APPLIED VETERINARY RESEARCH

RESEARCH ARTICLE
Published Online: February 15, 2025
https://doi.org/10.31893/avr.2024010

Bibliometric analysis of the Santa Ines sheep breed

Concepta McManus[a] | Samuel Rezende Paiva[b] | Felipe Pimentel[c] | Daniel Pimentel[a] | Vanessa Peripolli[d] ✉ | Tiago do Prado Paim[e]

[a]Universidade de Brasília, Instituto Federal Catarinense, Campus Araquari, Brazil.
[b]Embrapa, Universidade de Brasília /IB, Campus Darcy Ribeiro, 70910-900, Brasília, DF, Brazil.
[c]Universidade Anhembi, Embrapa Recursos Genéticos e Biotecnologia, 70770-917, Brasília, DF,Brazil.
[d]Instituto Federal Catarinense, Universidade Anhembi Morumbi, Campus Paulista, 01310-200, São Paulo, SP, Brazil.
[e]Instituto Federal Goiano, Instituto Federal Goiano, Campus Rio Verde, 75901-970, Rio Verde, GO, Brazil.

Abstract Santa Ines is the main Brazilian hair sheep breed. The importance of this breed has increased significantly in the last 20 years, even though lamb production in Brazil remains incipient. This study aims to characterize the bibliographic production of this sheep breed. Here, we presented a map of citations, co-occurrences of keywords, co-citations, and bibliographic coupling for studies on Santa Ines sheep. Data were obtained from Scopus (Elsevier) and analyzed via VOSviewer software and the SciVal platform (Elsevier). Several salient points are raised in the bibliographic mapping analysis. Research has focused on the areas of parasitology, alternative feedstuffs, and traditional quantitative genetics. Research groups are regionalized, with most research in the Northeastern region, with important groups in the Distrito Federal and São Paulo. There is little research on Santa Ines breed in other regions, such as Northern or Southern Brazil, although animals of this breed are raised in these regions. Research has plateaued in recent years. International collaboration is low, with most publications in Brazilian journals.

Keywords: authors, citations, lamb, papers, VOSviewer

1. Introduction

Brazil holds the 23rd position worldwide in national lamb production (FAO 2023). Brazilian sheep production is characterized by dispersed stakeholders, with 80% classified as smallholder farmers and concentrated in Northeast Brazil. The Santa Ines is Brazil's most numerous and widespread breed of sheep (McManus et al., 2014).

The Santa Ines breed was formed in the Northeast Region of Brazil, probably in some regions of Ceara, Paraíba, and Rio Grande do Norte states, from accidental crosses between the Bergamasca, Morada Nova, and Somalis breeds and animals without a defined breed standard (Ribeiro and García, 2016). According to ARCO (Brazilian Society for Sheep Registry - http://www.arcoovinos.com.br/), its origin is confirmed by its traits, such as size, ear type, head shape, and wool remnants, which are due to Bergamasca, whereas its lack of wool and coat types are due to the Morada Nova. The participation of Somalis is seen in the fat around the tail head when the animal is very fat.

Molecular studies have been conducted to investigate aspects of the origin, diversity, management decisions, and parentage of Santa Ines sheep. There are five major haplogroups (HPGs) of sheep (Meadows et al., 2006). Bandelt et al., (1999) studied the relationships between haplotypes via network analysis. Two significant events are to be seen in the formation of Brazilian breeds, one older (H27) with European breeds and a more recent one (H28), including only Brazilian breeds. Therefore, the present Santa Ines breed had several events of introgression from other breeds, especially Bergamasca, Suffolk and Dorper, from the oldest to the newest (McManus et al., 2020a; Paim et al., 2021).

Its origin, aptitudes, characteristics, and qualities are frequently cited in the literature, but usually, there is little objectivity in the citations (Ribeiro and García 2016). In this context, bibliometric tools allow us to conduct a systematic, transparent, and replicable review of existing research and provide more abundant, relational, contextual, and holistic intellectual landscape knowledge (Brito-Ochoa et al., 2020; Han et al., 2020; Kraus et al., 2020). The present study aims to examine publication patterns of Santa Ines sheep in Brazil via bibliographic measurements.

2. Materials and Methods

2.1. Search strategy

The literature on Santa Inês sheep was identified in Scopus (Elsevier database). The search parameters were "(TITLE-ABS-KEY (Santa AND Ines) AND TITLE-ABS-KEY (sheep))". The information included year of publication, language, journal, title,

 Received: August 2, 2024 | Accepted: January 12, 2025

author, affiliation, keywords, document type, abstract, and citations, which were exported in CSV format. We retrieved a total of 1248 papers on the 15th of February 2023.

2.2. Data analysis

VOSviewer (version 1.6.18) was used to map co-authorship, co-occurrence, citation, bibliographic coupling, co-citation and keywords (Van Eck and Waltman 2010; 2013; 2017). The parameters for the analyses are shown in Table 1. The circle size in VOSviewer positively correlates with the keyword occurrence or countries in the title and abstract. The color of the line connecting words is more vibrant if the word/researcher/country is commonly found in different studies. If the connection is small, then the color is more transparent. It was possible to download cluster information for further analyses.

Table 1 Bibliometric parameters for publications on Santa Ines Sheep.

	Total	Min Doc	Threshold	Linked	Clusters
Authors	4096	5	263	256	16
Country	72	2	23	15	5
Keywords	2145	5	158	271	15
Citations					
Citation	1075	10	333	214	20
Sources	152	5	42	42	7
Authors	4096	5	263	260	9
Coupled					
Coupled	1075	10	333	302	10
Sources	152	5	42	42	5
Authors	4096	5	263	262	7
References					
Cited Ref	31817	3	321	310	12
Authors	42663	30	346	346	6
Sources	9566	20	177	108	6

In bibliographic coupling, two works reference a common third work, whereas co-citation occurs when two documents receive a citation from the same third document (Figure 1).

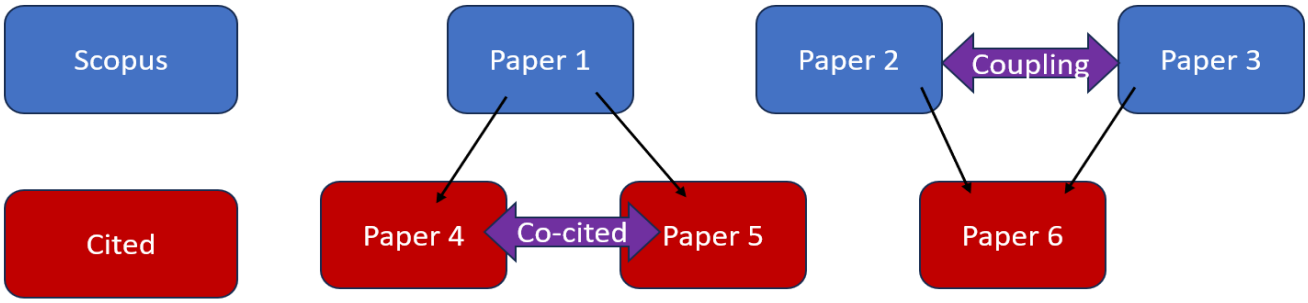


Figure 1 Explanation diagram for bibliographic coupling and co-citations.

According to Mas-Tur et al. (2021), co-citation occurs when two documents receive a citation from the same third document. Author cocitation analysis (ACA) provides insight into how authors, as domain experts, connect ideas between published works (Chen et al., 2010). Bibliographic coupling occurs when two studies cite the same third document. While ACA is relevant to authors, bibliographic coupling is relevant to authors, institutions, and countries. The data were cleaned in OpenRefine (https://openrefine.org/). We excluded the research parameters from the keywords section. Duplicate terms such as ovine, sheep and *Ovis aries* and singular and plural terms were combined.

We used fractional counting, in which each paper has only one unit that is fractionated according to the number of coauthors (Cancino et al., 2017; Gaviria-Marin et al., 2018; Martínez-López et al., 2018). When fractional counting is used, the strength of a coauthorship link between two authors is determined not only by the number of documents coauthored by the authors but also by the number of authors of each coauthored document.

The overall change in the number of documents may reflect a change in overall scientific production in all areas of knowledge worldwide. To compare the overall change in documents in all fields with this specific field from 2005-2022 (the last year evaluated), we calculated the ratio of the number of documents in this area to those published in all areas [Eq 1] in 2005 as well as linear regression from 2000-2015.

$$Ratio_{Year=\frac{\sum Number\ of\ papers\ in\ specific\ area}{\sum Number\ of\ papers\ in\ all\ areas}}$$ [Eq 1]

This was recalculated in 2022 [Eq 2].

$$\frac{Ratio_{2022}}{Ratio_{2005}}$$ [Eq 2]

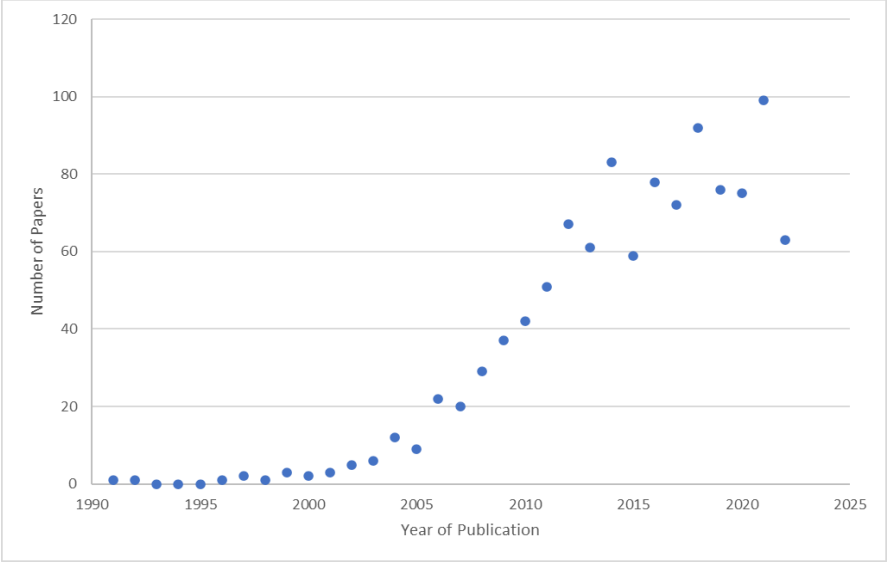
A value greater than one (1) means that the area of knowledge is growing faster than the world mean, and a value less than one means that it is growing at a slower rate.

The set of papers was imported into the SciVal platform, and citation parameters, such as use in policy documents and impact factors, were calculated. We summarized the main findings of these papers concerning the breed and identified the main silent points remaining for these animals.

3. Results

There was an increase in papers on Santa Ines from 2000--2015 (Figure 2a), with a stabilization after this of approximately 80 papers per year (y = - 430519 + 423.84x -0.1043x^2; R^2 = 0.89). These papers are focused on Brazilian authors, as expected (Figure 2b), and the main contributing states are São Paulo and Bahia (Figure 2c). The Field Weighted Citation Impact (FWCI) of these papers was 0.65 (with a World Mean of one (1)) and an average of 7.4 citations per publication. This number increased to 1.01 in international collaboration. A total of 3.2% of the papers were in the top 10% of the most cited publications worldwide, and 7.5% were in the top 10% of journals. A total of 14.8% were published with international coauthors, and 0.1% were published with corporate authors.

a



b

c

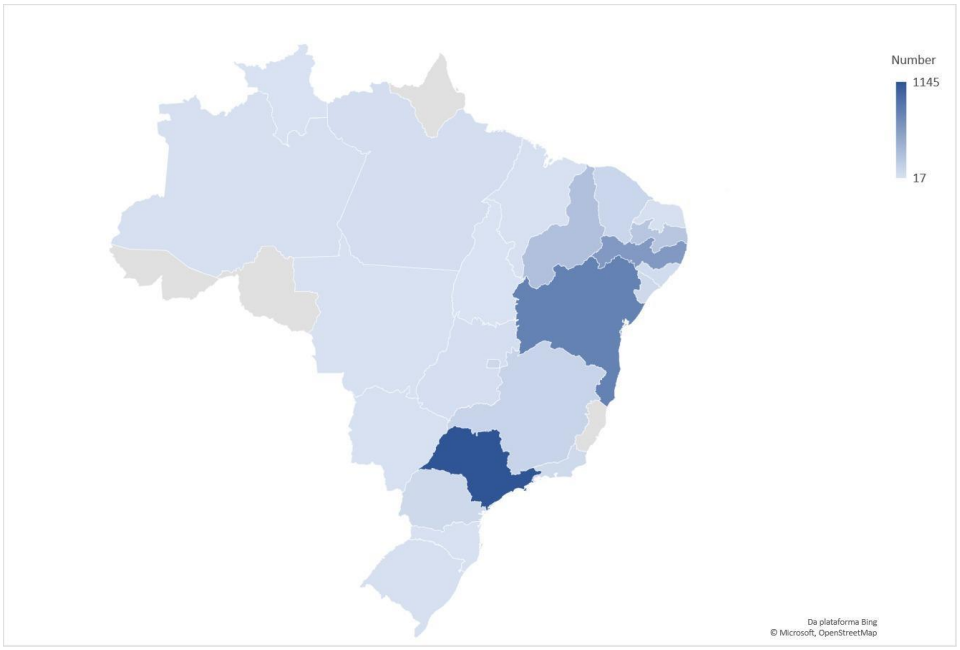
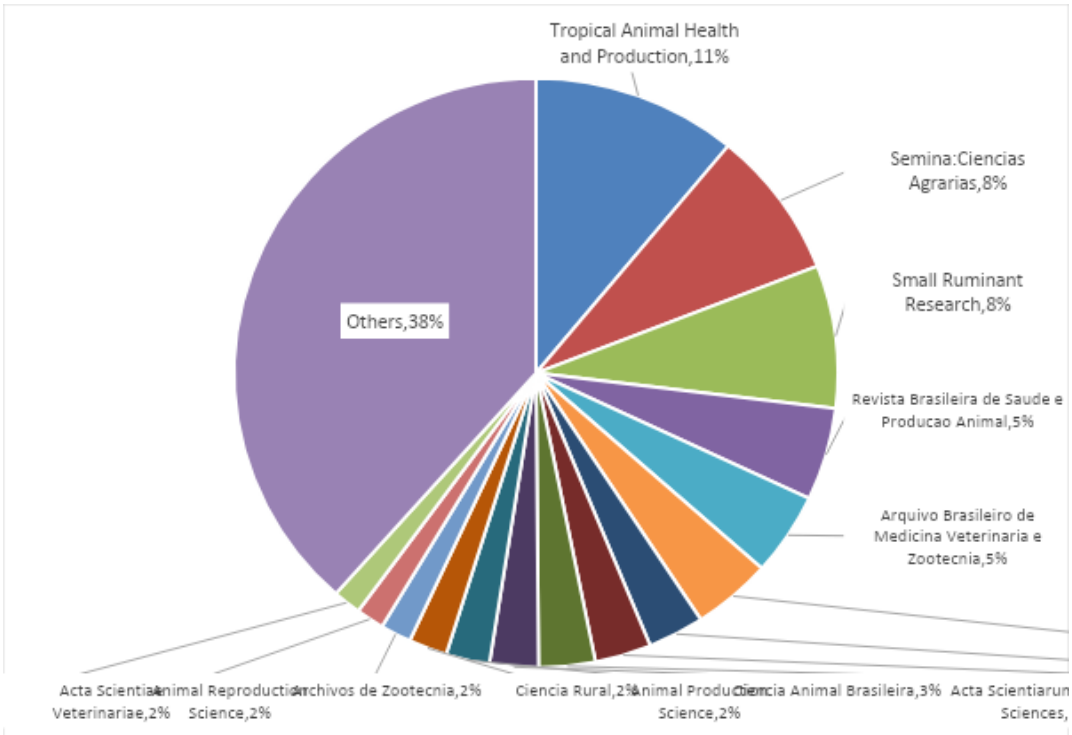


Figure 2 Number of papers for Santa Ines sheep per year (a), country of production (b) and state of Brazil (c).

Seven of the top 10 journals published on Santa Ines sheep are Brazilian, such as Semina: Ciências Agrárias; Revista Brasileira de Saúde e Produção Animal; Arquivo Brasileiro de Medicina Veterinária e Zootecnia; Pesquisa Veterinária Brasileira; Revista Brasileira de Zootecnia; Acta Scientiarum - Animal Sciences; and Ciência Animal Brasileira (Figure 3a). However, Tropical Animal Health and Production was the most important journal, while Small Ruminant Research was the third most important journal and Livestock Science the eighth most important journal. A total of 21.6% were published in Q1 journals, and 33.6% were published in Q2 journals. Publications are in the areas of Agricultural and Veterinary Sciences (Figure 3b), as expected, and are financed by CAPES and CNPq (Figure 3c), as well as FAPs (State Research Financing Foundations).

a



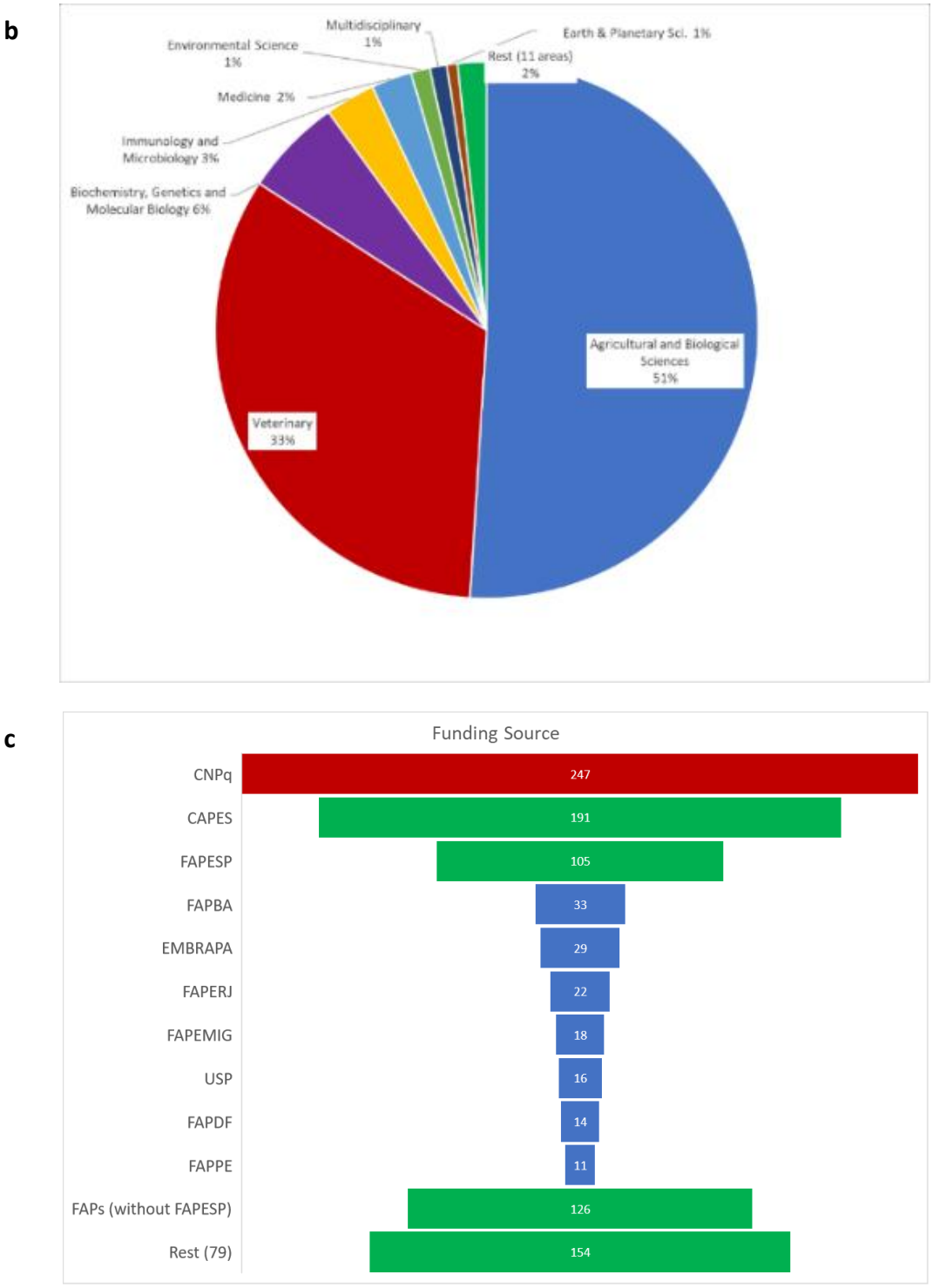


Figure 3 Publishing source (a), area of knowledge (b) and funding source (c) for publications on Santa Ine sheep.

The major groups of authors can be seen in Figure 4a, with important groups at the Universidade de São Paulo/Universidade de Brasília (light blue), pink from northeastern universities, such as the Universidades Federal do Piauí and Bahia; red (Paraíba); green (Southwest Bahia); and other groups in orange (Universidade de São Paulo). No major groups were observed in southern China. These groups tend to be regionalized. Older groups produced papers with higher average citations (Figures 4b, and 4c).

Most papers are produced by Brazilian authors, without significant international collaboration (Figures 4d, 4e, and 4f). When collaboration exists, it is linear (from Brazil to a single country) without creating networks. The major topics (Figures 4g, 4h, and 4i) studied included reproduction (red), gastrointestinal parasites (green), alternative feeds (lilac), and welfare (yellow), with the highest number of citations related to nutrition and carcass quality.

Highly cited papers (Figure 5) include those related to heat tolerance (brown - McManus et al., 2009), gastrointestinal infections (pink/green - Amarante et al. 2004), genetics (gray – Silva et al., 2011) and breeding (orange - Sarmento et al., 2006). The most cited papers include the Revista Brasileira de Zootecnia, Tropical Animal Health and Production and Small Ruminant Research. Journals such as Plos One and Animals are more recent. More citations are seen internationally than in Brazilian journals.

Citation networks are largely restricted to the researched area, such as reproduction (Figure 5d- purple) or veterinary science (red), with a central core of broad-themed animal production journals.

Bibliographic coupling (Figure 6) shows strong groups working on different themes, similar to those stated above. Authors tend to be coupled with specific research areas such as genetics (green), nutrition (red), parasitology (light blue), and breeding (purple). More citations are presented in papers related to parasitology and animal welfare, such as heat tolerance.

The results of the co-citation analyses were similar to those of the bibliographic coupling analysis (Figure 7). Van Soest et al., (1991) and NRC (2007) are standard texts for diet analyses and nutrition in experiments. Clusters of co-citing journals can be seen (Figure 7b), including those on reproduction (yellow), health (green), and animal science (Brazilian – red; or international – blue).

The red group (Figure 7c) refers to papers on nutrition, whereas the yellow cluster looks at animal welfare and genetic resources. Parasitology and animal health are represented by the dark blue cluster, and the green and purple clusters represent production systems.

In terms of public policy, 17 papers (2.3% of the total) were cited by 9 public policy bodies from 6 countries. These documents had a Field-Weighted Citation Impact (FWCI) of 1.60. These include the Food and Agriculture Organization of the United Nations, the EFSA, the UK Government, and the World Organization for Animal Health.

4. Discussion

Bibliographic mapping has been used to examine breeds, species, and even journals (Pimentel et al., 2023). The number of publications per year about Santa Ines sheep has stabilized over the last 10 years. This may be due to the preference for publishing in Brazilian journals, which may not be referenced in the Scopus database, or may reflect a growing preference for other breeds, such as Dorper. Moreover, the funding for science in Brazil has decreased during these years, and the interest in funding sheep studies has likely decreased, as it is not a main industry for Brazil, although it is important for smallholder farming in Northeast Brazil (McManus et al., 2014).

The evaluation of the regions of affiliation of the authors clearly revealed Brazilian inequality in science production. Sao Paulo Universities had a greater number of researchers and more funding, consequently resulting in greater scientific production, even though the main region of interest for hair sheep breeding in Brazil is Northeast Brazil, where the sheep industry has greater relevance. There is a lack of knowledge concerning hair sheep breeds in this region.

The 17 papers cited in public policies could be grouped according to the subject as nematode resistance to drugs (Albuquerque et al., 2017), sheep resistance to steroidal saponin poisoning (Gracindo et al., 2014), nutritional evaluation of additives or alternative protein sources (Oliveira et al., 2013; El-Zaiat et al., 2014; Viana et al., 2014; Sousa et al., 2018; Lima et al., 2019a), grazing behavior (Emerenciano Neto et al., 2020), development of innovative techniques for reproduction (Freitas et al., 2018; Santos et al., 2020) and health diagnosis (Martins et al., 2013), meat and carcass traits (Lima et al.,., 2019b), heat tolerance (Correa et al., 2013; Titto et al., 2016) and genetics (Vargas Junior et al., 2014; Paim et al., 2021; Santos et al., 2021). Paim et al., (2021) explored the genetic origin of Santa Ines, showing the contribution of Brazilian Bergamasca and recent introgressions from other breeds, mainly Suffolk. Santos et al., (2021) explored the genetic parameters and breeding values of traits that indicate resistance to gastrointestinal nematode infection in Santa Ines sheep via pedigree and genomic information. Gracindo et al., (2014) explored the tolerance of Santa Ines animals to steroidal saponin poisoning, which is a common problem for sheep grazing on *Brachiaria* spp. Correa et al., (2013) and Titto et al., (2016) reported greater heat tolerance in Santa Ines animals than in other hair and wool breeds. Santa Ines animals presented the lowest rectal temperature after sun exposure, and it was the only one to recover at 60 min after heat stress in the morning (Titto et al., 2016).

The most cited papers (normally older) are McManus et al., (2009) on heat tolerance, Amarante et al., (2004) on gastrointestinal nematode infections and Silva et al., (2011) and Sarmento et al., (2006) on genetics. McManus et al., (2009) evaluated how the diversity of coat colors in Santa Ines (brown, black and white) is related to heat tolerance. These authors reported that white-coated animals had lower heart and breathing rates coupled with lower rectal temperatures; therefore, they concluded that white-coated Santa Ines are more adapted to the climatic conditions of Central Brazil. However, McManus et al., (2020b) noted the change in coat color from white varieties to almost entirely black varieties at present.

Amarante et al., (2004) evaluated resistance against nematode infections and compared Santa Ines with Ile de France and Suffolk. These authors reported similar susceptibilities to *Trichostrongylus colubriformis* between the breeds. Santa Ines animals presented increased resistance to *Haemonchus contortus* and *Oesophagostomum columbianum*. Therefore, this study highlights the importance of conserving this genetic resource and being careful in crossbreeding, as *H. contortus* is one of the main health issues in tropical sheep breeding.

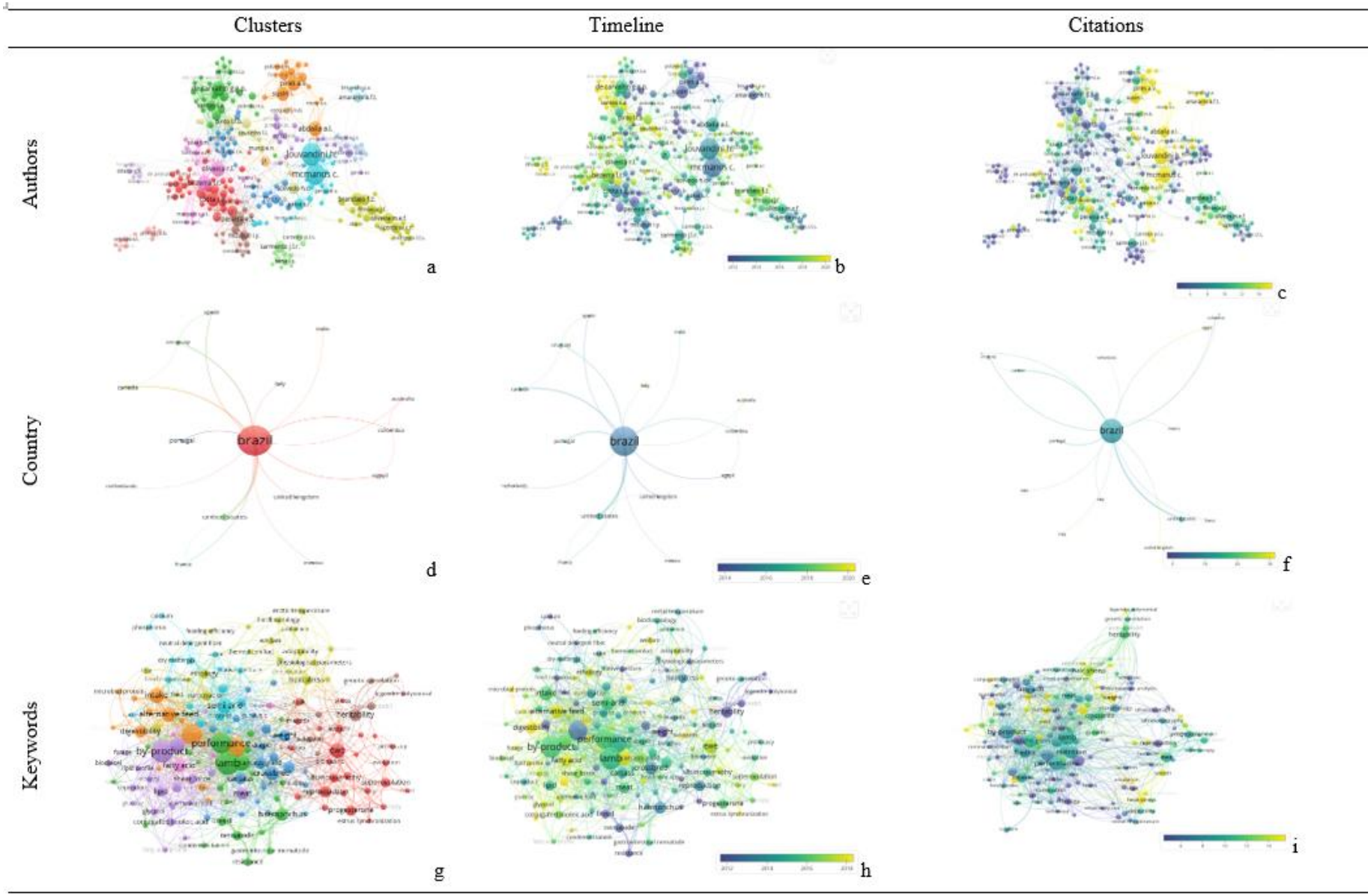


Figure 5 Citation mapping for Santa Ines sheep authors (a, b, c), country (d, e, f) and keywords (g, h, i).

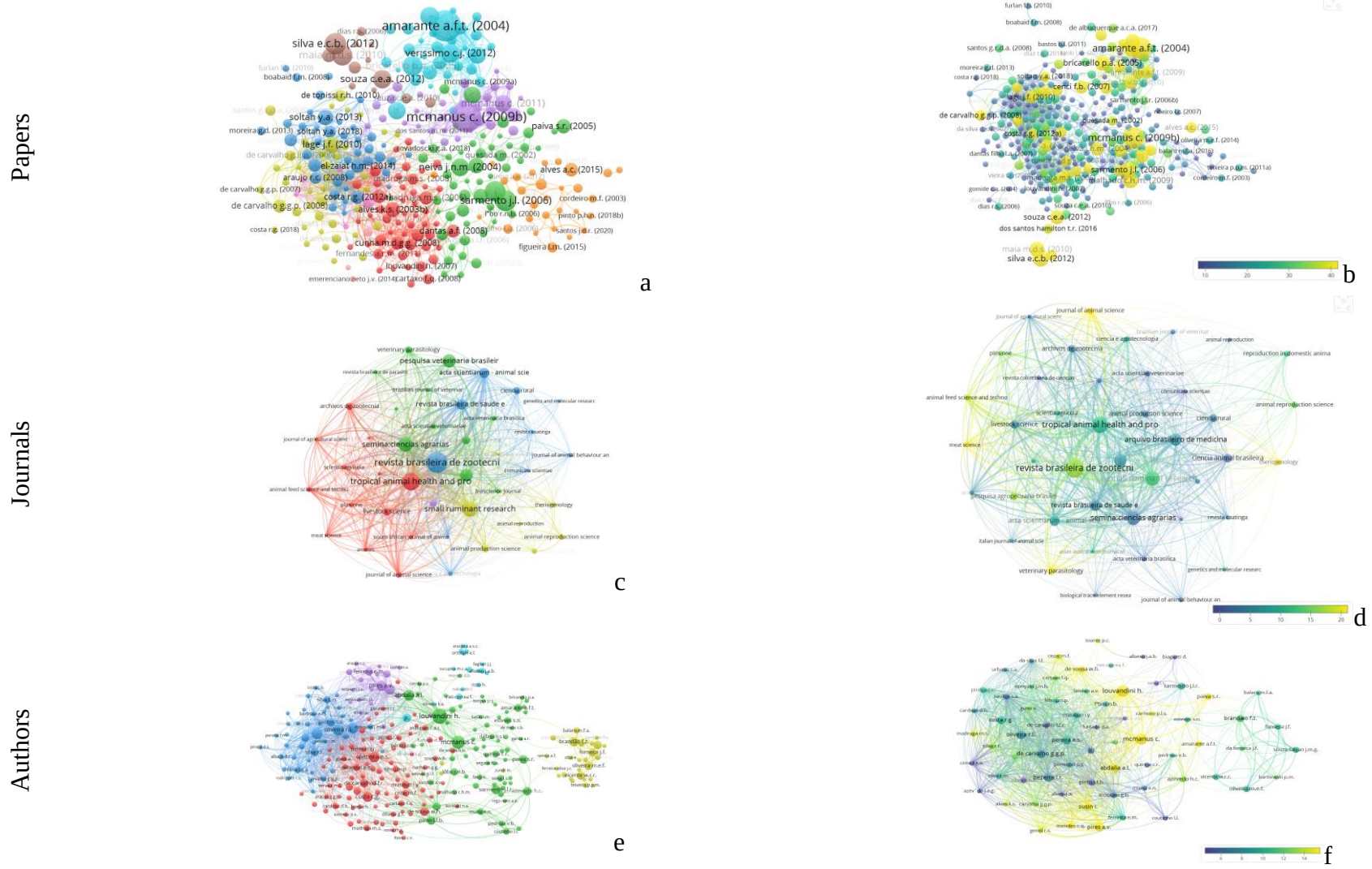


Figure 6 Bibliographic coupling mapping for Santa Ines sheep papers (a, b), journals (c, d) and authors (e, f).

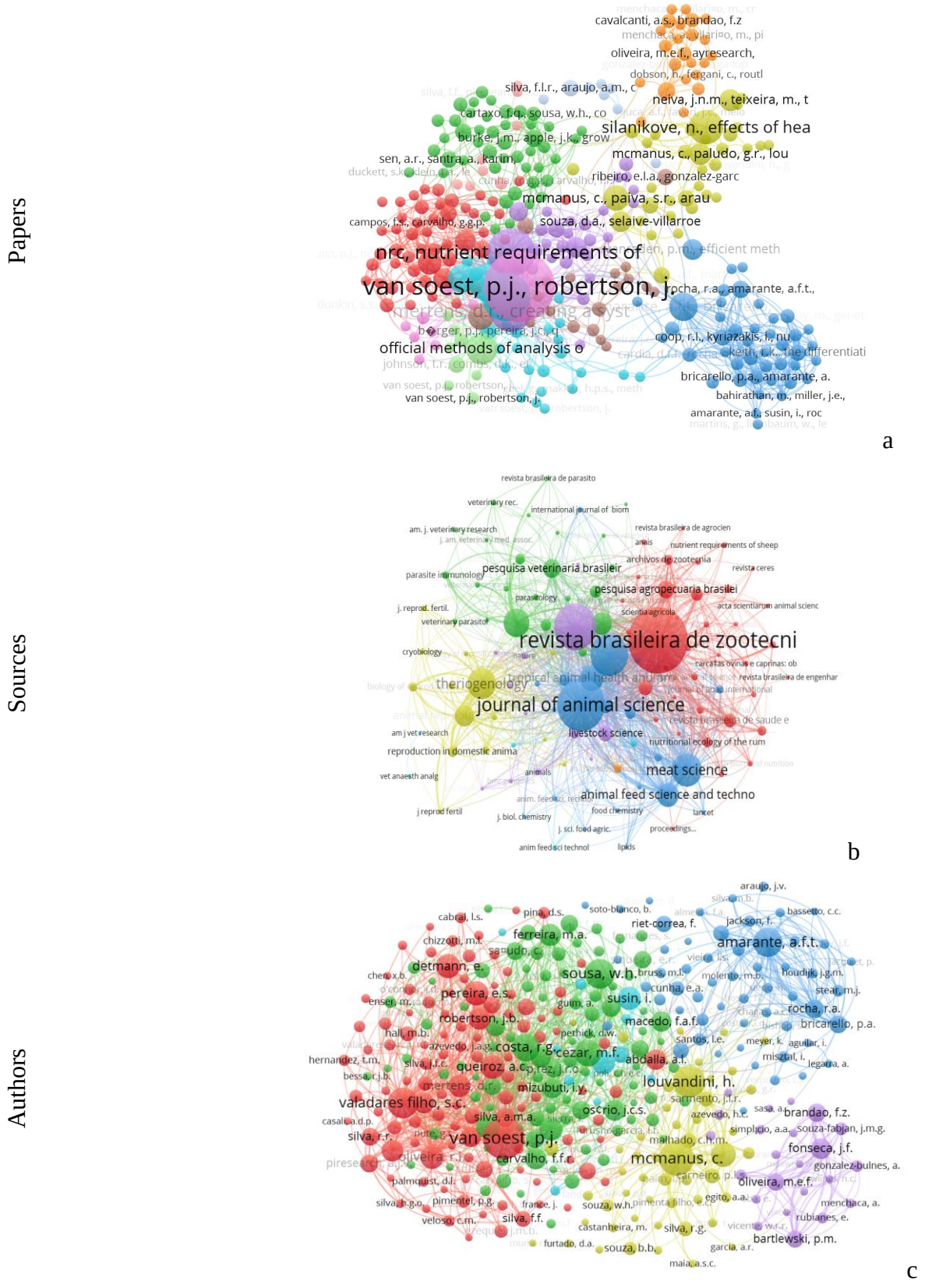


Figure 7 Co-citation reference mapping for Santa Ines sheep papers (a), sources (b) and authors (c).

Sarmento et al., (2006) evaluated growth curve models for Santa Ines sheep and concluded that the Gompertz model had a better fit. Another highly cited paper in genetics (Silva et al., 2011) studied Santa Ines animals with a molecular

genetics focus. These authors identified a new allele of growth and differentiation factor 9 (GDF9), named $FecG^E$ (Embrapa), which leads to the substitution of phenylalanine with cysteine in a conserved position of the mature peptide. The ovulation rate (82%) and prolificacy (58%) of homozygote ewes harboring the $FecG^E$ allele have increased. Another study explored the uniqueness of Santa Ines as a genetic resource and attempted to achieve genetic conservation of this breed.

Santa Ines, like any other Brazilian hair sheep, does not have a countrywide official animal breeding program for genetic evaluation of the germplasm (Sena et al., 2021). Data are available on population parameters (Colusse et al., 2019), but little is known about population structure (Teixeira Neto et al., 2013), although these authors noted an effective population size of 172.5 animals.

Although this is a local genetic resource, international interest is seen with publications in major journals such as Tropical Animal Health and Production and Small Ruminant Research. Papers in these journals also had more citations. This is also observed in Brazilian publications in general (McManus et al., 2020c; McManus et al., 2023).

Hair sheep breeds are a genetic resource of paramount importance for worldwide lamb production due to climate change (McManus et al., 2020b; Paim et al., 2022). Therefore, a high meat-producing hair sheep can be an extremely valuable genetic resource in the near future, and Brazil would capitalize on it if it has an organized animal breeding program to prove its genetic value and a good health system to guarantee sanitary conditions for exportation of the germplasm. Much of the information on the breed is anecdotal, with a lack of scientific production about production systems and the production chain, including those linked to a circular economy, involving this genetic resource. Moreover, most of the traits presented historically as naturally selected in Santa Ines, such as heat tolerance, adaptation for poor-quality feeding, parasite resistance, and minimal care, are not well studied and characterized, especially in comparison with other Brazilian hair sheep (Gomes et al., 2013; McManus et al., 2022). One of the main advantages of locally adapted genetic resources is minimal shepherding and veterinary care. Therefore, the traits of these animals must be investigated for further scientific evidence of the capabilities and pitfalls of this genetic resource, as many comparative studies are conducted with temperate breeds.

This study outlines major research carried out on Santa Ines sheep, primarily in Brazil. Little genetic work is seen beyond the quantitative aspects of production. Important and more recent topics, such as microbiomes and omics, are missing. Moreover, the adaptive traits of Santa Ines have not been scientifically proven and explored. The knowledge of these traits from a genomic perspective can be very important for sheep worldwide in a climate change scenario.

Although the breed shows a country-wide distribution, there is a lack of studies in some regions, including the northern and southern regions, where these animals could constitute economically relevant production systems. Therefore, we present the main observations of the bibliometric mapping of Santa Ines and the content of the highly cited papers and those cited in public policies. Santa Ines requires a national official animal breeding program to capitalize on the germplasm soon.

5. Conclusions

Studies on Santa Ines sheep need to expand beyond the themes currently observed. This is also true for nutrition, health, and systems studies in different regions of the country. The scientific production of Santa Ines should be stimulated in other areas in the country, especially the Cerrado and the Caatinga biomes, where these animals could constitute economically relevant production systems.

Ethical Considerations

Approval from the Animal Care Committee was not obtained for this study, as all the analyses were performed using pre-existing databases.

Conflict of Interest

The authors declare that they have no competing interests.

Funding

The authors acknowledge the Coordination for the Improvement of Higher-Level Personnel (CAPES), Brazil, and the Brazilian National Council for Scientific and Technological Development (CNPq), Brazil, for scholarships.

References

Albuquerque, A. C. A., Bassetto, C. C., Almeida, F. A., & Amarante, A. F. T. (2017). Development of *Haemonchus contortus* resistance in sheep under suppressive or targeted selective treatment with monepantel. *Veterinary Parasitology, 246*, 112-117. https://doi.org/10.1016/j.vetpar.2017.09.010

Amarante, A. F. T., Bricarello, P. A., & Rocha, R. A. (2004). Resistance of Santa Inês, Suffolk and Ile de France lambs to naturally acquired gastrointestinal nematode infections. *Veterinary Parasitology, 120*, 91-106. https://doi.org/10.1016/j.vetpar.2003.12.004

Bandelt, H. J., Forster, P., & Röhl, A. (1999). Median-joining networks for inferring intraspecific phylogenies. *Molecular Biology and Evolution, 16*, 37-48. https://doi.org/10.1093/oxfordjournals.molbev.a026036

Brito-Ochoa, M. P., Sacristán-Navarro, M. A., & Pelechano-Barahona, E. (2020). A bibliometric analysis of dynamic capacities in the field of family firms (2009–2019). *European Journal of Family Business, 10*, 69-81. https://doi.org/10.24310/ejfbejfb.v10i2.10162

Cancino, C. A., Merigó, J. M., & Coronado, F. C. (2017). Big names in innovation research: A bibliometric overview. *Current Science, 25*, 1507-1518.

Chen, C., Ibekwe-SanJuan, I., & Hou, J. (2010). The structure and dynamics of cocitation clusters: A multiple-perspective cocitation analysis. *Journal of the American Society for Information Science and Technology, 61*, 1386-1409. https://doi.org/10.1002/asi.21309

Colusse, J. C., Fonseca, R., & Tomaz, R. S. (2019). Análise e seleção genética de populações de ovinos das raças Santa Inês e Morada Nova. *ANAP Brasil, 12*, 98-111. https://doi.org/10.17271/19843240122720192243

Correa, M. P. C., Dallago, B. S. L., Paiva, S. R., Canozzi, M. E. A., Louvandini, H., Barcellos, J. O. J., & McManus, C. (2013). Multivariate analysis of heat tolerance characteristics in Santa Inês and crossbred lambs in the Federal District of Brazil. *Tropical Animal Health and Production, 45*, 1407-1414. https://doi.org/10.1007/s11250-013-0378-3

El-Zaiat, H. M., Araujo, R. C., Soltan, Y. A., Morsy, A. S., Louvandini, H., Pires, A. V., Patino, H. O., Correa, P. S., & Abdalla, A. L. (2014). Encapsulated nitrate and cashew nut shell liquid on blood and rumen constituents, methane emission, and growth performance of lambs. *Journal of Animal Science, 92*, 2214-2224. https://doi.org/10.2527/jas.2013-7084

Emerenciano Neto, J. V., Difante, G. S., Medeiros, H. R., Aguiar, E. M., Fernandes, L. S., Trindade, T. F. M., Bezerra, M. G., Oliveira, H. C. B., & Galvão, R. C. P. (2020). Cultivated pastures affect nutrient intake and feeding behavior of sheep. *Tropical Animal Science Journal, 43*, 117-124. https://doi.org/10.5398/tasj.2020.43.2.117

FAO. (2023). *Food Outlook – Biannual report on global food markets*. Rome. https://doi.org/10.4060/cc3020en

Freitas, A. C. B., Ortiz Vega, W. H., Quirino, C. R., Bartholazzi Junior, A., Gomes David, C. M., Geraldo, A. T., Silva Rua, M. A., Cipagauta Rojas, L. F., Almeida Filho, J. E., & Burla Dias, A. J. (2018). Surface temperature of ewes during estrous cycle measured by infrared thermography. *Theriogenology, 119*, 245-251. https://doi.org/10.1016/j.theriogenology.2018.07.015

Gaviria-Marin, M., Merigó, J. M., & Popa, S. (2018). Twenty years of the *Journal of Knowledge Management*: A bibliometric analysis. *Journal of Knowledge Management, 22*, 1655-1687. https://doi.org/10.1108/JKM-10-2017-0497

Gomes, E. F., Louvandini, H., Dallago, B. S. L., Canozzi, M. E. A., Melo, C., Moreno-Bernal, F., & McManus, C. (2013). Productivity in ewes of different genetic groups and body sizes. *Journal of Animal Science Advances, 3*, 1-255. https://doi.org/10.5455/jasa.20130523111656

Han, J., Kang, H.-J., Kim, M., & Kwon, G. H. (2020). Mapping the intellectual structure of research on surgery with mixed reality: Bibliometric network analysis (2000–2019). *Journal of Biomedical Informatics, 109*, 103516. https://doi.org/10.1016/j.jbi.2020.103516

Kraus, S., Breier, M., & Dasí-Rodríguez, S. (2020). The art of crafting a systematic literature review in entrepreneurship research. *International Entrepreneurship and Management Journal, 16*, 1023-1042. https://doi.org/10.1007/s11365-020-00635-4

Lima, P. M. T., Crouzoulon, P., Sanches, T. P., Zabré, G., Kabore, A., Niderkorn, V., Hoste, H., Amarante, A. F. T. D., Costa-Júnior, L. M., Abdalla, A. L., & Louvandini, H. (2019). Effects of *Acacia mearnsii* supplementation on nutrition, parasitological, blood parameters and methane emissions in Santa Inês sheep infected with *Trichostrongylus colubriformis* and *Haemonchus contortus*. *Experimental Parasitology, 207*, 107777. https://doi.org/10.1016/j.exppara.2019.107777

Lima, P. M. T., Sousa, C. V. S. A. M., Paim, T. P., Corrêa, P. S., Lanna, D. P. D., McManus, C., Abdalla, A. L., & Louvandini, H. (2019). Fatty acid profile and carcass characteristics in castrated and uncastrated hair lambs. *Tropical Animal Health and Production, 51*, 775-780. https://doi.org/10.1007/s11250-018-1752-y

Martínez-López, F. J., Merigó, J. M., Valenzuela-Fernández, L., & Nicolás, C. (2018). Fifty years of the *European Journal of Marketing*: A bibliometric analysis. *European Journal of Marketing, 52*, 439-468. https://doi.org/10.1108/EJM-11-2017-0853

Martins, R. F. S., Prado Paim, T., Cardoso, C. A., Dallago, B. S. L., Melo, C. B., Louvandini, H., & McManus, C. (2013). Mastitis detection in sheep by infrared thermography. *Research in Veterinary Science, 94*, 722-724. https://doi.org/10.1016/j.rvsc.2012.10.021

Mas-Tur, A., Roig-Tierno, N., Sarin, S., Haon, C., Sego, T., Belkhouja, M., Porter, A., & Merigó, J. M. (2021). Co-citation, bibliographic coupling and leading authors, institutions and countries in the 50 years of *Technological Forecasting and Social Change*. *Technological Forecasting and Social Change, 165*, 120487. https://doi.org/10.1016/j.techfore.2020.120487

McManus, C., Hermuche, P., Paiva, S. R., Ferrugem Moraes, J. C., Melo, C. B., & Mendes, C. (2014). Geographical distribution of sheep breeds in Brazil and their relationship with climatic and environmental factors as risk classification for conservation. *Brazilian Journal of Science and Technology, 1*, 1-15. https://doi.org/10.1186/2196-288X-1-3

McManus, C., Neves, A. A. B., Pimentel, F., Pimentel, D., & Finan, T. (2023). Brazilian regions and international scientific collaboration. *Revista Tempo do Mundo, 31*, 173-203. https://doi.org/10.38116/rtm31art6

McManus, C., Paiva, S. R., Caetano, A. R., Hermuche, P., Guimarães, R. F., Carvalho Jr, O. A., Braga, R., Carneiro, P. L. S., Ferrugem-Moraes, J., Souza, C. J. H., Faco, O., Santos, S. A., Azevedo, H. C., Araujo, A. M., Façanha, D. A. E., & Ianella, P. (2020). Landscape genetics of sheep in Brazil using SNP markers. *Small Ruminant Research, 192*, 106239. https://doi.org/10.1016/j.smallrumres.2020.106239

McManus, C., Paludo, G. R., Louvandini, H., Gugel, R., Sasaki, L. C. B., & Paiva, S. R. (2009). Heat tolerance in Brazilian sheep: Physiological and blood parameters. *Tropical Animal Health and Production, 41*, 95-101. https://doi.org/10.1007/s11250-008-9162-1

McManus, C. M., Faria, D. A., Lucci, C. M., Louvandini, H., Alcantra, S., & Paiva, S. R. (2020). Heat stress effects on sheep: Are hair sheep more heat resistant? *Theriogenology, 155*, 157-167. https://doi.org/10.1016/j.theriogenology.2020.05.047

McManus, C. M., Lucci, C. M., Maranhão, A. Q., Pimentel, D., Pimentel, F., & Paiva, S. R. (2022). Response to heat stress for small ruminants: Physiological and genetic aspects. *Livestock Science, 263*, 105028. https://doi.org/10.1016/j.livsci.2022.105028

McManus, C. M., Neves, A. A. B., & Maranhão, A. Q. (2020). Brazilian publication profiles: Where and how Brazilian authors publish. *Anais da Academia Brasileira de Ciências, 92*. https://doi.org/10.1590/0001-3765202020200328

Meadows, J. R., Cemal, I., Karaca, O., Gootwine, E., & Kijas, J. W. (2006). Five ovine mitochondrial lineages identified from sheep breeds of the Near East. *Genetics, 175*, 1371-1379. https://doi.org/10.1534/genetics.106.068353

NRC. (2007). *Nutrient requirements of small ruminants: Sheep, goats, cervids, and New World camelids*. National Academies Press.

Oliveira, P. B., Lima, P. M. T., Campeche, A., Mendonça, S., Laviola, B. G., McManus, C., & Louvandini, H. (2013). Growth and carcass characteristics of Santa Inês lambs fed diet supplemented with physic nut meal free of phorbol ester. *Small Ruminant Research, 114*, 20-25. https://doi.org/10.1016/j.smallrumres.2013.05.007

Paim, T. P., Paiva, S. R., Toledo, N. M., Yamaghishi, M. B., Carneiro, P. L. S., Facó, O., Araújo, A. M., Azevedo, H. C., Caetano, A. R., Braga, R. M., & McManus, C. (2021). Origin and population structure of Brazilian hair sheep breeds. *Animal Genetics, 52*, 492-504. https://doi.org/10.1111/age.13093

Paim, T. P., Santos, C. A., Faria, D. A., Paiva, S. R., & McManus, C. (2022). Genomic selection signatures in Brazilian sheep breeds reared in a tropical environment. *Livestock Science, 258*, 104865. https://doi.org/10.1016/j.livsci.2022.104865

Pimentel, F., Paiva, S. R., Dias, L. T., Pimentel, D., & McManus, C. M. (2023). Donkeys in Brazil: Bibliometric mapping and breed information. *International Journal of Equine Science, 2*, 34-48.

Ribeiro, E. L. A., & García, E. G. (2016). Indigenous sheep breeds in Brazil: Potential role for contributing to the sustainability of production systems. *Tropical Animal Health and Production, 48*, 1305-1313. https://doi.org/10.1007/s11250-016-1109-3

Santos, G. V., Santos, N. P. S., Figueiredo Filho, L. A. S., Britto, F. B., Sena, L. S., Torres, T. S., Carneiro, P. L. S., & Sarmento, J. L. R. (2021). Comparison of genetic parameters and estimated breeding values for worm resistance in meat sheep obtained using traditional and genomic models. *Tropical Animal Health and Production, 53*, 283. https://doi.org/10.1007/s11250-021-02705-3

Santos, V. M. B., Pinto, P. H. N., Balaro, M. F. A., Santos, J. D. R., Taira, A. R., Espirito Santo, C. G., Gonçalves, F. M., Fonseca, J. F., & Brandão, F. Z. (2020). Use of oxytocin to attain cervical dilation for transcervical embryo transfer in sheep. *Reproduction in Domestic Animals, 55*, 1446-1454. https://doi.org/10.1111/rda.13795

Sarmento, J. L. R., Regazzi, A. J., Sousa, W. H., Torres, R. A., Breda, F. C., & Menezes, G. R. O. (2006). Estudo da curva de crescimento de ovinos Santa Inês. *Revista Brasileira de Zootecnia, 35*, 435-442. https://doi.org/10.1590/S1516-35982006000200014

Sena, L. S., Borges, L. S., Rocha, A. O., Castro, G. C., & Sarmento, J. L. (2021). Avanços no melhoramento genético de ovinos da raça Santa Inês. *Revista Científica de Produção Animal, 23*, 37-45. http://doi.org/10.5935/2176-4158/rcpa.v23n1p37-45

Silva, B. D. M., Castro, E. A., Souza, C. J. H., Paiva, S. R., Sartori, R., Franco, M. M., Azevedo, H. C., Silva, T. A. S. N., Vieira, A. M. C., Neves, J. P., & Melo, E. O. (2011). A new polymorphism in the Growth and Differentiation Factor 9 (*GDF9*) gene is associated with increased ovulation rate and prolificacy in homozygous sheep. *Animal Genetics, 42*, 89-92. http://doi.org/10.1111/j.1365-2052.2010.02078.x

Sousa, S. V., Araújo, M. J., Silva, T. P. D., Marques, C. A. T., Torreão, J. N. C., Bezerra, L. R., Lima, I. S. S., & Gottardi, F. P. (2018). Dietary supplementation for Santa Inês hair ewes on pasture at pre- and postpartum periods: Dry matter intake, digestibility, milk production, and mineral metabolism. *Tropical Animal Health and Production, 50*, 1903-1912. http://doi.org/10.1007/s11250-018-1643-2

Teixeira Neto, M. T., Cruz, J. F., & Carneiro, P. (2013). Parâmetros populacionais da raça ovina Santa Inês no Brasil. *Pesquisa Agropecuária Brasileira, 48*, 1589-1595. https://doi.org/10.1590/S0100-204X2013001200008

Titto, C. G., Veríssimo, C. J., Pereira, A. M. F., Geraldo, A. M., Katiki, L. M., & Titto, E. A. L. (2016). Thermoregulatory response in hair sheep and shorn wool sheep. *Small Ruminant Research, 144*, 341-345. https://doi.org/10.1016/j.smallrumres.2016.10.015

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics, 84*, 523-538. https://doi.org/10.1007/s11192-009-0146-3

van Eck, N. J., & Waltman, L. (2013). *VOSviewer manual*. Universiteit Leiden.

van Eck, N. J., & Waltman, L. (2017). Citation-based clustering of publications using CitNetExplorer and VOSviewer. *Scientometrics, 111*, 1053-1070. https://doi.org/10.1007/s11192-017-2300-7

Van Soest, P. J., Robertson, J. B., & Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science, 74*, 3583-3597. https://doi.org/10.3168/jds.S0022-0302(91)78551-2

Vargas Junior, F. M., Martins, C. F., Pinto, G. S., Ferreira, M. B., Ricardo, H. A., Leão, A. G., Fernandes, A. R., & Teixeira, A. (2014). The effect of sex and genotype on growth performance, feed efficiency, and carcass traits of local sheep group Pantaneiro and Texel or Santa Inês crossbred finished on feedlot. *Tropical Animal Health and Production, 46*, 869-875. https://doi.org/10.1007/s11250-014-0579-4

Viana, P. G., Lima, P. M. T., Paim, T. P., Dantas, A. M. M., Pereira, E. F., Gonçalves, V., McManus, C., Abdalla, A. L., & Louvandini, H. (2015). Gossypol was not detected in the longissimus muscle of lambs fed several forms of cottonseed. *Animal Production Science, 55*, 812-817. https://doi.org/10.1071/AN14035