Short Communication

Characterization of the floristic composition of the pastureland in the cattle area in a farm of Florianópolis – SC, Brazil

Yuseika Olivera-Castro[1] https://orcid.org/0000-0002-5330-2390, Maiara Mendes de Azevedo[2], Laura Livia Arias-Avilés[2], Luiz Carlos Pinheiro Machado Filho[2] https://orcid.org/0000-0002-8182-836[5], Pedro Pablo del Pozo-Rodriguez[3] https://orcid.org/0000-0003-2995-8514

[1]*Estación Experimental de Pastos y Forrajes Indio Hatuey, Universidad de Matanzas. Central España Republicana, CP. 44280, Matanzas, Cuba.*
[2]*Centro de Ciencias Agrarias. Universidad Federal de Santa Catarina, Florianópolis – SC. Brasil.* [3]*FAO. Cuba. E-mail:* yuseika@ihatuey.cu

Abstract

Objective: To characterize the floristic composition of the pasturelands, after two years and a half of applying different doses of calcareous, phosphoric and potassium fertilizers in the cattle area in a farm of Florianópolis – SC, Brazil.

Materials and Methods: The research was conducted in the cattle area belonging to the Ressacada farm, of the Federal University of Santa Catarina. The treatments were 12, in which different doses of calcareous, phosphoric and potassium fertilization were used. For such purpose, the method of the square meter frame was used, which was replicated four times in each treatment.

Results: The presence of 19 families with a wide diversity and 64 species, most of them herbaceous, was identified. In general, almost all the families were present in the paddocks. Those of higher representativeness were *Poaceae*, *Cyperaceae* and *Fabaceae*. The last one with significant increase with regards to the beginning of the study, although still below the optimum values to have certain impact on the pastureland.

Conclusions: An increase of the legumes occurred, and wide diversity of plant species that the animals use for their feeding was found, mainly represented by the families *Poaceae* and *Fabaceae*.

Keywords: application of fertilizers, biodiversity, botanical composition

Introduction

In Florianópolis, in the Santa Catarina state in Brazil, there is a wide diversity of species, which can be native or naturalized. In the Ressacada farm a variety of species from different families is found. Those that belong to *Cyperaceae*, grasses and legumes prevail.

The family *Cyperaceae* includes the species *Cyperus flavescens* L.; *Cyperus polystachyos* Rottb.; *Rhynchospora barrosiana* Guagl; *Rhynchospora holoschoenoides* (Rich.) Heiter; *Scleria distans* Poir., among others. Regarding grasses, *Acroceras macrum* Stapf; *Axonopus affinis* Chase; *Hemarthria altissima* (Poir.) Stapf & C.E. Hubb., *Ischaemum minus* J. Presl; *Sacciolepis indica* (L.) Chase; *Setaria distans* (Trin.) Veldkamp., can be found Among the legumes *Desmodium adscendens* (Sw.) DC., *Mimosa bimucronata* (DC.) Kuntze, *Trifolium repens* L.; *Trifolium pratense* L., and others, prevail.

The presence and permanence of these species in the pastureland can be affected by management, climate (incidence of the seasons) and soil conditions, mainly. Immobile nutrients, such as phosphorus (P) and potassium (K), are essential primary elements for plant growth (Martínez-Sáez *et al*., 2018).

This work was conducted in order to characterize the floristic composition, after two years and a half of applying different doses of calcareous, phosphoric and potassium fertilizers.

Materials and Methods

Location. The studies were conducted in the experimental farm Rassacada-UFSC, located in the Santa Catarina State, in the Tapera zone, south of the island. It is geographically located at 27º 41' 06.28" S; 48º32' 38.81" W, with predominance of flat-relief land and at 3 m.a.s.l.

Climate and soil characteristics. The study was conducted in the summer (January-April), with predominance of daily temperature of 27 ºC and average minimum temperature of 23 ºC, with more than 60 % of the total annual rainfall and a range of 90-160 mm, for a humid subtropical climate (De Andrade and Lamberts, 1996). The soil of the area is constituted by sandy sediments, of alluvial-colluvial,

Received: June 16, 2020
Accepted: September 15, 2020

How to cite this paper: Olivera-Castro, Yuseika; Azevedo M. de, Maiara; Arias-Avilés, Laura L.; Pinheiro-Machado-F, L. C. & Pozo-Rodríguez, P. P. del. Characterization of the floristic composition of the pastureland in the cattle area in a farm of Florianópolis – SC, Brazil. *Pastos y Forrajes*. 43 (3): 215-220, 2020.

wind and lacustrine origin, classified as Typical Hydromorphic Neo-soil (IBGE and IPUF, 1991).

Experimental design and treatment. A randomized block design was used, with four repetitions. The study was conducted in paddocks that were under a fertilization research, with 12 experimental treatments:

- T1: 0 calcareous, 0 P_2O_5 and 0 K_2O
- T2: 0 calcareous, 0 P_2O_5 and 1 K_2O
- T3: 0 calcareous, 1 P_2O_5 and 0 K_2O
- T4: 0 calcareous, 1 P_2O_5 and 1 K_2O
- T5: ½ calcareous, 0 P_2O_5 and 0 K_2O
- T6: ½ calcareous, 0 P_2O_5 and 1 K_2O
- T7: ½ calcareous, 1 P_2O_5 and 0 K_2O
- T8: ½ calcareous, 1 P_2O_5 and 1 K_2O
- T9: 1 calcareous, 0 P_2O_5 and 0 K_2O
- T10: 1 calcareous, 0 P_2O_5 and 1 K_2O
- T11: 1 calcareous, 1 P_2O_5 and 0 K_2O
- T12: 1 calcareous, 1 P_2O_5 and 1 K_2O

The fertilization recommendations were made taking into consideration the description made in the Handbook of fertilization recommendations for the Rio Grande do Sul State and Santa Catarina (SBCS-CQFS, 2004), elaborated from the soil analyses.

Animals and management. The studies were conducted in the cattle unit, which was managed during several years (2016-2019) with fertilization and in a Voisin rational grazing system (VRG), with predominance of the Brahama breed and dairy animals, with average weight of 300 kg.

Arad phosphate (natural phosphate), triple superphosphate 46 % of P_2O_5 and potassium chloride 60 % of K_2O_5, were used as input.

The calcareous fertilizer consists in a mixture of calcium oxide and magnesium oxide.

Measurements and processing. The characterization of the floristic composition was visually made (Machado *et al*., 1997), and the appearance percentage of the species among the prevailing families was estimated, besides the dung and uncovered soil. For such purpose, the method of m^2 framework was used, which was replicated four times per treatment, for a total of 48 frameworks. This was carried out at one moment, during the study season. For the data recording the Excel program was used.

Results and Discussion

Nineteen families were found, with representation of 64 species (figure 1). Wide diversity of the families was observed in the zone where the study was conducted. In general, almost all of them were present in the paddocks, which can be due to the fact that many of these species are considered as prevailing of the native or naturalized flora of the region (Mourelle *et al*., 2018). The ones with higher representativeness were *Poaceae*, *Cyperaceae* and *Fabaceae*. The other identified species belong to the families *Apiaceae*, *Asteraceae*, *Commelinaceae*, *Euphorbiaceae*, *Hypoxidaceae*, *Juncaceae*, *Lamiaceae*, *Lythraceae*, *Melastomataceae*, *Ochnaceae*, *Onagraceae*, *Polygalaceae*, *Rubiaceae*, *Scrophulariaceae* and *Xyridaceae*, which showed a very low appearance trend (from one to five species per family).

This richness in plant biodiversity denotes that in this region of southern Brazil there is a flora rich in plant families and species. Many of them can be used in cattle feeding (Hurrell *et al*., 2019).

Table 1 shows the percentage of the families when carrying out the floristic composition of the pastureland. As it is shown, there was increase in the presence of these families, since the beginning and until the end of the study, and in all the treatments.

As it was referred above, the *Poaceae* family was among the ones with more representation of species. Grasses, as they are also known, represent one of the most diverse plant groups in the world. They are used as food and feed. In many countries, livestock feeding is supported on systems based on pastures and forage plants, because they are considered low-cost resources (Vargas-Martínez *et al*., 2018).

At the beginning of the experiment (table 1), grasses began with a percentage over 50 %, although at the end of the study, the presence of these species decreased in a range of 40-45. This is due to the fact that the animal management was re-adjusted to a permanence cycle of one day, and to a rotation of, approximately, 35 days. This management adjustment could have influenced the increase of other families, as in the case of *Fabaceae*, in which increase was observed in all the treatments. The decrease of grasses could have also been influenced by the competition that occurs in the pastureland, as well as some indirect effects, which could have caused restrictions in the growth of these plants.

Soliveres-Codina and García-Palacios (2019) stated that competition is due to the fact that, under specific conditions, the environment and soil are capable of providing only limited quantities of the essential nutrients for the normal growth of a certain plant population. When populations exceed the limit of essential factors, competition begins. And, in this case, the presence of the species from the identified families could have influenced the decrease of grasses.

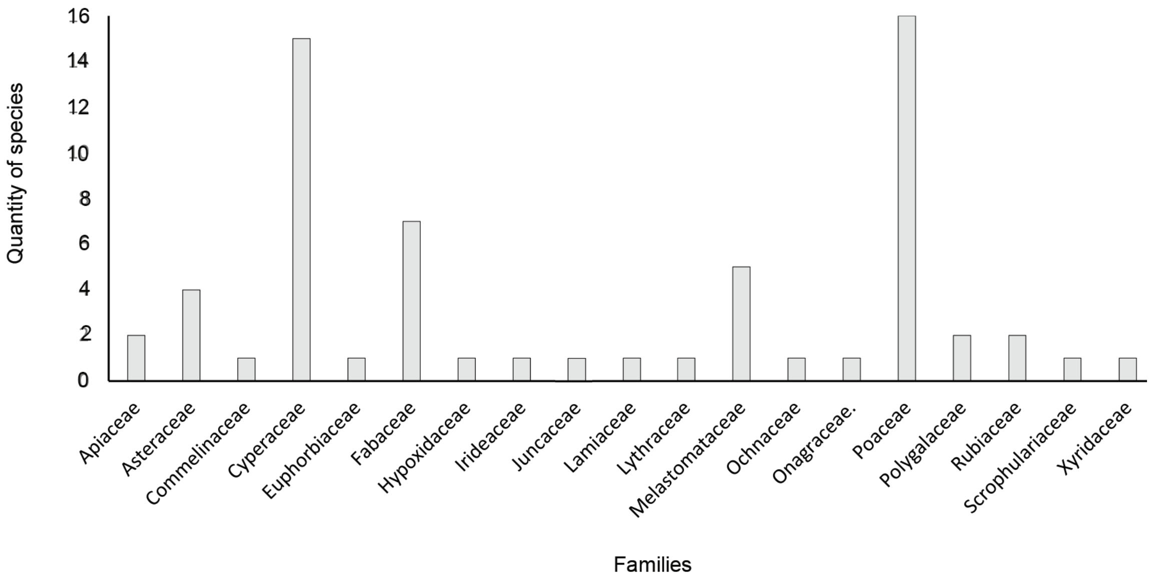

Figure 1. Quantity of species found per each family.

Table 1. Performance of the floristic composition of the pastureland, at the beginning and the end of the study. Family of plants.

Families/ Treatment	T1		T2		T3		T4		T5		T6		T7	
	2016	2019	2016	2019	2016	2019	2016	2019	2016	2019	2016	2019	2016	2019
Apiaceae	0,29	1,20	2,09	1,00	0,35	1,60	0,84	1,10	0,77	1,0	0,20	1,10	0,86	1,0
Asteraceae	0,56	0,06	0,05	0,12	0,62	0,12	1,29	1,00	0,18	2,15	0,81	0,06	0,24	1,0
Commelinaceae	0,00	0,00	0,00	0,00	0,00	0,00	0,04	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Cyperaceae	21,74	21,0	21,84	16,65	21,75	20,32	18,74	11,83	24,66	20,24	16,31	25,03	26,30	22,5
Bostas o excretas	1,26	3,81	2,61	1,75	1,5	1,06	2,08	3,00	0,86	3,00	0,79	5,0	1,46	1,10
Euphorbiaceae	0,24	0,31	0,46	2,10	0,57	0,40	0,49	2,10	0,63	0,90	0,42	2,10	0,74	0,8
Fabaceae	7,22	16,49	6,01	12,56	5,14	19,36	5,37	24,28	3,46	17,50	7,62	17,08	5,65	20,31
Hypoxidaceae	0,05	0,18	0,09	3,00	0,00	0,00	0,00	0,00	0,00	0,24	0,00	0,37	0,00	0,00
Juncaceae	0,00	0,00	0,00	0,00	0,15	8,00	0,05	5,00	0,00	0,00	0,05	0,05	0,00	0,00
Lamiaceae	0,05	0,00	0,00	0,00	0,00	0,00	0,06	0,00	0,10	0,05	0,00	0,00	0,00	0,00
Lythraceae	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,14	0,00	0,00	0,00	0,00	0,00
Melastomataceae	1,81	1,92	1,07	0,75	0,56	0,71	2,63	1,97	2,13	0,93	1,1	0,77	1,74	1,5
Ochnaceae	0,11	0,00	0,18	0,00	0,24	0,10	0,10	0,00	0,38	0,10	0,10	0,00	0,19	0,10
Onagraceae	0,05	0,00	0,09	0,00	0,05	0,00	0,00	0,00	0,04	0,01	0,05	0,00	0,10	0,05
Poaceae	59,62	54,71	63,23	54,74	64,51	40,13	63,50	46,61	60,08	44,79	68,9	44,18	54,18	41,30
Polygalaceae	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,05	0,00
Rubiaceae	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,05	0,00	0,00	0,00	0,00	0,10	1,50
Scrophulariaceae	0,10	0,05	0,00	0,00	0,22	0,05	0,10	0,05	0,05	0,00	0,00	0,00	0,00	0,00
Suelo descubierto	7,17	8,12	2,57	5,8	4,16	8,44	4,40	3,64	6,38	7,87	4,06	6,31	8,37	8,68
Xyridaceae	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,05	0,00	0,00	0,00	0,00	0,00

T1: 0 calcareous, 0 P_2O_5 and 0 K_2O; T2: 0 calcareous, 0 P_2O_5 and 1 K_2O; T3: 0 calcareous, 1 P_2O_5 and 0 K_2O; T4: 0 calcareous, 1 P_2O_5 and 1 K_2O; T5: ½ calcareous, 0 P_2O_5 and 0 K_2O; T6: ½ calcareous, 0 P_2O_5 and 1 K_2O; T7: ½ calcareous, 1 P_2O_5 and 0 K_2O; T8: ½ calcareous, 1 P_2O_5 and 1 K_2O; T9: 1 calcareous, 0 P_2O_5 and 0 K_2O; T10: 1 calcareous, 0 P_2O_5 and 1 K_2O; T11: 1 calcareous, 1 P_2O_5 y 0 K_2O and T12: 1 calcareous, 1 P_2O_5 and 1 K_2O.

Table 1. (Continuation).

Family/Treatment	T8		T9		T10		T11		T12	
	2016	2019	2016	2019	2016	2019	2016	2019	2016	2019
Apiaceae	0,99	1,10	0,22	1,02	0,26	0,10	0,74	0,00	0,29	0,08
Asteraceae	0,79	1,00	0,53	0,43	1,07	0,07	0,19	0,62	0,29	0,20
Commelinaceae	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,04	0,00	0,00
Cyperaceae	26,93	21,53	23,91	33,01	24,94	25,09	24,21	20,23	17,29	25,37
Bostas excretas	0,47	2,0	2,65	1,33	1,65	5,12	2,88	5,06	2,32	1,72
Euphorbiaceae	0,60	1,60	0,42	0,12	0,47	0,17	0,50	0,09	0,73	0,05
Fabaceae	3,88	19,55	7,39	18,93	4,66	20,29	4,40	24,86	7,84	25,85
Hypoxidaceae	0,05	0,05	0,09	0,06	0,05	0,60	0,09	0,05	0,10	0,30
Irideaceae	0,05	0,00	0,00	0,00	0,00	0,00	0,05	0,04	0,00	0,00
Juncaceae	0,00	0,00	0,05	0,05	0,00	0,00	0,09	0,06	0,00	0,00
Lamiaceae	0,05	0,05	0,10	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Lythraceae	0,15	0,10	0,05	0,04	0,00	0,00	0,00	0,00	0,00	0,00
Melastomataceae	1,99	1,08	2,91	1,04	0,84	1,00	1,77	0,45	1,0	0,61
Ochnaceae	0,05	0,05	0,14	0,10	0,00	0,00	0,19	0,00	0,05	0,24
Onagraceae	0,05	0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,15
Poaceae	56,53	45,31	58,58	41,27	65,36	47,1	60,98	45,07	68,04	41,76
Polygalaceae	0,10	0,00	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Rubiaceae	0,00	0,00	0,00	0,00	0,05	0,00	0,23	0,13	0,00	0,00
Scrophulariaceae	0,09	0,05	0,15	0,10	0,00	0,00	0,00	0,00	0,10	0,05
Suelo descubierto	7,23	7,13	2,63	3,09	1,29	0,56	3,63	2,01	1,77	2,5
Xyridaceae	0,00	0,00	0,04	0,04	0,00	0,00	0,05	0,00	0,05	0,04

T1: 0 calcareous, 0 P_2O_5 and 0 K_2O; T2: 0 calcareous, 0 P_2O_5 and 1 K_2O; T3: 0 calcareous, 1 P_2O_5 and 0 K_2O; T4: 0 calcareous, 1 P_2O_5 and 1 K_2O; T5: ½ calcareous, 0 P_2O_5 and 0 K_2O; T6: ½ calcareous, 0 P_2O_5 and 1 K_2O; T7: ½ calcareous, 1 P_2O_5 and 0 K_2O; T8: ½ calcareous, 1 P_2O_5 and 1 K_2O; T9: 1 calcareous, 0 P_2O_5 and 0 K_2O; T10: 1 calcareous, 0 P_2O_5 and 1 K_2O; T11: 1 calcareous, 1 P_2O_5 and 0 K_2O and T12: 1 calcareous, 1 P_2O_5 and 1 K_2O.

In all the treatments, it is relevant to highlight the increase of legumes, mainly represented by *Aeschynomene falcata* (Poir.) DC., *D. adscendens*, *Desmodium barbatum* (L.) Benth., *Desmodium incanum* DC., *M. bimucronata*., *T. repens* and *T. pratense*.

This increase is important, because it has been described that the presence of legumes in the pasturelands is an excellent alternative for improving nitrogen fixation to the soil, due to the capacity they have to fix that element and make it available for the species present in the pastureland (Carrilli, 2018).

This increase of the legumes could have also been influenced by the nitrogen balance in the soil, related to the presence of potassium, phosphorus, and other necessary elements for good plant development and growth.

According to Bianco and Cenzano (2018), in the studies about the function of legumes in pasturelands and of their importance for N fixation and subsequent increase in the associated forage, it is concluded that the N fixed by legumes shows values between 50 and 300 kg N/ha/year. In this regard, Arcos-Álvarez *et al.* (2018) stated that the systems with herbaceous or shrubby legumes associated with other species, can play a role in the ecosystem, due to this and other qualities of such species. In addition, they contribute to nutrient recycling in the pastureland, as well as to the increase and conservation of biodiversity and to the improvement of ruminant diet (Tarazona *et al*., 2013). Their inclusion in the systems also favors the occurrence of changes in nutritional indicators, with better utilization of the accompanying grasses, because of the increase of the protein content and digestibility of the diet, and of the reduction of fiber levels in NDF (Quintero *et al*., 2017).

Another indicator that was estimated in the pastureland was the dung or excreta percentage, because in grazing areas the excreta deposition has high significance for the contribution of nutrients to the pastures (Piazza *et al*., 2018).

According to the report by Crespo *et al.* (2015), in the grazed pastureland dungs constitute small microhabitats. In them a rich and varied edaphic fauna, sometimes highly specialized, which participates actively in the matter and energy flows between the fecal matter, the pastureland and the soil, is developed. Besides, the excreta contribute a high percentage of the nutrients consumed by cattle, which are returned to the pastureland (López-Vigoa *et al*., 2017).

In this study, the presence of manure in the paddocks was in a range of 0,80-5,12 %. Although the presence of the macrofauna was not quantified, it is known to be of high importance to incorporate the excreta to the soil and contribute to nutrient recycling, mainly due to the presence of earthworms and coleopterans, which constitute the largest populations of the macrofauna in pasturelands (Caicedo *et al*., 2018).

Regarding the indicator uncovered soil, in all the treatments the percentage was below 10 %. This value is considered low. According to Machado *et al.* (1997), an area that has less than 20 % depopulation or uncovered soil is considered of good cover by the plants. This variable is important, because it allows to know if reseeding or rehabilitation must be done in the area. According to the above-cited authors, this action should be undertaken when the percentage of depopulation or uncovered soil is over 60 %, for which the paddocks of the cattle area, site where this research was conducted, were not affected.

It is concluded that although the pastureland is catalogued as natural or naturalized, there was increase of legumes, due to the application of simultaneous fertilization which benefitted all the treatments. They showed a similar performance, with wide diversity of plant species from the families *Poaceae* and *Fabaceae*, which the animal utilizes for its feeding.

To determine the nutritional quality of the pastureland, do rehabilitation works and to sow cultivated species, which help increase the protein content in the pastureland, besides using protein forage species as feed supplement, is recommended.

Acknowledgements

The authors thank the international project «Silvopastoral Systems. An innovative technology for the ecological management of pasturelands», number 206/13, approved in the International Cooperation Program CAPES/MES-CUBA-Edital46/2013.

They also thank the professors and students of the Laboratory of Applied Ethology and Animal Welfare, of the Agricultural Research Center, belonging to the Federal University of Santa Catarina, as well as the workers of the cattle area of the Ressacada Farm.

Authors' contribution

- Yuseika Olivera-Castro. Elaborated the study project and conducted the research. Participated in the data taking and processing, as well as the manuscript writing and correction.
- Maiara Mendes de Azevedo. Contributed to measurement taking in the field and to the elaboration of the manuscript.
- Laura Livia Arias-Avilés. Contributed to measurement taking in the field and to the elaboration of the manuscript.
- Luiz Carlos Pinheiro Machado Filho. Contributed to the design and setting up of the experiments, as well as to the advisory of the research.
- Pedro Pablo del Pozo-Rodríguez. Contributed to the advisory of the research and to writing the manuscript.

Conflicts of interests

The authors declare that there are no conflicts of interests.

Bibliographic references

Arcos-Álvarez, C. N.; Lascano-Armas, Paola J. & Guevara-Viera, R. V. Manejo de asociaciones gramíneas-leguminosas en pastoreo con rumiantes para mejorar su persistencia, la productividad animal y el impacto ambiental en los trópicos y regiones templadas. *RECA*. 2 (2):1-31, 2018.

Bianco, Luciana & Cenzano, Ana M. Leguminosas nativas: estrategias adaptativas y capacidad para la fijación biológica de nitrógeno. Implicancia ecológica. *Idesia (Arica)*. 36 (4):71-80, 2018. DOI: http://dx.doi.org/10.4067/S0718-34292018005002601.

Caicedo-Rosero, D. M.; Benavides-Rosales, H. R.; Carvajal-Pérez, L. A. & Ortega-Hernández, Jessica P. Población de macrofauna en sistemas silvopastoriles dedicados a la producción lechera: análisis preliminar. *La Granja*. 27 (1):77-85, 2018. DOI: https://doi.org/10.17163/lgr.n27.2018.06.

Carrilli, Ana L. *Atributos de solo e composição de pastagem manejada com pastoreiro racional Voisin em área com histórico de lavoura*. Dissertação apresentada como requisito parcial à obtenção do título de Mestre em Agro-ecossistemas. Florianópolis, Brasil: Programa de Pós-Graduação em Agroecossistema. Centro de Ciências Agrárias, Universidade Federal de Santa Catarina, 2018.

Crespo, G.; Rodríguez, Idalmis & Lok, Sandra. Contribución al estudio de la fertilidad del suelo y su relación con la producción de pastos y forrajes. *Rev. cubana Cienc. agríc*. 49 (2):211-219, 2015.

De Andrade, Suely & Lamberts, R. *Estudo de estrategias, bioclimaticas no clima de Florianopolis*. Tesis doctoral. Florianópolis, Brasil: Centro Tecnológico, Universidade Federal de Santa Catarina, 1996.

Hurrell, J. A.; Delucchi, G. & Keller, H. A. Flora naturalized in Argentina and new records for southern Brazil. *Bonplandia*. 28 (1):71-76, 2019.

IBGE & IPUF. *Mapeamento temático do município de Florianópolis: Geologia, geomorfologia, vegetação, solo, uso do solo*. Florianópolis, Brasil: Instituto Brasileiro de Geografia y Estadística, Instituto de Pesquisa e Planejamento Urbano de Florianópolis, 1991.

López-Vigoa, O.; Sánchez-Santana, Tania; Iglesias-Gómez, J. M.; Lamela-López, L.; Soca-Pérez, Mildrey; Arece-García, J. *et al.* Los sistemas silvopastoriles como alternativa para la producción animal sostenible en el contexto actual de la ganadería tropical. *Pastos y Forrajes*. 40 (2):83-95, 2017.

Machado, R.; Seguí, Esperanza & Alonso, O. Metodología para la evaluación de especies herbáceas. Matanzas, Cuba: EEPF Indio Hatuey, 1997.

Martínez-Sáez, S. J.; Deribew, H. & Entele, Tefera. Contenidos minerales de algunos macro y microelementos en forrajes producidos en Finca Modelo, de la región de Asela, Etiopía. *Rev. prod. anim*. 30 (2):72-74, 2018.

Mourelle, Dominique; Macedo, R. B. & Prieto, A. R. Análisis palinológico actual y del cuaternario tardío en la región de los campos (Uruguay y sur de Brasil): estado de las investigaciones, dificultades y potencialidades. *Publicación Electrónica de la Asociación Paleontológica Argentina*. 18 (2):156–170, 2018. DOI: https://doi.org/10.5710/PEAPA.28.05.2018.258.

Piazza, María V.; Garibaldi, L. A.; Kitzberger, T. & Chaneton, E. J. Impactos ecológicos del ganado extensivo en bosques de coihue. *Macroscopia*. 6:14-19, 2018.

Quintero, S.; Molina, I. C.; Ramírez, J. S.; Barahona, R. & Arango, J. Calidad nutricional de forrajes usados en la intensificación ganadera sostenible en el trópico bajo de Colombia. *Memorias IX Congreso Internacional de Sistemas Silvopastoriles. Aportes de la ganadería a los objetivos de desarrollo sostenible*. Manizales, Colombia: CIPAV, 2017.

SBCS & CQFS. *Manual de adubação e calagem para os Estados do Rio Grande do Sul e Santa Catarina*. 10. Porto Alegre, Brasil: Sociedade Brasileira de Ciência do Solo, Comissão de Química e Fertilidade do Solo, 2004.

Soliveres-Codina, S. & García-Palacios, P. Sucesión secundaria, interacciones biológicas y funcionamiento de las comunidades asociadas a taludes de carretera: las interacciones planta-suelo importan más que las planta-planta. *Ecosistemas*. 28 (2):50-60, 2019. DOI: https://doi.org/10.7818/ECOS.1718.

Tarazona, A. M.; Ceballos, María C.; Cuartas, C. A.; Naranjo, J. F.; Murgueitio, E. & Barahona-Rosales, R. The relationship between nutritional status and bovine welfare associated to adoption of intensive silvopastoral systems in tropical conditions. In: H. P. S. Makkar, ed. *Enhancing animal welfare and farmer income through strategic animal feeding: some case studies*. Animal Production and Health Paper No. 175. Rome: FAO. p. 69-79, 2013.

Vargas-Martínez, J. de J.; Sierra-Alarcón, A. M.; Mancipe-Muñoz, E. A. & Avellaneda-Avellaneda, Y. El kikuyo, una gramínea presente en los sistemas de rumiantes en trópico alto colombiano. *Rev. CES Med. Zootec*. 13 (2):137-156, 2018. DOI: http://dx.doi.org/10.21615/cesmvz.13.2.4.