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Donkeys in Brazil: Bibliometric Mapping and Breed Information

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Abstract

In this paper, we looked at the distribution of donkeys (*Equus asinus*) in Brazil as well as the research being carried out with them. We used bibliographic mapping techniques to identify major themes, timelines, and research groups working with these animals. Donkeys are essential for producing mules (*Equus mulus*), and, especially in the Northeast region, they are vital in cattle production in Brazil. Nevertheless, there is little research being carried out, which may affect their survival in the long term, thereby impacting agricultural systems. Most research is on health and reproduction issues, and little is seen in production aspects related to genetics and nutrition. The body indices for Brazilian donkeys show that they vary from medium (Paulista) to small (Northeastern and Pêga) animals with an aptitude for strength (Body Index >0.90). The Northeastern and Pêga tend to have poorer thoracic development, but all show good traction capabilities (Dactyl Thoracic Index, Conformation Index). Northeastern donkeys are smaller animals and have lower load-carrying capabilities. This paper shows various areas where research in donkeys could be expanded.

Keywords

Citation analysis, *Equus mulus*, local breed, Northeastern, Paulista, Pêga

1. Introduction

In the letter from Pero Vaz de Caminha (the clerk of the fleet commanded by Pedro Álvares Cabral, who arrived in Brazil in April 1500) to the King of Portugal, it is evident that at that time farm animals did not exist in Brazil.

They neither plough nor sow. There are no bulls, cows, goats, sheep, chickens, or any other animal here, which is customary for men to live. Nor do they eat anything but this yam, which has been here for a long time, and this seed and fruit, which the earth and the trees shed. And with this they go so and so upright and so naive, that we are not so much, with how much wheat and vegetables we eat.

The colonization of America meant that the Portuguese and Spaniards brought animals from the Iberian Peninsula and North Africa to the new continent [1].

Donkeys belong to the kingdom Animalia, phylum Chordata, class Mammalia, order Perissodactyls, family Equidae, genus Equus. In 2003, the International Commission on Zoological Nomenclature decided that if domestic and wild species are considered subspecies of each other, the scientific name of the wild species takes precedence. This meant that the traditional name of the donkey, *Equus asinus asinus,* was changed to *Equus africanus asinus* [2]. The donkeys are divided into two trunks: the European trunk, *Equus asinus europeans*, probably originating in the Mediterranean region, and the African

trunk, *Equus asinus africanus*, originating in North Africa, the Nile basin or Abyssinia (present-day Ethiopia) [3,4].

Donkeys are thought to have been domesticated in northeastern Africa [5,6]. The oldest Egyptian monuments showed illustrations of donkeys from Abraham's journey to Egypt, as the donkey is mentioned in the book of Genesis (Genesis 12:16; Genesis 22:3) [7], confirming that the domestication of the donkey predated that of the horse. Domestication was thought to have occurred around 7,000 years ago [8]. The occurrence of domestic donkeys is thought to date from 4500 BC [9], with these animals appearing on an Egyptian palette dated to c. 3100 BC. Pathological damage from working donkeys was seen in animals buried with an Egyptian king outside Abydos c. 3000 BC. Donkeys were also found in the Near East around this time. Nomadic populations brought donkeys across the Sahara to Egypt and these populations still use donkeys today [10]. Regarding domestication, the prevailing idea is that the donkey, although used later than the horse in Europe, was used more remotely in Africa and Asia [8]. Greenfield *et al.* [11] showed the use of mouth bits as early as 2800-2600 BC in the Middle East.

The donkey (*Equus asinus*), also called asinine, ass, or donkey is a medium-sized perissodactyl mammal with a long snout and ears, used since prehistoric times as a pack animal. Its origin is linked to Abyssinia, where it was known as an onager or wild ass [12]. Evidence also shows that the African wild ass (*Equus africanus*) is the donkey's ancestor [5] and, in Western Asia, wild onagers were later crossed with donkeys [13]. These animals arrived in Europe brought by Greek wine merchants [14] and, according to this author, in Greece and Rome, all forms of equine medicine were called mulomedicina.

Christopher Columbus took donkeys on his first journeys to the American continent [15]. The discovery of this region and the later establishment of trade between Europe and the Americas meant that donkeys spread across the Americas. Both Portuguese and Spanish colonizers introduced the species during this period. The donkeys brought from the Madeira and Canary Islands by Martin Afonso de Souza were the first to be introduced in Brazil around 1534 [16,17], to the town of São Vicente (São Paulo State, Brazil). Later, Tomé de Souza brought donkeys from Cape Verde to Bahia State (in the year 1549) in the caravel[1] "Golf". The Spaniards introduced the species through two principal routes: i) the Bay of Panama, with animals introduced in the Antilles, which led to the spread of donkeys throughout Northern South America (Colombia, Venezuela, Ecuador, Peru, and northern Brazil), and (ii) the Rio de la Plata region (Argentina), introducing these animals to the southern cone of the continent [18,19]. At the same time, livestock were also introduced in areas of Portuguese domination. Brazil's southeastern and northeastern regions received these animals during the 15th and 16th centuries [20]. At the end of the last century [4], Italian and Spanish donkeys were imported and promoted by immigrants and the Ministry of Agriculture.

According to [21], the human movement in Brazil in the 19th century depended on the use of mules. After introducing these animals into the Brazilian economic structure during the colonial period, mules became the means of transport *par excellence* in the non-coastal regions of imperial Brazil [22]. The coffee and sugarcane crops depended on the services of the troops, both for the flow of production, as well as for the regional supply of products from other locations. The mule troops were reared mostly in the southern region of Brazil, so these animals traveled a long and very difficult route until they reached the places of demand for their services, which were mainly in the provinces of São Paulo and Minas Gerais. A route called "Caminho das Tropas" was created, linking the regions south and centersouth of the Brazilian territory [21], with the aim of facilitating the movement of the animals.

Overall, 14.5% of the equine population in Brazil are mules, and 8.9% are donkeys [23]. The distribution varies by region and state **(Figure 1)**, varying from 60% of the equines in the northeast and 3% in the south, with the highest percentages in the states of Ceara, Paraiba, and Piaui. Almost 100% of farms in the NE have these types of equines, compared with 6% in the South. There are approximately 380,000 donkeys in Brazil compared to 620,000 mules. While the donkey population is concentrated in the Northeast region, significant mule populations can be found in Minas Gerais (75,000), Mato Grosso (49,000), and Pará (83,000) States, among others. These states are significant for cattle production [24].

In Brazil, the main interest in donkeys is summarized in the donation of semen to produce mules, although donkey herds are of high genetic value [25]. In the Northeast, there are more donkeys than mules (27% more), while in the centerwest there are 90% more mules than donkeys. For centuries, a cross between donkey (2n = 62) and horse (2n=64) has been carried out. The mule (male donkey x female horse) and the reciprocal cross, the hinny (male horse x female donkey) are the most common equine hybrids [26], and both progenies are sterile (2n = 63). These hybrids have been seen to be robust, able to adapt to adverse environments, and docile, and are widely used on farms in Brazil [27]. As such, donkeys can be found on 237,575 farms and mules on 281,491 farms.

The decline in the number of donkeys in Brazil and other equids began with the introduction of engines used in cars. Because of that, according to [28], they began to be abandoned and reproduced indiscriminately, and today they are found in large numbers adrift in the Brazilian semiarid region, causing car accidents and overloading state authorities that are responsible for their capture and care [29].

Starting in 2016, Brazil has exported the hide of donkeys [30] to produce a medicine known as ejiao or *Colla corii asini* – CCA, a gelatine extracted from the skin of donkeys, an ingredient in tonics and face cream used in traditional Chinese medicine, popular in China [31]. There is no scientific proof that it works. Still, in the Asian country, ejiao is consumed in a variety of ways, such as in teas and cakes, and is used with the promise of treating various health problems, including anaemia, circulatory and reproductive problems, especially in women, in addition to insomnia such as irregular menstruation, anaemia, insomnia, and even sexual impotence. The free-ranging donkeys mentioned above were initially siphoned off to meet this trade [32].

[1]small, fast Spanish or Portuguese sailing ship of the 15th–17th centuries.

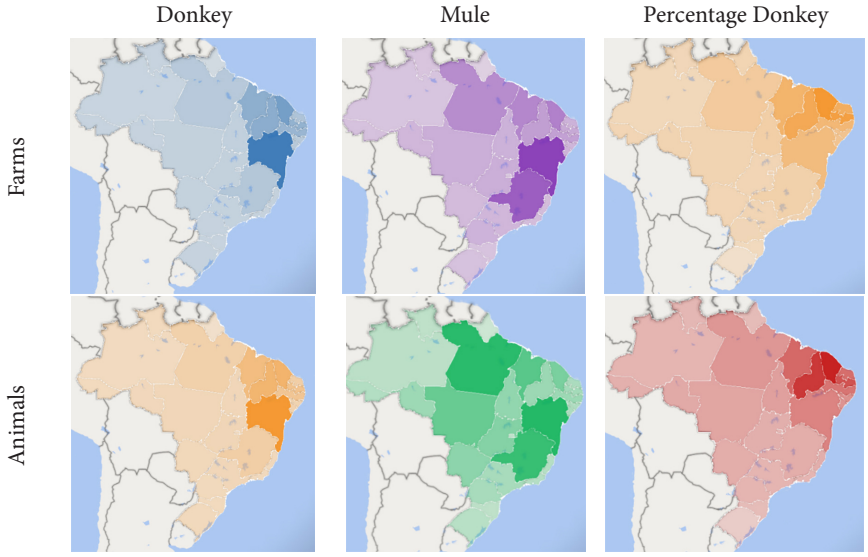


Figure 1. Heat maps for the distribution of donkeys and mules in Brazil.

To manufacture the product, the animals are collected from the caatinga and rural areas of the Northeast in large volumes, without a production chain that renews the herd, being slaughtered faster than the reproduction capacity. Donkey slaughter for the sale of skin on the foreign market, both legal and illegal, is threatening the existence of these animals. Queiroz *et al.* [33], considering only the records of the Ministry of Agriculture, Livestock and Supply (MAPA), showed that slaughter increased by more than 8,000% between 2015 and 2019 when 91,645 animals were killed. Between 2010 and 2014, there were just over 1,000 slaughters across the country. The Federal Court decided to suspend the slaughter of donkeys in Brazil for export to China (3/2/22)[2].

The Brazilian donkey breeds of Brazil, originating from animals brought by colonizers, underwent natural selection, developing adaptation characteristics in different environments [34]. There are three main breeds of donkeys in Brazil: Northeast (Nordestino Ecotype), Brazilian or Paulista, and Pêga.

Brazilian donkey breeds have haplotypes of origin in common with Asian and European breeds, originating from the somaliensis trunk [35], although this study only looked at Northeastern donkeys. Jordana *et al.* [19,36] also looked at this ecotype and found high admixture. A subdivision was observed in the somaliensis trunk, which suggests the existence of two distinct haplogroups from this origin or the possible presence of more domestication centers. Almeida [28] found, comparing the Paulista, Pêga, and Nordestino donkeys, that the Paulista has lower nucleotide diversity in the mtDNA control region than the other breeds. Alves *et al.* [37], looking at the mitochondrial control region (D-loop) in the three breeds, found five mitochondrial haplotypes with 19 polymorphic sites, two of them exclusively found in the Nordestino donkey. This latter group was found to be distinct from the other two groups. This study also found maternal influence of both Nubian and Somali clades in the formation of Brazilian donkeys, with the Pêga and Paulista being closer to the *Equus africanus somaliensis* and the Northeastern closer to *Equus africanus africanus*. According to [37], the greatest genetic distances between groups were observed for the Paulista and Nordestino donkeys, and the smallest distances between Pêga and Paulista. These authors also noted a high level of structuring and differentiation among Brazilian donkey breeds. It is important to note that these genetic studies may be influenced by sampling bias (for example, [35] only sampled in Ceará state).

1.1. Northeastern Donkey

These animals were important in the regional development of the northeastern region of Brazil and are considered a cultural symbol [29]. It is believed that the Northeastern (Nordestino) donkeys descend from North African animals, via the Portuguese islands such as Madeira, Santiago de Cabo Verde, and São Tomé. It is currently not a breed *per se*, but a group of animals that vary phenotypically (ecotype) in terms of height, color, head size, etc. Alves *et al.* [37] found high haplotype and nucleotide variability in this ecotype, indicating a lower level of artificial selection.

This ecotype is found from the south of Bahia to Maranhão States. The Northeastern donkey is of great service in that region, where it is used for agriculture and transport with low-income populations. It emerged from the need for a strong, resistant working animal, that was adapted to the harsh Caatinga semiarid biome. It is used for riding, traction, and plowing, although it is occasionally consumed as food in the Northeast [4]. They were very abundant, but with the mechanization of the countryside, the use of trucks to transport cargo, and the use of motorcycles as a means of transport, their use became increasingly restricted. Many animals were released and are now roaming free, often causing traffic accidents on northeastern roads and other problems [29].

In 1954, thousands of Northeastern donkeys were used to manufacture rabies vaccines. The donkey also suffered a 75% reduction in its herd between 1967 and 1981 [28]. Since then, the population has been decreasing yearly, due to the establishment of slaughterhouses in the region, and the

[2]https://www.yourhorse.co.uk/news/donkey-slaughter-banned-brazil/#:~:text=Brazil%20has%20reinstated%20a%20ban,in%20Brasilia%20on%203%20February

indiscriminate slaughter to export meat for pet food. Much of the Brazilian donkey meat is exported to Russia and Vietnam [38], with Belgium also being a historical importer. These authors also show that Italy and Portugal import raw skins and hides, while Mexico is the main importing country for live animals, but significant volumes (9,000 animals) were only seen in 2019. Exports are also highly variable, due to unconsolidated markets.

1.2. Pêga

The donkeys that gave rise to the Pêga may have been introduced in the time of D. João VI, coming from Egypt directly or via Abyssinia, where Portugal maintained regular trade. If there were crosses with Italians, these were recent. The second theory says that the Pêga descends from the cross between the Italian and Andalusian European breeds and the African donkey. The Egyptian breed is the one that is nearest to the Pêga [37], and there are two points of note:

1. The occurrence of the white coat is frequent in the Egyptian donkey, and no other variety shows this, neither the *Equus asinus africanus* nor the European *Equus asinus*.
2. The presence of a star and white limb ends found on the Egyptian donkey. A mixed origin was admitted, as an exclusive introduction of the African trunk was deemed unacceptable in the breeder's association. There was the introduction of Italian, Andalusian, and Egyptian animals. The characteristics of *Equus asinus africanus* prevail.

The breed originated at the beginning of the last century, around 1810, on the Cardume farm belonging to the priest from Minas Gerais Manoel Maria Torquato de Almeida, in the municipality of Entre Rios de Minas [39]. They started crossbreeding using Italian and Egyptian strains and a subsequent selection of the best animals. The breed gained strength on a farm in Lagoa Dourada, a municipality in Minas Gerais near São João del Rei, by Colonel Eduardo José de Resende, owner of the Fazenda do Engenho Grande dos Cataguazes. In 1847, they bought two males and seven females from Father Manoel and continued the improvement in successive crossings, with special care for standardization. Colonel Eduardo donated donkeys to his children, thus preserving the breed's history and formation.

The name Pêga was given by the custom in Lagoa Dourada of branding these animals by the fire with a symbol that looked like the handcuff (two iron rings) used to hold slaves by the ankle, called Pêga. The donkeys that gave rise to the breed were branded by fire by their owner, representing that device. Thus, all the animals of this original group had the Pêga brand and, thus, were recognized as a breed with the same name.

The demand for mule production came with the increase in mining in the 18th and 19th centuries in Minas Gerais, and interest in the Pêga donkey increased. The breed has a march gait and passes this trait on to asinine and mule descendants, who are good for riding and pulling carts, in addition to physical strength and endurance. The animals are rustic. Nowadays, the Pêga donkey is no longer concentrated in Minas Gerais, being found on farms throughout Brazil. Todd *et al.* [8] showed that Pêga is genetically linked to Iberian donkeys. According to [37], the variability of the Pêga breed is intermediate between the Paulista and Nordestino.

1.3. Paulista or Brasileiro

As the name says, this breed originates from the State of São Paulo (SP), southeastern Brazil. There is a similarity with the Pêga regarding its suitability for work, used for riding or traction. It may have originated from crosses between Egyptian donkeys and/or from crosses between European Italian (predominantly from Sicily), Andalusian, and African donkey breeds. In Brazil, they were crossed with donkeys from Portugal and called Paulista donkeys [16]. According to Glass [40,41], during the Constitutionalist Revolution, a battalion (Rio Pardo Cavalry Regiment) of soldiers mounted on donkeys was formed in Barretos -SP. Alves *et al.* [42] found this breed to be genetically close to Italian breeds, while Alves *et al.* [37] found low intrapopulation variability thereby indicating the need for studies on maintaining its genetic diversity. This was also seen in [43], using pedigree data, where highly inbred animals and excessive contributions of a few ancestors were found in the breed.

According to [44], the Paulista breed is predominant in the state and is used to produce medium-sized mules. Although the Association establishes a lower height than the exotic donkeys (Poitou, Spanish, and even Italian), it can produce excellent mules when the mares are of good stature. As it is a wider animal (chest and croup) than the Pêga breed, the animal has been used to transport coffee.

The Brazilian Donkeys Association was founded in 1939 [16,17], but there is no record of this association[3]. The Brazilian donkey was included in the Genetic Resources Conservation Program [1], although there are few published studies on the genetics of this breed. According to that institution's website, there was a Nucleus for the Conservation of Brazilian Donkeys of the Animal Science Institute in Sao Paulo State, which is also deactivated.

1.4. Size and Body Indices

The body indices for Brazilian donkeys **(Table 1)** show that they vary from medium (Paulista) to small (Northeastern and Pêga) animals with an aptitude for strength (Body Index >0.90). It should be noted that these indices are calculated using those available for horses, as none are available specifically for donkeys.

The Northeastern and Pêga tend to have poorer thoracic development, but all show good traction capabilities (Dactyl Thoracic Index, Conformation Index). Northeastern donkeys are smaller animals and have lower load-carrying capabilities than the other two breeds.

[3]https://www.gov.br/agricultura/pt-br/assuntos/insumos-agropecuarios/insumos-pecuarios/registro-genealogico/arquivos/AssociaesatualmenteregistradaspeloMAPA1Plan1.pdf

Table 1: Size and Body Indices for Brazilian Donkeys.

	Abbrev	Pêga [45,46]	Northeastern [47,48]	Paulista [49]	Aptitudes
Chest Circumference (m)	CC	1.48	1.26	1.47	
Body Length (m)	BL	1.41	1.14	1.32	
Croup Height (m)	CH	1.36	1.10	1.26	
Withers Height (m)	WH	1.31	1.09	1.20	
Chest Width (m)	CW	0.32	0.25		
Cannon Bone Circumference (m)	CB	0.17	0.14	0.17	
Hip Width (m)	HW	0.46	0.35		
Mid-back Height	MBH	1.34	1.10	1.23	
Space Under Horse	SUH	0.77		0.63	
Weight (kg)	W[1]	290	190	397	Weights > 550 kg are large or hypermetric; between 350 and 550 kg, medium or eumetric; and < 350 kg small or ellipometric.
Calculations are based on [50,51]					
Body Index	BL/CC	0.95	0.91	0.90	Elongated animal < 0.85 (speed); medium animal between 0.86 and 0.88; and short animal > 0.90 (strength).
Thoracic Development (TD)	CC/WH	1.13	1.14	1.23	Values above 1.2 indicate animals with good TD.
Pectoral Index	MBH/SUH	1.74	1.41	1.95	If the mid-back height (MBH) < the space under the horse (SUH), the animal is considered "far from the ground", favoring speed due to relatively long legs.
Conformation Index 1	CC^2/WH	1.67	1.43	1.80	
Dactyl Thorax Index	CB/CC	0.115	0.114	0.123	Not less than 0.105 in light animals, up to 0.108 in intermediary, up to 0.110 in light traction animals, and up to 0.115 in heavy traction equines. This index also indicates thoracic development.
Conformation Index (Baron & Crevat)	CC^2/CH	1.61	1.45	1.72	The saddle horse must show a CI of around 2.1125. Values above this indicate animals for traction.
Load Index 1	(CC^2*56)/ CH	90	80	96	The weight in kg that an animal can support without exaggerated force at trot or gallop.
Load Index 2	(CC^2*95)/ CH	153	135	164	The weight in kg that an animal can support without exaggerated force at a walk.
Riding Comfort degree	BH – (WH+CH)/2	1.37	1.06	1.26	The inclination at the point on the back where the saddle sits.
Compact Index 1	(W/CH)/100	2.13	1.80	3.15	Equines for heavy traction > 3.15; Close to 2.75 indicate light traction and 2.60 for saddle animals.
Compact Index 2	[W/(CH-1)]/100	8.06	31.77	15.27	> 9.5 for heavy traction relative to size, 8.0 to 9.5 for light traction, and 6.0 to 7.75 for saddle animals.

[1]CC3*80 when not measured directly.

1.5. Publications About Donkeys in Brazil

A survey of publications on donkeys in Brazil was carried out in SciVal® based on Scopus®. Publications were analyzed in VosViewer® to identify the main authors and themes. A more detailed explanation of this analysis can be found in [52]. The bibliographic mapping (**Supplementary File 1**; **Figure 2**) shows 170 documents, with groups based in the northeast and southeast, with newer groups emerging. Although it is a Brazilian theme, there is interaction with groups abroad, mainly with studies on diseases, reproduction, and genetics.

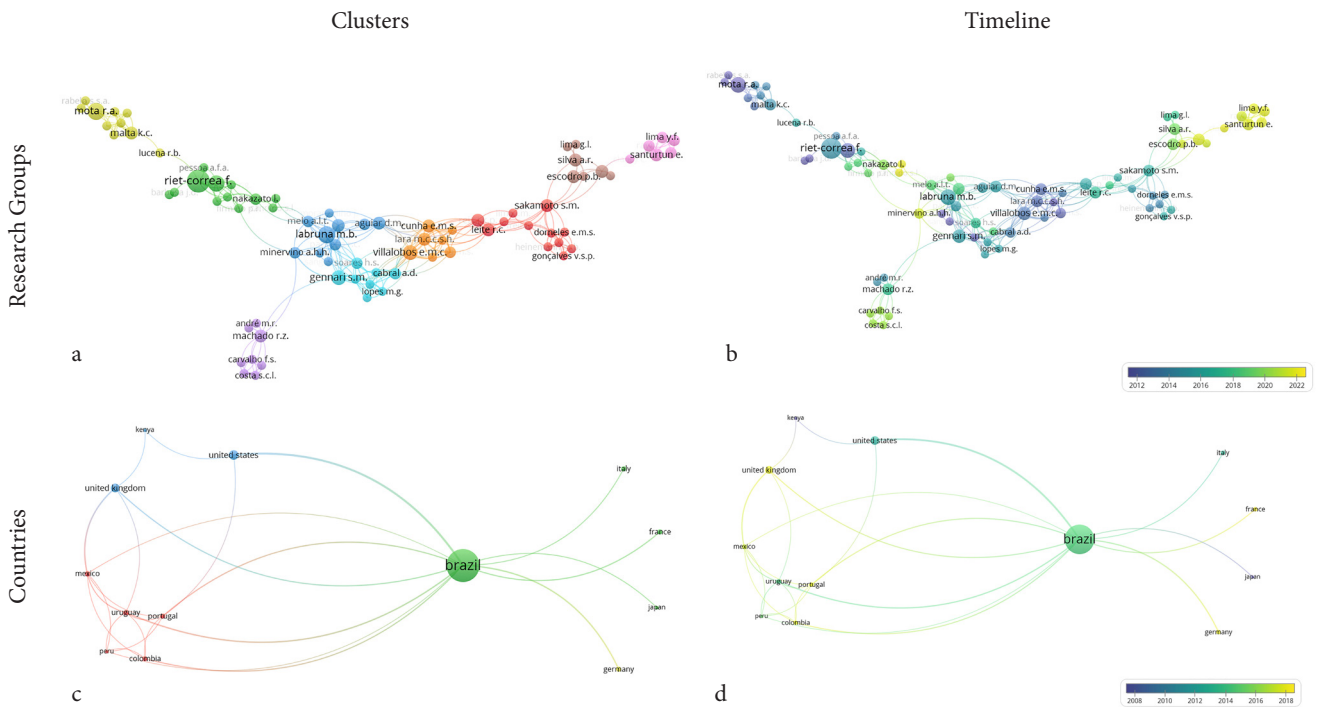
These links are relatively new **(Figure 2d)**. Author groups are clustered by location rather than by topic, including the northeast region (yellow and green) and São Paulo (blue). This may be due to the breed or specific regional issues and production system differences, as stated above. Animal health is the major area of research, followed by reproductive issues. Animal welfare is a recent problem, especially related to ejiao and sustainability.

It is noted that there are few documents on Brazilian (Paulista) donkeys **(Table 2)** and these are concentrated in Brazilian journals **(Figure 3)**. Major financing agencies of these studies are the Brazilian Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq – 30 papers), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES – 19 papers) and Fundação de Amparo à Pesquisa do Estado de Minas Gerais (FAPEMIG – 9 papers). Only 108 papers have funding information included.

Although the number of documents per year varies widely **(Figure 3d)** there has been a steady increase since 2006 ($y = 0.87x - 1737.3$ and $R^2 = 0.48$), with only 13 papers found before this date. The focus on infection and disease in the titles and keywords in papers is evident (**Figures 3e** and **3f**). This is also evident in the number of citations about donkeys in Brazil **(Table 2)** and cited articles about donkeys in Brazil **(Table 3)**.

Table 2: Authors with the highest number of citations about donkeys in Brazil.

Author	Institution	cluster	Documents	Citations
Labruna M.B.	USP	2	5	229
Gennari S.M.	USP	2	6	184
Horta M.C.	UFVSM	2	2	155
Riet-Correa F.	UFCG	1	12	91
Machado R.Z.	UNESP	7	4	63
André M.R.	UNESP	7	2	60
Freschi C.R.	UNESP	7	2	60
Martins T.F.	USP	2	3	58
Mota R.A.	UFRPE	4	4	56
Cabral A.D.	USP	2	3	46
Soares H.S.	USP	2	3	44
Dantas A.F.M.	UFCG	1	6	42
Lopes M.G.	USP	2	2	42
Pena H.F.J.	USP	2	2	42
Vitaliano S.N.	USP	2	2	42
Villalobos E.M.C.	IB/SP	8	4	41
Melo A.L.T.	UFMT	2	2	32
Pacheco R.C.	UFMT	2	2	32
Lima J.M.	UFERSA	3	2	30
Cavalcante P.H.	INTA	2	2	28



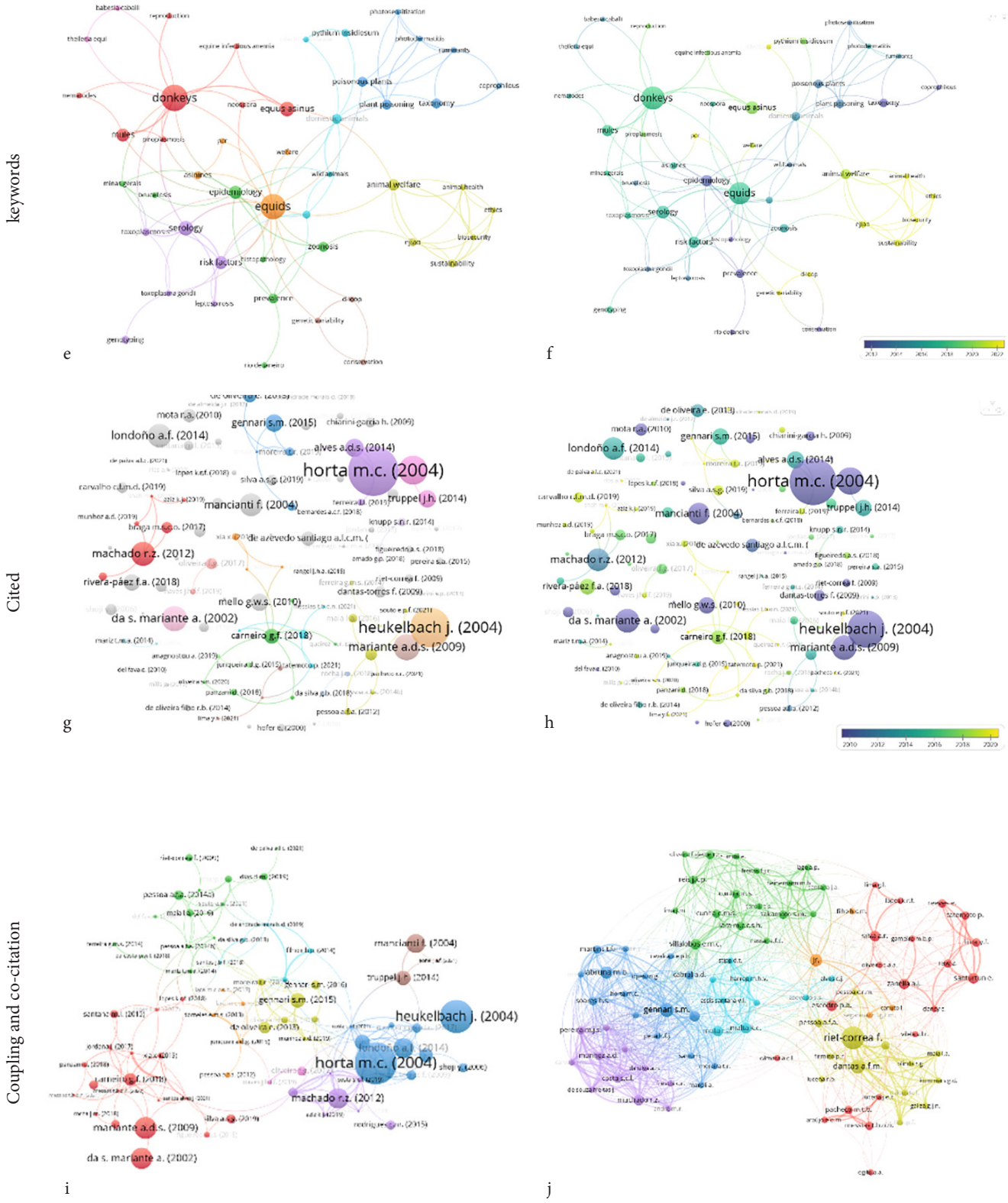


Figure 2: Bibliographic mapping on donkeys in Brazil showing **a)** major research groups, **b)** their evolution, **c)** main countries publishing on Brazilian donkeys, **d)** their evolution, **e)** principal keywords, **f)** their evolution, **g)** major cited papers, **h)** evolution of paper citation, **i)** major papers in bibliographic coupling, and **j)** major papers in co-citation analyses.

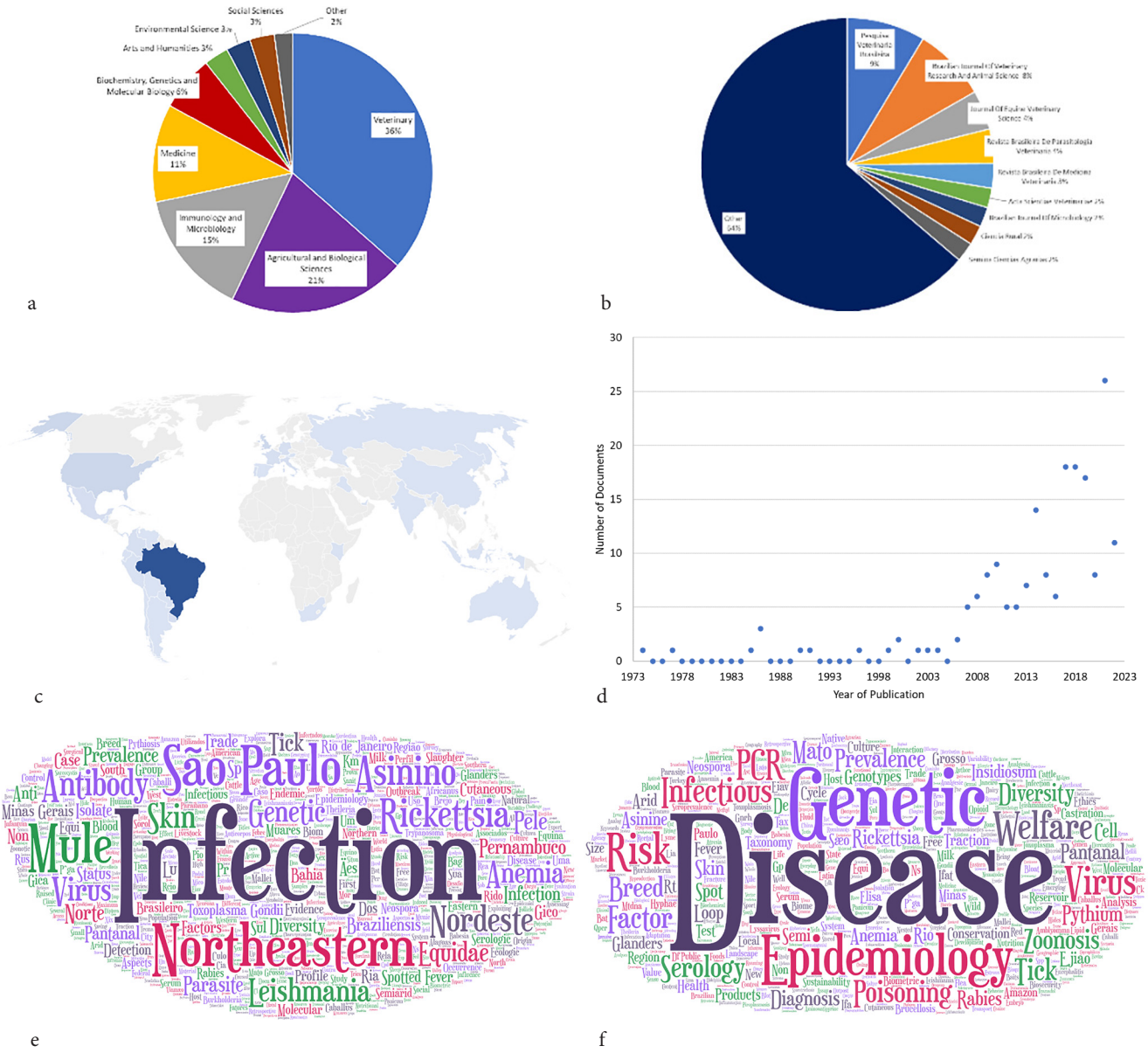


Figure 3: Information on Brazilian publications on donkeys **a)** area of knowledge, **b)** publication source, **c)** collaborating country, **d)** number of papers per year, **e)** cloud of words in the title, and **f)** cloud of words in keywords.

The top cited articles **(Table 3)** show citations for information on the general conservation of genetic resources **[1,53]**, but none on specific issues linked to donkey conservation. Most are linked to various types of viral and other infections and internal and external parasites **[54,55]**, many at a state or municipality level **[56,57]**. These studies show donkeys tend to be rustic, docile animals, used to foraging local native plants, resistant to diseases and parasites, and can undergo physical exertion. As such, the authors show that functional physical conformation for this purpose is preferred in this animal. Several other areas of studies with these animals are not investigated, such as nutrition, production, etc., or do not appear in the Scopus database. This "institutional neglect", as coined by **[58]**, may soon affect the farming structure in Brazil, given the importance of these animals for cattle farming and the production of mules. Unfortunately, recent studies on equine diversity in Brazil using Single Nucleotide Polymorphisms **[59]** did not include donkeys. Genetic studies to date, as stated above, are based on mitochondrial DNA (mtDNA) and microsatellites.

Table 3: Top 20 cited articles about donkeys in Brazil.

Author (year)	URL	Cluster	Citations
Horta M.C. (2004) [60]	https://doi.org/10.4269/ajtmh.2004.71.93	3	127
Heukelbach J. (2004) [61]	https://doi.org/10.1111/j.0269-283x.2004.00532.x	3	91
Mariante A.S. (2009) [1]	https://doi.org/10.1016/j.livsci.2008.07.007	1	50
Mariante A. (2002) [53]	https://doi.org/10.1016/s0093-691x(01)00668-9	1	48
Machado R.Z. (2012) [62]	https://doi.org/10.1016/j.vetpar.2011.11.069	5	45
Londoño A.F. (2014) [63]	https://doi.org/10.1016/j.ttbdis.2014.04.018	3	44
Mancianti F. (2004) [64]		8	41
Alves A.D.S. (2014) [65]	https://doi.org/10.1603/me14042	3	30
Gennari S.M. (2015) [66]	https://doi.org/10.1016/j.vetpar.2015.01.023	4	28
Truppel J.H. (2014) [67]	https://doi.org/10.1371/journal.pone.0093731	8	28
Rivera-Páez F.A. (2018) [68]	https://doi.org/10.1016/j.ttbdis.2017.10.008	3	26
Carneiro G.F. (2018) [4]	https://doi.org/10.1016/j.jevs.2018.03.007	1	23
de Oliveira E. (2013) [66]	https://doi.org/10.1645/ge-3210.1	4	20
Pessoa A.F.A. (2014a) [69]	https://doi.org/10.1590/s0100-736x2014000800006	2	16
Dantas-Torres F. (2009) [56]	https://doi.org/10.4322/rbpv.01803004	3	16
Braga M.S.C.O. (2017) [54]	https://doi.org/10.1590/s1984-29612017046	5	15
Oliveira F.G. (2017) [70]	https://doi.org/10.1016/j.prevetmed.2017.02.015	9	15

Major research groups **(Table 4)** are seen in USP (Universidade de São Paulo), UNESP (Universidade Estadual Paulista), and UFCG (Universidade Federal de Campina Grande).

A limitation of this type of analysis is the failure to highlight more recent publications or research groups that may become important in the future. Recent publications may not appear prominently in our analysis as they have had insufficient time to accumulate the necessary volume to become highlighted in a study of this type. The search may also be limited by a lack of specific terms in the document title, abstract, and keywords which are vital for this type of study. The study is also limited to the Scopus database, so papers in other databases may not be considered.

2. Concluding Remarks

Donkeys are important in the establishment and maintenance of humans in the countryside, traction and transport, and for producing mules which are widely used in cattle production systems. Nevertheless, research in Brazil with these animals is still incipient and centered on health issues with little information on production systems (such as nutrition, genetics, etc.). This failure to recognize their importance for livestock production systems and lack of information overall may affect the maintenance of these animals in production systems in the long term, thereby impacting the efficiency of agricultural systems.

Other uses for donkeys can be explored. Animals with a physical conformation considered pleasant to the eye, with colors and markings in different patterns, could be used as pets or in farm hotels, exhibition shows, visitor attractions, etc. Other uses, such as onotherapy, have been suggested [71], as well as use in guarding sheep and goats [72].

Donkeys can fulfill various functions on and off the farm, such as plowing, traction, locomotion over great distances, and general work activities. There are some studies on the use of these animals in dairy systems [73]. Cheese produced from donkey milk is highly valued [74], reaching up to 1000 euros per kilogram[4] for European pule cheese, but this is still at the research level in Brazil [4]. It is expected that, over time, animals with greater dairy aptitude can be selected. In Brazil, there is almost no culture of consumption of donkey or horse meat, but there are countries where its consumption is common [38], and may provide export opportunities.

As such, increased research on donkey production systems in Brazil is necessary. Issues include alternative uses of the animals and their products such as meat and milk, means of adding value to the production chain, and exploration for local and export markets. For this, research must go beyond current themes such as animal health, and look towards production systems as a whole, including welfare, nutrition, supply chains, and reproduction, as well as genetics and conservation of this valuable Brazilian farm animal genetic resource.

[4]https://www.huffpost.com/entry/most-expensive-cheese-pule_n_2122323

Table 4: Institutions with five or more publications on donkeys in Brazil (Scopus®).

Affiliation	Documents
Universidade de São Paulo	27
Universidade Federal de Campina Grande	16
Universidade Estadual Paulista Júlio de Mesquita Filho	16
Universidade Federal de Minas Gerais	14
Universidade Federal Rural de Pernambuco	12
Universidade Federal de Mato Grosso	12
Universidade Federal da Bahia	10
Universidade Federal da Paraíba	9
Instituto Biologico - Sao Paulo	7
Universidade Federal Rural do Rio de Janeiro	7
Universidade Federal Rural do Semi-Árido	7
Universidade Federal de Santa Maria	7
Universidade Federal de Uberlândia	6
Fundacao Oswaldo Cruz	6
Universidade Federal do Parana	5
Universidade de Brasília	5
Universidade Federal do Piauí	5
Universidade Federal de Pernambuco	5
The Donkey Sanctuary	5

Supplementary Materials

Supplementary Material includes information on the published papers from Scopus used for mapping bibliography on donkeys in Brazil.

Authors' Contributions

Felipe Pimentel responsible for data curation, and visualization; Samuel Paiva was responsible for data curation; Daniel Pimentel responsible for data curation, Writing original Draft; Laila Dias was responsible for validation and methodology; Concepta McManus responsible for supervision, methodology, validation and formal analyses; all authors were responsible for Writing Review & Editing.

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Conflicts of Interest

The authors declare no conflict of interest.

Ethics Approval

The information came from bibliographic sources. No permission was required.

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