Are medicinal plants an alternative to the use of synthetic pharmaceuticals in animal healthcare in the Brazilian semi-arid?

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Research

Abstract

Background: Despite the development of modern veterinary medicine, rural populations in developing countries continue to treat their animals with medicinal plants due to a combination of their low cost, easy availability, perceived efficacy and the absence of veterinary clinics. So, this study aimed to assess the consensus on the ethnobotanical knowledge from small-holders and to assess their preference either on medicinal plants or synthetic pharmaceuticals.

Methods: Interviews were conducted between January and March 2015 with 30 people of both sexes, aged 24-96 years in Dom Hélder Câmara, the largest rural settlement arisen by land reform efforts with remaining *Caatinga* vegetation in the state of Alagoas, northeast Brazil. The following indices were calculated to help interpret the data: Smith's Salience Index, Informant Consensus Factor (ICF) and Fidelity Level (FL).

Results: Fifty-four species of plants in 45 genera and 25 botanical families were reported as treatments for 33 veterinary diseases. The highest salience value was found for *Aloe vera* (0.361) and *Guapira graciliflora* (0.336). The highest ICF values were recorded for the categories Ecto and endoparasite (0.670) and Gastrointestinal (0.630). In 76.5% of cases only the plant was used and in 23.5% of the cases synthetic pharmaceuticals were also considered as a treatment option. The highest FL values were found for *G. graciliflora* (84.62%) and *Citrus limon* (75.00%).

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Conclusions: Our results suggest that medicinal plants are an important alternative to synthetic remedies in this area, especially for treating helminthiasis, which cause great damage in the production of meat and derivatives. FL results may serve as the basis for prioritization of species for pharmacological studies.

Key words: ethnoveterinary medicine, herbal medicine, livestock, phytotherapy, traditional knowledge.

Background

The use of medicinal plants remains an important alternative to synthetic medicines for the treatment of both human and animal ailments, mostly in the low income populations of developing countries (Souza *et al.* 2012). This is the case of some rural communities in Brazil, where the use of medicinal plants has ancient origins, with evidence of the practice depicted in rupester paintings of the first indigenous people 12,000 years ago (Silva 2003). With the advent of European colonization (*circa* 1500), Portuguese and African influences began to be added to the broad and diverse indigenous knowledge (Martins *et al.* 1995). Medicinal plants are particularly used in the semi-arid region of northeast Brazil, where livestock farming offers the lowest risk of production losses during the frequent dry periods that afflict the region (Andrade *et al.* 2006). Due to the high price and limited availability of synthetic drugs, many of the region's subsistence farmers rely on medicinal plants to treat their animals.

Ethnoveterinary medicine encompasses a range of traditional animal health practices that are based on beliefs, knowledge, techniques, methods and skills. As an academic field it strongly intersects with ethnobotany, since the main *materia medica* in the natural remedies are the medicinal plants. Despite many recent studies in this area (Abbasi *et al.* 2013, Ahmad *et al.* 2015, Ahmed *et al.* 2015, Ali-Shtayeh *et al.* 2016, Aziz *et al.* 2018a, Aziz *et al.* 2018b, Eshetu *et al.* 2015, Ritter *et al.* 2012), very few address the factors that influence the choice between natural and synthetic products, and if this choice is related to the infectivity nature of the diseases treated, as supposed by Mathias (2001). This is especially important since it relates directly to the perceived pharmacological efficiency of medicinal plants for infectious diseases, a phenomenon more widely studied in the field of pharmacology, but less reflected in the local medical-veterinary system.

Another question is whether socioeconomic factors influence the knowledge retention by women or men, older or younger and literate or illiterate. This information is helpful to know the dynamics of certain population, as well as to know who to access for new information in ethnobotanical studies.

In the present study, we investigated the factors influencing the knowledge on veterinary plants by small-holders in a low income rural community in the semi-arid region of northeast Brazil. Our objectives were: 1) to identify the most known and the most important medicinal plants and diseases within the local medical-veterinary system; 2) to investigate whether the source of the plant and temporal availability of the plant and its parts can enhance its preference; 3) to investigate the influence of socioeconomic factors on medicinal plant use; 4) to assess if the choice between medicinal plants and synthetic drugs is related to the infectivity nature of the veterinary diseases. We hypothesized that perennial plants and permanent plant parts are preferred than annuals and non-permanent, respectively. As well as we believe medicinal plants are preferred for treating non-infectious diseases due their low cost, and synthetic drugs will outstand in infectious diseases. Also, we expect that gender, age, literacy and factors related to the animal husbandry influence the ethnobotanical knowledge.

Materials and Methods

Study area

This study was conducted in 'Dom Hélder Câmara', the largest rural settlement arisen by land reform efforts with remaining *Caatinga* vegetation in the state of Alagoas, northeast Brazil. The study site is located at 09°52′50″ S and 36°49′21″ W, county of Girau do Ponciano. The settlement's territory once belonged to the Olival Tenório farming group, but was expropriated by the INCRA (Colonization and Land Reform National Institute) in 1999 and subsequently legally ceded to 287 beneficiary families, with about 1,300 inhabitants (Santos 2009). The greater part of the settlement is made up of plantation and livestock areas, the latter of which contain cattle, poultry, sheep, goats, pigs, horses and mules. There are 287 production units, each with an average length of between 8 and 12 ha. There is also a legal reserve area and a permanent protection area where farming is not permitted. The study area is located within the *Polígono das Secas* (Drought Polygon), whose pluviometric regime is characterized by climatic seasonality with dry summer (from 7 to 9 months) and rainy season in

autumn-winter (from 3 to 5 months) (Albuquerque 2010). The annual average temperature is 24° C, with rainfall between 250 and 800 mm annually. The characteristic vegetation of this region is called *Caatinga* and consists of arboreal-shrub forest, with xerophyte and deciduous plants.

Ethical protocol

The study was approved by the Research Ethics Committee of CESMAC, under protocol number 1377/12. The adherence to the research ethics protocol consisted of signing (collecting the fingerprint, in the case of the illiterate) a Term of Free and Informed Consent, after being explained the objectives of the research, risks and benefits, responsibilities, secrecy of information given in interview and legal and moral support for both parties, the researcher and the researched.

Interviewees profile

Thirty individuals of both genders (20 male, 10 female), aged 24-96 years, were interviewed individually during the months of January and March of 2015. The selection was based on a preliminary census, in which individuals were identified on the basis of citing the use of at least one plant for veterinary treatment. However, only 19 of these interviewees could be located. During the interviews, 11 additional interviewees were identified through the Snowball method (Bailey 1994), which consists in the search for new interviewees by the indication of people already interviewed.

Content of the interview

The following characteristics of the interviewee were recorded: gender and age; marital status; schooling level; residence time; village of the interviewees' residence; place of origin of the interviewees; and time of activity in raising animals. Additionally, two free lists were generated: (1) medicinal plants used in the treatment of animal diseases, and (2) diseases that affected the animals. Quinlan's recommendations for obtaining free lists were followed (Quinlan 2005). The Reading back technique, which consists of repeating the responses of the interviewee to help him remember more items, was used to obtain a more complete list (Albuquerque *et al.* 2014). After the free listing exercise, we asked about each plant: local name, place of collection, part used, preparation and route of administration, treated animals, experience of use and origin of the plant. Concerning the veterinary diseases mentioned, we asked: affected animals, perception of the disease and form of treatment (plants or synthetic medicines).

Voucher specimens

The cited plants were collected with the help of a key informant on a guided tour of the forest and then identified from specialized bibliography (Lorenzi & Matos 2008) and compared with the exsicates from the herbarium of the Universidade Federal de Alagoas (UFAL) - *Campus* Arapiraca, also counting on searches in the site The International Plant Names Index (IPNI 2015), to help in the identification. Herborization processes (pressing, drying and herborization) were carried out and the exsicates were deposited in the herbarium of UFAL - *Campus* Arapiraca.

Data analysis

Smith's Salience index of the plants and diseases cited was then calculated using the software Anthropac version 1.0 (Borgatti 1988), to identify the most important plants by frequency and average ranking in free listings.

The Informant Consensus Factor (ICF) was calculated in two distinct ways: First, for categories of diseases (ecto- and endoparasitic, gastrointestinal, dermatological, reproductive, multisystemic, respiratory, nervous system, external injuries, bleeding and poisoning, circulatory system, sensory system and musculoskeletal system). Second, the ICF was taken for each disease as single. We used the formula: ICF = (Nur - Nt) / (Nur - 1), where Nur is number of use citations in each category and Nt = number of species used (Caulkins & Hyatt 1999).

The ICF values of the diseases were collected in the following groups: infectious, non-infectious, nutritional and parasitic diseases. The means of the ICF values of each group were compared to each other.

In order to know which treatment the interviewees first use in case of an animal disease to appear, we calculated the frequency of citation of the use of medicinal plants, synthetic medicines and when both were used concomitantly. We also checked for relation with diseases' infectivity.

The Fidelity Level (FL) index (Friedman *et al.* 1986), which consists of the percentage of interviewees who cite a given plant for the same function, was calculated for the most salient veterinary diseases using the formula: FL (%) = (Np / N) × 100, where Np is the number of interviewees citing a use of a plant species to treat a particular disease; and N is the number of interviewees who use the plant as a remedy for treating any disease.

ANOVA was used to assess whether socioeconomic factors and factors related to the animal husbandry influence on the number of plant species cited. The factors tested were: age, gender, scholarity, place of birth, experience in animal husbandry, time in settlement, number of animal species, number of animals in present and number of animals in past. Complementarily, regression analysis was used to assess the explanatory power of the significant factors. Thereover, it was worthy to test whether the animal species the interviewees possess to have influence on the number of plant species cited. So, Multiple Regression analysis was used with the animal species as factors, namely: bovine, ovine, equine, caprine, swine, donkey, mule, chicken, turkey, duck, guineafowl, dog and cat. All differences were considered significant at $P<0.05$.

Results

Local perceptions of animal health

Among the interviewees, the most frequent animals currently created were domesticated fowl (mainly chickens), 345 animals; followed by bovine (N = 88 animals); sheep (N = 29); and equids (N = 27). In the past, the most numerous animals were sheep (N = 148 animals); fowl (N = 132); bovine (N = 88); and goats (N = 42). For the question "What animal is the most important for you?", we obtained 19 responses for bovine; 8 for equids and one each for goats, sheep and fowl. Bovine were cited as the animals that become sick most frequently (15 replies). Forty-six species of plants were used for treating cattle. Sheep and horses were treated with 27 and 26 species of plants, respectively. Twenty-five plants were reported for the treatment of all animals. Fowls, goats, swine and pets were treated with 17, 11, 7 and 4 plants, respectively.

Ethnoveterinary plants and uses

A total of 54 species of medicinal plants were cited through the free list method, distributed between 45 genera and 25 botanical families. Six plants were not identified to the genus level and 4 plants were not identified at the level of the botanical family. These plants were used to treat 33 veterinary diseases. The full list of medicinal plants in this study are available in the supplementary file.

The largest number of species was found in the Fabaceae family (8 species), followed by Euphorbiaceae (5 species). The families Anacardiaceae and Lamiaceae had 4 species each. There were 2 species mentioned in the families Liliaceae, Capparaceae, Apocynaceae and Bignoniaceae. Seventeen families had only one species (Table 1).

Table .1 Number of plant species and citations per botanical family

Family	Number of species	Number of citations
Fabaceae	8	17
Euphorbiaceae	5	10
Anacardiaceae	4	15
Lamiaceae	4	9
Liliaceae	2	12
Capparaceae	2	6
Apocynaceae	2	2
Bignoniaceae	2	2
Nyctaginaceae	1	13
Asphodelaceae	1	12
Verbenaceae	1	10
Unidentified	8	13
Others		...contain only one species

The most cited plants were: *Guapira graciliflora* (46.4%); *Aloe vera* (L.) Burm. f. (42.9%); *Allium sativum* L. (39.3%); and *Lippia alba* (Mill.) N.E.Br. (35.7%). The highest salience value was found for *A. vera* (0.361), slightly followed by *G. graciliflora* (0.336). *L. alba* obtained a salience of 0.281; followed by *A. sativum* (0.235); and *Chenopodium ambrosioides* L. (0.181) (Table 2).

Concerning the occurrence of the medicinal plants, 37 plant species (68.51%) grow spontaneously nearby woods, 13 plants (24.07%) are cultivated in backyards or in rural allotments, and 4 plants (7.41%) are apparently not present in the settlement, being bought or brought in from another region.

The most commonly cited plant parts for the preparation of medicine were bark (22 species, 77 citations), leaves (21 species, 53 citations) and underground parts (6 species, 22 citations). Thirty-six species were reported being available throughout the year, 22 species only during one part of the year and 7 are absent. Bark has the highest availability (the bark of 22 species is available all year round).

Table 2. Frequency, average rank and salience index of the medicinal plants

Plant species	Frequency (%)	Average Rank	Salience
Aloe vera (L.) Burm. f.	42.9	1.92	0.361
Guapira graciliflora (Mart. ex Schmidt) Lundell	46.4	2.46	0.336
Lippia alba (Mill.) N.E.Br.	35.7	2.9	0.281
Allium sativum L.	39.3	3.55	0.235
Chenopodium ambrosioides L.	21.4	1.67	0.181
Croton blanchetianus Baill.	17.9	4.8	0.120
Anadenanthera colubrina (Vell.) Brenan	21.4	4.83	0.106
Anacardium occidentale L.	21.4	5.17	0.101
Myracrodruon urundeuva Allemão	21.4	3.83	0.098
Capparis flexuosa (L.) L.	17.9	4.8	0.098
Citrus limon (L.) Burm. f.	14.3	3.75	0.079
Poincianella pyramidalis (Tul.) L.P. Queiroz	10.7	5.33	0.079
Ocimum gratissimum L.	14.3	4.25	0.072
Coutarea hexandra (Jacq.) K. Schum.	7.1	1.5	0.068
Luffa operculata (L.) Cogn.	10.7	5	0.065
Sideroxylon obtusifolium (Humb. ex Roem. & Schult.) T.D. Penn.	14.3	8.25	0.052
Ziziphus joazeiro Mart.	10.7	7	0.051

The main preparation technique was decoction (109 citations), followed by maceration (56) and *in natura* (25). The more detailed preparations of each treatment is available in the supplementary materials. The main form of administration of the medicines was oral with the use of the bottle as the main instrument of administration (142 citations).

The most used plants in combination with others were: *Allium sativum* (14 citations of associated use) and *Aloe vera* (12 citations). The most cited combination was *A. sativum* and *A. vera* (N = 6). The most frequent combinations were of two plants (18 citations) or three plants (11 citations). The maximum number of plants composing the same preparation was 4 plants (Figure 1).

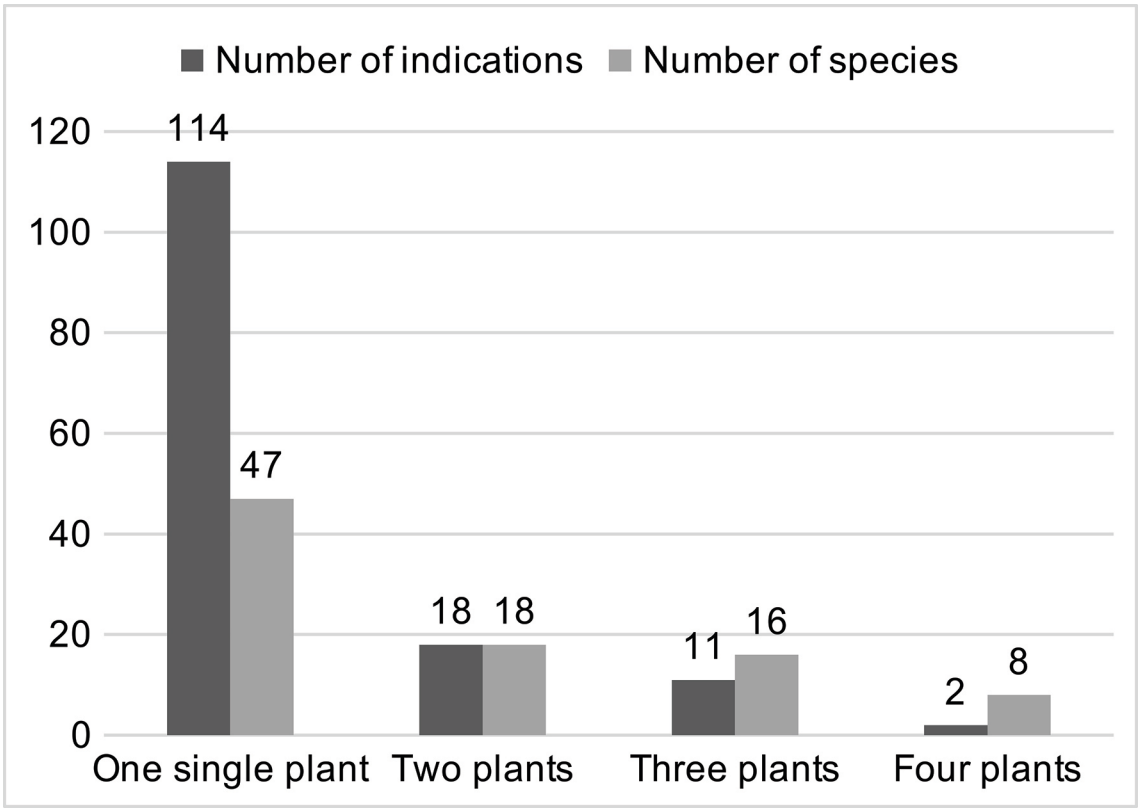

Figure 1. Indications of mixed medicinal plants

Measuring knowledge through socioeconomic and animal husbandry factors

Interviewees from 40 to 49 years cited the most plant uses. The mean citation for this group was 9.67 citations per informer. There was little difference between the citation averages of female and male interviewees: respectively, 6.2 and 6.45 citations per informer. According to the schooling level, the highest citation average was attributed to interviewees with incomplete elementary education (9.07 citations per interviewee) and Mobral (adult literacy) (6 citations per interviewee).

According to ANOVA, only one factor had contributed to the model significantly: the number of animals in present ($p<0.05$). So, a simple linear regression was conducted giving the number of plant species as a function of the number of animals in present. The intercept value was 3.1473 units and for each unit gained by the number of animals in present, there is an increase of 0.1031 unit of the number of plant species.

Once we knew that the number of animals had a significant influence over the citation of plant species, we tested for the influence of the animal species that interviewees possess. Only ovine had contributed to the model ($p<0.05$). So, we maintained only ovine as a predictor to explain the number of plant species in a simple linear regression, in which for each unit of the number of ovine animals, there is an increase of 1.1940 unit of the number of plant species.

Salient diseases

Through the completion of the free list, 62 veterinary diseases were identified. The most frequent diseases were: foot-and-mouth disease (73.3%); fever (46.7%); infectious coryza (46.7%); retained placenta (40%); and carbuncle (36.7%). The most salient disease was foot-and-mouth disease (0.572), followed by fever (0.343), goiter (0.285), infectious coryza (0.250) and "*manqueira*" (0.194).

Informant Consensus Factor (ICF)

The highest ICF values were recorded for the following disease categories: ectoparasite and endoparasite (0.670); gastrointestinal (0.630); dermatological (0.510); and reproductive (0.500). In three disease categories there was no consensus among the interviewees: circulatory system, sensory system and musculoskeletal system (Table 3).

Table 3. Informant Consensus Factor for categories of animal diseases

Categories	Number of citations	Number of species	ICF
Ecto- and endoparasitic	16	6	0.670
Gastrointestinal	47	18	0.630
Dermatological	40	20	0.510
Reproductive	23	12	0.500
Multisystemic	43	24	0.450
Respiratory	32	19	0.420
Nervous system	9	7	0.250
External injuries, bleeding and poisoning	22	17	0.240
Circulatory system	3	3	0.000
Sensory system	1	1	0.000
Musculoskeletal system	1	1	0.000

Informant Consensus Factor average of infectious and non-infectious diseases

The highest values of the Informant Consensus Factor (ICF) were for the following diseases: helminthiasis (0.640); infectious coryza, retained placenta, and lump (coincidentally 0.500); drool and snakebite (both, 0.400); and fever (0.370). Although foot-and-mouth disease had the highest salience value, there was no consensus among the interviewees on the form of treatment for this disease. According to the nature of the diseases, non-infectious and parasitic diseases the higher mean informant consensus values (0.385 and 0.318, respectively). Infectious and nutritional diseases, on the other hand, showed low values of ICF (0.188 and 0.000, respectively). 63% of infectious diseases are also treated by at least one of the interviewees by synthetic pharmaceuticals. 50% of non-infectious and 50% of parasitic infections can be treated by synthetic pharmaceuticals (Table 4).

Table 4. Informant Consensus Factor of the categories of diseases classified by the infectivity nature

Nature	Vernacular name	Technical name	Use of synthetic	Nur	Nt	ICF	Average ICF
Infectious	Caroço	Caseous lymphadenitis	Yes	3	2	0.500	0.157
	Gogo	Infectious coryza	Yes	17	9	0.500	
	Cabrunco	Carbuncle	No	6	5	0.200	
	Gripe	Influenza	Yes	6	5	0.200	
	Catarro	Catarrh	Yes	7	6	0.167	
	Febre aftosa	Foot-and-mouth disease	Yes	7	7	0.000	
	Mastite	Mastitis	Yes	3	3	0.000	
	Raiva	Rabies	No	2	2	0.000	
	Murrinha	Newcastle disease	No	3	3	0.000	
	Infecções	Infections	No	2	2	0.000	
Non-infectious	Contusões	Bruises	Yes	2	1	1.000	0.401
	Resto de parto	Retained placenta	Yes	23	12	0.500	
	Mordida de cobra	Snake bite poisoning	No	6	4	0.400	
	Febre	Fever	Yes	25	16	0.375	
	Diarreia	Diarrhoea	No	17	12	0.313	
	Inflamação	Inflammation	Yes	10	8	0.222	
	Feridas/cortes	Wounds/cuts	No	13	13	0.000	
Nutritional	Anemia	Anemia	No	3	3	0.000	0.000
	Papada inchada	Goiter	No	2	2	0.000	
	Sangue grosso	Hypercoagulability	No	3	3	0.000	
Parasitic	Verme	Helminthiasis	Yes	12	5	0.636	0.318
	Carrapato	Ticks	No	2	2	0.000	

Use of synthetic pharmaceuticals

In most cases, interviewees reported only the use of medicinal plants in the treatment of veterinary conditions (111). In 34 cases, synthetic pharmaceuticals were also considered as a treatment option, and in 14 of these cases the plant was used first; in 8 cases synthetic pharmaceuticals were preferred and in 12 cases there was no preference.

Fidelity Level index (FL)

The highest FL values were found for: *G. graciliflora* (84.62%); *Citrus limon* (L.) Burm. f. (75.00%); *Anadenanthera colubrina* (Vell.) Brenan (66.67%); *Croton blanchetianus* Baill. (60.00%); *C. ambrosioides* (50.00%); and *Anacardium occidentale* L. (50.00%) (Table 5).

Table 5. Plants more frequently used for respective diseases/symptons according to Fidelity Level index

Scientific name	Vernacular name	Disease	Citation	FL (%)
Guapira graciliflora (Mart. ex Schmidt) Lundell	Pau-piranha	Retained placenta	11	84.62
Citrus limon (L.) Burm. f.	Limoeiro	Infectious coryza	3	75.00
Anadenanthera colubrina (Vell.) Brenan	Angico	Infectious coryza	4	66.67
Croton blanchetianus Baill.	Marmeleiro	Diarrhoea	3	60.00
Chenopodium ambrosioides L.	Mentruz	Helminthiasis	3	50.00
Anacardium occidentale L.	Cajueiro	Snakebite poisoning	3	50.00

Discussion

Rural smallholders from the semi-arid region of northeast Brazil use a rich biodiversity of plants for veterinary use compared to studies form other localities (e.g. Lulekal *et al.* 2014, Uddin & Hassan 2014, Njoroge & Bussmann 2006, Melo Filho 2012). Other studies in the Brazilian semi-arid region confirm this observation (Silva *et al.* 2014, Amorim *et al.* 2018). In total, it has been estimated that a remarkable 400 species of medicinal plants are used in the Brazilian semi-arid region (Albuquerque 2010).

The predominance of the Fabaceae family was also recorded in ethnoveterinary studies conducted in the

caatinga, where 25 species were reported (Baptistel *et al.* 2014, Silva *et al.* 2018). This predominance can be related to the wide distribution of the family in the Brazilian territory: it is represented with 175 genera and 1500 species and can be found in any biome (Lorenzi 2008). The high content of flavonoids in the composition of the species of this family is also responsible for important pharmacological properties in the treatment of animals (Lima *et al.* 2018).

Plants growing spontaneously, either native or naturalized, in the woods were more used to treat animals than cultivated. This fact can be related to the proximity of native vegetation, which can be found both in the production areas, that are visited daily, and in the two protected areas (Permanent Protection Area and Legal Reserve Area). According to Amorozo and Viertler (2008), availability strongly influences knowledge and use of medicinal plants, and the diversity of wild species cited by users reflects local floristic richness.

The species *Aloe vera* (L.) Burm. f. and *Guapira graciliflora* (Mart. ex Schmidt) Lundell had the highest salience values. This means that both are often remembered and are often the first to come to the minds of interviewees. The prominence of these two species may reflect the high frequency of the diseases that they are used to treat. Both species are also readily available: *A. vera* is widely cultivated in backyards, while *G. graciliflora* is found in the forest.

The use of plant bark has been highlighted in previous studies in the semi-arid region (Baptistel *et al.* 2014, Silva *et al.* 2018). Melo Filho (2012) suggests that frequent use of leaves and barks is probably due to its ease of collection and greater availability. In the case of woody species, bark is available in all seasons, even in the dry season when the plant is devoid of leaves (Albuquerque & Andrade 2002). However, bark extraction can be unsustainable if it leads to non-passive lesions that can shorten the life time of the plant. Within the study area, three species (*Myracrodruon urundeuva* Allemão, *Schinopsis brasiliensis* L., and *Sideroxylon obtusifolium* (Humb. ex Roem. & Schult.) T. D. Penn.) are considered to be endangered and may therefore be sensitive to overexploitation, predominantly of its barks harvesting. Additionally, *Spondias tuberosa* L. was listed as a food that could disappear (Slow Food Brazil 2015). Several authors have found that the most frequent form of preparations are decoctions (tea) for oral administration (Antonio *et al.* 2015, Baptistel *et al.* 2014, Giordani *et al.* 2016, Melo Filho 2012, Silva *et al.* 2018, Zucchi *et al.* 2013).

Combinations of two plants were the most cited mixture, while the maximum number of plant species in the same preparation was 4. The use of two or more plants reflects the idea of synergy, where the associations of plants may increase therapeutic efficacy (Giday *et al.* 2007). However, it is important to note that for a typical medicinal tea to be considered as pharmaceutically safe it should not contain more than 4 to 7 plants combined (Lacerda *et al.* 2013).

The importance of cattle for the interviewees reflects their key role in subsistence livelihoods. Even with the difficulty of keeping animals, livestock farming is preferable because of the lack of irrigation systems for agricultural activities. Indeed, some smallholders may even build dams during the winter to keep animals in the summer (Santos 2009). The Brazilian semi-arid producer heavily depends on cattle, goats and sheep (Schmitz 2003). Duarte (2002) states that, in the Brazilian semi-arid region, small farmers prioritize livestock as a means of subsistence during periods of drought - either for food supplements from animal products (e.g. milk) or slaughter for consumption and/or sale.

Studies have reported that it is normally the elderly that have the greatest amount of ethnoveterinary knowledge (Almeida *et al.* 2010, Baptistel *et al.* 2014, Fernandes *et al.* 2014, Monteiro 2010). Our finding may reflect that interviewees in late adulthood in this research are the group that is most engaged in animal care. Interviewees with incomplete primary education cited more plant uses, contrary to other studies where the group of illiterates stood out (Lima *et al.* 2011). No discrepancy between citation means of female and male interviewees was observed, agreeing with other studies (Baptistel *et al.* 2014, Giraldi & Hanazaki 2010, Monteiro 2010). This was anticipated as men and women both play a role in the treatment of animals.

It's expected that the smallholders who own a larger number of animals detain a greater knowledge on medicinal plants of veterinary interest. That was confirmed by this study! Under this condition, animal management requires dealing with disease more frequently and with more animals. Not forgetting that the profile of respondents is low income, the greater the number of sick animals the higher the costs of buying synthetic medicines, which may be unfeasible. Medicinal plants are an alternative in this regard.

The positive relationship between number of animals raised and number of known plant species was even higher among ovine animals. This is a species often affected by various intestinal parasites in the semi-arid regions worldwide (Abebe & Esayas 2001, Alves *et al.* 2017, Nogueira *et al.* 2009, Souza *et al.* 2015). External and internal parasites are the most common threat to ovines, they can reduce their productivity and even cause death (Simmons & Ekarius 2009). Thus, we credit the level of demand for the management of this animal group as one of the causes of sheep farmers having greater knowledge on medicinal plants.

The large number of foot-and-mouth disease citations can be explained by the potential damage an outbreak of this disease can cause, including the obligatory sacrifice of the infected animal and isolation of the dead animal to avoid contagion. However, there was no consensus about how to treat this disease (ICF = 0). This reinforces the need for prophylactic measures such as vaccinating all animals prior to the onset of the disease - not only cattle, but also pigs, sheep, goats and buffalo of the genus *Bubalus* are affected. Biosecurity measures are also required since humans can also spread the virus through insecure practices (Brasil 2009). Ritter *et al.* (2012) also obtained higher ICF levels for antiparasitic and gastrointestinal categories, with 0.800 and 0.710, respectively. These high values were explained by the fact that they are easy to identify and have a high incidence. Lulekal *et al.* (2014) found greater consensus for the gastrointestinal, ectoparasitic and endoparasitic categories and dermatological diseases.

More than threequarters of the treatments for diseases involve only plants; a result that is common in studies with rural communities that use traditional veterinary medicine (Monteiro *et al.* 2011), but other studies show a greater dependence on modern veterinary medicine (Yigezu *et al.* 2014). However, it is important to recognize that the two practices do not cancel each other out and may be complementary in a cost-benefit relationship where the use of medicinal plants, as long as it is efficient, can replace or complement the treatment with synthetic pharmaceuticals. Mathias (2001) states that medicinal plants are less suitable for the control of epidemic and endemic infectious diseases, such as: foot-and-mouth disease, rinderpest, hemorrhagic septicemia, anthrax, manqueira and rabies. In these cases, vaccination is needed as a form of prophylaxis. However, Mathias (2001) also points out that, even in the case of infectious diseases, ethnoveterinary practices should not be discarded, and some local preventive methods may be effective and simple to use.

We have motivation to believe that the treatment of helminthiasis with medicinal plants is one of the most widespread in our study area. Githiori (2004) observed that diseases caused by helminths are the main limitation in grazing livestock farming in the tropics and subtropics and cause economically important losses mainly for small-scale farmers. The use of alternative therapy for the control of parasitic worms can entail a reduction of costs and a significant productivity gain (Oliveira *et al.* 2009). Infectious coryza is a highly contagious bacterial disease that affects the upper respiratory tract of fowls, especially chickens. Its economic impact is due to the weight loss in growing fowls with up to 40% loss (Cigoy *et al.* 2016). Ethnoveterinary medicine can be an inexpensive and readily available alternative to synthetic medications for common diseases and more chronic conditions such as colds, skin diseases, worms, wounds, reproductive disorders, nutritional deficiencies, and diarrhoea (Mathias 2001).

Fidelity Level values reflect the relationship between a medicinal plant and its most common use. These results may serve as a basis for species prioritization for pharmacological studies (Monteiro *et al.* 2011). A brief discussion of recent pharmacological studies concerning the uses of each species is now presented: *G. graciliflora* was mainly used for the retention of placental remains. Despite the registration of reports of this application in ethnobotanical studies, no pharmacological studies have been found. Studies have shown that *Citrus limon* fruit is widely used for the treatment of respiratory diseases for influenza, productive cough, tonsillitis, pneumonia, influenza and sinusitis. Nevertheless, *C. limon* is still poorly studied from a pharmacological point of view for respiratory problems although its potent antimicrobial activity has been demonstrated against 19 different bacteria (Prudente & Moura 2013). The bark of *A. colubrina* was used to treat respiratory diseases (especially coughs). Many compounds derived from the genus *Anadenanthera* have been isolated and studied, but there are a lack of studies on the pharmacological importance of their metabolites (Monteiro *et al.* 2006). *Croton blanchetianus* was mainly used to treat diarrhea and has been cited in other studies for the relief of intestinal constipation and other digestive disorders (Salatino *et al.* 2007). Mattos (1999) emphasizes the use of leaves and peels in folk medicine for the treatment of gastrointestinal disorders, rheumatism and headache. The citations

of *Chenopodium ambrosioides* were more numerous for the treatment of helminthiasis. Vita *et al.* (2014) tested the efficacy of *C. ambrosioides* on the control of endoparasites of hens (*Gallus gallus domesticus* L.), demonstrating satisfactory control values against nematodes (90% to 100% mortality) *in vitro* and *in vivo* assays. Bark extract of *Anacardium occidentalis* has been shown to have antiophidic properties against *Vipera russelli* venom by neutralizing the hydrolytic enzymes responsible for local tissue damage, inflammation, myonecrosis, vital organ dysfunction and alteration in coagulation components; it has also been observed to neutralize other effects of the venom, such as edema, hemorrhage and haemotoxic effects, including poison-induced lethality (Ushanandini *et al.* 2009).

Conclusions

The use of indices to evaluate the preference for medicinal plants or synthetic pharmaceuticals confirmed that there is no strong consensus for the treatment of more severe infectious diseases with plants. This probably indicates the low efficacy of herbal medicine for these diseases. It's important to take note that several plant species are used for these diseases, and some effort is necessary to raise awareness of the need to adopt sanitary measures such as isolation (quarantine) and slaughter of sick animals in case of rabies, foot-and-mouth disease and others, although we have realized that the role of vaccination is well accepted by the local small farmers. On the other hand, there are plenty of medicinal plants exhibiting potential for treating non-infectious diseases, for example: *G. graciliflora* which was strongly recommended for retained placenta, *C. limon* and *A. colubrina* were both recommended for infectious coryza. Those plants are inexpensive compared with synthetic medicines, and accordingly veterinary professionals could support their use by small farmers, after efficacy, dosage and side effects had been regulated by pharmacological studies.

Declarations

List of abbreviations: CESMAC: Centro de Estudos Superiores de Maceió (Center of Tertiary Studies of Maceió, BR). EJA: Educação de Jovens e Adultos (education program for youth and adults - elementary education and high school). FL: Fidelity Level index. ICF: Informant Consensus Factor. INCRA: Instituto Nacional de Colonização e Reforma Agrária (Colonization and Agrarian Reform National Institute). IPNI: The International Plant Names Index. Mobral: Movimento Brasileiro de Alfabetização (olden program for adult literacy). UFAL: Universidade Federal de Alagoas (Brazilian Federal University of the state of Alagoas).

Ethics approval and consent to participate: Before the first data collection, the study was approved by the Research Ethics Committee of CESMAC, under protocol number 1377/12. The adherence to the research was done by signing (collecting the fingerprint, in the case of the illiterate) of the Term of Free and Informed Consent, after being clarified (aloud) the objectives of the research, risks and benefits, responsibilities, secrecy of information given in interview and legal and moral support for both parties, the researcher and the researched.

Consent for publication: Not applicable.

Availability of data and materials: The data is available within this paper supplementary files. Voucher plant specimens were deposited in the herbarium of UFAL- *Campus* Arapiraca.

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Authors' contributions: JGS analyzed the data, searched literature and contributed mainly to the writing of the paper. AG collected the data, set up the database and contributed to analysis. RAC also collected and put the data analyzed in tables and graphs. LSR revised the orthography and set up the references. AFC and ECAS made a second repeat of the analysis and indicated incoherence in the previous results. AMSS adjusted the manuscript to the journal submission guidelines. DCOLS revised and included several points in the discussion. PB and RB conceived the project idea and provided theoretical assistance for literature review and research methodology. AGCA adapted the project to the context of this specific rural settlement, led to the formulation of the research questions and defined the content of the interviews. HCHS defined the methods of collection and analysis and supervised all stages of the study.

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Supplementary table: List of medicinal plants

Scientific name	Vernacular name	Voucher	Num. cit.	Occur.	Avail.	Diseases	Parts used	Preparation	Admin.	Animals treated	Human use
Amaranthaceae											
Alternanthera brasiliana (L.) Kuntze	Terramicina	N.F.	1	Cultivated	All year round	Fever	Leaf	Boil in water	Oral	Sundry	No
Anacardiaceae											
Anacardium occidentale L.	Cajueiro	ARA000013	6	Cultivated	Summer	Carbuncle, lump, snakebite	Nut	Break nut into pieces and boil it or soak	Oral	Sundry	Yes
Myracrodruon urundeuva Allemão	Aroeira	ARA000086	6	In the woods	All year round	Diarrhoea, cabuncle, fever, wounds, infectious coryza, inflammation	Bark	Boil or soak in water	Oral	Sundry	Yes
Schinopsis brasiliensis L.	Braúna	ARA000077	1	In the woods	All year round	Foot-and-mouth disease	Bark	Boil in water	Oral	Sundry	No
Spondias tuberosa L.	Umbuzeiro	ARA000011	2	In the woods	All year round	Diarrhoea, fever, foot-and-mouth disease	Bark, root	Boil in water	Oral	Sundry	Yes
Apiaceae											
Coriandrum sativum L.	Coentro	N.F.	1	Cultivated	Only when it grows	Snakebite poisoning	Leaf	Boil in water	Oral	Sundry	No
Apocynaceae											
Aspidosperma pyrifolium L.	Pereiro	ARA000004	1	In the woods	All year round	Diarrhoea, fever	Bark	Boil in water	Oral	Sundry	No
Calotropis procera (Aiton) W.T. Aiton	Algodão-seda	ARA000015	1	In the woods	All year round	Wounds	Sap/Latex, stem	Apply the latex on the wound	Topical	Bovine, ovine	Yes

Asphodelaceae											
Aloe vera (L.) Burm. f.	Babosa	N.F.	12	Cultivated	All year round	Helminthiasis, drool, infectious coryza, fever, anemia, carbuncle, ticks, foot-and-mouth disease, wounds, influenza, inflammation, goiter	Leaf, sap	Boil or soak in water, or use the gel in natura	Oral, bathing	Sundry	Yes
Bignoniaceae											
Handroanthus sp.	Pau-d'arco-roxo	ARA000023	1	In the woods	All year round except for the flowers	Catarrh, inflammation	Flowers	Boil in water	Oral	Sundry	Yes
Unidentified	Pau-d'arco-amarelo	N.F.	1	In the woods	Only in bloom	Catarrh	Flowers	Boil in water	Oral	Bovine, equine	No
Cactaceae											
Melocactus bahiensis L.	Cabeça-de-frade	ARA000018	1	In the woods	All year round	Retained placenta	Bark	Boil in water and wait to cool	Oral	Bovine, ovine, caprine	Yes
Cannabaceae											
Cannabis sativa L.	Maconha	N.C.	1	Absent	-	Epilepsy	Seeds	Boil in water	Oral	Bovine, ovine	No
Capparaceae											
Cynophalla flexuosa (L.) J. Presl.	Feijão-bravo	ARA000088	5	In the woods	All year round	Fever, catarrh, retained placenta, hypercoagulation	Bark, leaf	Boil in water or soak in water	Oral	Sundry	Yes
Cleome spinosa L.	Muçambê	ARA000076	1	In the woods	Only in bloom	Fever, inflamation	Leaf, flowers	Boil in water	Oral	Sundry	Yes

Celastraceae											
Maytenus rigida L.	Bom-nome	ARA000006	3	In the woods	All year round	Anemia, bloating, weakness, inflammation	Bark	Soak or boil in water	Oral	Sundry	Yes
Chenopodiaceae											
Chenopodium ambrosioides L.	Mentruz	ARA000009	6	Cultivated	Winter	Helminthiasis, foot-and-mouth disease, influenza, Newcastle disease	Sap, leaf, shoots, buds, bark	Extract the sap and give the animal, or make decoction or macerate	Oral	Sundry	Yes
Cucurbitaceae											
Citrullus lanatus (Thunb.) Matsum. & Nakai	Melancia	N.C.	1	Cultivated	Winter	Foot-and-mouth disease	Fruit	Knead the fruit to obtain juice	Oral	Bovine	Yes
Euphorbiaceae											
Croton blanchetianus Baill.	Marmeleiro	ARA000090	5	In the woods	All year round	Diarrhoea, fever, foot-and-mouth disease, wounds, hyper-coagulation, hobble	Bark, buds	Boil in water	Oral, topical	Sundry	Yes
Jatropha gossypiifolia L.	Pinhão-roxo	ARA000019	1	In the woods	All year round	Wounds	Latex, stem	Extract latex	Topical	Bovine, ovine	Yes
Jatropha mollissima L.	Pinhão-bravo	ARA000022	1	In the woods	All year round	Wounds	Latex, stem	Extract latex	Topical	Bovine, ovine	Yes
Manihot esculenta Crantz	Macaxeira	N.C.	1	Absent	-	Diarrhoea	Root	Boil in water	Oral	Sundry	No
Ricinus communis L.	Carrapateira	ARA000020	2	In the woods	All year round	Goiter, rabies	Leaf, seeds	Soak in water or make a necklace with the leaf petiole and use on the animal	Oral, topical	Bovine, dogs	No

Fabaceae											
Senna occidentalis (L.) H. S. Irwin & R. C. Barneby	Fedegoso	ARA000085	1	In the woods	All year round	Hypercoagulation	Bark	Boil in water	Oral	Bovine, ovine	No
Amburana cearensis (Allemão) A. C. Sm.	Imburana-de-cheiro	ARA000091	2	In the woods	All year round	Diarrhoea, cancer	Bark, seeds	Break into pieces and boil in water	Oral	Sundry	Yes
Anadenanthera colubrina (Vell.) Brenan	Angico	ARA000024	6	In the woods	All year round	Infectious coryza, carbuncle, lump, tumor	Bark, buds	Boil or soak in water	Oral	Fowl, bovine, equine, cats, dogs	Yes
Cajanus cajan (L.) Millsp.	Feijão-andu	ARA000083	1	Cultivated	Winter	Retained placenta	Leaf, buds	Boil 9 buds in water	Oral	Bovine	Yes
Libidibia férrea (Mart. ex Tul.) L.P. Queiroz var. leiostachya (L.) Wild.	Pau-ferro	ARA000092	1	In the woods	All year round	Retained placenta	Bark	Boil in water	Oral	Bovine, ovine, caprine, swine	Yes
Mimosa tenuiflora L.	Jurema-preta	ARA000007	2	In the woods	All year round	Wounds, mastitis	Bark	Boil in water or soak adding water and salt	Bathing	Sundry	Yes
Poincianella pyramidalis (Tul.) L.P. Queiroz	Catingueira	ARA000017	3	In the woods	All year round	Diarrhoea, fever, wounds	Bark, leaf, flowers	Boil in water or soak adding water and salt	Oral	Sundry	Yes
Vigna unguiculata (L.) Walp.	Feijão-de-corda	N.C.	1	In the woods	Winter	Retained placenta	Whole plant	Pasture for animals	Oral	Bovine, equine, ovine	No
Lamiaceae											
Hyptis pectinata L.	Sambacaitá	ARA000093	3	In the woods	All year round	Wounds, infectious coryza, mastitis, scabies	Leaf, bark	Boil in water	Bathing, oral	Sundry	Yes
Ocimum gratissimum L.	Alfavaca	ARA000008	3	In the woods	Winter	Diarrhoea, inflammation, retained placenta	Leaf	Boil in water	Oral	Sundry	Yes

Ocimum carnosum (Spreng.) Link & Otto ex Benth.	Alfavaquinha-de-vaqueiro	N.C.	2	In the woods	Winter	Retained placenta	Leaf, whole plant	Boil in water	Oral	Sundry	Yes
Plectranthus amboinicus (Lour.) Spreng.	Ciguleira	N.C.	1	Cultivated	All year round	Influenza, drool	Sap	Knead plant to obtain the sap	Oral	Sundry	Yes
Liliaceae											
Allium cepa L.	Cebola branca	N.C.	1	Cultivated	Winter	Blindness	Bulb	Chop and soak in water adding sugar	Topical	Ovine	No
Allium sativum L.	Alho	N.C.	11	Absent	Winter	Fever, helminthiasis, infectious coryza, influenza, anemia, drool, ticks, diarrhoea, foot-and-mouth disease, Newcastle disease, goiter	Bulb	Knead and soak in water	Oral	Sundry	Yes
Nyctaginaceae											
Guapira graciliflora (Mart. ex Schmidt) Lundell	Pau-piranha	ARA000094	13	In the woods	All year round	Retained placenta, mastitis, wounds, infections	Bark, leaf	Boil or soak in water	Oral, topical	Bovine, ovine, caprine, swine	Yes
Poaceae											
Cymbopogon citratus (DC.) Stapf	Capim-santo	N.F.	1	Cultivated	All year round	Fever	Leaf	Boil in water	Oral	Ovine, bovine, fowl, equine	Yes
Rhamnaceae											
Ziziphus joazeiro Mart.	Juazeiro	ARA000010	3	In the woods	All year round	Fever, infectious coryza, rabies	Bark, buds	Boil in water	Oral	Sundry	No

Rubiaceae										
Coutarea hexandra (Jacq.) K. Schum.	Quina-quina	ARA000095	2	In the woods	All year round	Infectious coryza, retained placenta	Bark	Soak in water	Oral	Bovine, ovine, caprine, fowl	Yes
Rutaceae										
Citrus limon (L.) Burm. f.	Limoeiro	ARA000014	4	Absent	In fruiting	Infectious coryza, influenza, Newcastle disease	Fruit	Squeeze the fruit in water	Oral	Fowl	Yes
Sapindaceae										
Serjania sp.	Mato-capela	ARA000078	1	Cultivated	Winter	Infections	Sap/ Latex	Knead to obtain the sap	Oral	Bovine	No
Sapotaceae										
Sideroxylon obtusifolium (Humb. ex Roem. & Schult.) T. D. Penn.	Quixabeira	ARA000016	4	In the woods	All year round	Contusions, wounds, carbuncle, diarrhoea, fever, infectious coryza	Bark	Boil or soak in water	Oral, bathing	Sundry	Yes
Solanaceae										
Solanum sp.	Jurubeba	ARA000012	1	In the woods	Winter	Catarrh	Fruit	Squeeze the fruit in water	Oral	Bovine, equine	Yes
Verbenaceae										
Lippia alba (Mill.) N. E. Br.	Erva-cidreira	ARA000084	10	Cultivated	All year round	Fever, diarrhoea, drool, wounds, retained placenta, helminthiasis	Leaf, buds, whole plant	Boil in water	Oral, bathing	Sundry	Yes
Unidentified										
	Anador	N.C.	2	In the woods	All year round	Fever, inflammation	Leaf, buds	Boil in water	Oral	Sundry	No
	Batata-de-purga	N.C.	3	In the woods	Winter	Helminthiasis, snakebite poisoning	Root	Chop and soak in water	Oral	Sundry	No

Batona	ARA000082	1	In the woods	Winter	Snakebite poisoning	Root	Soak in water	Oral	Sundry	No
Cabacinha	N.C.	3	In the woods	Winter	Catarrh, retained placenta	Fruit, seeds	Soak three-quarters of the fruit or boil in water	Oral	Bovine, equine, ovine, caprine	Yes
Moleque-duro	N.C.	1	In the woods	All year round	Catarrh	Leaf	Boil in water	Oral	Bovine, equine	Yes
Novalgina	N.C.	1	Cultivated	All year round	Fever, inflammation	Leaf	Boil in water	Oral	Ovine, bovine, fowl, equine	Yes
Pedaguia	ARA000080	1	In the woods	All year round	Retained placenta	Leaf, shoots	When green, just soak in water. When dry, boil in water.	Oral	Bovine	No
Piçarra	ARA000081	1	In the woods	Winter	Wounds	Leaf, bark	Boil in water	Bathing	Bovine, equine	Yes

Legend: Admin. – route of administration; Avail. – availability; Occur. – occurence; N.C. – not collected (no individuals were found in field); N.F. – not fertile (individuals were found and collected, but it was not possible to find them in flowering).