

Representativeness of the field of rural buildings and ambience in Brazilian journals

Representatividade do campo dos edifícios rurais e do ambiente nas revistas brasileiras

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ABSTRACT

According to CAPES, Rural Buildings and Ambience is an area of concentration within the knowledge subarea of Agriculture Engineering which is part of the field of Agrarian Sciences. In the last 20 years, the Brazilian journals on Agrarian Sciences that publish articles related to Rural Buildings and Ambience have significantly increased the number

of published documents, especially after the year 2006. Nevertheless, the number of articles in this area of concentration is not expressive when compared to the total of articles published in other areas of Agrarian Sciences. Considering the current scenario of the national agricultural production, especially for animal production, all parameters involving rural buildings, as well as climate and air quality analysis indoors, play a very relevant role in production efficiency, raising the importance of research in this area. Therefore, they would increase the number of published scientific articles. This work started with a systematic quantitative analysis of the last 21 years of scientific publications, considering 16 Brazilian journals and selecting 824 articles, revealing low representativeness of the area of concentration Rural Buildings and Ambiente within the field of Agrarian Sciences, although important information was collected and tabulated for the growth of this sector in the national industry.

Keywords: Rural Buildings And Ambiente; Quantitative Analysis; Primary Industry; Rural Development.

RESUMO

De acordo com a CAPES, Edifícios Rurais e Ambiente é uma área de concentração dentro da sub-área de conhecimento de Engenharia Agrícola que faz parte do campo das Ciências Agrárias. Nos últimos 20 anos, as revistas brasileiras de Ciências Agrárias que publicam artigos relacionados com Edifícios Rurais e Ambientação aumentaram significativamente o número de documentos publicados, especialmente após o ano de 2006. No entanto, o número de artigos nesta área de concentração não é expressivo quando comparado com o total de artigos publicados em outras áreas das Ciências Agrárias. Considerando o cenário actual da produção agrícola nacional, especialmente para a produção animal, todos os parâmetros que envolvem edifícios rurais, bem como a análise climática e da qualidade do ar no interior, desempenham um papel muito relevante na eficiência da produção, aumentando a importância da investigação nesta área. Por conseguinte, aumentariam o número de artigos científicos publicados. Este trabalho começou com uma análise quantitativa sistemática dos últimos 21 anos de publicações científicas, considerando 16 revistas brasileiras e seleccionando 824 artigos, revelando uma baixa representatividade da área de concentração Edifícios Rurais e Ambientais no campo das Ciências Agrárias, embora tenha sido recolhida e tabelada informação importante para o crescimento deste sector na indústria nacional.

Palavras-Chave: Edifícios Rurais e Ambiente, Análise Quantitativa, Indústria Primária, Desenvolvimento Rural.

1 INTRODUCTION

In the last few years, food production has significantly increased, as well as the regulatory requirements of the producing countries and of all sectors that commercialize agricultural products¹⁻⁶, searching for a cleaner and more sustainable production, with less impact on the environment and meeting animal welfare guidelines⁷⁻¹⁰.

In this context, rural buildings must meet all production gear, from sanitary and nutritional management, animal welfare, and with the least environmental impact that is

possible, in other words, a functional building which conducts the relation process and product to optimal income levels of cost and benefit^{5,11-14}.

The different typologies of plant and animal production buildings^{15,16}, the construction materials and the physical structures of these buildings, air quality inside the buildings, the thermal environment, the presence of contaminants in the air, animal behavior in terms of physiology and of the behavioral expression itself^{9,17-20}, among other topics are studied within the field of Rural Buildings and Ambience (RB&A).

The impact that a rural production building can cause on the production process itself, on the product and the workers, is very expressive. Especially in animal production, the quality of the physical environment^{2,3,11,12,21-30} (rooms, population density, construction materials, the ease of nutritional and sanitary management) and the quality of the indoor environment (pollutant gases, particulate materials, microorganisms, temperature and relative humidity, ventilation^{11,31-33}) are distinctive factors in the quality of the process and product.

The development of this activity, from the perspective of the quality of the indoor environment, Ambience, needs research works to test and prove scientific, technical and technological advances which can be applied to the production chain^{12,34-37}. In this direction,³⁸ 20 years ago, it was already known that poultry had become the activity that most incorporated technology, thus being considered a large industry of animal protein production with significant contribution to local economies. Currently, this prediction is confirmed, as have observed³⁹. Thus, there is still a great need to promote research on RB&A, resulting in publications and access to information for the public connected to the sector.

Brazil has a good number of national scientific journals in the field of Agrarian Sciences (AS). For some time, national and international scientists have been publishing their research results with significant periodicity (number of annual journals); for example, the journal *Revista Brasileira de Zootecnia*, which publishes scientific articles since 1972 (before 1992 with the name *Revista da Sociedade Brasileira de Zootecnia*), and the journal *Ciência Rural*, since 1971, which started with the name *Revista do Centro de Ciências Rurais* and publishes articles until the present times. Another example of a historical journal which has published for years topics related to AS is the *Brazilian Journal of Veterinary Research and Animal Science*, which had its first edition in 1938

with the title Revista da Faculdade de Medicina Veterinária da Universidade de São Paulo, but this journal interrupted its indexing in 2005.

The electronic online scientific library *Scielo* (scielo.br) of collections of Brazilian scientific journals lists 40 journal titles within the field of AS, less than half of which present an area dedicated to RB&A or a similar description - for instance, the journal *Engenharia Agrícola*, a publication of the Associação Brasileira de Engenharia Agrícola - or the publication of articles on this topic - for example, the journal *Pesquisa Agropecuária Brasileira*, a publication of the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), and the journal *Brazilian Journal of Poultry Science*, a publication of APINCO Foundation of Poultry Science and Technology.

In this context, the purpose of this article was to analyze quantitatively the number of publications and the relevance of the topic RB&A, in the aspects of thermal environment and materials, and of the presence of contaminants in the air, among the Brazilian journals, considering the last 21 years of publications.

2 METHODOLOGY

According to the classification of the Coordination for the Improvement of Higher Education Personnel (CAPES), Agrarian Sciences (AS) is considered an Area of Knowledge and is within the College of Life Sciences. Within AS, there are three important subareas for the analysis on which this article is based: Agricultural Engineering, Animal Husbandry and Agronomy. In each of them, there is a classification of areas and subareas of concentration as described below:

- Agricultural Engineering subarea: it contains the area of concentration Rural Buildings and Ambience and the subarea of concentration Rural Buildings Engineering, which is the object of study of this work.
- Animal Husbandry Subarea: it contains the area of concentration Animal Production, with two subareas: Animal Management and Animal Production Facilities.
- Agronomy Subarea: it contains the area of concentration Phytotechnics, with subareas of concentration in Management and Cultural Treatments, and Seedling Production.

The three subareas of knowledge can host research works regarding rural buildings and the quality of the agricultural production environment indoors. In this work, the area of concentration of Rural Buildings and Ambience (RB&A) will be exclusively considered, as a term that evokes the research topics related to this study, in other words,

animals, plants, climate, equipment, construction materials with the building and/or the environment (microclimate and air environment).

The quantitative analysis of the scientific articles in the field of RB&A, within the area of AS, had 16 Brazilian journals as sample universe presented in Table 1.

Table 1. Journals used in the quantitative analysis

| Journal | Start year | ISSN | Scope | Frequency of Publication |
|--|------------|---|---|--------------------------|
| Acta Scientiarum. Animal Sciences | 1998 | Print version 1806-2636 Online version 1807-8672 | Relevant areas of Animal Husbandry (Animal Production), including genetics and improvement, nutrition and digestion, physiology and endocrinology, reproduction and lactation, growth, ethology and welfare, ambience and facilities, food evaluation and animal production. | Continuous publication |
| Arquivo Brasileiro de Medicina Veterinária e Zootecnia | 1943 | Print version 0102-0935 Online version 1678-4162 | Areas of Veterinary Medicine, Food Technology and Animal Husbandry. | Bimonthly |
| Brazilian Journal of Poultry Science | 1999 | Print version 1516-635X Online version 1806-9061 | Publishes full scientific and technical articles, and review articles in the field of Poultry Science. | Quarterly |
| Brazilian Journal of Biosystems Engineering | 2007 | Online version 2359-6724 | Publishes articles of various sections related to Biosystems Engineering. | Quarterly |
| Ciência Animal Brasileira | 2000 | Online version 1809-6891 | Diffuser of scientific knowledge in the fields of Veterinary Medicine and Animal Husbandry. | Continuous publication |
| Ciência Rural | 1971 | Print version 0103-8478 Online version 1678-4596 | Contributes to the scientific areas of Agronomy, Animal Science, Veterinary Medicine and Forestry Science. | Monthly |
| Ciência e Agrotecnologia | 1976 | Print version 1413-7054 Online version 1981-1829 | Publishes scientific articles in the fields of plant and animal sciences, including Agronomy, Food Science and Technology, Agricultural Economics and Agribusiness, Rural Engineering, Veterinary Medicine and Zootechnology. | Continuous Publication |
| Engenharia Agrícola | 1972 | Print version 0100-6916 Online version 1809-4430 | Publishes original scientific articles, technical articles and bibliographic reviews, promoting the dissemination of the practical and scientific knowledge in the field of Agricultural Engineering. | Bimonthly |
| Pesquisa Agropecuária Brasileira | 1966 | Print version 0100-204X Online version 1678-3921 | Publishes original scientific-technological articles on Entomology, Statistics, Plant Physiology, Phytopathology, Crop Science, Pomology, Genetics, Soil Science, Technology, Veterinary Science, Animal Science etc. | Monthly |
| Revista Brasileira de Engenharia Agrícola e Ambiental | 1997 | Print version 1415-4366 Online version 1807-1929 | Agriambi publishes original scientific and technical articles in the fields of Irrigation and Drainage Engineering, Agricultural Meteorology and Climatology, Plant, Soil and Water Management, Rural Constructions and Ambience, Storage and Processing of Agricultural Products, Environmental Control and Management, Automation and Instrumentation, Energy in Agriculture and Agricultural Machines. | Monthly |
| Revista Brasileira de Saúde e Produção Animal | 2001 | Online version 1519-9940 | Publication of scientific articles and reviews within the field of animal health and production and Fisheries Resources. | Continuous publication |

| | | | | |
|-----------------------------------|------|---|--|------------------------|
| Revista Brasileira de Zootecnia | 1972 | Print version 1516-3598 Online version 1806-9290 | Original unpublished research articles that cover the broad area of Animal Science, such as Animal production systems and agribusiness, Forage, Nutrition, Breeding and genetics, Reproduction, Aquaculture, Biometeorology and Animal welfare. | Continuous publication |
| Revista Ceres | 1939 | Print version 0034-737X Online version 2177-3491 | It is intended for the publication of unpublished scientific articles, with technical and scientific relevance, resulting from studies related to innovations and solutions to the problems of agriculture, with emphasis in tropical-related studies. | Bimonthly |
| Revista Ciência Agronômica | 1971 | Print version 0045-6888 Online version 1806-6690 | It is addressed to professors, scientists, students, and others interested in the fields of Agrarian Sciences, Animal Science, Fishing, Food Production and Natural Resources. | Quarterly |
| Revista Engenharia na Agricultura | 2008 | Online version 2175-6813 | The journal Engenharia na Agricultura aims at publishing and disseminating scientific production in the several areas of Agricultural and Environmental Engineering, allowing the readers interested in this subject to access new scientific knowledge and technological innovations. | Continuous publication |
| Scientia Agricola | 1992 | Online version 1678-992X | Scientia Agricola publishes original articles, which contribute to the advancement of the agricultural, environmental and biological sciences. | Bimonthly |

The publications were selected by affinity or connection with the relative field, such as, for example, the article “The Effects of Perch Cooling on Behavior, Welfare Criteria, Performance, and Litter Quality of Broilers Reared at High Temperatures with Different Litter”⁴⁰, published in the Brazilian Journal of Poultry Science.

It was also considered that many articles used in the quantitative analysis of this work did not contain their general goal in the field of RB&A. Nonetheless, their contribution definitely affects this area, or its development had more extensively studied considerations in RB&A. For instance, the aim of the work “Glutamine supplementation plans for broilers reared in high-temperature environments”⁴¹, published in the Revista Brasileira de Zootecnia, was to evaluate the effect of the nutritional supplementation on carcass performance and the performance of broilers subjected to thermal stress. Thus, regarding the perspective of thermal comfort, in the field of Ambiente, the article was counted for this study.

The total number of publications selected for the quantitative analysis was 824 articles from 1999 to 2020. The tabulated data from each article analyzed were: title, journal, year of publication, content (animal, rearing stage or age, protected cultivation, construction materials and structures, equipment, climatology), whether it met rural buildings and/or ambiente, if it contained a physical experiment or not, measured/considered variables or parameters, which unit or research group, city and state of the units or research groups, article conclusions.

From the 824 articles considered in the 21 years of Brazilian publications analyzed, over 8500 rows of tabulated data were filled regarding the elements listed above. Table 2 is an example of how the data were tabulated for further analysis

Table 2. Example of tabulation of the data from a selected article

| | | |
|------|-------------------------------------|--|
| | Title | Extraction of rules by classification from weather station data to help in the forecast of temperature and humidity index for dairy cattle ⁴² |
| | Journal | Brazilian Journal of Biosystems Engineering v. 8(3): 220-226, 2014 |
| | Animal/Stage/Content | Dairy bovine |
| | Building (B) or Environment € | E |
| | Physical Experiment (Y-YES); (N-NO) | N |
| 692* | Variable/Parameter | air temperature, dew point temperature, relative humidity, temperature, and humidity index |
| | Unit/Research Group | DZ/UFSM |
| | City/State | Santa Maria/RS |
| | Conclusion/Highlight | Data mining allows establishing relationships between the main variables related to the Temperature and Humidity Index (THI) for dairy cows. Systems of rules such as those presented in this study can be incorporated into computer programs or manually applied in warning systems for predicting animal stress situations based on conventional weather forecasts. |

*position of the article in the general table of data

Regarding the analyzed field “whether it contained a physical experiment or not”, the authors understand that physical experiment is every experimental work that collects physical data (not simulated), such as temperature measurement, thermal photography, feed intake etc. Hence, the articles that were fixed in computational simulations (without the performance of physical measurements as a way of comparing real versus simulated), the publications of the Review type, purely numerical analyses such as climatic data, for instance, the articles on structural calculations for rural projects, the economic analyses of production, among others understood by the authors as non-physical experiment, were not considered physical experiments.

The variables or parameters measured by the analyzed articles often consisted in a series of data. Virtually all articles had the parameters of their experiments or their analysis occupying more than one field of classification. The article “Effect of a simulated heat wave in thermal and aerial environment broiler-rearing environment”⁴³ is cited as an example, published in Engenharia Agrícola, whose authors measured and analyzed the interactions among room temperature, bed temperature, the relative humidity of the air, and the concentrations of oxygen, carbon monoxide and ammonia. In this article, the parameters were classified in the fields “bed”, “air temperature”, “relative humidity of

the air”, “quality of the air/emissions”, “comfort/thermal stress”, according to the scope of the article itself.

Another example of the consideration of the parameters measured in an analyzed article was the publication “Coeficientes alométricos das partes e dos órgãos de codornas de corte mantidas em diferentes ambientes térmicos”⁴⁴, published in Arquivo Brasileiro de Medicina Veterinária e Zootecnia, which presented measurements related to the yield of carcass cuts such as the weight of breast, thigh, wing, and organs such as heart, liver, gizzard, in other words, not directly related to the rural buildings, but with experiments where different breeding temperatures were tested, leading to different performance results. Therefore, the variables or parameters verified in the articles occupied the fields according to Table 3.

Table 3. Parameters and variables of study in the studied articles

| | |
|---|--|
| • Deep bedding (pH, temperature, materials etc.) | • Nutrition/food/feed |
| • Carcass (performance) | • Physiological parameters (respiratory and heart rates) |
| • Indoor/outdoor climatology | • Blood parameters |
| • Animal behavior | • Milk production and quality |
| • Comfort/thermal stress | • Air quality/emissions |
| • Electric power consumption | • Radiation/heat flow/energy |
| • Water consumption and temperature | • Noise |
| • Protected cultivation | • Silos |
| • Egg performance (quality and production) | • Shading |
| • Animal performance (gain of weight, feed conversion etc.) | • Air temperature |
| • Plant/seed performance | • Body/rectal temperature |
| • Equipment, construction materials, design and structures | • Relative humidity of the air |
| • Lighting | • Ventilation/wind |

Finally, the influence of the Brazilian geography and of the international participation in publications on RB&A was quantitatively analyzed. The Brazilian and foreign research groups that participated as authors of the articles were tabulated, extracting from each analyzed article the state and the city of the research groups of each author, but not counting more than once a state or city of each article. For example, in the article “Avaliação de diferentes materiais para recobrimento de camas em baias de galpão modelo free-stall”⁴⁵, published in Revista Brasileira de Engenharia Agrícola e Ambiental, research groups from Lavras/MG and Juiz de Fora/MG participated, counting 1 in “Minas Gerais” (State), 1 in “Lavras” (City) and 1 in “Juiz de Fora” (City), although 4 research groups or different departments participated in the elaboration of the article.

3 RESULTS

Figure 1 below shows the number of publications over the 21 years analyzed in all AS fields and only in the field of RB&A for the 16 national journals considered.

Figure 1. a) Number of Brazilian publications in all AS fields and number of national journals analyzed; b) Number of Brazilian publications in the field of RB&A and number of national journals analyzed

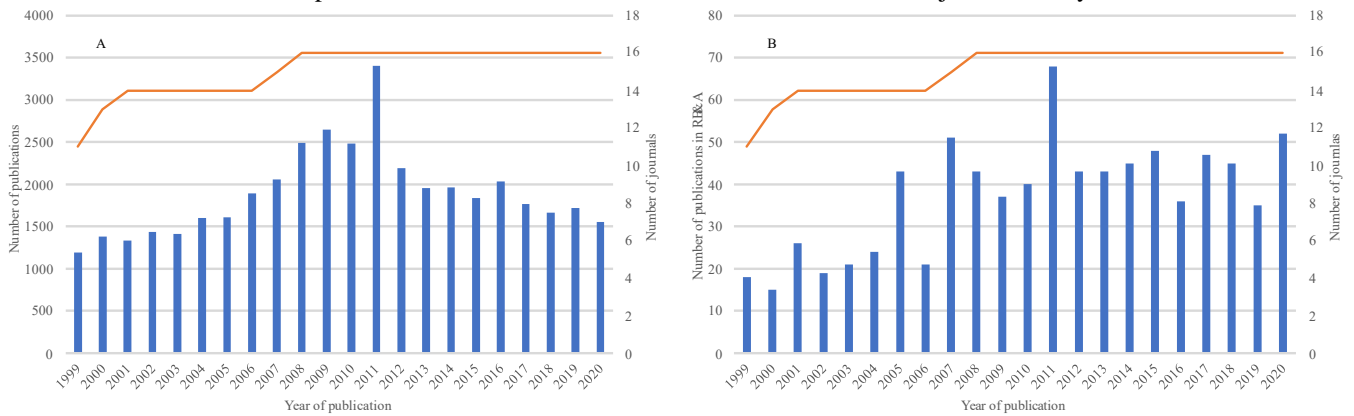


Figure 1A shows an evolution in the total number of publications in AS over the years because of the increase of new journals covering articles related to the topic RB&A, chosen in this work for analysis. It can be noticed that, in the total number of publications in AS between years 1999 and 2005, there was no significant increase, although the number of journals with articles on RB&A has jumped from 11 to 14.

However, between 2006 and 2011, when the number of journals had already reached the maximum number, i.e., 16 journals on RB&A, there was an important increase in the published articles, with a little more than 1600 articles in 2005 and in 2011, the publication of 3403 articles, in other words, an increase of 112% in the number of published articles.

It is noticed that from 2012, the number of articles in the 16 AS journals considered here started to decrease, reaching a level in the number of articles equal to the year 2005, where there were 14 journals of those selected for analysis in this article.

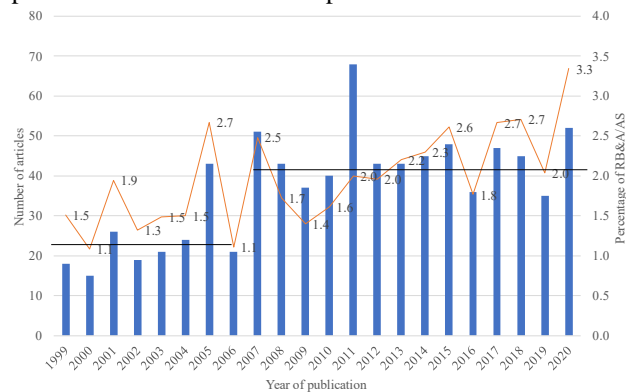
When only the publications on RB&A are considered (Figure 1B), although there have been important increments in the number of articles published in RB&A since 2007, and specifically in the year 2011, i.e., similar to what occurred with the total number of publications in AS (Figure 1A), there was no gradual reduction in the number of articles on RB&A after the year 2011.

From Figure 1A and 1B, it can be concluded that the patterns in the number of articles on AS and only on RB&A were practically the same until 2011, when they started

to present different behaviors, with a decrease in the number of articles on AS and the maintenance in the number of articles on RB&A.

The representativeness of RB&A within the field of AS can be considered low, as shown in Figure 2. The average of publications on RB&A until 2006 was a little more than 20 articles, representing 1.4% of all articles published in the field of AS. Nevertheless, after 2007, the average of publications has increased to a little more than 45 articles, which means 2.2% of articles published in the field of AS.

Figure 2. Representativeness of scientific publications in RB&A in the field of AS

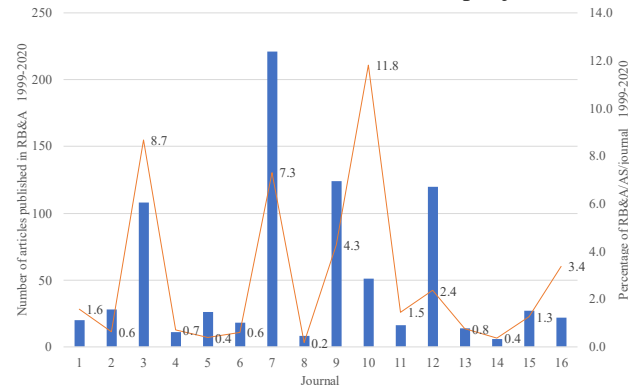


It is noticed that after the year 2006, except in 2005, there was an increase of 0.8% of publications in RB&A related to the field of AS, which represents an increment of 25 articles/year resulting from scientific researches.

Given the vast area of coverage of the Agrarian Sciences, even in journals more directed to the field of Rural Engineering, the representation of Rural Buildings and Ambience is low, resulting in an important warning for researchers who investigate this sector.

The 16 journals considered in this research for the analysis of the quantitative impact of the field of RB&A on the area of AS were selected considering an evident line of publication in the field of Rural Engineering in their scopes of scientific publications or potential lines of publications, such as, for instance, in Revista Ciência Agronômica, which has the field “Animal Science”. In this direction, Figure 3 shows the representativeness of the field RB&A in each journal analyzed.

Figure 3. Representativeness of RB&A in the field of AS per journal between 1999-2020



For a better understanding of Figure 3, Table 4 shows the list of journals according to their numbering.

Table 4. List of the Journals considered in this research

| | | | |
|----|--|-----|---|
| 1. | Acta Scientiarum. Animal Sciences | 9. | Revista Brasileira de Engenharia Agrícola e Ambiental |
| 2. | Arquivo Brasileiro de Medicina Veterinária e Zootecnia | 10. | Brazilian Journal of Biosystems Engineering |
| 3. | Brazilian Journal of Poultry Science | 11. | Revista Brasileira de Saúde e Produção Animal |
| 4. | Ciência Animal Brasileira | 12. | Revista Brasileira de Zootecnia |
| 5. | Ciência Rural | 13. | Revista Ceres |
| 6. | Ciência e Agrotecnologia | 14. | Revista Ciência Agronômica |
| 7. | Engenharia Agrícola | 15. | Scientia Agricola |
| 8. | Pesquisa Agropecuária Brasileira | 16. | Revista Engenharia na Agricultura |

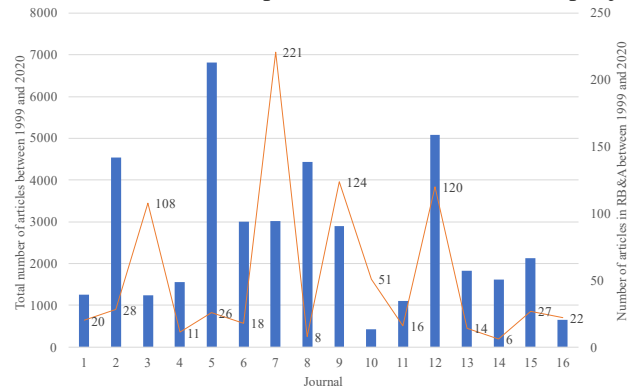
The result shows that there is the same trend of low RB&A/AS/journal relation, although some among them, specifically the Brazilian Journal of Poultry Science, Engenharia Agrícola, Revista Brasileira de Engenharia Agrícola e Ambiental and Brazilian Journal of Biosystems Engineering, demonstrate an increase in this relation, confirming a greater preference of submission of articles by the authors of the field of RB&A to such journals.

Revista Brasileira de Zootecnia also presents an important history of publications related to RB&A compared to other journals, occupying the third position in the number of published articles in the field analyzed. Nonetheless, the percentage of RB&A/AS in this journal is in the sixth position because of the large total number of articles published (a little more than 5000 articles in 21 years). Figure 4 shows the ratio of the total number of articles and of articles on RB&A.

The journal Brazilian Journal of Biosystems Engineering, although ranking the fifth position in number of articles published on RB&A between 1999 and 2020 (its first volume is from 2007), is notably the journal that has published the most in this field in percentage articles on Rural Buildings and Ambience in relation to the total of articles

published by the journal. Therefore, it can be considered the reference journal for publications in the field of RB&A, in a purely quantitative analysis.

Figure 4. Number of articles published in AS and RB&A per journal



Most publications on RB&A study the various types of animals that are used as food source. Other objects of study have also been verified, such as construction materials for buildings or other supporting units for agricultural production, numerical and experimental verifications of building structures or other supporting units, the microclimatic analysis of full-scale sheds or reduced models, the horticultural and seed production in a protected environment (actual agricultural greenhouses), equipment for microclimatic improvement or animal welfare, agricultural waste, among other with less quantitative impact.

Therefore, for this work, the division of the objects of study of the articles was considered according to Table 5 for the corresponding quantification of the articles on RB&A.

Table 5. List of Journals considered in the research

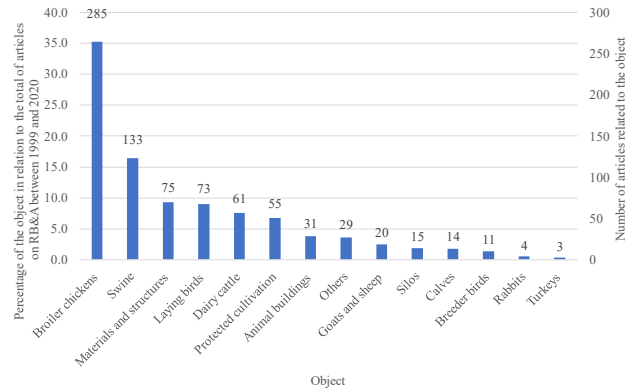
| | |
|-------------------------|--|
| • Laying birds | • Sheds |
| • Breeder Birds | • Materials and structures |
| • Calves | • Turkeys |
| • Dairy cattle | • Silos |
| • Goats and sheep | • Swine |
| • Rabbits | • Others (shear quails, equipment, beef cattle, |
| • Protected cultivation | horses, climate and zoning, gas monitoring and |
| • Broiler chickens | emission, trees, frogs, buffalo, 1-day old chicks, |
| | partridges) |

The division presented above and in Figure 5 (bellow) does not refer to the parameters measured in the articles, but to the scope of the article itself, such as, for instance, in the article “Interface homem-máquina para controle de processos de resfriamento com ar forçado visando à economia de energia”⁴⁶, published in the journal

Ciência Rural and which is focused on the development of an equipment that will support farm production.

Figure 5 shows a clear supremacy of the number of articles related to broiler chicken in the analyzed national journals, so that one out of every three articles published in Rural Buildings and Ambience has broiler chicken as the object of study.

Figure 5. Number and representativeness of the objects of study of the articles on RB&A between 1999 and 2020



According to the data from FAOSTAT⁴⁷ (division of the Food and Agricultural Organization of the United Nations, responsible for providing free access to the statistical data on food and agriculture of more than 245 countries and territories), the production of food from animal origin in Brazil can currently be considered as observed in Table 6.

Table 6. Status of the Brazilian production of food from animal origin in 2019 according to FAOSTAT (in units of animals)

| Production | Laying hens | Other laying birds | Beef cattle | Broiler | Sheep+goat | Swine | Rabbit | Turkey | Dairy cattle |
|-----------------------------------|-------------|--------------------|-------------|----------|------------|---------|--------|--------|--------------|
| Brazil (millions) | ≈ 250 | ≈ 31.5 | ≈ 32 | ≈ 5,800 | ≈ 9 | ≈ 46 | ≈ 0.8 | ≈ 95 | ≈ 16 |
| Worldwide ¹ (millions) | ≈ 6,460 | ≈ 215 | ≈ 324 | ≈ 72,000 | ≈ 1,100 | ≈ 1,300 | ≈ 925 | ≈ 635 | ≈ 265 |
| BR/Total ² | ≈ 4% | ≈ 15% | ≈ 10% | ≈ 8% | < 1% | 3.5% | < 0.1% | 15% | 6% |

¹number of animals for food production counted by FAO

²percentage of animals in Brazil relative to the world number

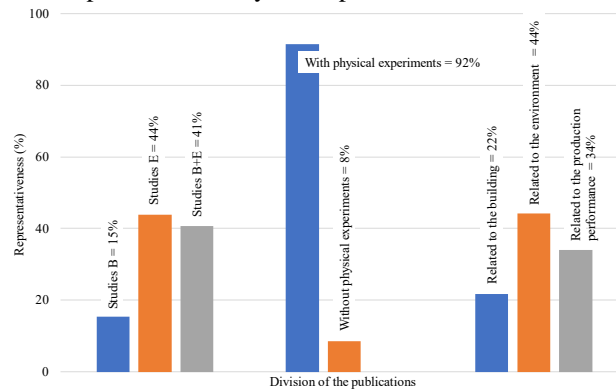
As observed in Table 6, the production of animal protein in Brazil is significant and fundamental as food source, contributing to the reduction in the food deficit and to the generation of foreign currency. Brazil is one of the world’s largest producers of broiler chickens and swine. According to the Poultry and Swine Intelligence Center of Embrapa, the Brazilian production of chicken and pork meat in 2019 was, respectively, of 13.245 and 3.983 million tons. The production costs were high in February 2021 compared to January in the same year. The production cost of the kilo of the live broiler in the State of

Santa Catarina ranged from R\$ 4.44 in January to R\$ 4.91 in February. On the other hand, the cost per kilo of live swine produced in a full-cycle system in Santa Catarina ranged from R\$ 6.63 in February to R\$ 6.88 in January of 2020.

The scientific publications on Rural Buildings and Ambience do not always contain aims and experiments that incorporate data collection and analysis of the buildings, their envelope, and the production environment. Therefore, we understand how relevant it is to count the publications which contained goals related only to the building itself (construction materials, structure analysis, lamp type), only to the air environment and thermal comfort (microclimate, ventilation, comfort indexes) or publications containing both considerations, building + air environment (effect of the type of tile on the shed microclimate).

Thus, Figure 6 clarifies the division of the publications in a graphic form that facilitates the identification that in 85% of the articles, Ambience was considered within the research goals, revealing the significant relevance of the topic for the area considered, i.e., RB&A.

Figure 6. Representativeness of the research works on the building and/or ambience, on the use of physical experiments, and on the macro parameters analyzed in publications on RB&A



On the other hand, the performance of physical experiments in the research works that have generated the publications is considered here as a prominent factor in articles on RB&A, and likewise, Figure 6 shows the great relevance that the physical experiment has on the investigations. Furthermore, of the analyzed articles, most of the parameters studied, measured, considered, calculated, or evaluated are relative to the built environment, to the thermal comfort and air quality, in other words, variables linked to the Ambience line. Therefore, Figure 6 also presents the percentage division of the macro parameters in the publications related to the field of RB&A.

In this study, 26 parameters or parameter groups are listed. Among them, we can clearly see those that are related to the building itself, to the environment, microclimate, and thermal comfort, as well as those referring to the performance and biological characteristics of animals and plants. Thus, the division of the parameters can be verified in Table 7.

As an example of the extraction of the parameters from each work, the article “Relação de variáveis ambientais em baias cobertas com polietileno e desempenho da rã-touro (*Rana catesbeiana*)” can be cited⁴⁸, published in the journal Engenharia Agrícola, from where the following parameters were listed: temperature, water temperature, relative humidity of the air, climatology, animal performance (live weight, weight gain, food conversion), and thermal comfort.

Table 7. Parameters of the analyzed articles

| | | |
|--|---|--|
| Relative to the building | Equipment, materials, design and structure Bed | Shading Silos Energy consumption |
| Relative to the environment | Comfort/thermal stress Indoor/Outdoor climatology Protected cultivation Ventilation/wind Temperature | Lighting Air quality/emissions Radiation/heat flow/energy Moisture Noise |
| Relative to the production performance | Animal performance Nutrition/food/feed Animal behavior Physiological parameters Plant/seed performance Egg performance | Carcass Body/rectal temperature Milk production and quality Blood parameters Water consumption and temperature |

Another example is the article “Evaluation of litter material and ventilation systems in poultry production: I. overall performance”⁴⁹, published in the Revista Brasileira de Zootecnia, considering the following variables: ventilation, animal performance, and bed.

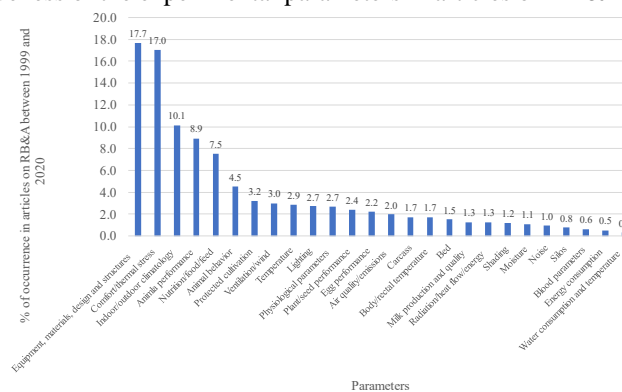
Knowing that ambience directly influences the productive performance of the biological entities considered in the publications on RB&A, either plants or animals, the quality of the building internal air has the highest number of variables considered, followed by the production performance itself. Since the building reflects much more on the ambience than on the production performance, it is very common to verify studies on the building linked to ambience results or variables; for instance, the influence of the type of tile on the thermal performance of a shed⁵⁰.

Nevertheless, the largest percentage share among all parameters of the articles on RB&A is of publications containing “equipment, materials, design and structures”, with 17.7%, as shown in Figure 7.

Although a parameter relative to building presents the highest percentage value among all parameters considered, the parameters related to ambience and production performance are interspersed and sum, in sequence, more than 50% of the variables in the articles until the next item referring to building. Conversely, when the parameter “materials” is separated from the first placed item, it goes to 13%, reaching the second position of the list.

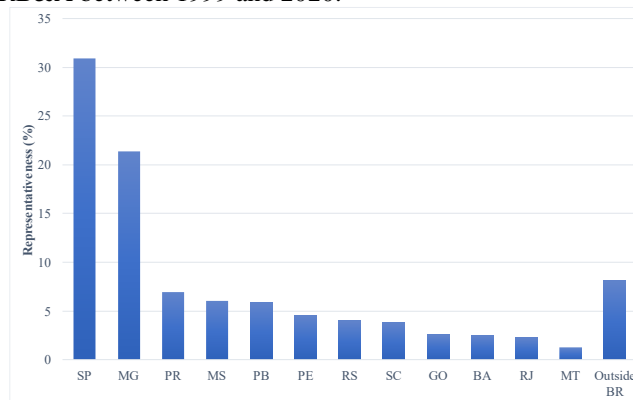
The influence of the research centers consolidated in Brazil is significant when we analyze the publications on RB&A in the country from a quantitative point of view. The states of São Paulo and Minas Gerais, over the past 21 years, have generated or had research groups participating in more than half of the articles published in the area.

Figure 7: Representativeness of the experimental parameters in articles on RB&A between 1999 and 2020.



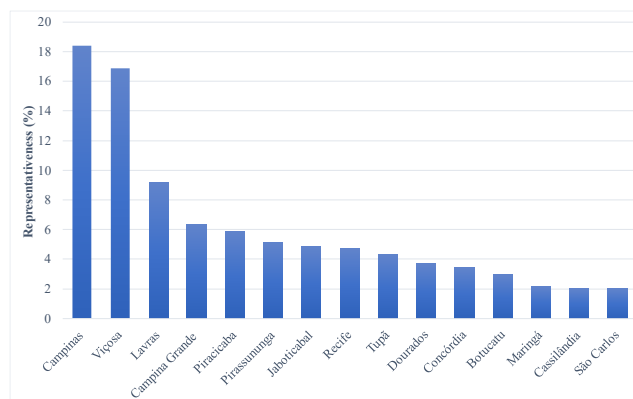
To better observe this statement, a Figure 8 presents the quantitative percentage division of participating groups distributed by Brazilian states; however, only the states with more than 1% of representativeness are presented, which means some Brazilian states did not reach this boundary and are not shown in Figure 8. Additionally, the international research groups are also present in Figure 8 and have been counted in the articles where all authors were from international groups or participated as co-authors in national publications on RB&A.

Figure 8: Quantitative distribution of the participation of the research groups present in the Brazilian states in the publications on RB&A between 1999 and 2020.



Campinas, Viçosa and Lavras occupy the first three positions, respectively, confirming the distribution by Brazilian state. Among the 15 main cities considered in this article, in a purely quantitative classification, 6 are in the state of São Paulo and 2 are in the state of Minas Gerais, emphasizing the important contribution of these two states and their vocation for research in the field of Rural Buildings and Ambience.

Figure 9: Participation of research groups per Brazilian city in publications on RB&A in the period from 1999 to 2020.



4 CONCLUSIONS

The quantitative analysis of the representativeness of the scientific publications on Rural Buildings and Ambience in Brazilian journals of the field of Agrarian Sciences revealed that:

- The representativeness of the number of articles in the field of Rural Buildings and Ambience within the area of knowledge Agrarian Sciences can be considered very low, with average values lower than 3% per year in relation to the average total number of articles published in the 16 selected journals.
- Some of the 16 journals considered arouse greater interest for the publication of

articles on Rural Buildings and Ambience, such as the “Brazilian Journal of Biosystems Engineering”, with 11.8% of the total, and the “Brazilian Journal of Poultry Science” and “Engenharia Agrícola”, with 8.7% and 7.3%, respectively, from the total number of articles published along the range considered.

- Most of the publications had as object of study the production of “Chickens” and “Swine”, demonstrating affinity in the field of Rural Buildings and Ambience in Brazil.
- The research works that originated the analyzed articles on Rural Buildings and Ambience were conducted, in their vast majority, employing actual physical experiments (excluding physical computational models) for data collection. Among them, 85% considered in their methodological scope an analysis relative to Ambience.
- Throughout the considered range, the experimental parameters relative to the environment have been more studied than those relative to building and those regarding production performance. “Equipment, materials, design and structures” resulted in the highest percentage of occurrence in the articles on Rural Buildings and Ambience, leaving the parameter “Comfort/thermal stress” in the second place. Given the amplitude of the first placed parameter (4 sub-parameters), when they separate, the percentage is divided and is drastically reduced.
- • Regarding the distribution of publications on Rural Buildings and Ambience in Brazil, more than half have been performed with research groups (however, not exclusively) residing in the states of São Paulo and Minas Gerais, where Campinas/SP and Viçosa/MG were the cities that have contributed with the highest participation, demonstrating high added value of the research groups and their respective researchers.

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