The grazing behavior and diet selectivity of two lamb breeds on secondary successional pastures in the Chiloé Archipelago

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ABSTRACT

The aim of this experiment was to investigate the grazing behavior and diet selectivity of the Chilota and Suffolk Down lamb breeds on secondary successional pastures in the Chiloé Archipelago (Chile). Eight Chilota and six Suffolk Down lambs (males) and their dams were selected and marked on their backs with an identification number. A 1-ha paddock of Calafatal (the principal feed resource for ruminants in Chiloé) was used every month. Additionally, every month, eight Chilota lambs and their dams were allowed to graze a 1-ha paddock of naturalized pasture. Data were recorded over a 24-h period once a month for 3 consecutive months through direct observations of grazing behavior. Subsequently, feces were extracted for microhistological analysis. The results showed that the consumption of grasses was highest and the consumption of shrubs the lowest despite the dominance of shrubs in Calafatal. The longer browsing times for Chilota lambs ($P=0.02$) did not reflect a higher content of shrubs in their feces relative to Suffolk Down lambs ($P=0.01$). Although the diet composition was similar between breeds and between pastures, the richness of plant species (particularly grasses) and the selection of plants by lambs were higher in Calafatal than in naturalized pasture due to the higher grass content of the naturalized pasture. In summary, Chilota and Suffolk Down lambs grazing Calafatal showed a similar grazing behavior. The longer browsing times of Chilota lambs did not reflect a higher shrub content in their feces relative to Suffolk Down lambs.

1. Introduction

The Chiloé Archipelago (41° 44′ to 43° 17′ S, 72° 45′ to 74° 30′ W) is located in southern Chile. The principal feed resource for domestic and wild ruminants in Chiloé is Calafatal pasture (**CP**), a secondary successional plant formation[1],

created by logging of the native forest to transform soils in agricultural fields and pastures, which were under grazing management. The intensity of grazing by sheep (grazing intensity, **GI**) is low (2 o.e.[2] ha^{-1} year^{-1}). This system is dominated by shrubs (e.g., *Berberis chilensis* and *Berberis microphylla*), several trees (e.g., *Drimys winteri*), ferns (e.g., *Blechnum penna marina*) and an herbaceous stratum including *Agrostis capillaris*, *Holcus lanatus*, *Anthoxanthum odoratum*, *Trifolium repens* and *Plantago lanceolata*.

Another type of secondary successional area, naturalized pasture (**NP**), is also a product of human intervention in forested land, coupled to higher grazing intensities than

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¹ We defined two secondary successions, Calafatal and naturalized pastures, based on the different botanical species as a consequence of the different grazing intensities used. Both secondary successions cannot be considered either as structured pastures or as provisional resources. The original forested ecosystem was modified to an herbaceous stratum by logging, which is kept through grazing. However, pressure to continue its evolution promotes the establishment of woody species; if grazing ceases, these ecosystems will quickly leave the herbaceous state to pass to a shrub–tree state, towards the forested state again.

² The ovine equivalent (o.e.) is a measure of the stocking rate corresponding to the energetic requirements of a sheep (55 kg LW) rearing a 100-day-old suckling lamb.

in Calafatal (5 o.e. ha^{-1} year^{-1}). This pasture type is dominated by species such as *Holcus lanatus* and *Trifolium repens* (De la Barra, 2008).

The Chilota sheep breed has particular genetic and phaneroptical characteristics. These characteristics reflect the agroecological and inbreeding history of the breed showing more rusticity than other breeds of sheep found in the Archipelago (Martínez et al., 2012).

To date, no studies investigating the grazing behavior or diet selectivity of Chilota lambs have been published. Particularly, in Chile, lambs have greater importance in meat production for human nutrition relative to ewes.

The hypothesis tested in this study was that Chilota lambs, because of their greater rusticity, can consume greater amounts of fiber-rich feed than Suffolk Down lambs. Accordingly, Chilota lambs would represent an alternative solution to the problem of uncontrolled bush encroachment in Chiloé. The main objective of this study was to identify the characteristics of the grazing behavior and diet selectivity (measured with microhistological technique and diet sampling) of Chilota lambs relative to Suffolk Down lambs during grazing on Calafatal in Chiloé. Also, diet selectivity of Chilota lambs was evaluated under grazing on two different forage type resources available in the Chiloé Archipelago, i.e., Calafatal and naturalized pasture.

2. Materials and methods

2.1. Location

The methodology used in this study was approved by the Committee for the Ethical Use of Animals in Experiments of the Universidad Austral de Chile. The experiment was conducted at the Butalcura Experimental Research Station (Chiloé, Chile) from October to December 2011. The experimental site consisted of 5 ha of Calafatal pasture and 5 ha of naturalized pasture.

2.2. Animals

Fourteen 2-month-old male lambs (and their dams), namely, eight Chilota and six Suffolk Down lambs (including no twins), with a live weight (**LW**, average $\pm$ SEM) of 14.36 ± 2.37 kg and a body condition score (**BCS**) of 2.71 ± 0.27, were randomly selected from a large free-grazing flock of Chilota and Suffolk Down sheep. The lambs were marked on their backs with an identification number. Although dams were estrus-synchronized using intravaginal hormone device (Eazi-Breed^{TM} CIDR®, Pfizer, New York, USA) and were born in a range of no more than 48 h, the most of the newborn lambs were females, being not possible to get more animals with the same characteristics (especially Suffolk Down lambs) for the experiment. Additionally, eight 2-month-old male Chilota lambs (and their dams, including no twins) with a LW of 15.59 ± 3.84 kg and a BCS of 2.96 ± 0.35, were randomly selected from the large free-grazing flock of Chilota sheep and were marked on their backs.

2.3. Treatments

The eight Chilota breed lambs and the six Suffolk Down breed lambs, and their dams, were allocated to graze on CP (separated by breed using mesh dividers), allowing comparing both breeds under the main secondary succession in the Archipelago. The remaining eight Chilota breed lambs were allocated to graze on NP, allowing comparing Chilota breed lambs under both types of secondary successions present in the Archipelago. As a result of technical decisions, these eight 2-month old male Chilota lambs were included in the diet selectivity experiment but not in the grazing behavior experiment. For all studies, each lamb represented an experimental unit.

2.4. Grazing management

From October to December, the animals were rotated through the five paddocks every 5 days in the CP because of the low DM availability (measured at soil level) during October, November and December 2011 (475, 584 and 763 kg ha^{-1}, respectively). In the NP, the animals were rotated through the five paddocks every 7 days because of the low DM availability in this pasture during October, November and December (574, 709 and 1018 kg ha^{-1}, respectively). Water was available to the animals at all times.

2.5. Botanical composition of pastures

At the beginning of each experimental period (October, November and December), a 1-ha experimental area of CP and a 1-ha experimental area of NP were selected from five 1-ha paddocks of each type of pasture. Three samples (consisting of 5 pooled subsamples each) cut to soil level (0.10 m^2 each) were taken from each 1-ha area in each experimental period. The botanical composition of each sample was determined at the Animal Production Institute of the Universidad Austral de Chile by separating the species by hand, drying each species separately (in an oven at 60 °C for 48 h) and weighing the dried material.

2.6. Chemical analysis

The chemical composition of each pasture type (CP and NP) was assessed from 3 composite samples obtained from each 1-ha area at the beginning of the experimental period. A chemical analysis was performed at the Animal Production Institute of the Universidad Austral de Chile to determine dry matter content (DM), crude protein (CP, AOAC, 1996), acid detergent fiber (ADF, AOAC, 1996), neutral detergent fiber (NDF, Van Soest et al., 1991) and metabolizable energy (ME). Metabolizable energy was estimated with a regression analysis using a "D" value (digestible organic matter/DM $\times$ 100) assessed *in vitro* (Tilley and Terry, 1963) according to Goering and Van Soest (1970).

2.7. Grazing behavior study

An adaptive period of 15 days was necessary to accustom the animals to the experimental conditions (removal from the flock) and to ensure that the lambs were completing the ruminant transition period and that they were able to select their own food. Each monthly grazing behavior assay was initiated on the fourth day after the animals entered the experimental paddock due to it was necessary to collect samples for microhistological analysis 5 days after the introduction of the animals to the pasture.

Data were collected by scan sampling every 10 min during daylight (from 09:00 to 21:00 h), and every 15 min at night (from 21:00 to 09:00 h). The evaluation was repeated once a month for the three consecutive months. The observations were made to identify the activities of the animals and were recorded manually. The percentage of time dedicated to each behavior during the 24 h period was calculated.

The ethogram for the activities recorded on the pasture was as follows: grazing (lamb consuming forage from pasture), standing (stance in which the lamb maintains its weight on his limbs without eating or ruminating), lying–ruminating (lamb lying and ruminating, which imply the regurgitation of the semi digested material, re chewing and saliva aggregation), standing–ruminating (lamb standing and ruminating), lying (lamb on sternal or lateral recumbency), walking (lamb moves forward in a two beat gait), browsing (lamb consuming leaves and branches from shrubs) and suckling (lamb makes udder contact to initiate nursing bouts, the behavior occurs between the lamb and its dam in order to obtain milk). Consistent with the findings of Olivares and Guzman (2005), drinking activity was sporadic during the experiment. For this reason, drinking behavior was not recorded.

2.8. Microhistological technique

Fecal sampling from all lambs (Chilota and Suffolk Down lambs grazing CP and Chilota lambs grazing NP) was conducted after 5 d grazing CP and NP. Samples were taken directly from the rectum and analyzed microhistologically to estimate the diet composition by identifying fragments of epidermis present in the stools (Castellaro et al., 2007).

Firstly, it was necessary to prepare a reference compilation of the epidermal patterns of the plant species present in each pasture. This procedure also involved the construction of a herbarium to prepare reference standards (Castellaro et al., 2007). The reference standards were obtained by scraping and sodium hypochlorite bleaching (in the case of grasses) and diaphanization (in the case of dicotyledonous herbs). The epidermis samples were fixed on a slide using glycerol gelatin mixed with phenol (Castellaro et al., 2007) and analyzed by optical microscopy (Olympus CX21 equipped with a 3.2-megapixel digital camera, at a magnification of $100 \times$ or $400 \times$) to obtain pictures of the epidermis.

Fecal samples were dried (in a forced air oven at 70 °C for 48 h), milled (sifted to 1 mm), bleached (sodium hypochlorite) and washed with tap water on a 140-mesh sieve. Subsequently, samples were mounted on a slide using glycerinated gelatin and phenol as the mounting medium. Five slides were prepared for each fecal sample. A total of 100 fields were evaluated under the light microscope at a magnification of $100 \times$. A field was considered valid for identification under the microscope if it had at least one identifiable plant species fragment (Castellaro et al., 2007).

The identification of the epidermal fragments present in the feces was performed by comparing the microscopic observations with pictures of the epidermal patterns based on the following characteristics: presence, frequency, shape, size and distribution of trichomes, shape of stomata; and presence or absence of other epidermal cells, such as siliceous or corky cells. The plant species identified were classified into five groups: grasses, graminoids, legumes, dicotyledonous herbs, ferns, shrub species and mosses.

The results of the microscopic observations were expressed in terms of relative frequencies. This measure is considered to represent a good estimator of the dry weight of mixtures of known composition. Subsequently, the frequency obtained for each plant species was transformed to density values using the tables proposed by Fracker and Brischle (1944).

2.9. Calculation of indices

Three different indices were calculated to compare diets and diet selectivity between both breeds (Chilota and Suffolk Down) grazing on Calafatal, and between both types of pasture (CP and NP), being grazed by Chilota breed lambs. Data used came from microhistological analysis of feces (representing the diet consumed) and from botanical composition of pastures (diet offered).

2.9.1. Similarity of diets

The Kulcynski index (**IS**) was calculated with data obtained from the microhistological analysis of feces. This index serves to compare the composition of the diets of two animals.

$$IS = \left[\frac{\sum_{I=1}^{n} 2 \times W_i}{\sum_{I=1}^{n} (a+b)_i} \right] \times 100$$

where W_i is the minimum of the two consumption percentages corresponding to the rates of consumption of a given plant species by two different animals, $(a+b)_i$ is the sum of the consumption percentages for the two animals, and n is the number of plant species.

This index ranges between 0 and 1, where 0 indicates completely different diets and 1 indicates completely identical diets.

2.9.2. Diversity index

A diversity index represents a quantitative measure of the richness of the diet. Diversity index values were estimated from the botanical composition of the diet of each animal by calculating the Shannon–Wiener diversity

index (H), expressed as relative diversity or evenness (J).

$$H = \sum_{i=1}^{n} (P_i)(\log_2 P_i); \; J = \frac{H}{H_{\max}}$$

where P_i is the proportion of species i in the diet, n is the number of plant species in the diet, $H_{\max}$ is the value of H if all of the species found in the diet had the same frequency, estimated with the equation $H_{\max} = \log_2 (n)$.

2.9.3. Selectivity index

To measure the degree of dietary selectivity shown by the animals, the tendency to select the principal plant species consumed was quantified by calculating the Ivlev selectivity index (Ei).

$$Ei = \frac{r_i - p_i}{r_i + p_i},$$

where r_i is the proportion of species i in the diet consumed (microhistological analysis of feces) and p_i is the proportion of species i in the pasture (botanical composition analysis).

The value of Ei ranges between -1 (rejection or negative selection) and 1 (preference or positive selection). $Ei = 0$ represents a random feed intake (random or in proportion to its abundance in the environment).

2.10. Statistical analysis

The data on the botanical and chemical composition of the pastures were analyzed with a repeated-measures ANOVA using the GLM procedure of SAS© statistical software. To quantify the association between the environmental temperatures and the behaviors occurring most frequently during the hours of observation, the results were presented in the form of descriptive statistics. Additionally, an ANOVA was applied to the data on grazing behavior at different time periods during the day (daytime and nighttime). This analysis was performed using the GLM procedure of SAS© statistical software. The behavioral data were also analyzed using logistic regression to estimate the odds ratio and to quantify the probability of occurrence of a given behavior. The fecal microhistology data were analyzed with a repeated-measures ANOVA with the GLM procedure of SAS©. The least mean squares were estimated and multiple range tests were performed to assess the significance of the observed differences between breeds.

To quantify the effect of the lamb breed on grazing behavior, the following linear statistical model was used:

$$Y_{ijk} = \mu + a_i + b_j + C_k + e_{ijk},$$

where Y_{ijk} is the amount of time that the kth lamb of the ith breed during the jth month was observed performing a given behavior, μ is the grand mean, a_i is the fixed effect of the ith breed, b_j is the fixed effect of the jth month, C_k is the random effect of the kth lamb and e_{ij} is the random residual term $\sim N (0, \sigma^2)$.

To assess the effect of the type of pasture on the occurrence of a given plant species, the following statistical model was used:

$$Y_{ij}k = \mu + a_i + b_j + e_{ijk},$$

where Y_{ijk} is the measured amount of a given plant species in the kth sample of the ith treatment during the kth month during the jth month, μ is the grand mean, a_i is the fixed effect of the ith type of pasture, b_j is the fixed effect of the jth month, and $e_{ij} =$ the random residual term $\sim N (0, \sigma^2)$.

To analyze the selectivity index and diversity index according to the lamb breed and pasture across months, a repeated-measures ANOVA was performed with the MIXED procedure of SAS and the UN model for covariances (best fit according to AIC). A Kolmogorov-Smirnov test was performed to assess the normal distribution of the error residuals, and Levene's test was performed to assess the homogeneity of variance.

3. Results

The number of plant species found during October, November and December was 21, 27 and 26, respectively, in CP and 12, 8 and 15, respectively, in NP (Table 1, summary table). Grasses were the most common plants in both pastures and increased in abundance from October to December. The highest contents of grasses ($P < 0.0001$) and legumes ($P < 0.001$) were found in NP, i.e., grasses such as *Anthoxanthum odoratum* and *Bromus aff. lithobius* ($P < 0.001$) and legumes such as *Trifolium repens* ($P < 0.0001$) (Table 1).

In CP, December had the highest CP, ME and NDF content compared with October and November (Table 2). In NP, December was the month with the highest values of NDF compared with October and November (Table 2).

In the grazing behavior study (incorporating an examination of the effects of environmental temperature), the principal activity observed during daylight (09:00–21:00 h) for the Chilota (Fig. 1A) and Suffolk Down lambs (Fig. 1B) was grazing (until 21:00 h). During this time, the temperature ranged between 8 and 12 °C. From 18:00 to 20:00 h, the temperature decreased, coinciding with a decrease in grazing activity. The principal activities observed at night (21:00–09:00 h) were lying and standing. During these hours, the environmental temperature ranged between 8 and 10 °C. Consistent with the findings of Olivares and Guzman (2005), drinking activity was sporadic during the experiment. For this reason, drinking behavior was not recorded.

The estimated odds ratio, including 95% confidence intervals, for the effect of breed on the behavioral pattern showed that the probability of finding Chilota lambs browsing was 1.84 ($P < 0.001$) times greater than that for Suffolk Down lambs. The other activities showed no significant differences.

During a 24-h period and at night (between 21:00 and 09:00 h), Chilota lambs showed longer browsing times than Suffolk Down lambs ($P < 0.05$) (Table 3A). During daylight, however, Suffolk Down lambs showed longer times for standing–ruminating activity than Chilota lambs ($P < 0.05$). The month of observation influenced standing, standing–ruminating, lying–ruminating and lying ($P < 0.01$) during a 24-h period, during the daylight hours (09:00–21:00) and at night (21:00–09:00 h). Moreover, the month of observation influenced grazing ($P < 0.0001$) during a 24-h period and during the daylight hours ($P < 0.0001$) and

Table 1
Botanical composition of Calafatal and NP during October, November and December (Summary table)[1].

LSM$_{SEM}$	Calafatal			Naturalized pasture			P[2]
	October (n=5)	November (n=5)	December (n=5)	October (n=5)	November (n=5)	December (n=5)	
Plant species							
Agrostis capillaris	$7.9_{0.7}$	$5.0_{0.8}$	$6.9_{2.1}$	$9.3_{0.5}$	$15.3_{4.4}$	$7.9_{2.2}$	ns
Anthoxanthum odoratum	$7.0_{1.4}^{ab}$	$7.6_{2.4}^{b}$	$26.6_{7.2}^{a}$	$8.5_{2.5}^{b}$	$33.7_{15.9}^{a}$	$35.9_{4.7}^{a}$	**
Bromus aff. Lithobius	$11.5_{1.2}^{ab}$	$4.6_{1.2}^{b}$	$16.4_{6.6}^{a}$	$35.9_{1.6}^{a}$	$25.9_{8.9}^{ab}$	$15.7_{3.7}^{b}$	**
Holcus lanatus	$3.9_{1.2}$	$4.1_{1.9}$	$14.3_{5.9}$	$12.4_{2.9}$	$11.7_{5.8}$	$22.2_{4.7}$	*
Grasses	$31.1_{0.2}^{b}$	$21.2_{3.3}^{b}$	$65.2_{14.9}^{a}$	$66.1_{2.9}^{b}$	$86.7_{3.2}^{a}$	$83.3_{1.3}^{a}$	***
Carex fuscula	$0.3_{0.3}$	$4.7_{2.4}$	$2.2_{1.7}$	–	–	–	nd
Eleocharis pachycarpa	–	$5.4_{2.5}$	$8.5_{8.5}$	–	–	–	nd
Juncus effussus	–	$1.6_{0.1}$	$3.3_{1.2}$	$16.0_{5.7}$	–	$3.9_{2.1}^{b}$	nd
Graminoids	$0.7_{0.7}$	$12.0_{4.6}$	$14.4_{11.5}$	$16.0_{5.7}$	–	$3.9_{2.1}$	**nd**
Lotus pedunculatus	$1.1_{0.6}$	$1.4_{0.2}$	$1.9_{0.1}$	–	–	$2.6_{1.8}$	nd
Trifolium repens	$1.57_{0.21}$	$1.12_{0.5}$	$1.6_{0.3}$	$0.1_{0.0}^{b}$	$0.19_{0.1}^{b}$	$3.3_{0.6}^{a}$	***
Legumes	$2.7_{0.6}$	$2.5_{0.5}$	$3.4_{0.3}$	$0.1_{0.0}^{b}$	$0.1_{0.2}^{b}$	$5.9_{1.4}^{a}$	**
Centella asiatica	$0.7_{0.4}$	$2.1_{0.8}$	$0.6_{0.6}$	–	–	–	nd
Plantago lanceolata	$1.7_{0.1}$	$16.4_{15.0}$	$2.41_{1.8}$	$0.31_{0.1}$	–	$0.29_{0.1}$	nd
Dicotyledonous	$6.7_{2.3}$	$24.2_{13.2}$	$7.7_{1.1}$	$0.6_{0.3}^{b}$	$0.2_{0.1}^{b}$	$3.7_{0.7}^{a}$	**
Blechnum penna-marina	$11.4_{2.4}$	$5.2_{1.8}$	$2.7_{1.4}$	–	–	–	nd
Total Ferns	$11.4_{2.4}$	$6.9_{2.8}$	$2.7_{1.4}$	–	$0.1_{0.1}$	–	**nd**
Berberis microphylla	$5.2_{2.0}$	$9.3_{4.0}$	$1.3_{0.7}$	–	–	–	nd
Shrub species	$8.9_{4.4}$	$9.9_{4.3}$	$1.6_{0.8}$	–	–	–	**nd**
Mosses	$1.0_{0.1}$	$1.7_{0.9}$	$0.5_{0.5}$	$1.2_{0.6}^{a}$	$0.4_{0.2}^{b}$	–	**nd**
Dry	$37.6_{1.8}$	$21.5_{9.2}$	$4.6_{0.6}$	$14.9_{3.9}^{a}$	$12.3_{2.9}^{a}$	$3.2_{0.7}^{b}$	***

[1] Different lower case letters (a, b, c) denote significant effect of the month within each pasture ($P < 0.05$).
[2] P denote significant differences between pastures (Calafatal and naturalized pasture), as a mean of three measurements performed during October, November and December in each pasture.
* $P < 0.05$; ns: no significant;
** $P < 0.001$; negative symbol (–): no-existing;
*** $P < 0.0001$; nd: no-determinable.

Table 2
Chemical analysis of Calafatal and naturalized pasture during October, November and December [1,2]

Pastures	Calafatal			NP			P[3]
Month LSM$_{SEM}$	October (n=5)	November (n=5)	December (n=5)	October (n=5)	November (n=5)	December (n=5)	
Item							
DM (%)	$27.96_{0.65}^{a}$	$28.28_{1.31}^{a}$	$20.17_{0.95}^{b}$	$19.35_{0.32}^{b}$	$21.55_{0.19}^{a}$	$17.48_{0.50}^{b}$	***
CP (%)	$15.64_{0.74}^{ab}$	$12.96_{0.61}^{b}$	$16.81_{0.44}^{a}$	$21.16_{0.29}a$	$18.42_{0.19}^{b}$	$17.25_{0.75}^{b}$	***
ME (mcal kg^{-1})	$2.32_{0.03}^{b}$	$2.34_{0.03}^{b}$	$2.57_{0.02}^{a}$	$2.64_{0.03}$	$2.63_{0.01}$	$2.66_{0.02}$	***
NDF (%)	$52.16_{0.88}^{a}$	$48.58_{1.12}^{b}$	$54.12_{0.45}^{a}$	$46.97_{2.80}^{b}$	$48.90_{0.33}^{b}$	$58.32_{0.45}^{a}$	***
ADF (%)	$27.53_{0.34}$	$25.54_{0.66}$	$27.44_{0.35}$	$22.52_{0.72}^{b}$	$25.25_{0.14}^{ab}$	$26.53_{0.76}^{a}$	***

[1] NP: naturalized pasture; DM: dry matter; CP: crude protein; ME: metabolizable energy; NDF: neutral detergent fiber; ADF: acid detergent fiber.
[2] Different small letters (a, b, c) denote significant effect of the month within each pasture ($P < 0.05$).
[3] Denote significant differences between pastures as a mean of three measurements performed during October, November and December in each pasture.
*** $P < 0.0001$.

influenced suckling ($P=0.01$) only during the daylight hours. In terms of the mean values calculated for the 3 months, the month of observation influenced grazing, standing, standing–ruminating, lying–ruminating and lying ($P < 0.0001$).

The grazing and standing–ruminating times increased from October to December (Table 3B). In October, the time spent standing and standing–ruminating was longer ($P < 0.05$) in Suffolk Down lambs than in Chilota lambs.

A

B
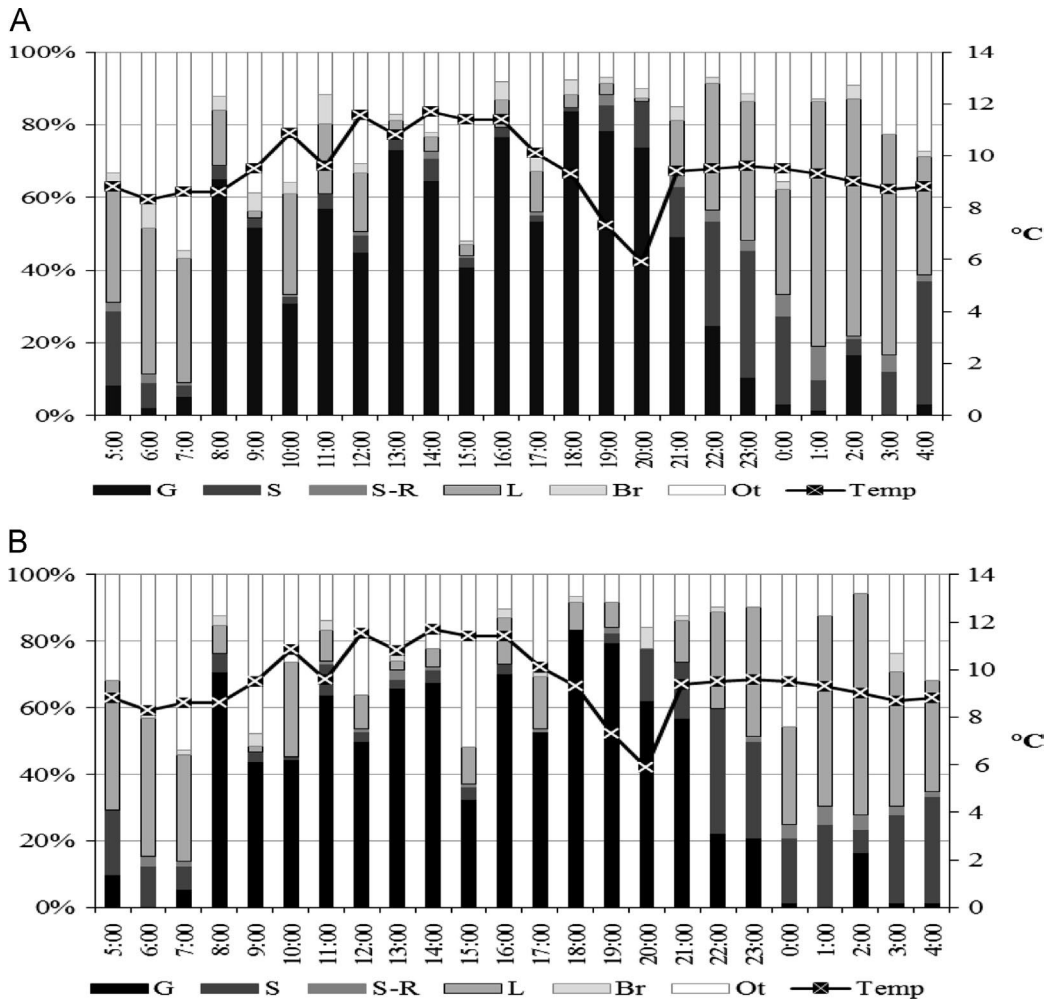
Fig. 1. Daily activities (% of whole activities) of Chilota (A) and Suffolk Down (B) lambs during three consecutive months (mean values), and air temperature; G: grazing; S: standing; S–R: standing–ruminating; L: lying; Br: browsing; Ot: Other activities (lying–ruminating plus walking plus suckling); Temp: air temperature.

However, lying time was longer in Chilota than in Suffolk Down lambs. In November, lying time was longer in Suffolk Down than Chilota lambs, but browsing time was longer in Chilota than Suffolk Down lambs (Table 3B). In December, no significant differences were found between breeds.

A microhistological analysis (Table 4, summary table) showed that the month of observation influenced the proportion of grasses ($P=0.04$) and dicotyledons ($P=0.002$) in the feces if the breeds were compared. However, the month of observation influenced the proportion of legumes ($P=0.0005$) and dicotyledons ($P=0.008$) in the feces if the pastures were compared.

Comparing breeds grazing on CP, the Suffolk Down lambs showed a higher content of dicotyledons and shrubs than the Chilota lambs. Comparing pastures, the Chilota lambs grazing CP showed a higher content of graminoids but a lower content of grasses, legumes, dicotyledons and shrubs than the Chilota lambs grazing NP. For all groups, the presence of grasses, such as *Agrostis capillaris* and *Anthoxantum odoraum*, in the feces was higher than the presence of other types of identified plant species. Chilota lambs grazing NP

showed higher percentages of grasses (during October and November) and legumes (during December) and lower percentages of graminoids (during October, November and December) in their feces than Chilota lambs grazing CP. During December, Chilota lambs grazing CP showed lower percentages of fern and shrub species than Suffolk Down lambs grazing the same pasture and Chilota lambs grazing NP.

Chilota and Suffolk Down lambs (grazing on CP) had similar diets throughout the months of study. Similarly, Chilota lambs grazing on CP and NP had similar diets (Table 5). Suffolk Down lambs showed a higher diet diversity than Chilota lambs ($P=0.03$), and the effect of month was also significant (Tables 5, $P=0.0003$). A significant pasture × month interaction was also found (Table 5, $P=0.0001$). The diet diversity was higher in CP during October and November and lower in December than in NP (Fig. 2A). The selectivity index calculated for grasses (the most heavily consumed plant group for all breeds, pastures and months, Table 5) showed that there was no difference between the breeds in diet selection.

Table 3A
Grazing behavior of Chilota and Suffolk Down (S. Down) lamb breeds, during 24 h, daylight (09:00–21:00 h), and night time (from 21:00 to 09:00 h) (A) and as a monthly mean during October, November and December (B) (LSM$_{SEM}$, Chilota, $n=8$; Suffolk Down, $n=6$)[1, 2]

Activity (min)	24 h		09:00–21:00 h		21:00–09:00 h	
	Chilota	S. Down	Chilota	S. Down	Chilota	S. Down
Grazing	534.79$_{34.16}$	536.39$_{32.48}$	422.92$_{28.01}$	413.89$_{31.90}$	111.88$_{11.69}$	122.50$_{11.36}$
Standing	147.71$_{32.71}$	162.50$_{49.02}$	15.83$_{3.74}$	18.33$_{6.45}$	131.88$_{30.91}$	144.17$_{43.96}$
Lying Rum	10.21$_{4.31}$	6.67$_{5.05}$	3.33$_{2.25}$	3.33$_{2.80}$	6.88$_{3.82}$	3.33$_{2.62}$
Standing Rum	265.21$_{47.62}$	286.67$_{58.79}$	134.58$_{8.20}$	148.33$^{*}_{7.17}$	130.63$_{42.30}$	138.33$_{55.94}$
Lying	393.13$_{55.10}$	367.50$_{60.37}$	92.50$_{32.92}$	86.67$_{28.31}$	300.63$_{41.54}$	280.83$_{60.20}$
Walking	43.96$_{9.20}$	49.72$_{9.69}$	22.08$_{6.16}$	28.89$_{6.84}$	21.88$_{6.25}$	20.83$_{7.32}$
Browsing	39.38$_{11.94}$	21.67$^{*}_{7.95}$	25.00$_{9.32}$	15.00$_{5.47}$	14.38$_{5.95}$	6.67$^{*}_{4.32}$
Suckling	5.63$_{2.35}$	8.89$_{3.81}$	3.75$_{2.03}$	5.56$_{2.88}$	1.88$_{1.79}$	3.33$_{2.62}$

[1] Results are the mean of three consecutive measures (one per month).
[2] Asterisk (∗) denote significant effect of lamb breed ($P < 0.05$).

Table 3B
Grazing behavior of Chilota and Suffolk Down (S. Down) lamb breeds, during 24 h, daylight (09:00–21:00 h), and night time (from 21:00 to 09:00 h) (A) and as a monthly mean during October, November and December (B) (LSM$_{SEM}$, Chilota, $n=8$; Suffolk Down, $n=6$).[1, 2,3]

Activity	Chilota			Suffolk Down			P[3]
	October	November	December	October	November	December	
Grazing	449.4$^{c}_{28.0}$	529.4$^{b}_{15.76}$	625.6$^{a}_{24.0}$	453.3$^{c}_{11.3}$	544.2$^{b}_{23.0}$	611.7$^{a}_{10.6}$	0.72
Standing	268.1$^{a}_{9.1}$	62.7$^{b}_{32.0}$	93.1$^{b}_{13.7}$	320.8$^{a*}_{8.1}$	64.17$^{c}_{7.7}$	102.5$^{b}_{15.1}$	0.37
Lying Rum	0.0$_{0.0}$	15.0$_{5.0}$	15.6$_{3.7}$	0.0$_{0.0}$	2.5$_{2.5}$	17.5$_{6.7}$	0.20
Standing Rum	128.8$^{c}_{5.4}$	231.9$^{b}_{16.7}$	435.0$^{a}_{14.6}$	156.7$^{c*}_{4.7}$	228.3$^{b}_{12.3}$	475.0$^{a}_{19.4}$	0.55
Lying	525.0$^{a}_{23.2}$	465.0$^{b}_{11.8}$	189.4$^{c}_{12.4}$	417.5$^{b*}_{8.8}$	508.3$^{a*}_{11.3}$	176.7$^{c}_{16.2}$	0.36
Walking	48.8$_{10.6}$	34.4$^{}_{9.7}$	48.75$_{7.2}$	58.3$_{5.8}$	47.5$_{12.5}$	43.3$_{5.4}$	0.86
Browsing	13.8$^{c}_{4.8}$	76.9$^{a}_{8.3}$	27.5$^{b}_{7.9}$	21.7$^{ab}_{2.9}$	32.5$^{a*}_{11.1}$	10.83$^{b}_{4.17}$	0.02
Suckling	6.3$_{2.6}$	5.6$_{2.2}$	5.0$_{2.5}$	11.7$_{2.3}$	5.6$_{3.6}$	2.5$_{2.5}$	0.22

[1] Different lower case letters (a, b, c) denote significant month effect ($P < 0.05$).
[2] Asterisk (∗) denote significant effect of lamb breed within the same month ($P < 0.05$).
[3] P value denote significant differences between breeds (mean of three months).

Comparing breeds, the greatest diet selectivity was found in November ($P < 0.0001$), whereas the lowest diet selectivity was found in December (Table 5). Comparing pastures, a significant pasture × month interaction was found (Table 5, $P < 0.0001$). Thus, strong selection was observed in CP during October and November, but the selectivity was near zero in CP during December and in NP for the 3 months (Fig. 2B).

4. Discussion

Traditionally, small herds of cattle and sheep graze in natural areas of Chiloé Archipelago. These shrubland and wooded areas are important not only for traditional livestock feeding but also for the conservation of biodiversity. However, good grazing management of these areas implies a prior knowledge of diet selection behavior because herbivores exert a major influence on vegetation composition through selective plant consumption. Only an unbiased use of all species in a community can maintain plant biodiversity under a high GI (Provenza et al., 2003).

Because sheep are highly social, their behavior may modify their selectivity, influencing not only the grazing area but also the plant resources (Sibbald et al., 2008).

Lambs, like the young of several other species, learn their grazing behavior and diet selectivity from their dams (Provenza and Balph, 1988). For this reason, our study was performed with 2-month-old lambs (at an age when they were able to find their food by themselves) and was completed when they were 4 months old.

In this experiment, lambs tended to graze steadily during the daylight hours. At times, this tendency was independent of the environmental temperature. Lin et al. (2011) evaluated the effect of different GI levels on the grazing behavior of fat-tailed sheep breeds and reported that two principal grazing periods occurred, a shorter grazing period in the morning and a longer one in the afternoon (Fierro and Bryant, 1990). The explanation of these findings was that ruminants prefer to consume food during the afternoon due to the greater digestibility of the forage compared with that of forage harvested in the morning (Burns et al., 2005). Olivares et al. (2009)

Table 4
Microhistological composition of feces (% DM) of Chilota and Suffolk Down lamb breed (after grazing a Calafatal) and Chilota lamb breed (after grazing a naturalized pasture) (Summary table).[1,2,3,4]

Month	October			November			December		
Pastures	Calafatal		NP	Calafatal		NP	Calafatal		NP
Breed	Chilota	S. Down	Chilota	Chilota	S. Down	Chilota	Chilota	S. Down	Chilota
LSM$_{SEM}$	(n=8)	(n=6)	(n=8)	(n=8)	(n=6)	(n=8)	(n=8)	(n=6)	(n=8)
A. capillaris	$18.5^b_{1.7}$	$11.6^c_{1.0}$	$27.5^a_{2.1}$	$17.6^b_{1.8}$	$19.8^b_{1.4}$	$32.1^a_{2.4}$	$29.6_{2.2}$	$23.3_{3.7}$	$32.2_{3.9}$
A. odoratum	$21.9^a_{1.6}$	$25.6^b_{2.0}$	$12.0^a_{1.5}$	$5.97_{1.0}$	$8.48_{1.4}$	$8.90_{1.7}$	$5.33_{0.9}$	$6.33_{0.4}$	$6.49_{1.7}$
B. lithobius	$0.5^b_{0.2}$	$0.6^b_{0.1}$	$4.2^a_{0.4}$	$3.3^a_{0.8}$	$0.5^b_{0.1}$	$2.7^a_{0.5}$	$2.3^b_{0.5}$	$2.6^b_{0.5}$	$6.5^a_{1.0}$
H. lanatus	$1.3_{0.4}$	$1.2_{0.2}$	$1.1_{0.2}$	$0.5^b_{0.1}$	$1.3^a_{0.3}$	$0.4^b_{0.1}$	$0.4_{0.1}$	$0.6_{0.3}$	$0.9_{0.2}$
Unidentified	$30.2_{4.5}$	$28.5_{1.7}$	$30.2_{1.6}$	$25.3^b_{2.4}$	$28.2^b_{1.4}$	$27.3^a_{2.5}$	$25.4^a_{1.9}$	$26.1^a_{4.7}$	$12.0^b_{0.8}$
Grasses	$\mathbf{79.2^b_{2.2}}$	$\mathbf{74.4^b_{3.2}}$	$\mathbf{87.7^a_{1.1}}$	$\mathbf{67.3^b_{4.6}}$	$\mathbf{71.3^b_{1.0}}$	$\mathbf{86.9^a_{0.8}}$	$\mathbf{87.5_{1.6}}$	$\mathbf{81.5_{2.4}}$	$\mathbf{82.6_{1.8}}$
C. fuscula	$0.7_{0.2}$	$0.9_{0.2}$	$0.4_{0.2}$	$2.2^a_{0.4}$	$2.6^a_{0.4}$	$0.3^b_{0.1}$	$0.9^b_{0.2}$	$1.7^a_{0.4}$	$0.4^b_{0.1}$
E.pachyc	$8.5^a_{1.8}$	$7.1^a_{2.0}$	$1.5^b_{0.4}$	$17.8^a_{4.8}$	$9.5^{ab}_{1.4}$	$0.6^b_{0.2}$	$3.9_{0.9}$	$4.2_{0.8}$	$2.0_{0.5}$
J. effussus	$0.4_{0.1}$	$0.3_{0.1}$	$0.1_{0.1}$	$0.2^b_{0.1}$	$1.7^a_{0.3}$	–	$0.6_{0.2}$	$0.2_{0.1}$	$0.3_{0.2}$
Graminoids	$\mathbf{10.8^a_{1.9}}$	$\mathbf{9.1^a_{2.3}}$	$\mathbf{2.3^b_{0.3}}$	$\mathbf{21.8^a_{5.1}}$	$\mathbf{16.1^a_{1.4}}$	$\mathbf{1.1^b_{0.2}}$	$\mathbf{6.4^a_{1.2}}$	$\mathbf{7.7^a_{1.2}}$	$\mathbf{3.4^b_{1.0}}$
L. peduncul	–	–	–	–	–	–	–	$0.1_{0.1}$	$0.3_{0.2}$
T. repens	$0.1_{0.1}$	$0.1_{0.0}$	$0.2_{0.1}$	$0.2_{0.1}$	–	$0.1_{0.1}$	$0.2^b_{0.1}$	$0.2^b_{0.1}$	$0.6^a_{0.1}$
Legumes	$\mathbf{0.1_{0.1}}$	$\mathbf{0.1_{0.1}}$	$\mathbf{0.2_{0.1}}$	$\mathbf{0.2_{0.1}}$	**–**	$\mathbf{0.1_{0.1}}$	$\mathbf{0.2^b_{0.1}}$	$\mathbf{0.3^b_{0.1}}$	$\mathbf{0.9^a_{0.1}}$
C. asiatica	$0.3_{0.1}$	–	–	–	–	$0.1_{0.1}$	–	$0.2_{0.1}$	–
P. lanceol	–	–	–	–	–	–	–	$0.1_{0.0}$	$0.1_{0.1}$
Unidentified	$2.2^b_{0.3}$	$3.0^b_{0.6}$	$6.9^a_{0.5}$	$4.5^b_{1.3}$	$4.5^b_{0.4}$	$9.8^a_{0.9}$	$3.5^b_{0.8}$	$4.2^b_{0.7}$	$8.4^a_{1.2}$
Dicotyl	$\mathbf{9.5^b_{1.9}}$	$\mathbf{15.5^a_{2.9}}$	$\mathbf{9.0^b_{0.7}}$	$\mathbf{9.2_{1.2}}$	$\mathbf{10.9_{0.7}}$	$\mathbf{10.5_{0.9}}$	$\mathbf{5.4^b_{1.1}}$	$\mathbf{8.6^{ab}_{1.5}}$	$\mathbf{10.9^a_{1.3}}$
B. penna-m	$0.4_{0.2}$	$0.6_{0.1}$	$0.6_{0.3}$	$1.6_{0.2}$	$1.6_{0.3}$	$1.1_{0.5}$	$0.4^b_{0.1}$	$1.1^a_{0.2}$	$0.7^{ab}_{0.3}$
Ferns	$\mathbf{0.4^b_{0.2}}$	$\mathbf{0.6^a_{0.1}}$	$\mathbf{0.6_{0.3}}$	$\mathbf{1.6_{0.2}}$	$\mathbf{1.6_{0.3}}$	$\mathbf{1.3_{0.5}}$	$\mathbf{0.4^b_{0.1}}$	$\mathbf{1.1^a_{0.2}}$	$\mathbf{1.13^{ab}_{0.3}}$
B. microphy	$0.1_{0.1}$	$0.4_{0.2}$	–	–	$0.1_{0.0}$	–	$0.1_{0.1}$	$0.1_{0.1}$	$0.28_{0.2}$
Shrubs	$\mathbf{0.1_{0.1}}$	$\mathbf{0.4_{0.2}}$	$\mathbf{0.1_{0.1}}$	**–**	$\mathbf{0.1_{0.0}}$	$\mathbf{0.2_{0.1}}$	$\mathbf{0.1^b_{0.1}}$	$\mathbf{0.9^a_{0.4}}$	$\mathbf{0.9^a_{0.3}}$
Mosses	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	$\mathbf{0.1_{0.1}}$

[1] Different lower case letters (a, b, c) denote significant effect of the treatment ($P < 0.05$).

[2] NP: naturalized pasture; S. Down: Suffolk Down; E. pachyc: E. pachycarpa; L. peduncul: L. pedunculatus; P. lanceol: P. lanceolata; B. penna-m: B. penna-marina; B. microphy: B. microphylla; Dicotyl: Dicotyledoneous species; negative symbol ($-$): no existing.

[3] P value between breeds (as a means of three measurements performed during October, November and December): Grasses: 0.44; Graminoids: 0.50; Legumes: 0.53; Dicotyl: 0.009; Ferns: 0.19; Shrubs: 0.01.

[4] P value between pastures (as a means of three measurements performed during October, November and December): Grasses: 0.005; Graminoids: < 0.0001; Legumes: 0.01; Dicotyl: 0.05; Ferns: 0.37; Shrubs: 0.01.

reported that the activities of sheep during the day were consistent with two peaks of grazing, one in the morning and another in the afternoon. In the present experiment, the continuous grazing activity observed during daylight could be explained by the small variation in environmental temperature over a narrow range of 9–12 °C.

Fasting (or in certain cases, a very low level of grazing activity at night) was followed by increased grazing activity during the day. At night, irrespective of the month, both breeds of lambs were standing, standing–ruminating or simply lying as a means of finding shelter. The lambs avoided grazing in the dark. This tendency could represent an attempt to decrease the risk of predation (Hessle et al., 2008) and could also help to conserve energy. These results suggest that the animals tend to synchronize their behavior (Gautrais et al., 2007), showing greater activity at dawn and dusk and less activity at midday or midnight. Sheep and goats grazing between 06:00 and 11:00 h showed peaks of grazing and ruminating during hours when the temperature was mild and peaks of resting during hours when the temperature was extremely high (De Moura Zanine et al., 2006; Olivares and Guzman, 2005; Olivares et al., 2009). In the present study, lying–ruminating occurred during the same daylight hours as grazing irrespective of environmental temperature. Lying and standing occurred during the hours of darkness.

Olivares et al. (2009), working with Merino and Suffolk Down sheep and Boer goats in a wheatgrass pasture, studied grazing behavior for 3 consecutive days in 3 plant phenological stages (vegetative, reproductive and dry). In all stages, the principal activity recorded was grazing, a finding consistent with those reported by several authors (Caris, 2004; Olivares and Guzman (2005); Schlecht et al., 2006). In this case, the differences observed were not between sheep breeds but between sheep and goats.

The time spent browsing during a 24-h period was longer in Chilota lambs than in Suffolk Down lambs as a result of the significant difference between breeds in browsing time at night. This result can be explained by adaptations of the limbs (differences between breeds in the

Table 5
Similarity of diets, average Diversity index and average Diet Selectivity index for lambs of Chilota and Suffolk Down breeds (after grazing a Calafatal) and Chilota lambs (after grazing a naturalized pasture).[1,2]

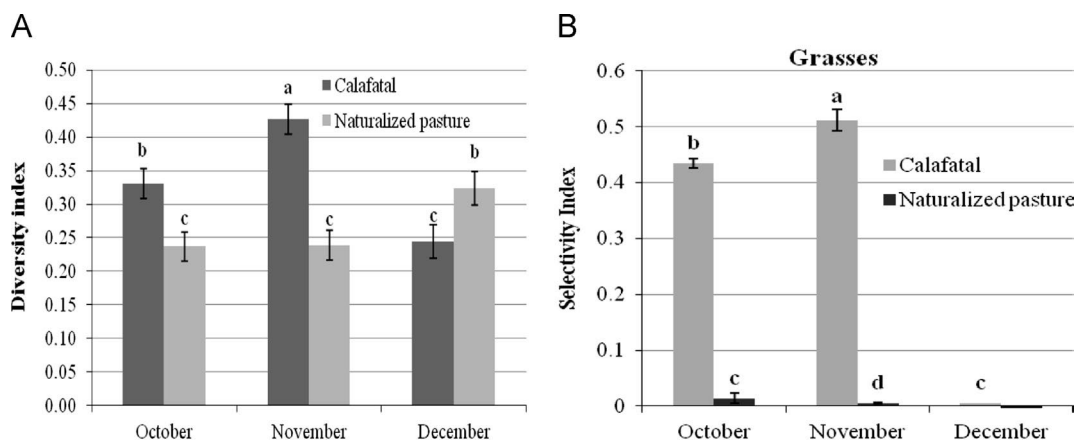| Similarity index			October		November		December	
Chilota/Suffolk Down			0.936		0.942		0.940	
Calafatal/Naturalized pasture			0.911		0.879		0.922	
Diversity index	Chilota	Suffolk Down	Oct	Nov	Dec	Breed effect	Mo	Int
Between breeds	$0.34^{B}_{0.01}$	$0.39^{A}_{0.02}$	$0.36^{b}_{0.02}$	$0.43^{a}_{0.02}$	$0.29^{c}_{0.02}$	*	***	ns
	Calafatal	NP	Oct	Nov	Dec	Pasture effect	Mo	Int
Between pastures	$0.34^{A}_{0.02}$	$0.27^{B}_{0.02}$	$0.29_{0.02}$	$0.33_{0.02}$	$0.28_{0.02}$	*,***	ns	***
Selectivity index	Chilota	Suffolk Down	Oct	Nov	Dec	Breed effect	Mo	Int
Between breeds	$0.36_{0.01}$	$0.35_{0.01}$	$0.42^{b}_{0.01}$	$0.53^{a}_{0.01}$	$0.13^{c}_{0.01}$	ns	***	ns
	Calafatal	NP	Oct	Nov	Dec	Pasture effect	Mo	Int
Between pastures	$0.36^{A}_{0.01}$	$0.04^{B}_{0.01}$	$0.28_{0.01}^{a}$	$0.26_{0.01}^{a}$	$0.07^{b}_{0.01}$	***	***	***

[1] NP: naturalized pasture; Mo: month; Int: interaction.
[2] Different capital (A, B) and lower case (a,b,c) denote breed and month different means, respectively.
* $P < 0.05$.
** $P < 0.001$.
*** $P < 0.0001$; ns: no significant.

Fig. 2. Diversity index (A) and Selectivity index (B) for Chilota sheep breed, during October, November and December, grazing on Calafatal and naturalized pasture.

relative weight and size of the cannon bone) that facilitate grazing on locally occurring poor-quality forage. Sheep are also able to select shoots and woody species, which characterize bushy and shrubby habitats (Rogosic et al., 2006). Therefore, the high ME content and the low NDF values reported for shrubs, such as *Berberis microphylla* (calafate), the principal plant species occurring in CP and, thus, the species with the highest availability for consumption (De la Barra, 2008), facilitate their use by sheep as an alternative food and also represent a solution to the problem of bush encroachment (due to inadequate grazing intensities) in the Chiloé Archipelago.

In both breeds of sheep, the grazing times increased from October to December in accordance with the increased forage availability in both CP and NP.

During the daylight hours, the standing–ruminating time was greater for Suffolk Down lambs than for Chilota lambs, but this behavior did not reflect previous longer grazing or browsing times. Indeed, the probability of browsing was greater in Chilota lambs than in Suffolk Down lambs.

Following grazing, the presence of an arboreal and shrub layer could be a decisive influence on browsing or standing–ruminating behavior in both lamb breeds, protecting them from environmental changes. Caris (2004) observed sheep with or without shrubs (*Acacia caven*) present in their environment. For these animals, the most important activity within the day was eating, and the presence of a tree layer as a source of protection influenced the occurrence of drinking, resting and walking. Other factors, such as the type of day (sunny or cloudy) or the physiological condition of the animal, also determine the amount of time spent on each activity, with grazing the most important activity reported (Hirata et al., 2008).

Based on the monthly observations, the Chilota lambs showed longer lying times than the Suffolk Down lambs during October. In contrast, the Suffolk Down lambs showed longer lying times than the Chilota lambs in

November. The reason for these differences was that the Chilota lambs spent a longer time browsing, resulting in a decrease in lying time. Most likely, the basis for this finding was that the nutritional quality of the bushes during November was greater than that in December. Monthly measurements indicated an increase in grazing times in both lamb breeds and a decrease in lying times (especially in the Chilota lambs) from October to December. Therefore, the greatest grazing time was recorded in December, indicating that the lambs of both breeds preferred to consume herbaceous plant species rather than shrubs.

Lin et al. (2011) have reported that sheep increase or maintain their grazing time by decreasing resting time to avoid the effect of shorter days. The same effect was observed in the present study, as daylight and the supply of pasture increased from October to December. Additionally, the values reported for grazing during daylight hours were higher than those reported by Lin et al. (2011) in fat-tailed sheep breeds during a daylight period (16 h) with a GI of 4 (moderate grazing); the values were lower than those obtained with a GI of 5 (heavy grazing).

The microhistological results of the feces were consistent with the botanical composition of each pasture. Chilota lambs grazing NP showed a higher content of grasses, legumes and dicotyledons in their feces than Chilota lambs grazing CP, most likely due to the higher abundance of these plant groups in NP than in CP.

The presence of certain plant species in the feces, including *Acaena ovalifolia*, *Agrostis capillaris*, *Leontodon taraxacoides* and *Leucanthemum vulgare*, is consistent with the botanical composition of grasslands exposed to heavy rainfall, as in the Chiloé Archipelago (De la Barra 2008). Shrubs represent the primary forage resource in CP. However, although the Chilota lambs grazing CP showed longer browsing times (and browsing probabilities) than the Suffolk Down lambs grazing CP, the Suffolk Down lambs showed a greater shrub species content in their feces than the Chilota lambs grazing CP.

Although the composition of the diet was similar between breeds and between pastures, the richness of plant species in the diet (measured by the diversity index) was greater in CP due to the presence of a greater number of plant species (especially grasses) in this pasture than in NP. The botanical composition data showed that grasses were the principal plant vegetable species in both pastures during the study. Castellaro et al. (2009) have evaluated the degree of dietary similarity and the diversity of diet in Merino and Suffolk Down breeds and concluded that both breeds consumed similar diets. However, the degree of overlap between diets was high, suggesting that competition between these breeds may have occurred. In the present experiment, the diet selectivity index showed a decrease in the selection of grasses by lambs grazing CP, most likely due to the increase of grass species in CP during December (from 31.1 in October and 21.2% in November to 65.2% in December). The almost zero selectivity showed by Chilota lambs grazing NP (over the 3 months of study) can be explained by the greater availability of forage (Animut and Goetsch, 2008), primarily grasses, which constituted more than 60% of the DM in

pasture during October and more than 80% of the DM in pasture during November and December. Moreover, no relationship was found between the selectivity index and the chemical composition of the pastures.

Lastly, the parameters examined in this study could affect meat production. Based on our findings on the botanical composition of the lamb feces and the grazing selectivity of the lambs, strong influences could be expected on the fatty acid profile of different adipose muscle tissues and, therefore, on meat quality.

5. Conclusion

Under the conditions of this study, grazing behavior differed between the daylight hours and nighttime and was also influenced by the month of observation. In terms of diet selectivity, grasses were consumed most heavily by both lamb breeds; shrubs were consumed least heavily even though they were predominant in CP. Although the composition of the diet was similar between breeds and between pastures, the month of observation influenced the proportions of plant species in the lamb feces. The richness of plant species (particularly grasses) and their selective consumption was higher in CP than in NP.

In summary, Chilota and Suffolk Down lambs grazing CP showed similar grazing behavior. The browsing time of Chilota lambs was longer than that of Suffolk Down lambs, but the shrub content in the feces of the Chilota lambs was not greater than that of the Suffolk Down lambs.

Conflict of interest statement

None.

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