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The state of the art of agroecological and organic animal production systems in Brazil: a systematic review

O estado da arte dos sistemas de produção animal agroecológicos e orgânicos no Brasil: uma revisão sistemática de literatura

El estado del arte de los sistemas de producción agroecológica y orgánica de animales en Brasil: una revisión sistemática

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Abstract

Despite Brazil's proficiency in conventional animal production, research in the field of agroecological animal production remains incipient. We conducted a systematic review to assess the current state of scientific knowledge regarding agroecological and organic animal production in Brazil. Employing a methodology adapted from the PRISMA statement, we scrutinized 34 selected papers and technical reports. Our findings indicate that a majority (75%) of the analyzed literature is centered on Brazil's principal conventional animal production sectors, namely, beef (20.5%), dairy (34%), and poultry (20.5%). Furthermore, approximately 61% of the reviewed articles focus on production systems within the Cerrado and Atlantic Forest biomes. Notably, case studies emerged as the predominant research methodology, adopted by 38.2% of Brazilian researchers. In summation, it is evident that organic and agroecological animal production warrants further in-depth investigation. The adoption of holistic approaches is imperative in the evaluation of such production systems, which aim to provide sustainable food sources, healthy environment, and societal well-being.

Keywords: Brazilian biomes; Gaps in scientific knowledge; Assessment methods; Geographical distribution.

Resumo

Apesar da experiência do Brasil com produção animal convencional, a pesquisa no campo da produção animal agroecológica permanece incipiente. Realizamos uma revisão sistemática para avaliar o estado atual do conhecimento científico sobre a produção animal agroecológica e orgânica no Brasil. Utilizando metodologia adaptada da declaração PRISMA, examinamos 34 artigos e relatórios técnicos selecionados. Nossos resultados indicam que a maioria (75%) da literatura analisada está centrada nos principais setores de produção animal convencional do Brasil: bovinocultura de corte (20,5%), leite (34%) e avicultura (20,5%). Além disso, aproximadamente 61% dos artigos revisados se concentram nos biomas do Cerrado e da Mata Atlântica. Os estudos de caso foram a metodologia de pesquisa predominante, adotada por 38,2% dos pesquisadores brasileiros. Concluímos que é evidente que este tema merece uma investigação mais aprofundada. Ainda, a adoção de abordagens holísticas é fundamental na avaliação de tais sistemas de produção, que visam fornecer alimentos sustentáveis, um ambiente saudável e o bem-estar da sociedade.

Palavras-chave: Biomas brasileiros; Lacunas no conhecimento científico; Métodos de avaliação; Distribuição geográfica.

Resumen

A pesar de la competencia de Brasil en la producción animal convencional, la investigación en el campo de la producción agroecológica de animales sigue siendo incipiente. Realizamos una revisión sistemática para evaluar el estado actual del conocimiento científico sobre la producción agroecológica y orgánica de animales en Brasil. Empleando una metodología adaptada de la declaración PRISMA, examinamos 34 documentos técnicos y artículos seleccionados. Nuestros hallazgos indican que la mayoría (75%) de la literatura analizada se centra en los principales sectores de producción animal convencional de Brasil, a saber, bovinos de carne (20,5%) y de leche (34%) y avicultura (20,5%). Además, aproximadamente el 61% de los artículos revisados se enfocan en sistemas de producción dentro de los biomas del Cerrado y la Mata Atlántica. Destacamos los estudios de caso que surgieron con la metodología de investigación predominante, adoptada por el 38.2% de los investigadores brasileños. En resumen, es evidente que este tema merece una investigación más profunda. La adopción de enfoques holísticos es imperativa en la evaluación de tales sistemas de producción, que tienen como objetivo proporcionar fuentes de alimentos sostenibles, un ambiente saludable y el bienestar social.

Palabras-clave: Biomas brasileños; Brechas en el conocimiento científico; Métodos de evaluación; Distribución geográfica.

INTRODUCTION

Brazil is a great animal protein producer. In 2022 the country was the third major producer of cattle milk, the second in poultry meat, and the second in cattle meat (FAO, 2024). Unfortunately, most of these productions are based on conventional systems, which threaten the natural environment with massive inputs of chemical fertilizers, defensives, and synthetic veterinary drugs.

Fortunately, since the beginning of the 2000s, Brazil has stimulated organic food production in various ways. For example, there are government guidelines for rural extension policies (Brasil, 2010), the publication of legal frameworks for organic production (Brasil, 2003), the availability of formal education on the subject (from technical to graduate courses) (Souza, 2017; Oliveira, Freitas and Ramos, 2022), and public purchase policies for organic products (Brasil, 2009).

Despite the Brazilian know-how on animal production, organic animal production is very incipient. We proceeded a preliminar survey in the National Register of Organic Producers, which only includes certified organic producers. From 26.546 registered organic producers in February 2022, most have some crop production, while only 518 (1.95%) producers declared that they raise animals. Of the latter, 329 (1.23%) are bee producers, while the other 0.72% encompasses all other farm animals: 80 are milk and dairy producers, 115 of poultry, 16 of pigs, 8 of beef cattle, and 7 of goats or sheep. This register only comprehends organic and certified producers.

Although no official data is available, some agroecological experiences have also occurred in Brazil, mainly because producers are aware of the health problems chemical inputs can cause (Navolar; Rigon; Philipp, 2012) and due to some rural social movements that have embraced agroecology (Scopinho; Gonçalves; Melo, 2016). In addition, agroecological food production is fomented together with organic production by public policies such as the National Policy for Agroecology and Organic Production, which had its first version in 2013. For this reason, some people consider the organic and the agroecological production systems synonyms. For example, the Brazilian law on organics states that "the concept of organic agricultural and industrial production system

encompasses the following: ecological, biodynamic, natural, regenerative, biological, agroecological, permaculture, and others that meet the principles established by this law" (Brasil, 2003). However, agroecology is also a comprehensive approach and may be understood as a science, a social movement, and a practice (Wezel *et al.*, 2009). It is possible to make organic production based on substituting conventional techniques for organic ones – attending regulations established by law and certification bodies – i.e., without changing the logic of the production system. Nevertheless, it is a mere second step towards an agroecological transition. This one targets the transformation of farming and food systems co-created to suit different local contexts and is based on a social-ecological systems approach (Wezel, 2020).

Now, considering the context of international scientific production, Soussana *et al.* (2015) observed low participation in agroecological animal production. According to these authors, although several studies relate ecology or the environment to animal production, few adopt an agroecological perspective. Thus, only 5% of the indexed studies on agroecology have the keyword "livestock" (animal production or animal herds). The integration of agroecology with animal production has yet to be much considered in the agroecological scientific literature (Soussana *et al.* 2015).

Since much of Brazilian science is published in Portuguese, whether the same themes are relevant to improving and increasing organic or agroecological animal production in the country is still being determined. Therefore, this study aims to analyze what has been published regarding local experience, and the gaps that must be filled. For this purpose, we present a systematic review to investigate the state of the art of organic and agroecological animal production scientific knowledge in Brazil.

METHODOLOGY

The Prisma 2020 statement (Page *et al.* 2021) was adapted, as it was initially planned for health studies. Within the Metasearch engines capable of consulting various databases simultaneously, the chosen was Google Scholar. We also consulted Scielo Brasil, a public database that stores many Brazilian journals, but no new result was achieved. Both searches aimed at article titles only.

We also adapted the Population, Intervention, Comparator, Outcome (PICO) framework, commonly used to structure the reporting of eligibility criteria for reviews of interventions in health studies (Page *et al.*, 2021), into Population, Intervention, Outcome (PIO), which is a more suitable structure for social, economic and environmental studies. For population, the selection included any animal production systems studied (2nd term column of Table 1); for intervention, organic, agroecological, or agroecological transition production systems (1st term column of Table 1); and for outcome, studies that reported livestock productive, economic, social, environmental, or sustainability indicators or analysis.

We looked for all possible combinations of the first-column of portuguese terms and the second-column of portuguese terms, as shown in **Table 1**. All English translations are presented in parentheses. Using the Boolean Operators the equation used was: (agroecologia OR agroecológica OR Orgânica NOT (solo OR matéria OR carga OR "adubação orgânica" OR fração OR química) OR produção orgânica OR agricultura natural OR "Produção de" OR Permacultura OR Permacultural) AND (Bovinocultura OR criação de OR pecuária OR produção de OR avicultura OR caprinocultura OR ovinocultura OR carne OR leite OR ovos OR aves OR suínos OR galinhas OR caprinos OR ovinos). When we used the term "organic" ("orgânica" in Portuguese), many other subjects appeared as "organic chemistry" or "orgânic fraction", so many restrictions had to be applied to focus on the research theme.

We used the terms "Brazilian organic production" and "Brazilian agroecological production" to search for papers published in English.

The adapted Prisma flow diagram is presented in **Figure 1**. In the identification step, the number of identified articles in the search is presented, and the number of removed ones is indicated in the box on the right. From 754 initial registers, only 125 were used in the screening step, where records that were not published in scientific journals were removed (e.g., thesis, events proceedings, educational material). In this step, articles published since 2004 – because the first Brazilian law regulating organic production was published in December 2003 – and available online until November 15th, 2022, were selected.

Studies conducted in other countries or unrelated to organic or agroecological systems were also excluded.

Table 1. List of Intervention and Population: Portuguese terms combined for paper research.

Intervention terms	Population terms
Agroecologia (agroecology) Agroecológica (Agroecological) Orgânica -solo -matéria -carga -"adubação orgânica" -fração -química (organic, excluding: soil, matter, charge, fertilization, fraction, chemistry) Produção orgânica (organic production) Agricultura natural (natural agriculture) Produção de (production of) Permacultura (permaculture) Permacultural (permacultural)	Bovinocultura (beef cattle farming) Criação de (animal farming) Pecuária (cattle farming/breeding) Produção de (production of) Avicultura (aviculture) Caprinocultura (goat farming/husbandry) Ovinocultura (sheep farming/husbandry) Carne (meat) Leite (milk) Ovos (egg) Aves (poultry) Suínos (pork) Galinhas (chicken) caprinos (caprines) ovinos (sheep)

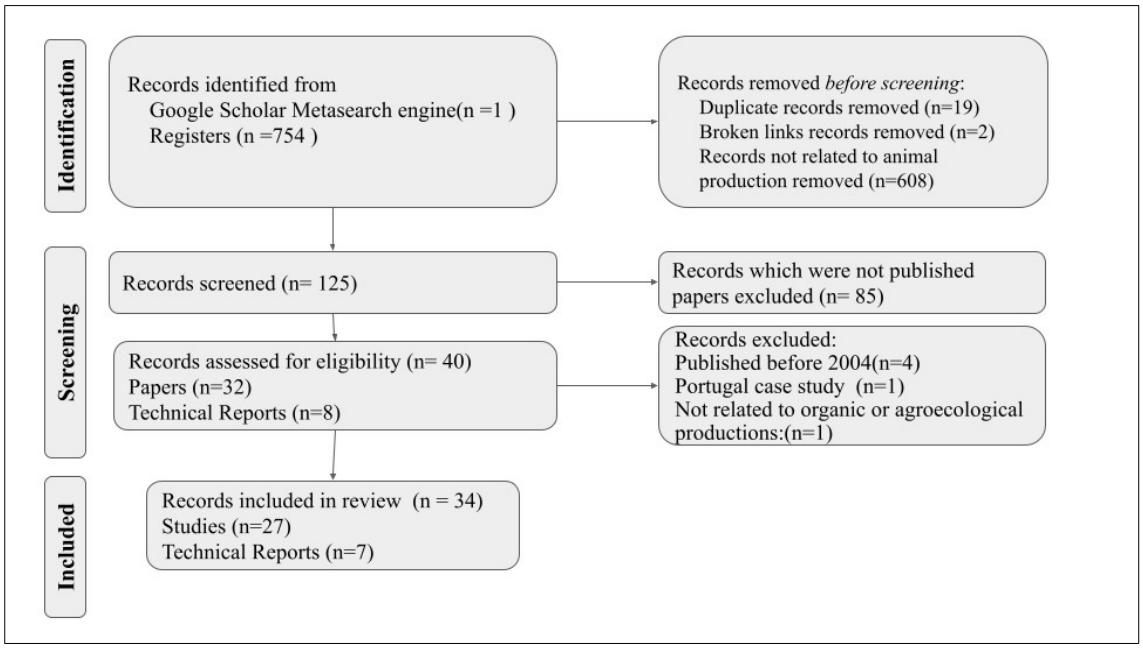

Figure 1. Prisma flow diagram.

Finally, 34 papers and technical reports were included in the systematic review, and an analysis based on article screening was conducted. The following data were extracted from each article: animal production system, location state and biome, kind of alternative agriculture studied, theoretical concepts used (only if there was a theoretical discussion; introduction discussions were not considered), and methodology of study. For case studies, we proceeded with an in-depth analysis and listed the number of production systems included, the main focus of analyses, and the methods used in the studies. Electronic sheets (Google sheets) were used for the descriptive analysis.

RESULTS AND DISCUSSION

Overview

Of the 34 articles included in this review, only three (8.8%) were written in English. Although Portuguese scientific materials are essential for locals, English materials allow researchers from other countries to collaborate and contribute to alternative animal production systems in Brazil.

We had seven animal production systems analyzed: dairy cattle (12 papers; 35.3%), beef cattle (7 papers; 20.5%), aviculture (7 papers; 20.5%); and 3 (8.8%) were about Sustainable and Integrated Agroecological Production (PAIS is the acronym in Portuguese); and aquaculture, apiculture, goat or sheep husbandry and multi-species production systems (on family farming experiences) had 1 (2.9%) paper each.

It is worth noting that 75% of the analyzed articles are about Brazil's three major conventional livestock: beef, dairy, and poultry. No article regarding pig production was found and included in this review. Considering that the country was the third largest producer in the world, producing 5.1 million tons of pig meat in 2022 (FAO, 2024) and that some less intensive production systems have already been developed, like the free-range system, we expected more papers on it. The only article found was a review of alternative food for agroecological production systems, so no articles focused on a pig farming alternative system were found and included. It was also a surprise finding only one paper on apiculture or meliponiculture. Our investigation of the National Register of Organic Producers showed that 63% of organic animal producers work with bee products.

We suspect that these bees' production are mainly used as support to pollination of fruits and vegetables production and not the main focus or activity. Another explanation for this outcome could be the lack of integration between production and scientific research as explained by Cultri (2022, p.138), his statement affirms that in Brazil, there are still few experiences and practices in apiculture and meliponiculture that establish a dialogue between popular, scientific, and technological knowledge.

Although PAIS is mainly used with aviculture, it is a system integrated to horticulture and uses permacultural design logic. For this reason, PAIS studies were analyzed apart from other aviculture systems. This system was initially designed for properties in the mountainous region of the Rio de Janeiro state and comprehended a circular system with a chicken coop in the center, gardening beds around, and a passage for chickens to reach a pasture area. The gardening beds are equipped with a simple irrigation system. This model became a social technology kit donated and installed in 19 Brazilian states (Foschiera; Andrade, 2020). The PAIS program also had technical support and, in one experience, a sales location. In 2010, 2700 PAIS units had already been installed in Brazil (Fernandes, 2011).

Articles (n=3) related to the PAIS program, which were included in this review, present an economic or social analysis of this system. One of the studies pointed to the economic viability of the PAIS: 92% of the producers interviewed by Andrade, Silva and Caleman (2016) in the state of Mato Grosso do Sul demonstrated satisfaction with the program. In contrast, Foschiera and Andrade (2020) showed that only 29% of the producers studied in the state of Tocantins were still using it, mainly due to the lack of water for the system and difficulties without using chemical products. Although the PAIS has become a technology kit, it must rely on on-site analysis by technicians to make the necessary adaptations to the location where it is being installed. For example, the circular design system is not suitable for some landscapes as it needs a flat surface area for the circular system.

Of 34 of the analyzed articles, only Ferreira, Barros and Belvilacqua's (2020) has focused on a system with diverse animal species, investigating women's work in nine family farming experiences. In this arrangement, animal production is usually used for family meals, and the excess goes to the market. It was observed that most of the studies focus on

systems that target the market and not subsistence systems, which are also important because they promote food security for many rural families.

Considering the epistemological frameworks, we found a variety of alternative agriculture systems being practiced in Brazil. From the 34 studies analyzed, 18 (52.9%) used an organic agriculture framework that targets to fulfill the compliance of organic law and normative; 13 (38.2%) agroecology framework and 1 (2.9%) used organic and agroecological frameworks. The lasting 2 (5.8%) studies used natural agriculture framework. No studies were found that explicitly cited the use of permaculture, biodynamics, biological, or regenerative frameworks.

Eighteen (52,9%) studies did not discuss theoretical concepts about the agriculture style they approached. This definition is bottom-line and should be explained because some authors use agroecology and organic production as synonyms. Although it is possible to conjugate both frameworks (usually called "organic on an agroecological basis"), agroecology goes beyond organic requirements. Wezel *et al.* (2009) state that agroecology is a science, a social movement, and a practice simultaneously. However, just the practice part can be regulated on a legal framework.

Geographical distribution of studies

Brazil has six biomes: Amazon Rainforest, Atlantic Forest, Caatinga, Cerrado, Pampa, and Pantanal. Each biome has its characteristics and aptitudes for agriculture and animal production, but they are constantly under deforestation pressure. **Table 2** shows the number of papers for each biome divided into different animal production systems.

We could verify that in all biomes, production systems must be redesigned to reduce human activities' pressure in public and private areas, allowing food production and nature conservation to coexist. One example is the technical report that refers to Caatinga. Sheep and goats are commonly raised (and their meat is consumed) in the Northeast Region of Brazil, where Caatinga is located. Caatinga is a biome where water is scarce, and growing exotic and more productive grasses takes work. According to Silva *et al.* (2022), “Caatinga biome is the largest and wettest semi-arid environment globally, occupying 10% of the Brazilian territory. (...) Half of the original vegetation from the

Caatinga has already been deforested". Silva *et al.* (2002) results showed that five factors are crucial for understanding the spatial variability of deforestation in this biome: agricultural credit, cattle, goats, distance from roads, and mining activities. Cavalcante, Holanda Junior, and Soares (2007) conducted a review of research results applicable to organic production systems utilizing native vegetation for sheep or goat husbandry. This paper presents a range of adapted techniques aimed at mitigating deforestation pressure and establishing more resilient, climate-adapted animal production systems.

Table 2. Number of animal production systems approached in each of the six Brazilian biomes.

Animal production systems	Biomes						Not defined	Total
	Amazon Rainforest	Atlantic Forest	Caatinga	Cerrado	Pampa	Wetlands (Pantanal)		
Dairy cattle farming	1	7	0	1	0	0	3	12
Beef cattle farming	0	0	0	3	1	3	0	7
Aviculture	1	0	0	5	0	0	1	7
PAIS (small aviculture integrated with horticulture)	1	0	0	2	0	0	0	3
Aquaculture	0	1	0	0	0	0	0	1
Goat or sheep husbandry	0	0	1	0	0	0	0	1
Apiculture	0	0	0	1	0	0	0	1
Multiple animal production systems								
Aviculture and pig farming	0	0	0	0	0	0	1	1
Aviculture and dairy cattle	0	1	0	0	0	0	0	1
Total	3	9	1	12	1	3	5	34

The Cerrado biome is a neotropical savanna occupying 23% of Brazilian territory. Its area has been converted to pasture (29.5%) or cropland (11.7%), and 8.2% is formally protected (Brasil, 2016 *apud* Noojipady *et al.*, 2017). Atlantic Forest occupies 15% of the Brazilian territory, but only a limited part remains untouched. Sixty percent of the Brazilian population lives in this biome, and 70% of the gross domestic product is generated in the same region. In 2009, estimations affirmed that the remaining vegetation cover of the Atlantic Forest in Brazil ranges from 11 to 16% (Ribeiro *et al.*, 2009). More recently, Rezende *et al.* (2018) pointed to a current vegetation cover of 28%. Cerrado is where major cattle production occurs (in terms of production value) followed by Atlantic

Forest (Buainain *et al.*, 2020). Both biomes had together 21 (61%) articles. This is a high percentage, and confirms that research in Brazil is still incipient for alternative animal production systems, and the few that exist are clustered in the traditional food production areas.

Comparison of Brazilian studies to Dumont *et al.* (2014) research issues gap

Regarding agroecological animal production, Dumont *et al.* (2014) identified key research themes that could increase knowledge about its technical, organizational, and innovative aspects. The authors assembled a multidisciplinary team of seven scientists working in animal production. They were invited to consult their peers on priority research topics for the animal production sector to deal with contemporary challenges. The themes were: climate change, increase in population and poverty, reduction in animal product consumption – especially in developed countries – and increase in the use of arable land to produce biofuels. Scientists from different backgrounds reviewed the final list of 40 topics and discussed them in an interdisciplinary panel. These themes were condensed into four main themes: (1) animal adaptive capacities; (2) food resources and forage production; (3) design and evaluation of animal production systems and (4) ways to scale up agroecological animal production.

In this review, we did not restrict included articles to agroecological systems and consider that the four main themes are relevant not only to agroecological systems but also to natural and organic ones (which will be called "alternative animal systems" in order to recognize the particularities of each framework).

For Dumont *et al.* (2014), animal adaptive capacities are imperative in redirecting animal breeding programs' targets from productive to robustness criteria. This redirection would cause better adaptation to fluctuating feed quantity and quality and other results of climate change such as high temperatures or loss of biodiversity. Brazil has some environmental conditions adapted breeds of farm animals, like goat breeds adapted to the hot northwest climate (Canindé, Moxotó e Repartida); pig breeds that were used in traditional family farming (Piau, Nilo-canastra, Pirapitinga and Caruncho), and bovine breeds raised since colonial times that adapted to different biomes conditions (Panteneiro, Franqueiro,

Caracu and Curraleiro). These breeds are not used in commercial animal production mainly because of their low productivity. For fish species, there are many native ones used in aquaculture and available in fish markets, such as Dourado, Pacu, Pirarucu, Surubim, and Tambaqui. However, no research was found on native breeds or animals in alternative production systems. Only Resende (2020) discusses this topic in the research about the use of homeopathy for dairy cattle, which fits in with the issue of "managing host-pathogen interactions" addressed by Dumont.

For Dumont *et al.* (2014), producers must reduce dependency on external inputs, making feed resources and forage systems central. Unfortunately, some organic animal production systems depend on organic grains or concentrated feed instead of developing grass-legume mixtures or silvopastoral systems. Regarding this topic, Tonet, Silva, and Pontara (2016) conducted a review on alternative feed options for poultry and swine in agroecological systems. They compiled a list of 19 alternative feeds for poultry and 19 for swine. The authors also highlight that there is a need for more rigorous nutritional studies in order to keep the animals' productive performance. Also, given their primary emphasis on nutritional considerations, it should be noted that certain options may not be economically viable. For instance, a significant majority of swine farms may not have access to eggs or fat-free milk for inclusion in pig diets.

Mattos, Nechet and Silva (2010) was the unique experimental research included in this review. In this study, the authors assessed the use of horticultural crop residues for poultry feed. Their results indicate a significant increase in egg production, suggesting that a more efficient utilization of nutrients can be achieved on the farm through the use of vegetable waste. However, additional research is necessary to explore the potential use of crops residues for other livestock species, preferably, combining nutritional and economic assessments. The transportation costs of these residues may economically render their use unfeasible; therefore, this material should come from the farm itself or neighboring farms. Furthermore, given Brazil's rich biodiversity, investigations into using native herbs and trees as feed for production animals are also justified.

Twenty articles included in this review could fit Dumont's theme of design and evaluation of new animal production systems. Many involved economic, socioeconomic, or

environmental evaluation of animal production systems. Still, only a few used methods capable of valuing interaction among system components, as Dumont *et al.* (2014) suggested. These methods are vital to diversified farming systems, which are expected on an agroecological basis, but are rare in organic farming. Four case studies that will be discussed later used tools of holistic perspective that consider a set of qualitative and quantitative indicators suggested by Dumont *et al.* (2014).

Dumont *et al.* (2014) included the following issues in the theme of scaling-up agroecological animal production systems: mechanisms contributing to the success or failure of systems and producers' motivations; new arrangement among stakeholders; attributes influencing product acceptability; landscape scale management; organization of extension services and efficiency of public funding. Eleven articles in this review address these topics, given that it is a comprehensive theme. For example, Grzebieluckas and Silva (2013) investigated why four producers abandoned organic production, while Moraes (2014) analyzed the willingness of conventional livestock farmers to become organic livestock farmers.

In this review, there were studies regarding enterprises' actions, such as Rover and Anschau (2013), which explains development strategies of three cooperative networks of milk production; Ferreira, Rodrigues and Baptista (2015) investigated sustainable entrepreneurship, or market and regulation analysis for organic milk, presented in Machado *et al.* (2021) and Machado *et al.* (2022). Other four research studies that describe university actions such as extension or education based on animal production systems implementation could also help extension services to be more effective. No article included in this review discussed public funding for animal production systems. However, public funding for agroecological and organic policies and extension services are the main topics of the agroecological movement in Brazil.

Methods used in the studies

We found seven distinct research methods: two studies performed action research, two performed participatory action research, thirteen performed case studies (single and multiple case design), one performed descriptive study, one performed experimental

research, two performed secondary data analyses, and six performed surveys. We also found seven articles that were literature reviews. They are not formally considered a scientific research method but are also substantial in consolidating the field of alternative animal production systems apart from conventional animal production systems. **Table 3** presents the research methods used in each animal production system. The topics covered by literature reviews included in this study were organic beef cattle farming in Pantanal (Santos *et al.*, 2005); agroecological aviculture (Lima *et al.*, 2019); sustainable entrepreneurship and natural agriculture (Ferreira; Rodrigues; Baptista, 2015); laws and regulation on dairy cattle farming (Machado *et al.*, 2022); homeopathy (Resende; Almeida; Fajardo, 2020); alternative food for poultry and pigs (Tonet; Silva; Pontara, 2016) and on sheep and goat husbandry (Cavalcanti; Holanda Junior; Soares, 2007). We found that organic or agroecological apiculture and pig farming still need publications. Ferreira, Rodrigues and Baptista (2015) published a case study on a specific organic company using the literature and the company's website review. In this case, we decided to classify this study as a literature review.

Medeiros (2010) presented a descriptive study of two agroecological and organic properties: one mainly based on horticulture and another on milk production. Despite not presenting productive values, they highlighted the systems' strengths and limitations. Both systems shared low productivity levels (when compared to conventional production system) and a focus on the local market, where organic products have yet to be widely known, resulting in sales at low prices.

Of four action research studies (including participatory ones), two aimed at family farming settlements, one at an education institution, and one at a traditional family farming area. Three of them (Bridi *et al.*, 2020; Canaver *et al.*, 2006; Muniz *et al.*, 2017) presented the results of university extension projects where professors and students took part in establishing animal production systems (one apiculture and two milk cattle farming) in family properties which were selected as demonstrative units. The projects promoted training for interested producers and presented the results afterward. Cardoso, Moreira and Caetano (2021) evaluated the establishment of an agroecological poultry sector in a public educational institute, which allowed training on the matter to students,

institute employees, nearby indigenous and rural producers. All four studies showed promising results, mainly in social impact for the involved communities. The participatory ones also highlighted the importance of getting students to know and understand local realities.

Table 3. Number of articles that mentioned one of animal production system regarding each research methods.

Animal Production System	Action Research	Case Study - multiple case design	Case Study - single case design	Descrip-tive Study	Experi-mental Research	Literature Review	Participa-tory Action Research	Secon-dary Data Analysis	Survey	Total
Dairy cattle farming	0	2	4	1	0	2	2	1	0	12
Beef cattle farming	0	2	0	0	0	1	0	1	3	7
Aviculture	1	2	1	0	1	2	0	0	0	7
PAIS - small aviculture integrated with horticulture	0	0	1	0	0	0	0	0	2	3
Aquacul-ture	0	1	0	0	0	0	0	0	0	1
Goat or sheep husbandry	0	0	0	0	0	1	0	0	0	1
Apiculture	1	0	0	0	0	0	0	0	0	1
Multiple animal production systems										0
Aviculture and pig farming	0	0	0	0	0	1	0	0	0	1
Small aviculture and dairy cattle	0	0	0	0	0	0	0	0	1	1
Total	2	7	6	1	1	7	2	2	6	34

Machado *et al.* (2021) used secondary data analysis of organic milk producers from the National Register of Organic Producers, comparing 2018 and 2020, and mapped and characterized 39 organic milk producers that answered an online questionnaire. They found that organic milk producers are becoming more numerous and are predominantly located in South and Southwest Brazilian regions. Fifty-eight percent of them are

exclusive milk producers, while 42% have a greater variety of products. In São Paulo and Minas Gerais states, third-party audits certify most properties. In Rio de Janeiro and southern region states, certification occurs mainly by participatory means.

Abreu, Oliveira and Balduíno (2021) analyzed monthly (from 2019 to 2021), the number of beef cattle slaughters in Mato Grosso do Sul state in organic and sustainable production systems. The sustainable system had its last protocol launched in 2017 and became a quality guarantee less rigorous than the organic one. It concerns mainly on traceability, origin of animals (which must be from the Pantanal biome), nutritional and sanitary management, animal facilities, pre-slaughter handling, in addition to establishing minimum standards for socio-environmental responsibility. But, unlike organic practices, the use of chemosynthetic medications is permitted, as long as the withdrawal period is doubled. The use of feed from conventional sources, including genetically modified organisms (GMOs) is also allowed. Both systems had a reduction in the ICMS tax rate (67% and 50%, respectively) in Mato Grosso do Sul state. Although Covid pandemic impacted results, it was shown that sustainable production slaughters showed a sharper increase while organic ones kept their stabilization tendency. It is of note that the Brazilian National Register of Organic Producers does not have any production volumes, prices or margins data. Thus, researchers depend on other data collection (questionnaires or producer associations database).

Surveys are crucial research tools for comprehensively understanding specific locations and circumstances. Both the previously discussed articles by Foschiera and Andrade (2020) and Andrade, Silva and Caleman (2016) were about the PAIS program's social results. Ferreira, Barros and Belvilacqua (2020) studied women's role in animal husbandry in agroecological transition. For this purpose, nine properties in Zona da Mata of Minas Gerais state were covered. They found that women were in charge of animal husbandry, and the products were primarily for self-consumption, with the surplus being sold. The authors pointed out that women's work "was not valued or treated as 'productive'" and highlighted that gender equality is challenging for the agroecological approach.

The other three surveys were on beef cattle farming. Matias *et al.* (2015) assessed if there

were sustainable practices in organic production in Mato Grosso do Sul state. Grzebieluckas and Silva (2013) analyzed the interruption of organic livestock production, which will be discussed later. Moraes (2014) evaluated the perception of organic conversion among rural producers in São Miguel das Missões, a municipality in Rio Grande do Sul state. She affirmed that conventional beef cattle farming is losing space to soy producers and, in some cases, producers rotate yearly soy production and finishing of beef cattle. Of interviewed producers, 89% also used chemical inputs, but 77% were curious about organic conversion. She concludes that organic cattle farming may be possible for the interviewed producers, but technical support and orientation are required for this conversion.

The case study was the most used research method by Brazilian researchers. In this review, 13 case studies were included. The results of the in-depth analysis are summarized in **Table 4**. We found four dimensions of analysis that could be assessed, in combination or not: social, economic, productive, and environmental. Four studies (30%) assessed all dimensions; two (15%) assessed social and economics dimensions; two (15%) assessed productive and economics dimensions; one (7,6%) assessed productive and social dimensions; two (15%) assessed only economic dimension, and two (15%) assessed only environmental dimension.

Although Sachet *et al.* (2021) identified that 60% of South American case studies that addressed agroecology as a social movement were from Brazil, this social approach is not so strong when dealing with animal production studies. When researchers understand that alternative animal production systems demand a holistic approach, they will search for methods (or a combination of them) that allow the analysis of all four dimensions (considered a sustainability analysis for some authors). The socioeconomics and productive dimensions analysis tends to be a more traditional approach to animal production systems and represents seven (54%) studies. Five studies used more than one method in their analysis, and the articles showed three methods that allowed a holistic approach: "Ambitec-agro", "Emergy analysis", and "Mesmis". We can also notice that researchers from different study fields authored the studies, for example geography, economics, business, animal science, and agroecology.

Table 4. In-depth analysis of case studies.

Authors	Animal Production	Declared alternative agriculture studied	Theoretical concepts used	Number of cases	Analysis's Main focus	Methods
Rover; Anschau (2013)	Dairy cattle farming	Agroecology	Agroecology	3	Socioeconomics	Documental analysis and interviews
Alves *et al.* (2009)	Dairy cattle farming	Organic	Organic legislation and statistical data	1	Productive and Economic analysis	Costs and revenue analysis; productive indicators
GONÇALVES *et al.* (2022)	PAIS	Agroecology	Rural Sustainable Development, Agroecology and Family Farming	1	Economic	Investment analysis
Ferreira Darnet *et al.* (2022)	Dairy cattle farming	Agroecology	Agroecology	1 settlement, 559 families	Environmental	Geoprocessing
Holmströmet *et al.* (2020)	Dairy cattle farming	Organic	Not detailed	7	Economic	Cost analysis comparison
Aguirre *et al.* (2019)	Beef cattle farming	Organic	Not detailed	2	Productive and Economic analysis	Costs analysis; productive indicators
Demattê Filho *et al.* (2014)	Aviculture	Natural Agriculture	Not detailed	1	Environmental	System for Weighted Environmental Impact Assessment of Rural Activities (APOIA- novo rural)
Soares *et al.* (2022)	Dairy cattle farming	Organic	Not detailed	1	Environmental, socioeconomic and productive	Ambitec-Agro
Santana *et al.* (2022)	Dairy cattle farming	Organic	Not detailed	1	Productive and social	Interviews and field observation
Neves *et al.* (2016)	Beef cattle farming	Organic	Not detailed	9	Socioeconomic	Ambitec-Agro
Nascimento *et al.* (2022a)	Aviculture	Organic	Not detailed	2	Environmental, socioeconomic and productive	Emergy Analysis
Nascimento *et al.* (2022b)	Aviculture	Organic	Not detailed	2	Environmental, socioeconomic and productive	Economic cost assessment, emergy synthesis and Five Sectors of Sustainability model (5SENSU)
Nunes *et al.* (2017)	Aquaculture	Agroecology	Not detailed	3	Environmental, socioeconomic and productive	Framework for the Evaluation of Natural Resources Management Systems Incorporating Sustainability Indicators (MESMIS)

Grzebieluckas and Silva (2013) and Aguirre *et al.* (2019) studied organic beef cattle farming in Brazil's center-west region. Although both case studies are not directly comparable, they show very different realities in the same Brazilian region. Grzebieluckas and Silva (2013) interviewed four producers who had left organic production and returned to conventional production because they have higher costs for the maintenance of pastures (because they could not use fertilizers or herbicides) and had difficulty feeding the animals with organic feed. Aguirre *et al.* (2019) interviewed veterinarians responsible for each system and compared the costs of conventional and organic beef cattle farming. Their findings were that organic system had 24,9% and 20,02% lower costs on nutrition and forage, respectively, because they produced feed on the property and used natural grassland of the Pantanal biome While producers observed by Grzebieluckas and Silva (2013) took a whole year more to have organic cattle ready to slaughter, the system in Aguirre *et al.* (2019) took only 83 days more.

Another probable difference is that producers in Grzebieluckas and Silva (2013) tried to keep raising the animals in the same logic of conventional production, just depending on inputs substitution, while the system in Aguirre *et al.* (2019) took advantage of environmental possibilities.

Another difference was that Grzebieluckas and Silva (2013) producers received 7% more for the organic animal and affirmed the price should be 35% higher to cover the organic production costs, while Aguirre *et al.* (2019) practiced a 10 to 15% higher price than conventional animals. That may have been caused by the five years interval between both studies or because the studies were conducted in different cities.

Also, a common characteristic observed in dairy cattle farming was that the destination of milk production could follow two directions: on-site processing or delivery to a dairy cooperative or industry. If producers were far from dairy cooperatives or enterprises with organic milk as a strategic objective, organic dairy farmers would have on-site facilities for processing the milk into value-added dairy products, thereby enhancing the economic viability of their operations. This locational aspect is crucial and should be evaluated when producers choose organic conversion. Not all dairy industries can produce organic products and may not pay higher prices for organic milk producers. Also, recently some

dairy industries stopped receiving organic milk, giving producers only one option besides delivering it to non-organic industries, certainly causing vast financial loss.

Study limitations

We later identified that the terms apiculture and meliponiculture could have been included as population terms in this study, and this may be the reason why just one study on it was found. Despite the Brazilian average productivity being low, in 2022, Brazil was the ninth-largest honey producer globally (FAO, 2024). Vidal (2020) asserts that Brazil has the world's largest capacity for organic honey production, with the Northeast region, in particular, demonstrating high competitiveness in the global market for apicultural products. Furthermore, meliponiculture represents a viable alternative for agroecological and organic producers, facilitating increased production (Silveira, 2023) with comparatively simpler and safer management practices.

Finally, our screen did not include studies focused on pastures or grazing systems. Depending on the technology studied some of them could be applied on organic and agroecological animal production. Unfortunately, most of the time, researchers focus more on the technology itself than in its real and possible applications. As Machado Filho *et al.* (2023) states for the realization of agroecological food production, it is necessary to be acquainted with successful technological alternatives verified by scientific research, coupled with traditional and ancestral practices and knowledge. In that study Machado Filho *et al.* (2023) focused on technologies already available that could be used on agroecological animal production systems. In another way, our study focused on what has already been planned and/or used for organic or agroecological animal production systems. These systems (should be or) are a combination of technologies locally adapted to the natural environment and social conditions. Agroecology professionals must have a toolkit of these technologies to assemble organic or agroecological animal production systems adapted to local restrictions. Future literature reviews may search for other technologies that could be used to adapt cultures (animals or plants) to the agroecosystems, to fulfill this gap.

CONCLUSIONS

This study aimed to analyze the state of the art of organic or agroecological animal production in Brazil. We found only 34 articles that could be included. Although the country has ample research on conventional animal production, our study shows that organic or agroecological animal production research has much space for improvement among Brazilian researchers.

As this area of research is "new," we found that some authors mix concepts such as "green," "conventional," "sustainable," "organic" and "agroecological" livestock. The research must explicitly indicate which type of production system will be analyzed. Especially when it comes to agroecological and/or organic animal production, it is essential to be apparent if the researcher is only considering legal aspects and requirements of organic systems or if the objective of the production is to achieve the agroecological principles and elements, as systematized by Wezel *et al.* (2020).

Regarding the lack of studies in certain areas, we point out pig farming and beekeeping for organic or agroecological production systems. There was also a lack of studies on the ability of animals to adapt to different biomes or the improvement of native breeds. On the other hand, 38% of studied articles were case studies, pointing out that alternative production systems are resilient enough to exist with little research, almost no specialized professionals, and production chains that still need to be more organized.

As a recommendation for future research on agroecological animal production, considering how the agroecological concept is comprehensive and holistic, we understand that its analysis should cover at least social, economic, and environmental aspects. In this way, future studies will offer more systemic and interdisciplinary approaches.

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