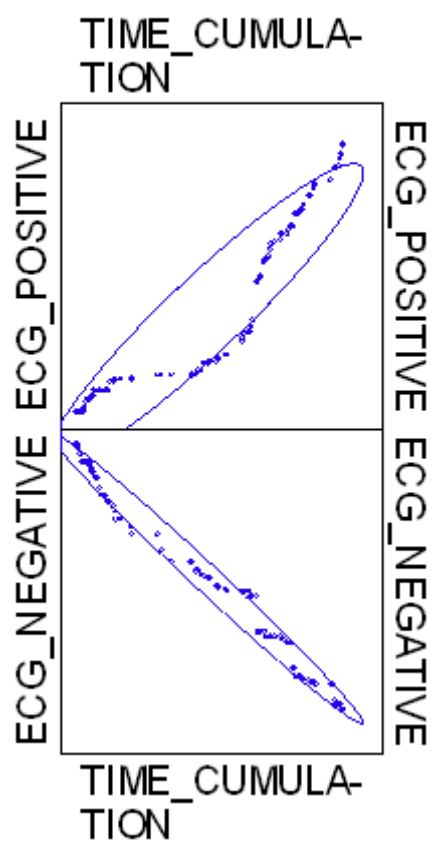


Results for DATA_GPS = GOATS FEBRUARY 2000

Number of Observations: 103

Pearson Correlation Matrix	
	TIME_CUMULATION
ECG_POSITIVE	0.940
ECG_NEGATIVE	-0.992

Scatter Plot Matrix

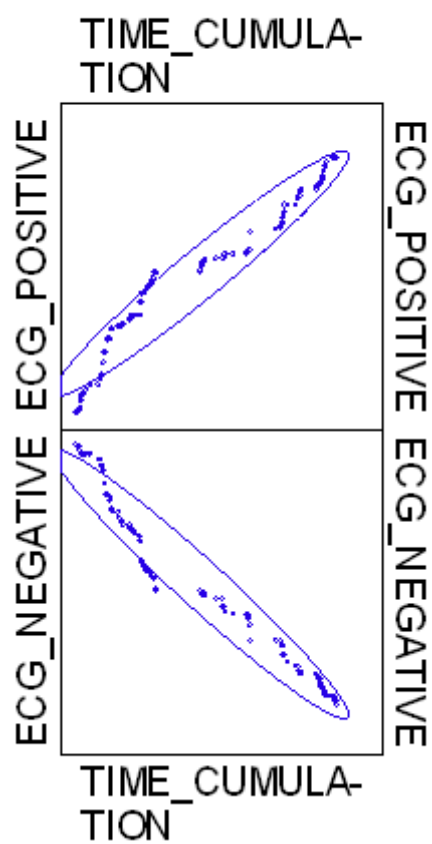


Results for DATA_GPS = SHEEP MAY 1999

Number of Observations: 159

Pearson Correlation Matrix	
	TIME_CUMULATION
ECG_POSITIVE	0.968
ECG_NEGATIVE	-0.972

Scatter Plot Matrix

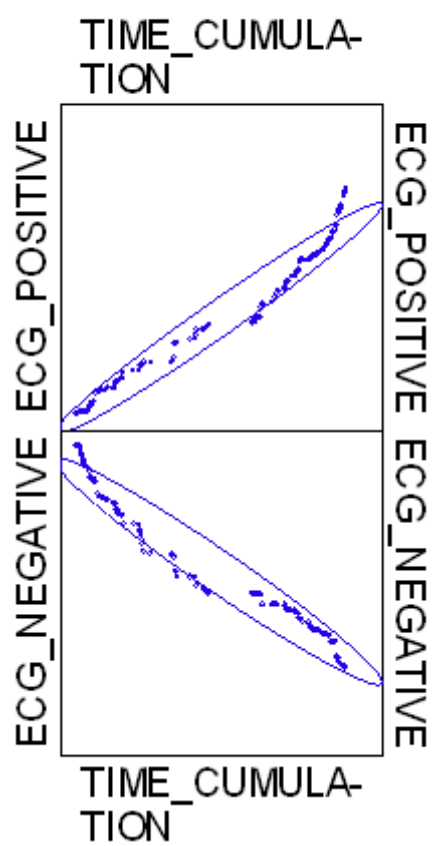


Results for DATA_GPS = GOATS MAY 1999

Number of Observations: 188

Pearson Correlation Matrix	
	TIME_CUMULATION
ECG_POSITIVE	0.983
ECG_NEGATIVE	-0.976

Scatter Plot Matrix

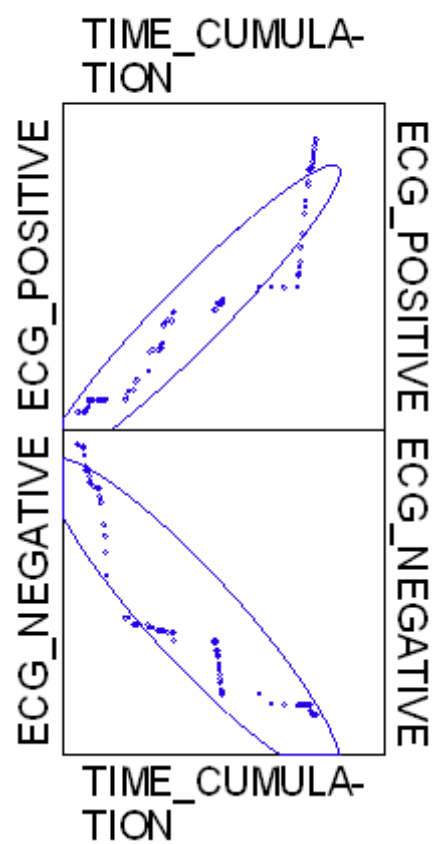


Results for DATA_GPS = SHEEP DECEMBER 1999

Number of Observations: 101

Pearson Correlation Matrix	
	TIME_CUMULATION
ECG_POSITIVE	0.955
ECG_NEGATIVE	-0.916

Scatter Plot Matrix



Results for DATA_GPS = GOATS DECEMBER 1999

Number of Observations: 199

Pearson Correlation Matrix	
	TIME_CUMULATION
ECG_POSITIVE	0.994
ECG_NEGATIVE	-0.908

Scatter Plot Matrix

