Chapter

# Magallanes Sheep Farming

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## Abstract

The Magallanes region in Chilean Patagonia encompasses 13 million hectares with approximately 3.6 million used for agricultural and livestock systems. This portion is located to the east of the Andean Mountain chain in the rain shadow zone, with annual precipitation increasing along an east to west gradient from 200 to almost 1,000 mm. To fully describe sheep farming in the Magallanes region, many topics need to be addressed, including sheep production and management, existing vegetative communities, livestock-wildlife interactions, and economic diversification into agritourism and another sheep industry products. All these give shape to the story of the development of sheep farming in Magallanes, which is important at the regional and national level. Three key points are identified that together can lead to a successful future for the industry: sustainable management, human resources and the market.

**Keywords:** Chilean Patagonia, sheep production, grazing systems, fodder crops, artificial insemination, breeding, meet quality, wool production, sheep cheese, wildlife, animal welfare, agritourism

## 1. Introduction

The first sheep were brought to the Magallanes region from Chiloe in 1845 as a food source for the region's new human settlements. The Magallanes governor encouraged the development of a larger sheep industry, which began in January 1877 with the arrival of the first Cheviot sheep from the Falkland Islands (Malvinas). Progress in Magallanes throughout the last 145 years has transformed the region into the most important sheep farming area of Chile via the development of both, meat and wool production. In the last 20 years, improvements have been realized through a strategic use of management techniques (strategic feeding, grazing, soil fertility, water supply, crossbreeding and brush control) and new technologies (plow machinery, direct drilling, artificial insemination, embryo transfer, dietary supplement formulation, satellite imagery, silage baling, and electric fence) that have enhanced both, process efficiency and product quality, forward to sustainability management.

To understand the different aspects of sheep farming and its development within the socioeconomic and environmental context of the Magallanes region, this chapter covers topics including location, climatic conditions and main characteristics of the livestock use area, common grazing management systems,

locally-adapted fodder crops, artificial insemination, the main breeds (Corriedale, Merino mainly and meat crossbreed), breeding, lamb meat quality under different grazing regimes, wool management, lactation curve and cheese production, animal welfare, sheep-wildlife interactions, and rural tourism.

## 2. Geographical area and weather

The Magallanes region corresponds to an extensive territory located in the extreme south of Chile and the South American continent, encompassing the meridional section of Patagonia and the occidental part of the Isla Grande de Tierra del Fuego, and the numerous archipelagos that make up a strip adjacent to both parts, ending in the south with the Cape Horn archipelago. The region extends from 48° 40′ to 56° 30′ south latitude (the greatest latitudinal amplitude in Chile), covering an area of 132,033.5 km$^2$ (**Figure 1A**) [1]. The region is characterized by a marked physical contrast, generating different geological, orographic and climatic zones, which determine high amplitude in terms of vegetation types [3]. Likewise, there is a pronounced gradient of precipitation from west to east, going from more than 5.000 to less than 200 mm per year respectively [4, 5]. These characteristics make it evident that, in Magallanes, the territory of the eastern section is the most suitable for human life, and that is where the cattle activity has been established since 1870 [1, 6].

The livestock use area is located mainly in the eastern section of the Magallanes region, extending between 50° 36′ and 55° 19′ south latitude and 67° 2 'and 73° 47' west longitude, covering a surface area of 35,962.6 km$^2$ distributed mainly in the provinces of Magallanes, Tierra del Fuego and Ultima Esperanza (15,577.9, 13,502.2 and 6,559.9 km$^2$ respectively). With less representativeness and in the southernmost distribution lies the livestock territory of the Chilean Antarctic province with 322.5 km$^2$

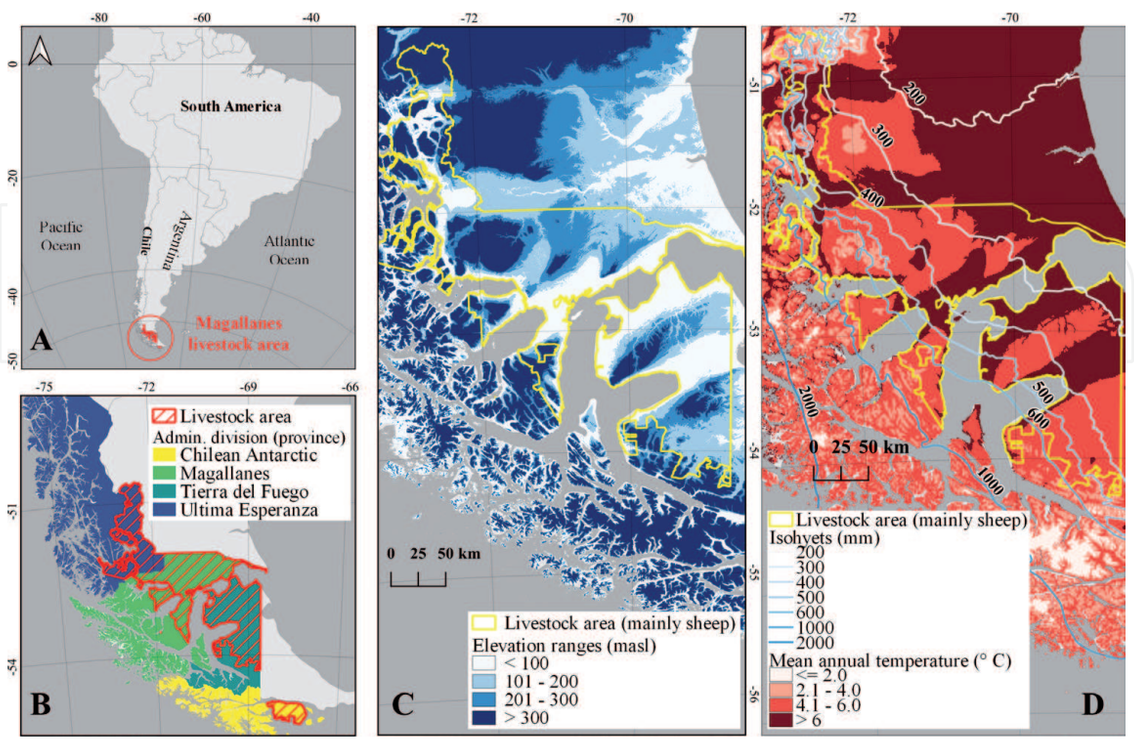


**Figure 1.**
*Cartographies of the area of livestock use in the Magellan region. A: General location. B: Livestock use according to administrative division. C: Elevation ranges. Source: Own elaboration from ASTER GDEM digital elevation model. D: isohyets (mm·year$^{-1}$) and isotherms (annual mean ° C) (prepared by author based in Ref. [2]).*

(**Figure 1B**) [7]. The livestock use area can be divided into three provinces from north to south (the area corresponding to the Chilean Antarctic province is not considered in this analysis). The first section located in the Ultima Esperanza province presents spatial and topographic patterns different from the other sections (Magallanes and Tierra del Fuego), corresponding mainly to a transition strip between mountain ranges and the eastern plains, characterized by plateau sectors crossed by mountain chains with heights that rarely exceed 1000 masl (**Figure 1B**). The Magallanes and Tierra del Fuego sections present similar characteristics, beginning with a western sub-Andean transition strip that gives way to extensive eastern plains, corresponding to mainly flat territories, with low elevations and moderate undulations (**Figure 1C**) [3].

According to [8], from a climatic point of view, based on Koppen classification, this area can be defined as a trans-Andean climate with steppe degeneration in its western fringe and a cold steppe climate in the eastern plains sector. In the former, we can find annual average temperatures ranging from 2.6 to 6.6° C, while in the cold steppe climate the annual average temperatures can range between 4 and 7.4°C (**Figure 1D**) [2, 8]. On the other hand, the area of interest is located in the sotavento zone (east) of the Andean Patagonian mountain range, which despite presenting spatial discontinuities in its southern distribution, is the main geographical feature of the region and forms an orographic barrier that generates local climatic changes [5, 9]. This is how rainfall in the livestock use area can drop from approximately 600 mm to less than 200 mm per year in the direction of the Atlantic coast in the sections of Magallanes and Tierra del Fuego, while in Ultima Esperanza the rainfall ranges from 1,000 mm to 300 mm in the same direction W-E (**Figure 1D**) [2].

The marked variation in rainfall in the area of livestock use is reflected in the present vegetation, which could be categorized into three ecoregions: the Patagonian steppe, the deciduous Magellan forest and evergreen forest, but the latter have a small participation. The dominates the sub-Andean region, is present in the three provinces of the area of livestock use, characterized by associations of *Nothofagus pumilio* (lenga) and also including forests of *Nothofagus antarctica* (ñirre) and associations with *Nothofagus betuloides* (coihue de Magallanes) in the most humid sectors [3]. It is worth mentioning that in this ecoregion and specifically in the area of livestock use, there are extensive areas of forests that were formerly burned with the purpose of enabling land for livestock [10] and that today are known as naturalized grasslands. Dominating the area of the eastern plains, we find the Patagonian steppe, defined as a hard grass community without the presence of trees [8]. The characteristic specie of this ecoregion in Magallanes is the tussock *coiron* (*Festuca gracillima*), which may be present to different degrees of dominance or even absent in some cases. In this ecoregion, three large types of communities can be distinguished: a) natural grasslands, made up of coiron grasslands, vegas (mesic grasslands) and saline grasslands, b) scrublands, represented mainly by *Chilliotrichium diffusum* (romerillo) and other species less distributed and c) heaths (sub-shrubs), where *Empetrum rubrum* (murtilla) stands out [11]. It is important to highlight that 91.8% (24,434.2 $km^2$) of the Patagonian steppe area present in Chile is located in the livestock use area of the Magallanes region and the Chilean Antarctic [11].

## 3. Grazing systems in Patagonian grasslands

The soils in the grazing fields in the region de Magallanes in Southern Chile are glacial and fluvio-glacial, with sandy-loam and loam-clay-sandy textures and a shallow surface soil horizon with mid to high organic matter content. The soils classification is dominated mainly for mollisols, but also histosols, inceptisols, espodosols and aridisols. Mineralization is very slow, implying severe nitrogen deficiency, also

phosphorus and sulfur are limiting factors; pH values range from west to east from less than 4.8 rising to 7.7 where topography favors humidity and the accumulation of salts [11]. The photoperiod in summer is 12–14 hours/day, favorable for most long-day grasses. Dominant vegetation includes 32.7% of native shrubs and tussock grasses (*Chiliotrichium diffusum – Festuca gracillima*); 26.9% of tussock and naturalized grasslands (*Festuca spp, Poa spp)*; 12.2% of dense shrubs (*Ch. diffusum-Empetrum rubrum*) and 16.5% forests (*Nothofagus pumilio*). Sown and improved pastures (*T. repens; D. glomerata; Festuca spp)* comprise 2.5% of the total area, and about 5% is scattered highly productive humid areas or wetlands (also called vegas) of glacial and morrenic origin (graminoids). The mean nutritive value of native grasslands is low (roughly less than 9% protein and 8.75 MJ EM/kg DM) but selectivity and seasonal variations allow an extensive grazing system sustaining at present over 1,570,000 sheep [12] and 100,000 cattle [7].

### 3.1 Patagonian grazing systems

Sub-Antarctic rangelands were originally dominated by dense high tussocks (*Festuca sp.)* and less palatable shrubs. However, after the onset of the sheep industry, stock numbers rose to about 3 million by mid-20th century [13] and the grazing vegetation community shifted, first towards short tussocks and an inter-tussock cover of dense, low stature grasses and geofites, and later towards growing patches of invaders such as *Taraxacum sp., Agrostis sp., Aira sp.* or *Hieracium sp.* and even bare soil following the humidity gradient. In contrast, wetlands are dominated by more palatable species [14, 15] with higher growth rates in comparison to the sites dominated by *F. gracillima* [16].

The extensive grazing management in Patagonia (Magallanes region in Chile and Southern Patagonia in Argentina) is defined as a seasonal continuous grazing system, with summer set-stocking on paddocks above 150 m of altitude. Early on, grazing was adapted for wool production, a productive system with lower nutritional demand. The productive system has since shifted towards meat production, increasing the nutritional requirements of sheep due to the pregnant ewe and lamb raising [17]. Considering an estimation of dry matter consumption by an ewe of 50 kg live weight raising one lamb is around 650 kg DM year$^{-1}$.

The Sub-Antarctic rangelands (also called coironales) have an herbage mass production between 33 and 1439 kg DM ha$^{-1}$ year$^{-1}$ (depending on edaphoclimatic condition and grazing management) and are dominated by *F. gracillima* [16], a low palatability tussock species with low nutritional value that does not fulfill the minimum requirements of energy and protein for sheep maintenance and growth [18]. By comparison, wetlands or valley greens in Magallanes represent just 5% of the total productive surface with herbage mass production that ranges from 500 kg DM to 11,000 kg DM ha year$^{-1}$ [16, 19]. These differences are due to the wetland's intrinsic properties [14, 20] and poor farm organization to do not separately fence wetlands from the less productive sites (rangelands dominated by *F. gracillima*), leading to overgrazing due to continuous use, and increasing the heterogeneity within and between paddocks due to selective grazing [21], increasing the risks of soil erosion and ecosystem degradation for both rangelands and wetlands. Therefore, due to their difference in growth potential, rangelands dominated by *F. gracillima* need to be managed from an extensive management approach whereas wetlands are more adapted to an intensive use [17].

#### *3.1.1 Continuous grazing system*

Extensive pasture size and large herd numbers (thousands of animals), combined with the climatic conditions and cultural traditions, have led to seasonal

continuous grazing being the most common livestock production management approach. This extensive management system is characterized by large paddocks of hundreds of hectares, designed to separate stock categories rather than to target defoliation periods. The defoliation period is determined by season, sheep physiological periods and location of the grazing sites. In sub-Antarctic rangeland, snow cover determines when and where herds graze. The grazing year is split in two periods, with summer grazing from December to May in wetlands or sites with altitudes of 150 m above sea level or greater. Winter grazing occurs from May to December in lower altitude sites with a more favorable temperature range during the coldest months [17, 22]. Winter grazing generally overlaps with lactation and postpartum periods [22, 23].

Even though the disadvantages of continuous grazing in highly productive livestock systems are clear, in low-producing rangelands, the disadvantages are more ambiguous. It has been indicated in medium and long-term experiments [24] continuous grazing with the correct stocking rate, calculated based on herbage mass production, is an effective way to control desertification and achieve good animal performance [24, 25]. However, it is recognized that continuous grazing can increase heterogeneity [25] and weed invasion [26] on overgrazed sites.

Sheep actively select preferred species based on plant phenology (tender shoots and new regrowth, flowers and fruits) thus, in continuous grazing management, sheep overgraze the more palatable material, under grazing or leaving untouched older shoots. Recommended grazing practices imply an even, controlled defoliation height, followed by a specific regrowth period. The latter is supported by physiological plant research performed in several species [27–31], suggesting that, independent of the grazing system or ecosystem evaluated, vegetative species, particularly forage species, depend on energy reserves to regrow following defoliation [32] and to survive after drought periods [33]. Thus, selectivity must be avoided through careful estimation of grazing pressure. This requires more, smaller paddocks of similar vegetative communities, and strict control of grazing frequency. Animal nutrition must be considered, since enforcing the consumption of low nutritive value material may not be tolerated by younger or pregnant sheep. Modifying the traditional system is a major task implying qualitative and quantitative changes in both labor and mind set.

### *3.1.2 Rotational grazing*

For rotational grazing to be performed, it is necessary to improve farm organization and increase the number of paddocks, separating different vegetative communities, such as wetlands, rangeland and forests, to avoid the negative effects of seasonal continuous grazing [21]. Several types of rotational grazing have been proposed for rangeland grazing management, however, as sheep reproductive phenology has to be considered [23], two of them could be applied in the Magallanes region: 1) rotational deferred grazing; 2) traditional rotational grazing with a high animal density [17, 24, 25].

Rotational deferred grazing: In this system, each paddock is rested for a full year at some point in a multi-year rotation to allow species recovery and reseeding [24] and to recover ecosystem resilience after years of defoliation [25]. There are no clear results in animal performance when rotational deferred grazing is compared to continuous grazing [24]. Furthermore, [25] indicated that in Moy Aike Chico, there were no important differences between a rotational deferred grazing system and continuous grazing in terms of animal production.

Traditional rotational grazing: There have been a few examples in the region with different frequencies and intensities. However, high intensity grazing is not

recommended in rangeland settings due to the diminishment in animal performance and the low durability of the rangeland [24]. Grazing with low intensity and short duration at an experimental level (Experimental station Leleque, Southern Patagonia) showed an improvement in animal performance, however, the low growth rates during winter together with a low precipitation, mains factors that limit the herbage growth in Patagonia, meant the resting periods would not be long enough for forage species to recover [25]. There is not enough evidence of the benefits of rotational grazing over continuous grazing in ecosystems with low potential growth under a proper stocking rate [24, 25, 34]. However, rotational grazing showed benefits over continuous grazing in sites with high potential growth such as in sites with higher rainfall or wetlands.

In 2004 a rotational experiment with lambs was carried out on a wetland in Tierra del Fuego. The wetland was excluded from the rest of the paddock and regenerated by direct drilling (zero tillage) with a mix of species including *Lolium perenne*, *Festuca arundinacea*, *Dactylis glomerata*, *Trifolium repens* and *Plantago lanceolata* at a seeding rate of 28 kg $ha^{-1}$ of grasses and 8 kg $ha^{-1}$ of broadleaf species. Nitrogen, phosphorus, potassium and sulfur were applied at 46–46 – 22 – 22 kg $ha^{-1}$, respectively. The original botanical composition evaluation identified *Azorella trifurcata*, a creeping plant without livestock value, as the dominant species. The natural grassland reported an average gross protein value of 40 g $kg^{-1}$ in. After four seasons, the trend of dry matter production was analyzed. In the first year, approximately 1035 kg DM $ha^{-1}$ were produced, and the annual average for the next three years was no more than 3600 kg DM $ha^{-1}$ while the natural grassland in the exclusion zone (5 hectares) produced up to 700 DM kg $ha^{-1}$ annually during the four seasons. In the last season, lamb liveweight gain after one month of rotational grazing (stocking density of 80 lambs $ha^{-1}$) was 2.05 kg per lamb $moth^{-1}$, significantly higher than the gains in the traditional grazing system (1.39 kg per lamb and a stock density of 2 lambs $ha^{-1}$).

### 3.2 Future perspective

Modification of the traditional management is imperative to stop the depletion of the ecosystem functioning caused by sheep overgrazing in the Magallanes region. Ecosystem parameters such as vegetation, soil and water have to be considered to reach a sustainable productive system. Remote sensing technologies are an excellent tool for planning and evaluating changes in paddock grazing duration and timing, where University of Magallanes has developed this technology with use of satellite image in the agricultural area of the region from 2003. Also, the study of soil microbiology is an incipient area in development and could be an excellent assistance for soil fertility and grassland production. Efforts to shift the traditional paradigm from a sole focus on animal condition and performance to one that includes ecosystem functioning exist [35]. However, controlled experiments have to be performed to determine the necessary resting periods for the recovery of the rangeland and wetland vegetation, soil and water parameters.

## 4. Fodder crop

Livestock production in Magallanes depends on rangelands as the main source of food [36]. However, rangeland vegetation alone cannot meet sheep nutritional requirements, especially during peak nutritional demand (for example, the third trimester of pregnancy) [37]. Although wetland areas can provide food in quantity and quality, these are in a state of progressive degradation or are not capable

of sustaining an acceptable production throughout the year due to erratic forage production. Since the beginning of sheep production in the region, farmers have seen the need to establish forage crops as a hay source, during critical physiological periods and harsh weather, or for grazing with the objective of increasing lamb weights before slaughter.

Establishment and development of sheep farming began in the Magallanes region during the second half of the 19th century. Large land concessions by the State and investment from private companies allowed the growth of the sector in the southernmost region of Chile [36]. Establishment of forage crops should be considered within its historical context.

In 1976, the Magallanes region had around 248,504.6 ha of sown grasslands, which could be divided between annual crops and permanent grasslands [38]. Ten years later, there were between 104,878 ha [39] and 194,185 ha [40], which were based on the use of forage mixtures such as cocksfoot (*Dactilys glomerata*), common velvetgrass (*Holcus lanatus*), white clover (*Trifolium repens*), monophytic grasslands of common velvetgrass, alfalfa (*Medicago sativa*), *Festuca rubra* and *Agropyron elongatum*. Although the Tierra del Fuego Livestock Society planted 10,000 ha year$^{-1}$, today the vast majority are missing or in a state of degradation [41].

Current numbers indicate that there are no more than 6,039.2 ha of forage crops, of which the vast majority is alfalfa. However, [42], estimates that there are currently around 9,800 ha of alfalfa in the region. This is because state subsidy programs that begun in 2004 have allowed ranchers to establish fodder crops. Sowing grasslands is a necessity on the part of the agricultural sector and the area devoted to forage crops has been increasing. Although there is a wide range of species and cultivars on the market, only a few are able to establish themselves and produce desired yields due to edaphoclimatic conditions.

Among the most adaptable species are oats (*Avena sativa*) as the main annual crop and alfalfa and mixed meadows (mixes of cocksfoot -*Dactylis glomerata*-, tall fescue -*Festuca arundinacea*- and white clover –*Trifolium repens*) as permanent meadows. There are two different establishment methods for perennial plantings in Magallanes: a) traditional tillage; b) zero tillage by direct drilling. This last method is unique, but its effectiveness depends on site conditions such as species competition, soil humidity and soil depth. Some examples of typical direct drilling in the region are alfalfa on tussock steppe (without use of herbicide) and mix of grasses with white clover on meadows.

Rainfall during the growing season strongly influences yields since regional production is based on dryland systems with no irrigation, but there is an incipient advanced irrigation technologies as center pivot in Tierra del Fuego. The current varieties of oats have yields that can range between 5,000 and 10,000 kg DM ha$^{-1}$ [43, 44]. Other annual crops such as hybrid rye can produce between 8,000–12,000 kg DM ha$^{-1}$ [45]. Cocksfoot can yield from 3,000 to 7,000 kg DM$^{-1}$ in the third year from the establishment, while tall fescue can produce 4,000–6,000 kg DM ha$^{-1}$.

Without a doubt, alfalfa is the main forage crop in the Magallanes region. This species is preferred because of its ability to establish itself in the vast majority of the soils and climatic districts of Magallanes (**Figure 2**). Fall dormancy level 3–4 varieties capable of going into dormancy in the autumn-winter months are used. At least three years are required for the crop to enter full production, increasing forage production from 400 kg DM ha$^{-1}$ [46] in the first year to a potential of 12,000 kg DM ha$^{-1}$ [47].

Management of forage crops in Magallanes is based, normally, on cutting for hay or silage during December and January. In March and April, following regrowth, fields are grazed in order to increase the weight of lambs before slaughter.

**Figure 2.**
*Fodder crop of Alfalfa in Torres del Paine, Magallanes region (Image by Jorge Ivelic-Sáez).*

## 5. Artificial insemination

Farm productivity depends on each sheep producing at least one lamb each year. The use of natural service during the breeding period is the most common practice in commercial Magallanes farms. However, since the 1970s, artificial insemination (AI) has been part of the production system, especially in stud farms, in order to accelerate the genetic progress and the production of flock replacements (males and females).

### 5.1 Artificial insemination: a productive tool

AI has been used mainly in genetic and selection programs, in order to improve the commercial traits of interest [48]. For dual purpose breeds such as Corriedale, increasing fleece weight, reducing fiber diameter, and augmenting lamb weight at weaning are normally the traits to be improved via introduction of animals with a higher genetic value [49]. In Merino animals, fleece weight and reduced fiber diameters are the main selection traits. Among the different alternatives, intracervical AI using fresh semen is the most widely used AI technique.

#### *5.1.1 Preparing the animals for artificial insemination with fresh semen*

Selection of males is the first step in AI programs. Regardless of the origin (self-produced or acquired from a sheep stud farm), rams will be selected according to their phenotypic and productive characteristics. Genital tract soundness, evaluation for brucellosis (*Brucella ovis*), and conformation of legs, hoofs, and mouth, are normally checked by the farmer at least one month before the onset of the reproduction season. A good body condition and body weight will also be checked prior to the AI program as it influences the reproductive efficiency of animals [50], particularly prolificacy in Magallanes [51]. Similarly, females selected as recipients will be checked for body condition and any health issues, paying special attention to age, teeth, mouth and udder conformation and soundness.

### *5.1.2 Estrus synchronization protocols*

Different estrus synchronization protocols are used in Magallanes selected based on factors such as labor, cost and efficiency. Although some producers may use the natural estrus, two options of synchronization are commonly utilized. The first one is the use of prostaglandin analogs in one or 2 doses, separated by 11–12 days [52]. The second one uses progestogens in the form of sponge pessaries or CIDR devised, used for 11 to 14 days available in the market with estrus concentration of 90% of the animal in 81 h after sponge withdrawal [53]. A protocol using equine chorionic gonadotrophin (eCG) hormone at the time of CIDR withdrawal is normally used to improve ovulation rate and fertility [54].

### *5.1.3 Artificial insemination facilities in Patagonia*

Due to cold weather conditions, the use of indoor facilities is highly recommended. The basic infrastructure is a room for semen extraction, with a head stock for a female in heat, and a lower area for the personnel to have a better access to the ram penis. Lubricant gel, warmed water and artificial vagina for practicing, are the basics for obtaining semen. After semen collection, quality evaluation (e.g., volume, concentration, motility, etc.) and dilution takes place. This occurs in the lab area, where room temperature is maintained between 20 and 25°C. Access to the sheep in heat is through a window located at the height of the vulva, with the operator standing in an insemination pit in the floor of the lab and barn, and the ewes will be transported in a trolley with wheels on rails.

### *5.1.4 Fresh semen artificial insemination*

Regardless of the synchronization protocol, the use of teaser rams helps in the identification of ewes in heat. Teaser rams are painted with a mix of edible oil and colored soil in a ratio of 2 liters of oil per 1 kg of soil. The use of a harness with a crayon has been previously evaluated, however; special attention must be paid to crayon selection, since temperatures below 0°C, which are normally observed during the winter, interfere with a good painting of ewes in heat. The mix with oil must follow a soil color gradient, starting with light colors and finishing with dark ones (e.g. yellow, red, blue and finally black) as this allows the identification of animals in different reproductive cycles, which normally lasts between 14 to 17 days.

Females are normally taken into the yards once a day, early in the morning. Those ewes showing a clear rump mark are separated, while those not presenting heat returns to the paddock with the teaser rams. Ewes in heat are artificially inseminated in the afternoon. However, in order to increase pregnancy rates, two checks in the day are recommended, early in the morning and in the afternoon, with ewes being artificially inseminated in the afternoon and the following morning, respectively. Every two or three days, the painting of the teaser rams is redone.

Fertility rates between 60 and 70% can be achieved with this method [48]. During AI the ear tag of each of the ewes is recorded, in addition to ram number and day and time of AI. After AI, ewes are maintained in a quiet place, with access to food and water, before being taken to their paddock. The use of dogs during all process is normally restricted in order to reduce stress in the animals, which could affect fertility.

### *5.1.5 Frozen semen artificial insemination*

Sometimes, the farmer has the opportunity to import frozen semen from different countries (e.g., New Zealand and Australia due to their good sanitary status, similar to Magallanes). If this is the case, the use of intrauterine laparoscopic AI is the best course of action, with the use of eCG (200–300 IU) as a complementary management, to increase ovulation rate and the number of twins, with higher expected genetic potential. Fertility with frozen semen has been calculated to be over 70% [55].

### 5.2 Management concepts associated to artificial insemination

Good animal nutrition before and after AI reduces stress, and the farmer needs to consider forage quantity and quality, as well as access to water. Ultrasound pregnancy diagnosis is performed 90 days after AI, in order to check for fertility, but more importantly, to identify single- from twin-bearing ewes. Hence, the latter can be supplemented with a high protein (22%) concentrate to reduce lamb mortality at birth [18], which, under Magallanes environmental conditions, can range from 22 to 62%, being higher in twins [56]. All these managements contribute to increased AI success in Magallanes, making the system more productive and sustainable.

## 6. Breeding, breeds, and management of sheep production system in Magallanes

Since the second half of the 19th century, the establishment and development of sheep ranching began in the southernmost region of Chile, Magallanes. Large land concessions by the State, and an important commitment from private companies allow an accelerated growth of this industry, being sheep an intrinsic part of the local culture until today.

Natural rangelands in the world, which largely dominate the geography of Magallanes, are those areas used mainly for grazing because they cannot be cultivated. In these large rangelands, the grazing system is "extensive", not only in the sense that it is carried out over large areas, but also because level of inputs, and management of animals is relatively low, with a stocking rate around 0.8 sheep equivalent $ha^{-1}$.

### 6.1 Animal and natural resources

The sheep population in Chile is 2,037,516 heads and the 77.1% is located in Magallanes (1,571,056), the southern region of Chile [12]. In this area, sheep production is the most important, and almost the only agricultural industry. It has been developed for the last 145 years (**Figure 3**).

Corriedale is the main breed and represents 55% of the regional stock, just as a purebreed. Some operations have introduced different Merinos, as Australian Merino, MPM (Multi Purpose Merino, developed by an Australian stud, and imported for some breeding seasons into Magallanes), 4 M (Marin Magellan Meat Merino, developed by Marin family in a big sheep operation, from MPM and other Merino lines, and registered officially as the first local purebreed), and most important in recent years the Dohne Merino, and crosses during the last three decades. Because of the increasing value of meat in the total income of sheep business, it is common to see terminal cross use, typically with Suffolk rams but also some Polled Dorset, Texel, and White Suffolk. The regional average weaning percent is below 80%.

Breeding season is in fall, and lambing in spring. The extensive management system with very low inputs, low human intervention, and changing annual climatic conditions leads to erratic results.

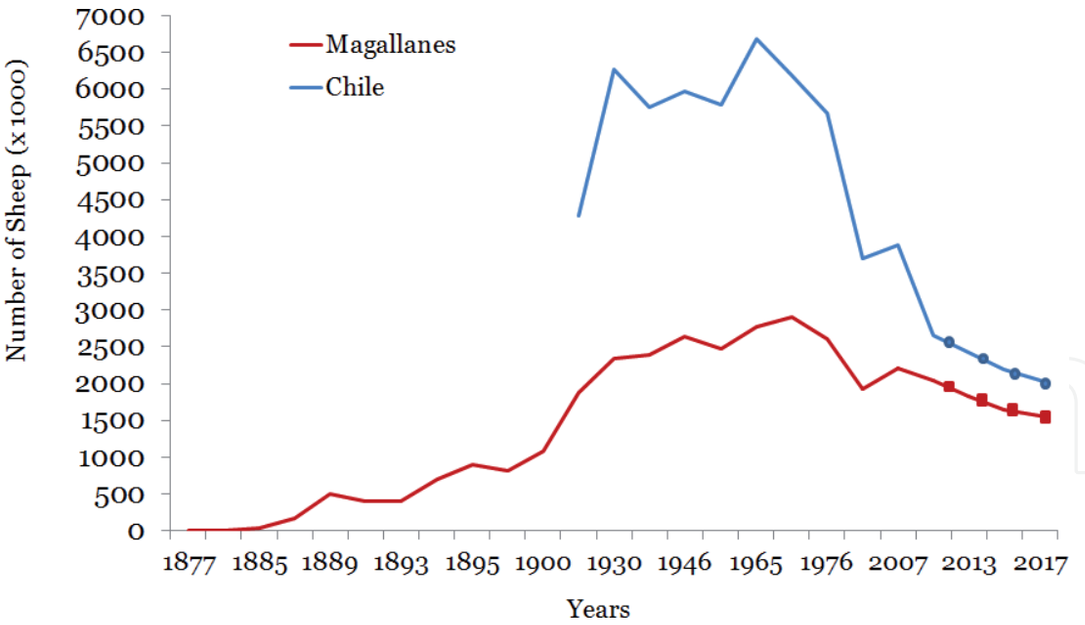


**Figure 3.**
*Number of sheep in Chile and Magallanes region. Dots in red and blue lines counting data between VI to XII region and farms with higher than 60 sheep [7, 12, 13, 38, 39, 57].*

Land is owned by medium to large producers. The most common situation are flocks with over 4,000 sheep. The meat and wool market is well developed in Magallanes and strongly oriented to exportation. The region has the potential to increase sheep numbers by at least 30% based on increased production estimates from improving 600,000 ha. of rangeland [58].

### *6.1.1 Management*

Sheep production has traditionally been dual purpose; producing wool and meat, with a carcass average weight for lamb increasing from 10.8 in 1987 to 14.1 in 2020, meanwhile the market is targeting 14 to 16 kg [35].

In this scenario, meat, which at one time in the past was considered a by-product of the wool-focused Magellan sheep industry, today drives the income of sheep

**Figure 4.**
*Herding sheep from summer to winter range, Tierra del Fuego (Image by Oscar Strauch).*

ranching in the region. Furthermore, San Isidro Farm (Canepa family) in conjunction with INIA Kampenaike introduced three races of hair sheep (White Dorper, Dorper, Katahdin) in 2012 with a high meat performance.

Sheep operations are based on year-round grazing of private land, with incipient use of strategic supplementation. Most ranches own summer range and winter on separate range (**Figure 4**). Over half do pre-lambing shearing, and lambing is on pasture at springtime.

## 7. Meat quality

The Magallanes region is not only recognized for its natural parks, such as Torres del Paine, but also for the vast pastoral landscapes and extensive sheep farming developed in this unique environment. The main product is lamb meat, which is exported to different countries, predominately in Asia (China: 45%) and the EEC (Italy: 12%) [59].

Magallanes lamb meat is a grass-fed product that normally comes from young animals (4 to 5 months of age), with an average carcass weight of around 13 kg, raised on natural pastures and maintained, in general, with their mothers until mark time. This gives them a mix of milk and grass nutrition which results in a very interesting product quality. Studies developed by INIA (Agricultural Research Institute), have demonstrated that lamb meat from Magallanes has on average 21% protein content, and a total fat content of 6.4%, which is lower compared to other type of meats. When considering the intramuscular fat (2.5%) and cholesterol (53 mg/100 g), this product may be considered as lean. Tenderness is another remarkable attribute of Magallanes lamb meat, with Warner-Bratzler shear-force results of 1.75 kgf, which positions it as a very tender meat. In addition, it has a similar content for SFA (2900 mg/100 g) to other meats, but a higher PUFA content (628 mg/100 g), compared to some reports in beef. However, the n-6/n-3 ratios (1.3 mg / 100 g) and conjugated linoleic acid (CLA; 25 mg / 100 g) contents represent values that are considered good and desirable from a nutraceutical point of view [60].

### 7.1 The role of Magallanes lamb meat in human nutrition

The meat of lamb produced in Magallanes is characterized for having a high content of iron (Fe) and zinc (Zn). The average content of Fe for lamb meat in the three different areas of production in Magallanes is 3.9 mg/100 g of meat. This value is significantly higher compared to other meats (**Table 1**). Similar results are observed for Zn content which, with an average of 4.5 mg/100 g of meat, is superior to the Zn content described for other meats (**Table 1**).

| Meat | Fe | Zn |
|---|---|---|
| Magallanes lamb | 3.9 | 4.5 |
| Foal | 3.3 | 2.4 |
| Lamb | 2.3 | 2.4 |
| Chicken | 0.8 | 1.3 |
| Beef | 1.9 | 4.0 |
| Pork | 0.9 | 2.1 |

**Table 1.**
*Iron and zinc levels in meat from different species (mg/100 g) [61, 62].*

Iron is well known for its role in human health and disease, where deficiencies may result in anemia, leading to functional impairments, affecting cognitive development, immunity mechanisms, work capacity, learning ability, and are associated with increased rates of morbidity. Deficiencies during pregnancy may result in higher risk of sepsis, maternal mortality, perinatal mortality, and low birth weight [64]. According to the WHO [65], the iron requirements of 97.5% of individuals, in terms of absorbed iron, are higher in menstruating women (2.38 mg/day), 12–16 year-old girls and boys (2.02 and 1.92 mg/day, respectively), and lactating (1.31 mg/day) and pregnant woman (1.14 mg/day). Therefore, Magallanes meat lamb consumption is an excellent source for these groups to cover their daily iron requirements.

An adequate intake of zinc has critical impacts for human homeostasis, immune function, oxidative stress, apoptosis, and aging. A deficiency, even mild, may lead to arteriosclerosis and anemia [66]. The recommended daily dietary zinc requirement is estimated at 15 mg/day [67, 68]. The consumption of Magallanes lamb meat could certainly help cover this recommendation. In conclusion, the high content of iron and zinc, the low n-6/n-3 ratio and high CLA content, low cholesterol, and tenderness, make Magallanes lamb meat a healthy food with desirable organoleptic characteristics.

## 8. Wool production

Magallanes was an adequate location for extensive sheep production when wool was a commodity of worldwide importance. Historically, wool was bought in bulk directly on the farm through private deals, but since the 1980s the system has evolved to prices defined by proper conditioning and bale sampling for wool fineness (**Table 2** and **Figure 5**).

Almost the entire wool crop is exported to a world market dominated by China. The wool exportation of Magallanes 50 years ago was 13,000 tons [70], but decreased to 5000 tons in the 2017 season [57]. **Table 2** shows the price evolution to higher values while wool stocks have simultaneously trended down in recent years with a mean yield of 65% for Standard Wool Company [63] and Agropat[1].

Industry trends towards lamb production and fine wools has changed traditional management from extensive grazing with the dominant Corriedale breed, focused on medium fineness wool production (24.5–31.5 μm and 4.0 kg fleece weight per ewe), to more intensive grazing systems based on dual purpose breeds, focused on lamb production and finer wools. Evaluation and breeding programs to meet shifting market demands have been proposed for different resources availability. In Magallanes there are some Corriedale studs grouped in the Corriedale Breeders Association: El Kark (Kroger family); America (Cardenas family); Jerónima (Vilicic family); Avelina (Menendez family); El Trébol (Maclean family); Tehuel Aike (Almonacid family); Chañarcillo (Gutierrez family); Las Vegas (Retamal family); Maria Isabel (Cavada family)[2].

In Magallanes two new Merino crosses breeds have been registered in the past ten years: 4 M Merino (Marin Magellan Meat Merino – Tres Chorrillos farm by Marin family) and PRM (Patagonian Robertson Merino – Tres Hermanos farm by Robertson family), both aiming for finer wool (17–22 μm) and heavier lambs, while maintaining the hardiness of Corriedale. For another side, Dohne Merino has been introduced successfully in the region by Hugo Vera in 2004 (Josefina farm), and has

[1] Cecilia Cavada, Agropat Ltda, Punta Arenas.

[2] https://www.asogama.com/los-planteles; Peter Maclean (El Trébol) and Cecilia Cavada, Agropat Ltda.

| Season | Greasy Wt. | Yield | Clean Wt. | Clean price | Greasy Price |
|---|---|---|---|---|---|
| | M.T. | % | M.T. | US$ | US$ |
| 1998/9 | 5362 | 62 | 3324 | 1.43 | 0.89 |
| 1999/0 | 6723 | 64 | 4303 | 1.47 | 0.94 |
| 2000/1 | 6530 | 65 | 4245 | 1.58 | 1.03 |
| 2001/2 | 5551 | 64 | 3553 | 1.80 | 1.15 |
| 2002/3 | 5852 | 66 | 3862 | 2.88 | 1.90 |
| 2003/4 | 5432 | 66 | 3585 | 3.10 | 2.05 |
| 2004/5 | 5714 | 65 | 3714 | 2.66 | 1.73 |
| 2005/6 | 5808 | 63 | 3659 | 2.25 | 1.42 |
| 2006/7 | 5943 | 64 | 3804 | 2.37 | 1.52 |
| 2007/8 | 6208 | 65 | 4035 | 2.84 | 1.85 |
| 2008/9 | 4920 | 65 | 3198 | 2.29 | 1.49 |
| 2009/10 | 5558 | 65 | 3613 | 3.34 | 2.17 |
| 2010/11 | 4789 | 65 | 3113 | 4.55 | 2.96 |
| 2011/12 | 4324 | 65 | 2811 | 6.08 | 3.95 |
| 2012/13 | 4534 | 65 | 2947 | 5.37 | 3.49 |
| 2013/14 | 4682 | 65 | 3060 | 5.54 | 3.62 |
| 2014/15 | 4557 | 65 | 2951 | 5.63 | 3.65 |
| 2015/16 | 4923 | 64 | 3130 | 5.43 | 3.45 |
| 2016/17 | 4421 | 63 | 2793 | 4.80 | 3.03 |
| 2017/18 | 4866 | 64 | 3102 | 6.15 | 3.92 |
| 2018/19 | 4570 | 65 | 2971 | 8.00 | 5.20 |
| 2019/20** | 2524 | 65 | 1641 | 5.67 | 3.69 |
| 2020/21** | 2749 | 65 | 1787 | 3.50 | 2.28 |

*M.T. = metric tons. **In these seasons, many farmers did not sell their wool production for low prices, because of the pandemic situation.*

**Table 2.**
*Price, yield, and wool stock purchased by Standard Wool Cia. from 1998 to 2021 [63].*

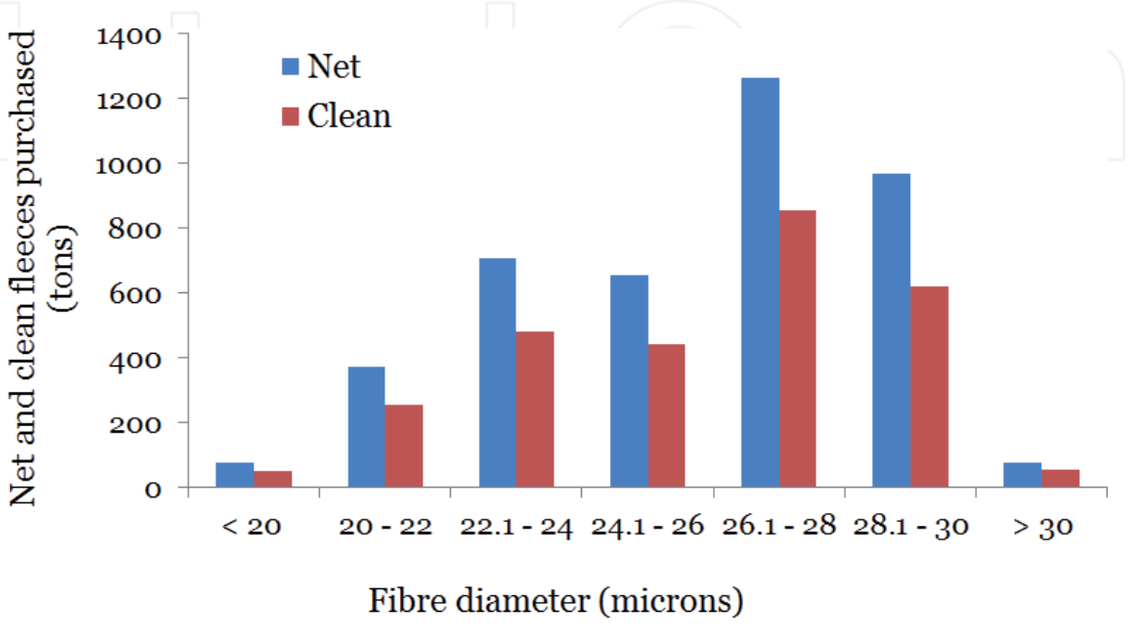


**Figure 5.**
*Net and clean wool purchased according to fleeces fibre diameter (season 2018/2019) [69].*


**Figure 6.**
*The traditional shearing process in Magallanes, different process stages from A to J. (Image by Sergio Radic S.).*

resulted in higher profitability on some farms in comparison to traditional breeds [71]. **Figure 5** show fleeces fibre diameter for one season, highlighting the range 26.1 to 28 microns as the main diameter in the region.

Shearing practices have also changed to include two options: (a) traditional timing of post-lambing shearing from the end of December to February; (b) pre-lambing shearing in late August and September. The pre-lambing shearing with positive results in lamb marking, lessened ewe mortality [69] and cleaner fleeces [35], this management arrived late in 80′ by the farmers Carlos García and Ivo Robertson. The tally-hi shearing method used in Magallanes was upgraded by New Zealand technicians. The shearing process starts with animals separated in a corral (**Figure 6A**) into different categories, and then they are moved into the shed (**Figure 6B** and **C**). Subsequently the sheep are sheared (**Figure 6D** and **E**), fleeces are cleaned on a table (**Figure 6F**) and placed into the wool press (**Figure 6G**) to build the bale (**Figure 6H**), and finally the wool bales are placed all together where each one has a note with a description of wool type and farm name (**Figure 6I**) and the ewe is released to outside (**Figure 6J**).

## 9. Lactation curve and cheese production

There is one dairy sheep operation that was set up as a pilot program in the 1990s by the University of Magallanes (coordinated by Sergio Kusanovic) in the city of Puerto Natales (Chilean Patagonia). The program uses East Friesian sheep (from

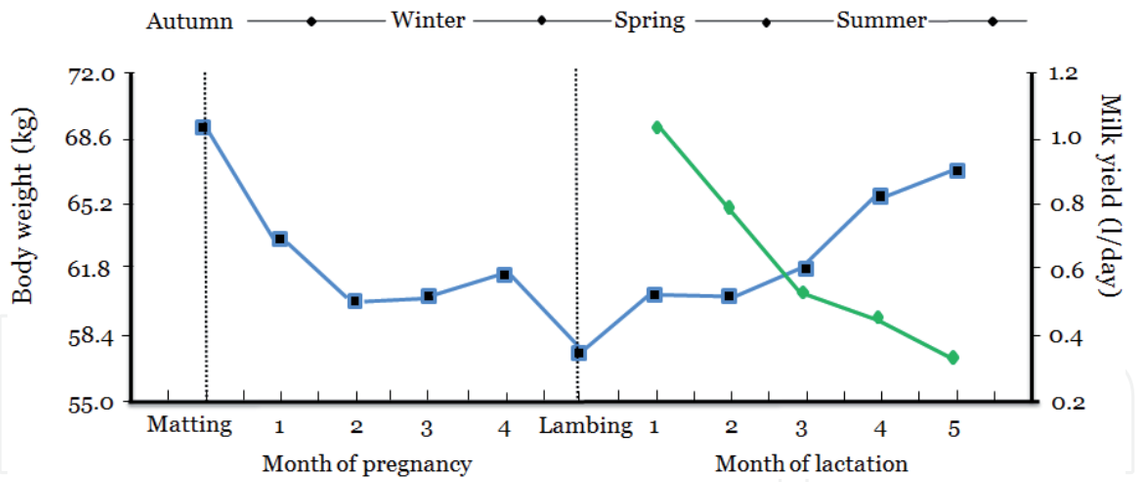


**Figure 7.**
*Milk yield (dotted green line) in lactation period and body live weight (solid blue line) during the year of East Friesian sheep [72].*

Bolson city in Argentina) and was developed with the goal of cheese production at a local scale. The lactation curve (**Figure 7**) and cheese production is based on grassland grazing and strategic supplementation with 200 g $d^{-1}$ of commercial concentrate (15% CP; 2.6 Mcal EM kg $DM^{-1}$) from flushing two weeks prior to breeding through the breeding period. The sheep are fed under a grazing system in the first 100 days of pregnancy. For the last 50 days of pregnancy, 400 g DM $d^{-1}$ of alfalfa hay is supplemented [73]. Because the nutritional management is mainly by grasslands, it is a way to develop organic farming, a production method with a specific market focus on products of premium quality and high standards [72].

The feed ration and body reserve are very important inputs for adequate milk yields in dairy sheep at the end of pregnancy and during lactation. For the latter, in systems that base their feeding management on grasslands, body weight at pregnancy, lambing and lactation may be considered indicators of animal nutritional status and body reserve level.

This initiative developed by the University of Magallanes produces the southernmost cheese of Chile. The higher concentrations of fat, total solids and protein (6.2%), present in sheep milk compared to goat (3.4%) and dairy cattle (3.2%), result in high yields in the production of dairy products [74]. There is a possibility to generate a brand image with this kind of cheese in the Chilean Patagonia. The commercialization of sheep cheese in Magallanes traditionally corresponds to consumers of foreign origin, but also markets to gourmet stores, hotels or restaurants, where there is the highest consumption [75].

## 10. Best livestock practices and animal welfare in Magallanes

In a highly globalized world characterized by increasing demands by the large international markets, the Magallanes region has some intrinsic advantages, including its geographical location, associated with characteristics of extensive production that allow for reducing the risks associated with animal welfare. Although this system minimizes human-animal interactions (limited number of operations and/or contacts)[3], livestock should be managed and overseen by capable personnel to ensure the correct execution of management and create a positive human-animal interaction.

[3] At least three times per year, for operations (shearing, branding, and breeding).

Although the concept of welfare refers to a state of physical and mental health where the animal is in complete harmony with the environment that surrounds it [76], today we focus on "one health", a concept that entails good management and animal care that leads to good human health and positive collateral outcomes, both economic and social [77].

Animal welfare today is structured on five fundamental domains: adequate nutrition and water availability, health and disease prevention, good environment and provision of opportunities, behaviors and freedom to express them, and finally, mental state, which is determined by the experience of the four former domains, logically resulting in both negative and positive parameters. The complex part for extensive production systems is to find the right moment(s) to apply practical, quick, valid, reliable, and repeatable measuring techniques (direct and indirect indicators, based on the resources or the animal, to evaluate its state and condition) to generate an accurate picture of sheep production today in the Magallanes region.

In order to ensure a livestock sector that is both sustainable and adheres to both national (Law Chile 20380, decree-law numbers 28–29-30) and international requirements, rules, and regulations, the sheep industry, farms and livestock personnel are slowly but satisfactorily developing changes in some practices, especially those related to animal handling and painful procedures (tail docking, castration), where the Good Livestock Practices manual is one of the first to be generated on this subject in the region. It is essential today to have plans that allow for storage of adequate food and water supplies, constant health monitoring, and adequate facilities to minimize and facilitate animal handling in delicate procedures such as transport, herding, and shearing, among others, as well as allowing the manifestation of both natural and normal behaviors during production processes.

Finally, it is highly recommended that the personnel working in production units know and understand the concepts related to sheep management and production, which will result in adequate competence, minimizing risks, injuries and potential processes that generate negative effects in the production chain.

## 11. Sheep farming and wildlife interactions in Magallanes

The relationship between wildlife and animal production involves ecological interactions such as competition for foraging resources and space, and predation [78]. Wildlife-livestock interactions are mostly assumed to be detrimental to human economic activities, leading to wrong attitudes and prosecution of wild species in areas of coexistence with livestock [78]. The situation of sheep ranching in Magallanes is not different; sheep either compete with wild herbivores or are killed due to carnivore predation. Therefore, producer views towards wild species are generally negative [79, 80]. However, despite the economic importance of sheep production in Magallanes, studies about sheep interactions with wildlife are rather scarce, with more information from Argentinean Patagonia [81, 82].

When sheep ranching arrived in southern South America in the late 19th century [83], guanaco (*Lama guanicoe*), a large South American camelids and the main wild herbivore of the Patagonian steppe, numbered between 7 and 10 million individuals [84]. Since that time, guanaco have been considered the main competitor for sheep by ranchers [85], and their numbers declined to about 600,000 animals by the end of the 20th century. They currently occupy less than 40% of their original range [86]. The decline in guanaco abundance and distribution is associated with high numbers of sheep and resulting reduction in preferred forage [85]. Extensive sheep ranching seems to have produced an increasing degradation of guanaco habitat due to overgrazing, changes in the structure and composition of vegetation, displacing

guanaco and changing their distribution [87]; however, sheep-guanaco interaction outcomes are still controversial [88, 89].

Available information is mostly limited to dietary composition of both species, indicating a large overlap in food items [81, 90]. It is assumed that this large herbivore consumes great amounts of vegetation, the equivalent of two to three sheep. Camelids, however, have low metabolism rates, implying lower food consumption, so the opposite situation should be considered [91]. Although ranchers in Magallanes do not place an economic value on guanaco, they are perceived as an obstacle to domestic sheep production [79]. There are efforts from Chilean government agencies under the Ministry of Agriculture to support the sustainable use of guanaco [92]. After several years of guanaco counts, annual hunting quotas under 3% of estimated guanaco population have been established to give guanaco economic value [92]. Currently, the guanaco population inhabiting productive lands in Magallanes is estimated at 297,844 individuals [93].

Other wildlife that might use similar food resources and space with sheep are herbivorous birds like the lesser rhea (*Rhea pennata*; [94]) and wild geese (*Chloëphaga* spp) like the upland goose (*C. picta*; [95]). However, these herbivorous birds are not seeing as competitors like guanaco because of their smaller size and lower conspicuity. Nonetheless, there is a lack of studies on wild birds interacting with sheep ranching in Magallanes and most of information occurs in Argentinean Patagonia [96] and the Falkland Islands [95].

Similarly, since the advent of sheep ranching in southern Patagonia, large predators, like puma (*Puma concolor*), and meso predators, like culpeo (*Lycalopex culapeus*) and gray foxes (*L. griseous*), have been interacting with sheep ranching in rural Magallanes [97]. This interaction with wild native carnivores generates economic losses to ranchers because puma and foxes are a source of sheep mortality. Additionally, the attack and predation of sheep by domestic dogs is a growing concern worldwide, and Magallanes is not an exception. In Chile, domestic dog predation on livestock lacks legal regulation.

According to official government records, carnivores impact animal production in Magallanes [98]. Between 2012 and 2017, 2259 livestock animals were killed by carnivores, 83% of which were sheep (1887 head) [98]. The majority of those attacks were reported on the Island of Tierra del Fuego (59%). If reported attacks are organized by predator species causing mortality, 78% of attacks corresponded to domestic dogs (55 events) accounting for 1855 predated livestock (82%) [98]. Foxes (*Lycalopex* spp) were reported to predate 208 livestock (9%), and puma predation on livestock was 1% (13 animals) [98].

Farmers hunt native carnivores despite this activity is illegal in Chile [80]. This situation could be associated to the lack of governmental programs to verify livestock mortality causes and issue compensation of economic loss [80]. Recently, sheep ranches near Torres del Paine National Park, one of the main protected areas in Magallanes, have changed their perception of puma because the presence of this large carnivore is a source of an important touristic activity in the area producing important economic revenues [80]. Other animals that are perceived as harmful for sheep farmers include raptors like southern caracara (*Caracara plancus*) and buzzard eagle (*Geranoaetus melanoleucus*), which predate on newborn lambs [99], but there are not formal reports from Magallanes.

It is necessary to differentiate sheep losses because of wildlife from those caused by deficient ranch management. Several sheep ranches seem to have incorrect estimates of appropriate stocking rate density that can cause overgrazing and degradation of the steppe that finally drive to poor animal conditions and economic losses, which is not directly related to the presence of wild herbivores. The importance

of large carnivores in overall ecosystem health must be considered before lethal control. Predation prevention methods like night shelters or guard dogs, should also be used where appropriate [100].

## 12. The agritourism potential in Magallanes: Farm tourism or tourism on farms?

The farms in the Magallanes region have been characterized by developing and preserving an extensive infrastructure, consisting of numerous interrelated buildings to meet the demands and services of a sheep farm, which has historically been extensively developed [101]. Usually the farms are huge estates, hundreds or thousands of hectares in size, and in many of them there are still tools, machinery and furniture typical of the colonizing era from the mid-19th century to the early 20th century [102]. These locations are nestled within natural landscapes that include lakes, rivers and wide landscapes such as the Patagonian steppe, where the horizon and the sky display dramatic sunrises and sunsets. Furthermore, prior to the establishment of these ranches, these sites were inhabited by ancestral peoples who knew the territory and its resources very well [103]. All these conditions provide an ideal setting for agritourism [104] as a way to combine culture, nature, leisure and recreation in a landscape experience.

Tourism on farms in the Magallanes region is emerging and poses opportunities and challenges to innovate in regional economic development. Currently, the offer for tourism on estancias is traditional and restricted to activities typical of nature tourism such as wildlife observation, walks, horseback riding, photography and fishing, among others. To a lesser degree, activities typical of agriculture (**Figure 8**) are available, such as organic agriculture and observation of traditional tasks such as sheep herding or shearing, among others. Often, but not always, this offer is associated with spending the night in the manor houses itself and tasting local cuisine, so that the experience is complemented by the charm of the architectural heritage and historical legacy [101]. However, this type of tourism faces endemic problems such as seasonality, lack of specialized human resources and poor connectivity. Usually the distances are exaggerated, the accesses are tortuous, and even in many of them digital connectivity problems persist, which makes it difficult to implement online


**Figure 8.**
*a) Herding of sheep in Magallanes, one of the favorite activities to observe by tourists in estancias in the region (image by Claudio Vidal). b) Sheep bath, as another interesting farm task for tourism (image by Sergio Radic K.).*

marketing and reservation systems, resulting in a loss of service. In addition, many times the tourist product offered is limited to passive observation experiences, but the tourist storytelling to enrich the visitor's experience and feed their learning and interest, is absent. Thus, this type of tourism wanders between "farm tourism", where the central activities are related to the ranch trade [105], or "tourism on farm", a farm where tourist activities other than the traditional.

Today, the particularities of the tourist atlas of the Magallanes territory can be considered counterproductive for the development of farm tourism in isolated areas. The profitability of agritourism as such is low and occurs as a complementary element to other economic activities, but it is not the main one [106]. Tourist concentration is persistently monopolized and overshadowed by Torres del Paine National Park, considered by many to be the gem of Patagonia and the main pole of attraction for regional tourism [107]. Thus, perhaps a relevant option would be the diversification of tourism content on the basis of local identity; generate a local identity to offer a different product, where tourists enjoy and learn about distinctive aspects such as architecture, history, ethnography and rural life. This identity could be re-created from and for the territory, starting from the cultural histories and the memory of the ancestral peoples. There are numerous ethnographic, historical, architectural and family resources [103, 108, 109] to implement a touristic storytelling and generate an "experience scape", as has happened in other areas of farm tourism [110]. However, tourism research is required to consolidate facts, protagonists, sites and narratives for a continuous valorization of the cultural and natural heritage with potential for the development of tourism, whether it is for farm tourism or tourism on farms.

## 13. Final comments

After 145 years of sheep production, the Magallanes region has become a characteristic and important territory for sheep industry, and must continue to improve the quality level of products demanded by consumers. Three key points lead the future of the industry in the region: sustainable management, markets, and human resources; but the ability to integrate all these points in the same direction will support farm success. Through technology adoption and sustainable management practices, the industry can achieve soil, water, and grassland conservation and utilize best livestock practices that improve animal welfare and sheep-wildlife interactions. Improving and/or intensifying utilization of a small percentage of each farm (approximately between 2 and 5% depending mainly to stocking rate used and the dry matter production of grasslands) will achieve sustainable and profitable long-term production. Considering the economic side of production in the region, the market currently demands lamb carcasses around 14 to 16 kg and finer wool, between 17 to 22 μm. Then, each decision making must consider existing management and farm production system (meat, wool, or dual purpose) and quality product that can be produced. Broadening market potential through diversification is an important consideration, but must be evaluated within the context of each farm, in this way tourism, dairy products or knowledge of ecosystem services could play a significant role. Finally, human resources need to be specialized to face these challenges, for which technical abilities, undergraduate and postgraduate studies are a key component. The Agricultural and Aquiculture Sciences Department of Magallanes University and the Agricultural Research Institute (Kampenaike Experimental Station) will have an important role in disseminating technical knowledge and providing professional development in our region.

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## Conflict of Interest

The authors declare no interest conflict.

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