*Taurocerastes patagonicus* and its effects over grassland primary production in livestock area, Tierra del Fuego Island, Chile

**Introduction**

Sheep ranching has been one of the most important economic activities in patagonia since the late nineteenth century, however 87% of the Magellanic grassland farms subject to lost productivity due to erosion (Cruz and Lara 1987). According to this study, 98.7% of this erosion is due to anthropogenic causes related to livestock management.

According to Losey and Vaughan (2006), only in the United States each year dung beetles save farmers 380 million dollars a year in ecosystem services, including increased forage productivity, elimination of pests and diseases of fecal–oral route (Nichols et al 2008), increased forage area by preventing the accumulation of animal feces (Fincher 1981) and fertilizer savings because they avoid volatilization of nitrates and other nutrients to the atmosphere (Gillard 1967).

Increasing fodder productivity has been measured to be 20% to 100% kgs of dry matter per hectare using different species and in different environments (Doube and Marshal 2014, Doube 2008, Bang et al. 2005). This happens because they improve soil structure and by burying and manipulate herbivore feces, increase the amount of nitrates, phosphates, sulfates, organic carbon, improving soil structure by increasing aeration and soil permeability. In addition, there has been found to be increased activity of soil microorganisms and earthworms in areas that have been used by dung beetles (Marshal and Doube 2014).

In Patagonia there are several dung beetles, but in the Magallanes y Antartica Chilena Region there is just one species: *Taurocerastes patagonicus* (Phil.) from the Scarabaeide family. This dung beetle is known as “torito” or “little bull”, because the has two horn in its protorax (Peña 1996). As every genera in the Scarabaeidae family, *Taurcerates* presents development of this larvae in decomposition process and gallery construction for the protection of its larvae (Elgueta y Arriagada 1989).

*Taurocerastes* makes a galleries near to feed sites, transporting the dung ball with its front legs and move backwards (Elgueta y Arriagada 1989), this performance maybe happens as an adaptation to the heavy weather in Patagonia. If there are many works focussed in dung beetle all around the world, *Taurocerastes* *patagonicus* has been marginally studied, and only had a few distribution and natural history descriptions.

We need to know where there are, and which roll play into the natural ecosystem and livestock ecosystem. We make this study with the aim to know *Taurocerastes* *patagonicus* interactions with the livestock in Tierra del Fuego Island, determine which factors can defines its abundance, and what are its effect over the grassland in this area.

There are over 7.000 species of dung beetles on all continents except Antarctica. This group of beetles has been related with some ecosystem services in agricultural economy and livestock. Among the services that dung beetles provide are improvement of plant production by increasing the nutrients in the soils, the permeability of soil to water, changing soil structure with a matrix of tunnels, by reducing pasture fouling, and mixing surface soil and subsoil; doing that, they can promote root growth, increase water retention, increase aeration and reduce bulk density, and provide a more useful and healthy grazing land. In most environments with large grazing mammals dung beetles have co-evolved with the ecosystem (Doube & Marshall).

We know that dung beetles also have an important role preventing cattle disease. The artificial increase of population from some this species helps to reduce the parasitic disease transmission between livestock (Fincher 1973).

There are four basic types of dung beetles, based on their lifestyle: ball rollers, tunnellers, pad dwellers, and kleptocoprids. The ball rollers are mostly flyers, they could mould dung into a ball and roll it away, usually on the same day as they arrive. Dungs balls usually weigh 10-20 times the beetle´s weigh. Most species bury their balls some distance from the dung pad by excavating soil from under the ball (Doube & Marshall).

**Methods**

## *Study area*

This study was conducted in Tierra del Fuego Island, located at the southernmost tip of South America between parallels 52 and 55 ºS. Tierra del Fuego Island extends approximately 48,598 km2, of which 22,592.7 km2 correspond to the Chilean province of Tierra del Fuego.

The samples was taken of the northern part of the Chilean side of Tierra del Fuego Island, with an environment of fueguian steppe, this area has a Bsk Koppen climate classification. Also called cold semi-arid climate the big picture shows precipitation below potential evapotranspiration and some snowfall during the winter.

The Chilean Fueguian Steppe has a strong influence of west winds which reach over 100 km h-1 (Enlicher & Santana 1988, Santana et al. 2006), with precipitation ranging from 200 to 300 mm yr-1 more or less constant during the year. The area has a vegetation dominated by shrubs and graminoids, such as *Festuca gracillima*. (Pisano 1977, Dollenz 1995), and the local fauna presents a big herbivore (*Lama guanicoe* o guanaco), rats (like Tuco tuco), and other invasive species of herbivores (*Castor canadensis*, musk rat), insectivores (armadillo), and carnivores (like the mink)

Abundance of *T. patagonicus*

We selected three aleatory sites in an area of sheep livestock, and we make three transects samples of 100 m. in each one. Since January 23th to 29th 2014 in each transect, nine barber traps every 10 m was conducted (Fig. 1). The barber trap had a 200 mL of soap water without beetle attractor.

We counted *T. patagonicus* for each trap, we registered the time when we began ans when we finished the sampling. Doing that, we can standardise how many dung beetles we can capture for sampling hour. In addition, between two barbers traps, we counted the sheep dung for each transect with a 1x1 m quadrant (Fig. 1).

For see if there are a relationship between *T. patagonicus* abundance standardised by sampling hours and sheep dung abundance standardised by sheep carrying capacity of the site, we make a lineal regression analysis.

Plus, in each transect we registered: 1. Days without sheep), 2. Transect slope (Δm hight/m long), 3. Carrying capacity (sheep\*days/ha.). With this information and *T. patagonicus* abundance standardised by sampling hours, we made a GLM analysis for check which of this factors can determinate dung beetle abundance.

Grassland productivity

Since January 20th to November 3th 2014, 20 sheep exclusion boxes with 34 x 45 cm of size was conducted. We installed four different treatments to grassland productivity measure: 1) control (without dung, without beetles), 2) positive control (plus 150 gr fresh sheep dung at first day of experiment), 3) treatment 1 (plus male and female beetle, without dung), 4) treatment 2 (plus male and female beetle, plus 50 gr fresh sheep dung at three times: first day, 5th day and 9th day of experiment).

After this time we take of the boxes and cut the grass under them with scissors. The grass was putting in paper bag and taken to Agronomy School of the University of Magallanes where it was dried in a stove. Did that, the grass was weight in Institute of Patagonia through a precision scale. For determinate if there are grass differences between treatments we make an ANOVA for each one.

RESULTS

Abundance of *T. patagonicus*

The lineal regression between *T. patagonicus* abundance (effort sample standardized) and sheep dung abundance (animal carrying capacity standardized) was significant (R2=0.5591, P=0.02). There are an inverse relationship between both factors, which mean places where there are more dung beetles, has less sheep dung.

The best model that explains de abundance of *T. patagonicus* was that one which has like only variable the slope. Where are more slope, there are more *T. patagonicus* abundance.

Grassland productivity

There are no differences in weigh of grass between positive control and negative control, shows the presence of dung does not implies increase in the grass productivity. There are significant differences between Treatment 2 with negative control, and Treatment 2 with positive control, in that case the *T. patagonicus* presence make a difference in dry matter. The Treatment 1 has not significative differences with any other treatment.

**Discussion**

The region where we did this study present a very low productivity. The Bsk Köppen Climate Classification catalogue this part of Tierra del Fuego Island has a cold semi-aride climate, thus means, high wind effect, high evapotranspiration and low first productivity.

Furthermore, in south Patagonia, the growing grass time is a very short because the low temperatures in winter doesn´t allow the grown. In Magallanes y Antartica Chilena region the growing period of the grass is just between November and March. This very short time is a little helped by the long days that the region presents because the summer season, but even thus is not enough for sustain a big industry of livestock in the region. In this last 30 years because the low first productivity, the people have needed to include news outfits for made better their business, like making grass plantations, give to their animals supplementary food, searching for news systems of managing like *Hollistic* or *Voisin*, among others.

The south Patagonia climate characteristics determine a difficult scenario. Even thus, the ranchers have this important ecological interaction of species, they are the *Taurocerastes* *patagonicus* and *Lama* *guanicoe*, with years and years of co-evolution. The action of *T. patagonicus* over the dung of the *L. guanicoe* improve the productivity of the grass, which are the *L. guanicoe* food. The introduction of sheep in latest 1800, not only change de commercial activities in the Island, change the distribution of L. guanicoe and additioned a new herbivore to the alimentary chain.

There are evidence *T. patagonicus* use the sheep dung as much they use the guanaco dung. In our study we work only with the sheep dung because we want to know the relationship between the presence of that and the abundance of *T. patagonicus*. It seems *T. patagonicus* abundance has an inverse relationship with the number of sheep dung in the field (Fig.), and we think they are buried this dung in the ground, making less in the surface. The relationship between this factors create the dung extraction rate, and these are the slope of the equation...

In terms of *T. patagonicus* distribution, the relationship between their abundance and the slope of transects, the number of *T. patagonicus* are directly proportional to the slope angle of the sites where they are. This part, we should indicate the distribution of this dung beetle are improve for the factors that slope may include, like wind protection, solar radiation, among others.

We demonstrated *T. patagonicus* should increase the dry matter per day and they are using the sheep dung. However, the only presence of *T. patagonicus* not make any difference in dry matter weight (Treatment 1), but their presence plus the sheep dung auditioned (Treatment 2), actually create an increment (Fig. 4). If we focus in the ecosystem services provided by dung beetles around the world, in South Patagonia *T. patagonicus* could be the same thing not only with the native species of herbivores like *L. guanicoe*, with the sheep livestock as well. Doing that, not only improve this economic activity, but also improve de sanitary system in the Island. Plus, if the people can manage the number of this dung beetles, doing artificial additions or being careful with the parasite insecticide, they can increase their grassland productivity in their own lands.

**Acknowledgments**

We thanks to Maclean family for allow us work in their land, help us with this study and make us feel like home with their attentions. To WCS Chile for considered this study in its budget and the use of the pickup truck. To University of Magallanes of lend us the stove dryer (Agricultural School) and the precision scale (Botanical Lab, Institute of Patagonia). And special thanks to Mikaela and Leonardo, who are the interns of this project for the help in the field.

**References**

Peña LE 1996 Introducción al estudio de los insectos de Chile. Editorial Universitaria. Chile. 253 pp.

**Figures**

C:\Users\Usuario\Downloads\Transecto.tiff

Fig 0 Sample system scheme of barbers tramps for T. patagonicus abundance and quadrants for sheep dung abundance.

C:\Users\Usuario\Downloads\regresion 2.tiff

Fig 0 Relationship between sheep dung abundance and T. patagonicus abundance. The line indicates the tendency... R= , P= .

C:\Users\Usuario\Downloads\Pendiente vs abundancia.tiff

Fig 0 Relationship between T. patagonicus abundance and the slope of the hill where we make transects. The line represents the tendency with R= , P=

C:\Users\Usuario\Downloads\Dry matter per ha.tiff

Fig 0 Two different treatments and its positive and negative control, for T. patagonicus grass productivity experiment.