








Association of the forage management practices, weaning rate, and factors that influence technological adoption in beef cattle production

Matheus Dhein Dill^{1,2} , Paulo Rodrigo Ramos Xavier Pereira³ , João Armando Dessimon Machado⁴ , Gabriel Ribas Pereira⁵ , Vitor Francisco Dalla Corte⁶ , Odilene de Souza Teixeira⁵ , Júlio Otávio Jardim Barcellos^{4,5*} 

¹ Universidade Federal Rural de Pernambuco, Garanhuns, PE, Brasil.

² Universidade Federal do Rio Grande do Sul, Tramandaí, RS, Brasil.

³ Universidade Federal do Piauí, Bom Jesus, PI, Brasil.

⁴ Universidade Federal do Rio Grande do Sul, Programa de Pós-Graduação em Agronegócios, Porto Alegre, RS, Brasil.

⁵ Universidade Federal do Rio Grande do Sul, Programa de Pós-Graduação em Zootecnia, Porto Alegre, RS, Brasil.

⁶ Faculdade Meridional, Passo Fundo, RS, Brasil.

*Corresponding author:

julio.barcellos@ufrgs.br

Received: July 30, 2019

Accepted: May 16, 2020

How to cite: Dill, M. D.; Pereira, P. R. R. X.; Machado, J. A. D.; Pereira, G. R.; Dalla Corte, V. F.; Teixeira, O. S. and Barcellos, J. O. J. 2020. Association of the forage management practices, weaning rate, and factors that influence technological adoption in beef cattle production. *Revista Brasileira de Zootecnia* 49:e20190145. <https://doi.org/10.37496/rbz4920190145>

Copyright: This is an open access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.



ABSTRACT - The objective of this study was to verify the association of improved native grassland and winter and summer pastures on the weaning rate in beef cattle production. Subsequently, we also verified the socioeconomic and productive characteristics related to the adoption of technologies to increase the weaning rate of the farmers. The survey was conducted with 73 producers of Hereford and Braford cattle in the state of Rio Grande do Sul, Brazil. A data analysis was performed using the minimum ordinal squares method and the regression analysis (Tobit). The results showed that cattle farmers who adopt winter pastures have greater weaning rates, and the factors that influence this adoption are related to a greater number of employees on the farm and the use of a crop-livestock production system. In addition, farmers who receive a greater number of technical assistance visits per year are more likely to adopt winter pastures and improved native grassland. This information can be useful in the formulation of technological dissemination programs that aim at a sustainable production of beef cattle.

Keywords: cultivated pasture, native grassland, production system, weaning

Introduction

The global perspective for population growth and the increase in demand for beef meat have led to discussions on the rural extension actions needed to promote sustainable food production. In Brazil, most beef cattle herds are raised on pasture due to soil and climatic characteristics as well as the availability of land. In the state of Rio Grande do Sul (RS), native grasslands are the main source of vegetation, which presents variations in the quantity and quality of forage during the year. Moreover, forage production has been reduced due to the use of inappropriate management practices (e.g., high animal stocking rate and cultivation in areas without agricultural suitability), causing soil degradation, erosion, and the appearance of species of low nutritional value for animals (Medeiros and Focht, 2007).

In this context of pasture shortage, the feeding of cows becomes alarming, since the adequate response in kilograms of weaned calves depends on the conditions to which the cows were subjected.

This influences the rate of weaning, which indicates the percentage of weaned calves in relation to the number of cows exposed to bulls (Peacock et al., 1971), one of the main efficiency reproductive indicators, which should be above 70% in the cow-calf systems (Lampert et al., 2012; Dill et al., 2015b). In RS, this indicator is around 56%, demonstrating that the productive performance could be improved (IBGE, 2017). The productive (i.g., weight gain) and reproductive (i.g., weaning rate) indexes are consequences of a set of proper practices, mainly nutritional, sanitary, and organizational, in the herd. Thus, alternatives to improve reproductive performance include feeding management, native grassland improvement, cultivated pasture utilization, feed supplementation (i.e., protein, energy, and mineral), stocking rate adjustment, and management techniques (Oliveira et al., 2018).

However, the slow adoption rate of many farming practices is often a source of frustration for researchers and integrated agents of the beef supply chain (from producers to retailers). Additionally, reports performed by Mogensen et al. (2016) and Florindo et al. (2017) demonstrated that the use of the technology improves the productive performance of the farm; however, they did not directly assess how these technologies impact beef cattle production. Therefore, the originality of this study is highlighted because, aside from verifying the impact that technologies (pasture management) have on the reproductive performance of the herd, it also identifies the characteristics of farmers who use such technologies.

In this sense, the objective of this study was to verify how pasture management, through improved native grassland, winter and cultivated summer pastures, influence the weaning rate in beef cattle production. A secondary objective of this study was to identify which characteristics of livestock farmers affect the adoption of technologies that positively impact the reproductive performance of their cow-calf system.

Material and Methods

A preliminary questionnaire was elaborated by means of interviews with six specialists (experts in farm management and rural extension). Afterwards, the questionnaire was tested and refined through interviews with 10 farmers. After validation by the experts during the pre-test, an interview was performed with producers of Hereford and Braford herds in RS. The sample size was calculated using the equation (1) described by Anderson et al. (2003):

$$n = \frac{Z^2 \cdot p \cdot q}{\varepsilon^2} \quad (1)$$

in which n = sample, z = confidence level, p = proportion of one characteristic of the population to be sampled, $q = (1-p)$, and ε = error margin.

According to IBGE (2006), RS has 441,467 rural establishments, out of which 329,901 are cattle producers. The confidence level of 95% and an error margin of 10% were used. The sample resulted in 73 farmers, and the final questionnaire was applied in RS, Brazil. Thirty municipalities with significant representation in cattle production were included in the research (Aceguá, Alegrete, Bagé, Boa Vista do Inca, Caçapava do Sul, Cachoeira do Sul, Candiota, Dom Pedrito, Itaquí, Lavras do Sul, Maçambará, Manoel Viana, Pantano Grande, Pedras Altas, Pinheiro Machado, Quaraí, Quevedos, Rio Pardo, Rosário do Sul, Santa Margarida do Sul, Santa Maria, Santa Rosa, Santa Vitória do Palmar, Santana do Livramento, São Francisco de Paula, São Gabriel, São Sepé, Hulha Negra, Uruguaiana, and Vale Verde; Figure 1).

Snowball sampling was used to identify farmers; the interviewees were then asked to name another similar farmer. This methodology has the analogy of a snowball, which rolls down a slope and becomes larger and larger as more snow is collected along the slope (Anim, 1999). To characterize the profile of farms, the questionnaire contained questions related to productive structure and cattle raising indicators (area destined in hectares for beef cattle raising, total number of beef cattle (head), number of mated cows per year, weaning rate, number of bulls, age of heifers at their first mating, and age and weight of calves at weaning).

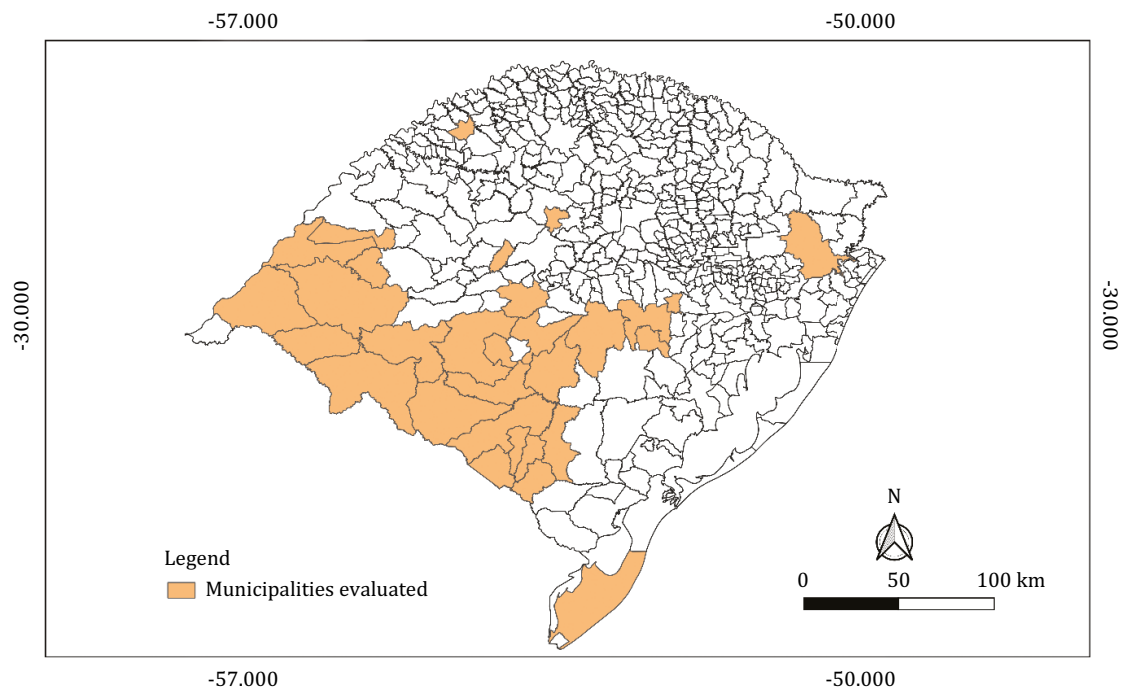


Figure 1 - Location of the farmers (state of Rio Grande do Sul, Brazil).

In addition, we also performed questions related to socioeconomic characteristics that were represented by the age of the producer, number of days accessing the internet, number of associations/unions that they participate, and technical assistance visits. Through a literature review, we observed that the variables that affect technological adoption can be represented by internet access and number of days accessed per month (Dill et al., 2015a); institutions involved, determined by number of associations and rural unions to which the farmer is affiliated (Llewellyn, 2007); and number of technical assistance visits performed on the farm per year (Abdulai and Huffman, 2005).

Farmers were asked about the number of hectares of improved native grassland, winter pastures, and summer pastures on the farm. Native grassland present structural diversity with a predominance of grasses and relatively low proportions of legumes (Nabinger et al., 2000). The main summer forage species cultivated were *Panicum maximum*, *Brachiaria brizantha*, *Brachiaria decumbens*, *Brachiaria humidicola*, *Cynodon spp.*, *Pennisetum purpureum*, *Pennisetum americanum*, *Sorghum spp.*, and *Brachiaria plantaginea*. The main winter forage species cultivated were *Lolium multiflorum*, *Avena strigosa*, *Avena sativa*, *Vicia sativa*, *Vicia villosa*, *Trifolium vesiculosum*, *Trifolium subterraneum*, *Trifolium repens*, *Trifolium pratense*, *Lotus corniculatus*, and *Medicago sativa* (Nabinger et al., 2000).

The statistical procedure was performed in two stages. In the first stage, by using the ordinary square least method, the objective was to verify the relationship between the weaning rate (percentage of calves weaned per year over the cows exposed to the bull, as a continuous dependent variable) and the utilization of summer pasture, winter pasture, and improved native grassland (dependent variables; binary variables considering 1 (one) for adopters and 0 (zero) for non-adopters). These different pasture managements were represented by the participation that each variable had in relation to the total area (hectares) used for beef cattle production on the farm. Once the variables influencing the weaning rate (i.e., winter and summer pastures and improved native grassland) were defined, the objective in the second stage was to identify the characteristics of farmers that influenced the adoption of these technologies.

The independent variables that affect technological adoption represented by internet access, institutions involved, and number of technical assistance visits performed on the farm per year (binary variables: considering 1 (one) for adopters and 0 (zero) for non-adopters) were transformed into natural

logarithm. The number of employees was also considered as a continuous variable (Boahene et al., 1999), which was obtained by dividing the number of people working on the farm by the total area in hectares, and also transformed into natural logarithm.

The age of the farmer (in years) (Johnson et al., 2010) was used as an independent and discrete variable. The other independent variables, characterized as crop-livestock integration and production diversification (>3 of farming activities), were considered as binary, considering 1 (one) for the farmers who have crop-livestock and/or diversification of production and 0 (zero) for farmers who do not have the mentioned activities.

To verify the characteristics of farmers that influence the adoption of improved native grassland and winter and summer pastures, the Tobit regression model was used. The analyses proved consistent for the Ramsey RESET test and for the White test of heteroscedasticity (Hair Jr. et al., 2009). The residues of the model showed a normal distribution, and the collinearity test by variance increase did not show collinearity.

Results

Survey participants were on average 46 years old, accessed the Internet 22 times a month, and received around five technical assistance visits in the previous year. On average, farmers participated in two associations, trade unions or farmer groups, and the majority of the farms (58%) have the crop-livestock integration system and 31% of interviewees have a diversified production with more than three agricultural activities (Table 1).

The 73 farms that constituted the sample had on average 1,380 hectares and 1,631 beef cattle head, among which 529 cows were mated by natural breeding using 22 bulls and by artificial insemination, using one bull for 24 females. The average age of heifers at first mating was 760 ± 152 days, and calves were weaned weighing around 181 ± 32 kg at 183 ± 43 days of age with an average weaning rate of 74 ± 10 %. This information refers to the average of all interviewees that includes all systems (native grassland, winter pasture, and summer cultivated pasture). According to the coefficient value (Table 2), the adoption of improved native grassland and winter pasture had a positive relation with increased weaning rate in beef cattle production.

The improved native grassland ($P = 0.003$) and use of the winter pasture ($P = 0.044$) influence the weaning rate. However, summer pasture ($P = 0.885$) showed no effect on this rate by the ordinary square least method (Table 3). The values of the coefficients of the Tobit model indicate that the adoption of the improved native grassland ($P = 0.025$) and the winter pasture ($P = 0.084$) is influenced by technical assistance orientation. The farmers with the largest number of employees ($P = 0.092$) and who have a crop-livestock integration system ($P = 0.019$) are more likely to adopt winter pastures.

Table 1 - Farmers' socioeconomic characteristics

Variable	Measurement method	Mean	Min.	Max.	SD
Age	Years	46.466	19	74	12.634
Internet access	Days per month	22.014	0	30	9.396
Technical assistance	Number of technical assistance visits (public/private) utilized in the previous year	4.548	0	30	5.888
Diversification (#)	0 = ≤ 3 activities 1 = >3 activities	0.315	0	1	0.468
Number of employees	Number of hired staff/area total (index)	4.498	0	20	3.308
Association membership	Number of associations, trade unions, and farmer groups that the farmer participates	1.904	0	4	1.069
Crop-livestock integration (#)	0 = without integration 1 = with integration	0.575	0	1	0.498

SD - standard deviation.

Dummy variable from 0 to 1.

Table 2 - Effect of the level of adoption of cultivated pastures and the weaning rate of beef cows

	Coefficient	SEM	P-value ¹
Winter pasture	0.099	0.048	0.044
Improved native grassland	0.090	0.042	0.034
Summer pasture	0.019	0.132	0.885

SEM - standard error of the mean.

¹ P-value greater than 0.01 indicates significance difference.**Table 3** - Factors that affect the adoption of the pasture management in cow-calf production system

Factor	Improved native grassland			Winter pasture		
	Coefficient	SEM	P-value	Coefficient	SEM	P-value
Age	0.012	0.016	0.467	0.111	0.301	0.711
Internet access	0.054	0.381	0.887	8.984	7.056	0.203
Technical assistance	0.513	0.228	0.025**	8.574	4.965	0.084*
Diversification	-0.142	0.549	0.794	-0.701	10.554	0.947
Number of employees	0.293	0.385	0.447	13.143	7.801	0.092*
Association membership	0.362	0.589	0.539	-5.991	10.969	0.585
Crop-livestock integration	-0.619	0.539	0.259	20.728	8.829	0.019**

SEM - standard error of the mean.

* P<0.10; ** P<0.05.

Discussion

Considering the average weaning rate obtained in the farms studied, it is possible to determine that the production systems are of large scale and have technical indicators above those obtained in RS state. These results are consequences of the adoption of forage management practices, such as improved native grassland and winter pasture, which optimize the reproductive results of the herd.

The forage management practices, as improved native grassland use in the postpartum period of cows and heifers, allows greater weight gains until the beginning of the mating season, leading to greater pregnancy rates when compared to animals allocated in native grassland (Lobato and Barcellos, 1992). In addition, the improved native grassland can increase profits and reduce environmental damage as a result of production optimization. Similarly, winter pastures allow adequate development of animals during the period in which the growth of native grassland decelerates (Rocha et al., 2003). Vaz et al. (2014) reported that cows kept in winter pasture composed of oats (*Avena sativa*), ryegrass (*Lolium multiflorum*), and vesicular clover (*Trifolium vesiculosum*) produced 22.6% more calves than cows retained exclusively on native grassland. However, the adoption of these technologies is often low because of the characteristics of rural farmers (Borges et al., 2014) and due to a lack of financial compensation to preserve native resources (Nabinger et al., 2009).

Regarding the characteristics of rural farmers that influence the adoption of technologies, it was possible to observe that the exchange of knowledge between farmers and technical assistants plays an important role in the decision-making process to adopt new technologies, which in turn, has further implications on the development of new approaches for a rural extension. According to Dill et al. (2015a), with the advancement of technological dissemination, the information on the benefits of innovations becomes more relevant, thus favoring adoption by farmers. Gillespie et al. (2007) observed that farmers that did not adopt the best management practices in beef cattle production in the United States lack a better understanding of new applied technologies techniques. They concluded that there is a high production cost to implement new technologies or that a certain technology may have no applicability on their farms. In this sense, it is necessary to develop training programs and implement technical assistance practices in the form of creating effective mechanisms to encourage sustainable

food production (Jara-Rojas et al., 2012). However, access to technical assistance and rural extension in Brazil are still among the main problems related to diffusion and technological adoption in rural areas. According to the Agricultural Census (IBGE, 2017), most rural producers do not receive technical assistance and only 20,1% of the farmers use some type of technical guidance to improve productive activities, and the access to technical assistance is more common in medium and large farms.

Rogers (2003) emphasized that technological adoption is a process of acceptance of new ideas, represented by five stages: the knowledge stage, which is the first contact with technology; the persuasion stage, in which the rural producer is interested in the attributes of innovation and looks for information to minimize the uncertainties and to base an opinion on the new idea; the decision stage, characterized as the moment at which the individual adopts or rejects the technology; deployment stage, when people put the technology into use; and the confirmation stage, when people try to reinforce the decision they have already made.

In a study performed in RS, Borges et al. (2014) identified that farmers' intention to use improved native grassland in beef cattle production is influenced by the availability of qualified technical assistance. Factors such as increasing weight gain, increasing the number of animals per hectare, increasing pasture retention, reducing feed costs, and preventing erosion also have a positive influence on the intention to adopt improved pasture technology. As observed, the process of technological adoption can often be delayed due to the various personal, social, economic, and institutional factors involved, even for those technologies that already offer recognized productive benefits in rural areas. This is a fact that deserves special attention in the beef cattle production of RS, because the diffusion and technological adoption are considered the main obstacles for the sustainable development of the activity. Perhaps, this has implications for the development of rural extension approaches.

The increase in the number of employees per area was positively associated with the increase in adoption of winter pasture. According to Barcellos and Suñe (2011), human resources are one of the most important points for beef cattle ranching development that comprises business vision, with a focus on increasing productivity. Therefore, the employee skill inherent to the rural activity (implicit knowledge) and the level of motivation (awarding programs) are all considered. The development of certain personal skills through training programs can sensibly influence the performance of the individual as well as benefit the enterprise through the specialization of its workforce. Given this context, it is also possible to infer that the intensification of production triggered by human resources tends to benefit the performance of the farm, since the rural enterprises have a variety of alternatives to be explored.

Farmers with crop-livestock integration systems have proved to be more likely to increase the adoption of winter pasture. The combination of livestock and crop or forest production in the same area tends to increase the amount of organic matter in the soil, favoring the production of biomass and increasing the stocking rate in pasture. Thus, integrated livestock farming can be considered a promising strategy for a sustainable increase in agriculture (Moraes et al., 2014; Gil et al., 2015). In a study performed in USA, which included production of beef calves and management, Pruitt et al. (2012) also identified a possible interaction between productive aspects and the complementarity among technologies as promoters of more technological uses.

In such a context, it is possible to see that the process of technological use includes productive factors and an intricate web of social relations in which the agents involved confront different ideas and develop different activities in their struggle to achieve success as rural businesses. Therefore, technological use should be analyzed considering the socioeconomic context as well as the existing productive aspects (Cáceres et al., 1997), because these factors interact with one another, either promoting or inhibiting dissemination and technological use in the rural environment (Souza Filho et al., 2011).

Conclusions

Through this investigation, the elements that guide cattle farmers to use different grazing strategies in their cow-calf systems are understood. Thus, adopting winter pastures in greater proportions optimizes

productivity through better weaning rates, enhancement of integrated livestock and agricultural practices, and improvement of the use of a larger number of employees in the farms. The presence of various technologies applied to diffusing agents on rural extensions programs on the farm stimulates farmers to introduce an improvement of native grassland and cultivated pastures to the production system. Therefore, technical assistance and rural extension actions deserve special attention in the development of public policies aimed at rural development.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: M.D. Dill, P.R.R.X. Pereira, G.R. Pereira, V.F. Dalla Corte and J.O.J. Barcellos. Data curation: M.D. Dill, P.R.R.X. Pereira, G.R. Pereira and J.O.J. Barcellos. Formal analysis: M.D. Dill, J.A.D. Machado, G.R. Pereira, V.F. Dalla Corte and J.O.J. Barcellos. Investigation: M.D. Dill, P.R.R.X. Pereira and J.O.J. Barcellos. Methodology: M.D. Dill, P.R.R.X. Pereira, J.A.D. Machado, G.R. Pereira, V.F. Dalla Corte, O.S. Teixeira and J.O.J. Barcellos. Supervision: J.A.D. Machado, G.R. Pereira, V.F. Dalla Corte, O.S. Teixeira and J.O.J. Barcellos. Validation: P.R.R.X. Pereira. Writing-original draft: M.D. Dill, O.S. Teixeira and J.O.J. Barcellos. Writing-review & editing: M.D. Dill, P.R.R.X. Pereira, J.A.D. Machado, G.R. Pereira, V.F. Dalla Corte, O.S. Teixeira and J.O.J. Barcellos.

Acknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001. The financial support of the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) is gratefully acknowledged.

References

- Abdulai, A. and Huffman, W. E. 2005. The diffusion of new agricultural technologies: the case of crossbred-cow technology in Tanzania. *American Journal of Agricultural Economics* 87:645-659. <https://doi.org/10.1111/j.1467-8276.2005.00753.x>
- Anderson, D. R.; Sweeney, D. J. and Williams, T. A. 2003. *Essentials of statistics for business and economics*. Thomson South-Western, Mason.
- Anim, F. D. 1999. A note on the adoption of soil conservation measures in the northern province of South Africa. *Journal of Agricultural Economics* 50:336-345. <https://doi.org/10.1111/j.1477-9552.1999.tb00818.x>
- Barcellos, J. O. J. and Suñe, Y. B. P. 2011. A cria e a expansão agrícola. p.71-78. In: *Bovinocultura de corte: cadeia produtiva e sistema de produção*. Barcellos, J. O. J.; Oliveira, T. E.; Marques, P. R.; Canellas, L. C.; Canozzi, M. E. A.; Gomes, A. T. and Moojen, F. G., eds. Agrolivros, Guaíba.
- Boahene, K.; Snijders, T. A. B. and Folmer, H. 1999. An integrated socioeconomic analysis of innovation adoption: the case of hybrid cocoa in Ghana. *Journal of Policy Modeling* 21:167-184. [https://doi.org/10.1016/S0161-8938\(97\)00070-7](https://doi.org/10.1016/S0161-8938(97)00070-7)
- Borges, J. A. R.; Oude Lansink, A. G. J. M.; Ribeiro, C. M. and Lutke, V. 2014. Understanding farmers' intention to adopt improved natural grassland using the theory of planned behavior. *Livestock Science* 169:163-174. <https://doi.org/10.1016/j.livsci.2014.09.014>
- Cáceres, D.; Silvetti, F.; Soto, G.; Rebolledo, W. and Crespo, H. 1997. La adopción tecnológica en sistemas agropecuarios de pequeños productores. *Agro Sur* 25:123-135. <https://doi.org/10.4206/agrosur.1997.v25n2-01>
- Dill, M. D.; Emvalomatis, G.; Saatkamp, H.; Rossi, J. A.; Pereira, G. R. and Barcellos, J. O. J. 2015a. Factors affecting adoption of economic management practices in beef cattle production in Rio Grande do Sul state, Brazil. *Journal of Rural Studies* 42:21-28. <https://doi.org/10.1016/j.jrurstud.2015.09.004>
- Dill, M. D.; Pereira, G. R.; Costa Jr., J. B. G.; Canellas, L. C.; Peripolli, V.; Braccini Neto, J.; Sant'Anna, D. M.; McManus, C. and Barcellos, J. O. J. 2015b. Technologies that affect the weaning rate in beef cattle production systems. *Tropical Animal Health and Production* 47:1255-1260. <https://doi.org/10.1007/s11250-015-0856-x>

- Florindo, T. J.; Florindo, G. I. B. M.; Talamini, E.; Costa, J. S.; Ruviaro, C. V. 2017. Carbon footprint and Life Cycle Costing of beef cattle in the Brazilian midwest. *Journal of Cleaner Production* 147:119-129. <https://doi.org/10.1016/j.jclepro.2017.01.021>
- Gil, J.; Siebold, M. and Berger, T. 2015. Adoption and development of integrated crop–livestock–forestry systems in Mato Grosso, Brazil. *Agriculture, Ecosystems and Environment* 199:394-406. <https://doi.org/10.1016/j.agee.2014.10.008>
- Gillespie, J.; Kim, S. and Paudel, K. 2007. Why don't producers adopt best management practices? An analysis of the beef cattle industry. *Agricultural Economics* 36:89-102. <https://doi.org/10.1111/j.1574-0862.2007.00179.x>
- Hair Jr., J. F.; Black, W. C.; Babin, B. J. and Anderson, R. E. 2009. *Multivariate data analysis*. 7th ed. Prentice Hall, New Jersey.
- IBGE - Instituto Brasileiro de Geografia e Estatística. 2006. *Censo Agropecuário 2006*. IBGE, Rio de Janeiro.
- IBGE - Instituto Brasileiro de Geografia e Estatística. 2017. *Censo Agropecuário 2017*. IBGE, Rio de Janeiro.
- Jara-Rojas, R.; Bravo-Ureta, B. E. and Díaz, J. 2012. Adoption of water conservation practices: a socioeconomic analysis of small-scale farmers in Central Chile. *Agricultural Systems* 110:54-62. <https://doi.org/10.1016/j.agsy.2012.03.008>
- Johnson, R. J.; Doye, D.; Lalman, D. L.; Peel, D. S.; Raper, K. C. and Chung, C. 2010. Factors affecting adoption of recommended management practices in stocker cattle production. *Journal of Agricultural and Applied Economics* 42:15-30. <https://doi.org/10.1017/S1074070800003266>
- Lampert, V. N.; Barcellos, J. O. J.; Kliemann Neto, F. J.; Canellas, L. C.; Dill, M. D. and Canozzi, M. E. A. 2012. Development and application of a bioeconomic efficiency index for beef cattle production in Rio Grande do Sul, Brazil. *Revista Brasileira de Zootecnia* 41:775-782. <https://doi.org/10.1590/S1516-35982012000300042>
- Llewellyn, R. S. 2007. Information quality and effectiveness for more rapid adoption decisions by farmers. *Field Crops Research* 104:148-156. <https://doi.org/10.1016/j.fcr.2007.03.022>
- Lobato, J. F. P. and Barcellos, J. O. J. 1992. Efeitos da utilização de pastagem melhorada no pós-parto e do desmame aos 100 ou 180 dias de idade no desempenho reprodutivo de vacas de corte. *Revista Brasileira de Zootecnia* 21:385-395.
- Medeiros, R. B. and Focht, T. 2007. Invasão, prevenção, controle e utilização do capim-annoni-2 (*Eragrostis plana* Ness) no Rio Grande do Sul, Brasil. *Pesquisa Agropecuária Gaúcha* 13:105-114.
- Mogensen, L.; Nguyen, T. L. T.; Madsen, N. T.; Pontoppidan, O.; Preda, T. and Hermansen, J. E. 2016. Environmental impact of beef sourced from different production systems - focus on the slaughtering stage: input and output. *Journal of Cleaner Production* 133:284-293. <https://doi.org/10.1016/j.jclepro.2016.05.105>
- Moraes, A.; Carvalho, P. C. F.; Lustosa, S. B. C.; Lang, C. R. and Deiss, L. 2014. Research on Integrated Crop-Livestock Systems in Brazil. *Revista Ciência Agronômica* 45:1024-1031. <https://doi.org/10.1590/S1806-66902014000500018>
- Nabinger, C.; Ferreira, E. T.; Freitas, A. K.; Carvalho, P. C. F. and Sant'Anna, D. M. 2009. Produção animal com base no campo nativo: aplicações de resultados de pesquisa. p.175-198. In: *Campos Sulinos: Conservação e uso sustentável da biodiversidade*. Pillar, V. P.; Müller, S. C.; Castilhos, Z. M. S. and Jacques, A. V. A., eds. Ministério do Meio Ambiente, Brasília.
- Nabinger, C.; Moraes, A. and Maraschin, G. E. 2000. Campos in Southern Brazil. p.355-376. In: *Grassland ecophysiology and grazing ecology*. Lemaire, G.; Hodgson, J.; Moraes, A.; Nabinger, C. and Carvalho, P. C. F., eds. CABI Publishing, Wallingford.
- Oliveira, T. E.; Barcellos, J. O. J.; Whittier, J.; Teixeira, O. S.; Freitas, D. S.; Oaigen, R. P.; Dill, M. D. and McManus, C. 2018. Risks associated to different methods of increasing pregnancy rate of cows in cow-calf systems. *Revista Brasileira Zootecnia* 47:e20180051. <https://doi.org/10.1590/rbz4720180051>
- Peacock, F. M.; Koger, M.; Kirk, W. G.; Hodges, E. M. and Warnick, A. C. 1971. Reproduction in Brahman, Shorthorn and crossbred cows on different pasture programs. *Journal of Animal Science* 33:458-465. <https://doi.org/10.2527/jas1971.332458x>
- Pruitt, J. R.; Gillespie, J. M.; Nehring, R. F. and Qushim, B., 2012. Adoption of technology, management practices, and production systems by U.S. beef cow-calf producers. *Journal of Agricultural and Applied Economics* 44:203-222. <https://doi.org/10.1017/S1074070800000274>
- Rocha, M. G.; Restle, J.; Pilau, A. and Santos, D. T. 2003. Produção animal e retorno econômico da suplementação em pastagem de aveia e azevém. *Ciência Rural* 33:573-578. <https://doi.org/10.1590/S0103-84782003000300028>
- Rogers, E. M. 2003. *Diffusion of innovations*. 5th ed. Free Press, Nova York.
- Souza Filho, H. M.; Buainain, A. M.; Silveira, J. M. F. J. and Vinholis, M. M. B. 2011. Condicionantes da adoção de inovações tecnológicas na agricultura. *Cadernos de Ciência & Tecnologia* 28:223-255.
- Vaz, R. Z.; Restle, J.; Pacheco, P. S.; Vaz, F. N.; Alves Filho, D. C.; Brondani, I. L.; Pascoal, L. L. and Argenta, F. M. 2014. Produtividade e eficiência de produção de vacas de diferentes grupos genéticos submetidas a pastagens cultivadas no pré ou pós-parto. *Semina: Ciências Agrárias* 35:2697-2708. <https://doi.org/10.5433/1679-0359.2014v35n5p2697>