



BIOLOGICAL SCIENCES

Ecology, interactions and human perceptions of *Cerdocyon thous* in rural landscapes in the state of Pernambuco, Brazil

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Abstract: Human populations maintain diverse relationships with wild animals that lead to both positive and negative interactions. The aim of the present study was to investigate the ecology, interactions and human perceptions of *Cerdocyon thous* in rural landscapes in the state of Pernambuco in northeastern Brazil. Interviews were held from November to December 2015. Data collection involved the use of a semi-structured questionnaire and photographs of the fox. Most interviewees (96.94%) demonstrated knowledge of the species, attributing eight different vernacular denominations to the animal. The interviewees also demonstrated knowledge regarding its habitats, active hours, diet, behavior and diseases. The respondents pointed out negative aspects, such as the transmission of diseases (48.72%), the death of domesticated animals and consequent negative economic impact (42.74%), attacks against humans and other animals (6.84%) and causing an environment imbalance (1.70%). The positive roles attributed to the fox regarded its use as a resource for medicinal purposes, craftwork, mystical-religious ceremonies and as a pet. There is a need for further information on *C. thous* and adequate protection measures should be taken in local communities to ensure the conservation of the species in rural landscapes.

Key words: Local knowledge, ethnozoology, rural areas, northeastern Brazil, fox.

INTRODUCTION

The expansion of livestock farming in northeastern Brazil is reflected in the conversion of forests into pastures and farms. Policies and programs in the region are insufficient and often inconsistent, since they are based on poor knowledge regarding resources and the complexities of the human-environment relationship (Albuquerque & Andrade 2002). This region encompasses different landscapes that have been undergoing changes due to human activities since the colonial period.

The *Agreste* is a transition region between the rainforest zone of the coast and the

semi-arid interior of northeastern Brazil that incorporates the Atlantic forest and *Caatinga* biomes. The *Agreste* primarily has sugarcane plantations and livestock farming activities, but also has productive diversity due to the variety of microclimates, soils and reliefs, including areas specialized in dairy cattle farming, fruit and vegetable crops, sisal, beef cattle farming and subsistence farming, such as beans, corn and manioc (Mueller 1996).

The Atlantic Forest biome in northeastern Brazil has pioneering formations, portions of dense and open rainforest, semi-deciduous and deciduous seasonal forests and is home to four of the five centers of endemism of the

biome. However, it is the most degraded region, with dozens of officially endangered species (Tabarelli et al. 2006). The Atlantic Forest is highly fragmented, with high rates of reduction, which is the major threat to mammals (Chiarello 1999, Onderdonk & Chapman 2000, Fahrig 2003).

In recent decades, the loss of biodiversity around the world has occurred on a scale without precedent and the intensification of agriculture is one of the main reasons for this global change (Matson et al. 1997, Tilman et al. 2001). Many carnivorous mammals are currently in a vulnerable or even critical state in terms of conservation and the major cause of the decline in the populations of these animals is the reduction or loss of habitats due to the expansion of agriculture, livestock farming and human colonization (Santos et al. 2004).

Conflicts between humans and carnivores constitute an urgent challenge to the conservation of these animals, especially on the recent frontiers of deforestation and rural landscapes, where the requirements of the living area and diet of carnivores are often in discord with human activities (Michalski et al. 2006). Therefore, designing effective strategies for the conservation of native species in landscapes that have been modified by humans requires an understanding of how wild species use these spaces (Ferreira et al. 2018).

Although the threats of habitat loss and fragmentation are serious, another important cause of death of adult carnivores is the hostility of humans (Woodroffe & Ginsberg 1998). A large number of carnivorous species are vulnerable to hunting, slaughter, poisoning, accidental deaths, being run over by a vehicle and other sources of death (Michalski et al. 2006).

The diverse interactions between humans and wild animals enable individuals to perceive

and interpret the world they know in their own way (Gibson 1979, Pezzuti & Chaves 2009). Wildlife directly and indirectly contributes to the subsistence of human communities and has been used as source of food, medicine, trade, ornamentation, recreation, ceremony and companionship (Alves & Souto 2010). However, there are also conflictive aspects of these relationships due to aggressive behavior, as some animals may attack other animals and people and some human cultural activities, such as hunting, target these animals. Carnivores are the mammals most involved in conflicts with humans, as some species are tracked and killed due to risks associated with the transmission of disease, harm to farming activities and the predation of domestic animals (Alves et al. 2009, Mendonça et al. 2011). Such conflicts have been recorded ever since animals were first domesticated (Nowell & Jackson 1996) and result from the sharing of the same habitats and resources (García-Grajales 2013).

Cerdocyon thous (Linnaeus, 1766) is a medium-sized carnivorous canine known as crab-eating fox, forest fox, wood fox or Maikong with distribution from northern South America and south of Amazonia to northern Argentina (Courtenay & Maffei 2004). In Brazil, this fox is found in all biomes (Beiseigel et al. 2013), inhabiting modified landscapes, sugarcane plantations and areas near roads and highways.

Although *C. thous* has a broad distribution, there are gaps in knowledge regarding its use of habitat, biology and conflicts with humans on agricultural lands. Thus, the aim of the present study was to investigate the ecology, interactions and human perceptions of *Cerdocyon thous* in rural landscapes in the *Agreste* and coastal forest zone of the state of Pernambuco in northeastern Brazil.

MATERIALS AND METHODS

Study area

The survey was conducted in 36 rural locations in four municipalities in the state of Pernambuco: one in the *Agreste* - Feira Nova (07° 57'03" S and 35° 23'21" W); area: 107,726 km²; number of inhabitants: 20.571 and three in the coastal forest zone - Glória do Goitá (08° 00'06" S and 35° 17'34" W); area: 231,832 km²; number of inhabitants: 29.019; Paudalho (07° 53' 48" S and 35° 10'47" W); area: 274,776 km²; number of inhabitants: 51.357; and Vitória de Santo Antão (08° 07'05" S and 35° 17'29" W); area: 335,941 km²; number of inhabitants: 129.974 (CPRM 2005, IBGE 2018) (Figure 1). Vitória de Santo Antão has the largest area and number of inhabitants in both the urban (113.429) and rural (16.545) zones. Feira Nova has the smallest rural area and smallest

number of inhabitants in the rural zone (4.258). Glória do Goitá has the smallest number of inhabitants in the urban zone (15.434) (IBGE 2018).

The climate is characterized as rainy tropical, with the rainy season (peak between June and July) and a dry season with a mean temperature of 30.5 °C (INMET 2015). The main vegetal formations are semi-deciduous forests with trees reaching 20 m, semi-evergreen forests, quite devastated deciduous forests with trees reaching 10 m and hypoxerophilic *Caatinga* (dry scrubland) (CPRM 2005).

The municipalities are characterized by a predominance of rural properties, with a rural economy focused on craftwork, small livestock farming and agriculture, predominantly subsistence farming as well as cassava, fruit, vegetable crops and sugarcane plantations.

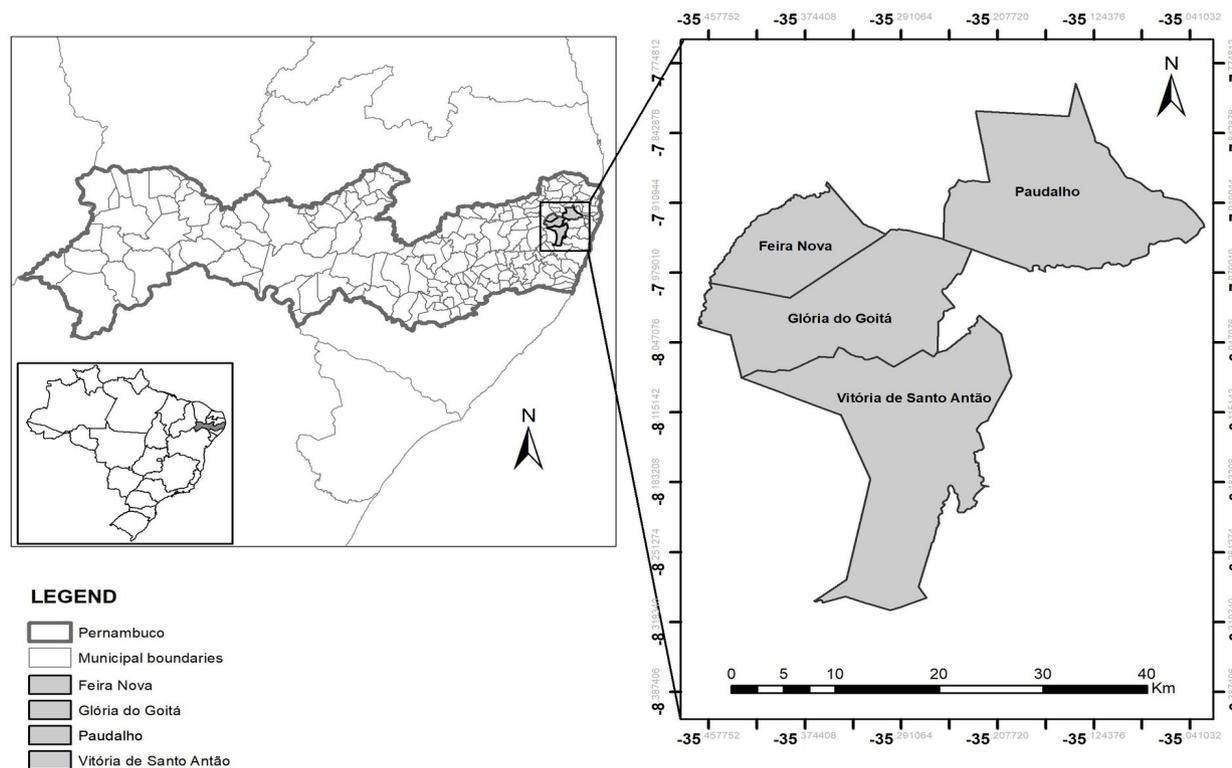


Figure 1. Map of Pernambuco highlighting municipalities of Feira Nova, Paudalho, Glória de Goitá and Vitória de Santo Antão.

Procedures

Interviews with residents of rural areas were conducted in November and December 2015. We first showed a photograph of *C. thous* to see if the interviewees identified the species and we commented on aspects of its biology, morphology and ecology. Subsequently, semi-structured questionnaires were applied based on Bernard (Bernard 1994). The data were analyzed using the “union of diverse individual skills” model (Marques 2001). Whenever possible, descriptive statistics were performed (mean, standard deviation and relative frequency). This study received approval from the Human Research Ethics Committee of

the Center for Health Sciences of the Federal University of Pernambuco (certificate number: 49839915.7.0000.5208).

RESULTS AND DISCUSSION

Socioeconomic aspects of respondents

One hundred ninety-eight individuals were interviewed: 113 (57.07%) men and 85 (42.93%) women with ages ranging from 19 to 80 years (mean: 53.89 ± 13.88 years). Mean age was 51.71 ± 14.16 years among the men and 56.8 ± 11.66 years among the women. The socioeconomic data of the respondents are summarized in Table I.

Table I. Socioeconomic aspects of respondents in study areas in Agreste and coastal forest zone of state of Pernambuco, Brazil (N; %).

		Men		Women	
		N	%	N	%
Age	19-30	9	7.96	4	4.71
	31-40	24	21.24	1	1.18
	41-50	16	14.16	19	22.35
	51-60	29	25.66	27	31.76
	61-70	26	23.02	28	32.94
	71-80	9	7.96	6	7.06
Education level	Incomplete primary school	50	45.05	50	62.50
	Illiterate	25	22.52	21	26.25
	Complete primary school	13	11.71	5	6.25
	Incomplete high school	9	8.11	2	2.50
	Complete high school	8	7.21	1	1.25
	Complete university	5	4.50	1	1.25
	Incomplete university	1	0.90	-	-
Occupation	Farmer	73	61.34	75	88.24
	Public servant	23	19.33	1	1.18
	Self-employed	14	11.76	-	-
	Housekeeper	-	-	8	9.41
	Shop owner	6	5.04	1	1.18
	Retired	2	1.68	-	-
	Student	1	0.84	-	-

Ecology of *C. thous* in agricultural landscapes

Natural areas and locations altered by human activities were cited as the habitat of *C. thous*, which is in agreement with data described in the literature. According to Lemos et al. (2011a), this fox is tolerant to anthropogenic disturbance and altered landscapes; moreover, the occurrence of this canine in various environments is related to different levels of disturbance. Dias et al. (2014) report that it is common for this animal to use the interior and edges of forests. Courtenay & Maffei (2004) report that the species inhabits altered areas near habitations. Juarez & Marinho-Filho (2002) recorded the species in farming areas. In the present study, *C. thous* was reported in different habitats, especially woodlands (47.61%) among natural environments and sugarcane

plantations (16.34%) among areas transformed by human activities (Figure 2). Although there is also evidence of carnivores that adapt to a wide variety of habitats impacted by humans, it is important identify the limits of their tolerance and their preferences, which can only be investigated in areas of greater interface with humans (Athreya et al. 2013). This adaptation demonstrates the high ecological plasticity of *C. thous*, which is evidenced in areas near plantations, residences and roadways, despite its preference for natural environments in the present study.

A total of 42.86% of the interviewees reported that *C. thous* was more active at night, 34.36% cited the morning hours, 22.39% cited the afternoon hours and 0.39% cited the predawn

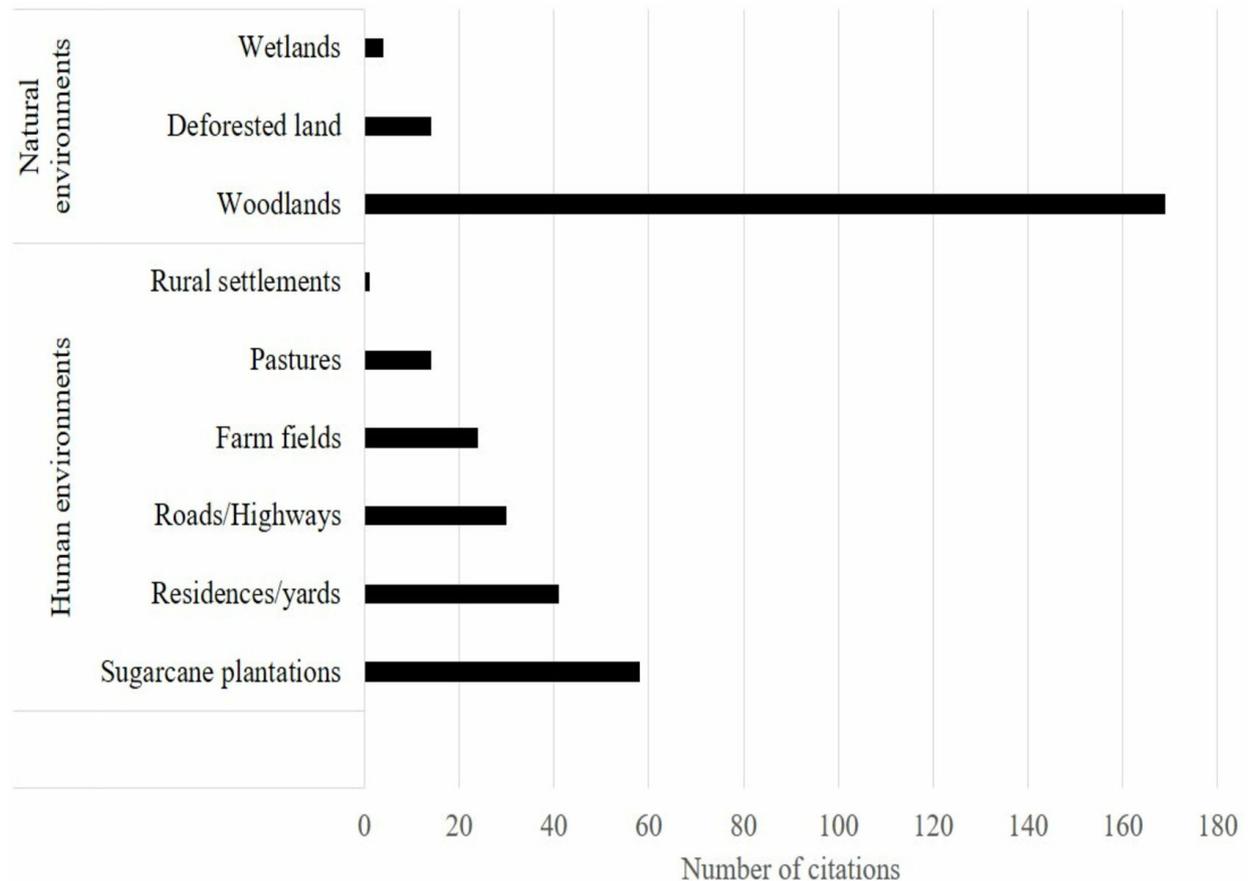


Figure 2. Environments related to the presence of *C. thous* cited by respondents.

hours. Indeed, the species has nocturnal and twilight habits, traveling alone or in pairs along the edges of forests and roads (Rocha et al. 2004, Reis et al. 2006, Abreu Júnior & Kohler 2009), where the animals are easily sighted searching for food. Some authors state that the period of activity is related to the period of activity of its prey items (Maffei & Taber 2003). According to Beltrán & Delibes (1994), environmental factors can exert an influence on the period of activity of the crab-eating fox. Activity in the morning and afternoon may be a reflection of the environmental change of the rural landscape, which may lead to an increase in encounters with humans.

Different food items consumed by the crab-eating fox were cited. The most frequently cited group was birds (77.20%), represented mainly by chickens (Table II). *C. thous* is considered a generalist species. Rocha et al. (2004) report that vertebrates are the most consumed food items by the species, especially rodents and birds, as well as reptiles, small invertebrates (insects) and a large number of vegetal items, including leaves and grasses. According to

Chieregatto et al. (2003), this canine feeds on insects, vertebrates, invertebrates and fruits, but has a preference for rodents and has a seasonal diet that varies according to the most abundant resources in the rainy and dry seasons. The effects of an agricultural environment altered by human activities include the presence of non-native rodents and *C. thous* plays an important role in controlling such populations (Rocha et al. 2004, Kasper et al. 2007).

Mendonça et al. (2011) report that these foxes often attack small farm animals due to habitat fragmentation and the reduction in the number of natural preys. In the present study, the generalist habit the crab-eating fox was confirmed and a preference for birds, especially chickens, was reported due to the abundance of this group on small farms in the region, demonstrating the adaptability of *C. thous* to rural landscapes for the purposes of survival.

The majority of interviewees (86.15%) reported that *C. thous* demonstrates aggressive behavior during the reproductive period or after having given birth, whereas 12.82% reported that the animal is not aggressive and 1.03% were

Table II. Food items consumed by crab-eating fox mentioned by respondents.

Categories	Relative frequency (%)	Food items	N° of citation
Birds	(77.20%)	Chickens, chicks, small birds, other birds, turkeys, tinamou	155, 36, 21, 15, 8,1,1
Vegetal items	(10.42%)	Fruit, sugarcane, seeds, cassava, sweet potato, leafy vegetables	4, 3, 2, 2, 1, 1, 1,1
Mammals	(4.89%)	Mice, rabbits, goats, guinea pigs, cats, dogs, pacas	16, 4, 3, 2, 4, 3
Arthropods	(0.33%)	Termites	1
Reptile	(9.98%)	Small lizards, snakes	2,1
Amphibians	(0.33%)	Frogs	1
Other	(5.80%)	Eggs	18

uncertain. According to the interviewees, the reproductive period may be influenced by the phases of the new and full moon and occurs in both winter and summer. Mendonça et al. (2011) also recorded interviewees in the semiarid region of the state of Paraíba who stated that the crab-eating fox is aggressive after having given birth to a litter and, according to hunters in the region, the species is considered dangerous and aggressive, with the possibility of attacking humans.

Human perceptions

The vast majority of interviewees (96.94%) was able to identify the species, which may be explained by the fact that it is a common canine that is easily encountered in diverse environments and is broadly distributed throughout Brazil (Beiseigel et al. 2013), including the entire state of Pernambuco as well as areas heavily altered by human activities (Cruz et al. 2002). In a study conducted in the semiarid region of the northeastern Brazil, Dias et al. (2014) report that recognizing and interacting with native species is a common occurrence in many locations. Mendonça et al. (2011) found that farmers in the state of Paraíba have knowledge on local species, including carnivores. In a study conducted in the municipality of Lapão in the state of Bahia, Barbosa et al. (2014) found that the majority of local residents have knowledge on wildlife in the region, including *C. thous*.

The species received different denominations from the interviewees, such as cat fox (36.73%), dog fox (36.42%), fox (11.73%), forest dog (4.94%), forest cat (4.32%), forest fox (4.01%), *guarã* (1.23%) and wolf (0.62%). According to Cruz et al. (2002), the species is also known as *goró*, *mariano* and *guaspira* in the state of Pernambuco.

Among the interviewees, 53.53% had not had any contact with the animal, whereas 26.77%

had any direct physical contact, such as a touch and bites and 19.70% only observed the foxes in the proximities of residences, roads, woods, sugarcane plantations, roadways and farms.

The majority of interviewees (53.46%) stated that the animal has no importance, 23.90% did not know whether the animal has importance and 22.64% stated that the crab-eating fox does indeed have importance.

Among the group who reported that *C. thous* has importance, 68.63% cited positive aspects and 31.37% cited negative aspects. The positive aspects were categorized in forms of use: craftwork, medicinal, mystical-religious activities and companionship (Table III). According to Marques (2001), human populations attribute importance to the species they know better and for which they have feelings and beliefs. In a study on the knowledge and use of fauna by hunters in the semiarid region of the state of Paraíba, Barbosa & Aguiar (2015) recorded different forms of use, such as medicinal (treatment of ailments), mystical-religious (inclusion of animals in rituals), as pets and as a food source. In another study conducted in the semiarid region of northeastern Brazil, Barbosa & Aguiar (2012) report that different species of fauna are used for mystical-religious purposes, such as amulets for the “evil-eye”, sacrificial rituals, cures for spiritual illnesses and folk stories. With regard to negative aspects, *C. thous* was seen as a species that causes conflicts due to the predation of farm animals and the transmission of disease, giving it a poor image in the communities surveyed.

Understanding the relationships that have been established between humans and animals is an important step in ensuring the sustainable use of the local/regional fauna and avoiding conflicts with communities (Licarião et al. 2013). Wild animals have been kept as companions for centuries and this widely spread traditional

Table III. Forms of use of *C. thous* identified by the communities studied (Agreste and coastal forest zone of state of Pernambuco, Brazil).

Category of use	Part used	Mode of use	Citation N°	Relative frequency (%)
Craftwork	Fur/skin	The skin can be used to make tambourines, drums, straps, shoes, bags, belts and rugs.	10	62.50
Medicinal	Fur/skin	The skin is used in teas and infusions without the ill person knowing what the tea is made of (indicated for asthma and shortness of breath). The skin is set to dry, ground into a powder and placed on burns (treatment of burns and wounds).	3	18.75
Magic-religious	Skin	Skin is tied to mane or tail of domesticated animal to avoid attacks from hematophagous bats	2	12.50
Companionship	Pups	Can be raised as pet when captures young.	1	6.25
Total			16	100

practice involves hundreds of species (Alves et al. 2013). In the present study, some interviewees reported that *C. thous* can serve a pet if raised from a very young age (Table III). In a study conducted with residents of the semiarid region of northeastern Brazil, Alves et al. (2016) report the occurrence of keeping wild animals as pets, which are often consumed as a food source by the “owners”. The earliest archaeological records from South America clearly indicate that although endemic foxes may never have been fully domesticated at any time, it is entirely conceivable that in the absence of the domesticated *Canis familiaris*, humans may have developed some sort of symbiotic relationship with foxes (Stahl 2012). However, Brazilian legislation prohibits the use of wild animals as pets or as a source of food. Transgressors can be subject to punishment and the practice exerts a negative impact on the conservation of *C. thous*. From the conservationist standpoint, it is preferable to keep domesticated animals,

such as dogs, cats, chickens, etc. (Alves et al. 2013), so that fewer wild animals are removed from their natural environment, diminishing the fragmentation and degradation of habitats and reducing conflicts between these animals and human beings.

Conflicts associated with the species

According to a global-scale review performed by Ferreira et al. (2018), only 7% of all studies report that the use of agroecosystems by carnivores resulted in conflicts with local human livelihoods, such as crop raiding, crop damage, livestock depredation and lethal or non-lethal injury to local people. In the study area, a total of 52.53% of the interviewees stated that *C. thous* causes problems for humans, whereas 32.32% stated that the animal does not cause problems and 15.15% were reported not knowing. The most cited problems were the transmission of diseases (48.72%), the death of domesticated animals and consequent negative economic impact

(42.74%), attacks against humans and other animals (6.84%) and causing an environment imbalance (1.70%), with negative impacts on the communities. In the study by Mendonça et al. (2011), residents of the semi-arid region in the state of Paraíba reported that foxes cause damage to crops, attack domesticated animals and transmit diseases to the residents.

Six types of diseases were associated with the crab-eating fox, which were categorized as respiratory problems (shortness of breath, asthma and allergies), skin disease (mange, rash, itching and dermatosis), phobias and fear, infections, leishmaniasis and rabies, the latter of which was the most cited (Figure 3).

Wild canids corresponded to 88% of rabies cases reported in the northeastern Brazil from 2002 to 2009 (Wada et al. 2011). According to Kotait et al. (2007), foxes in northeastern Brazil serve as reservoirs for rabies, with reports of transmission to humans (Bernardi et al. 2005). Moreover, Jorge et al. (2010) report the exposure of *C. thous* to distemper, *Leishmania* spp and parvovirus. For northeastern Brazil, Cerqueira et al. (1998) report that *C. thous* is the only species of fox infected by *Leishmania chagasi*.

In a study conducted with residents of the semi-arid region of the state of Paraíba, Mendonça et al. (2011) report that the risk of the transmission of diseases by *C. thous* is related to the destruction of natural habitats

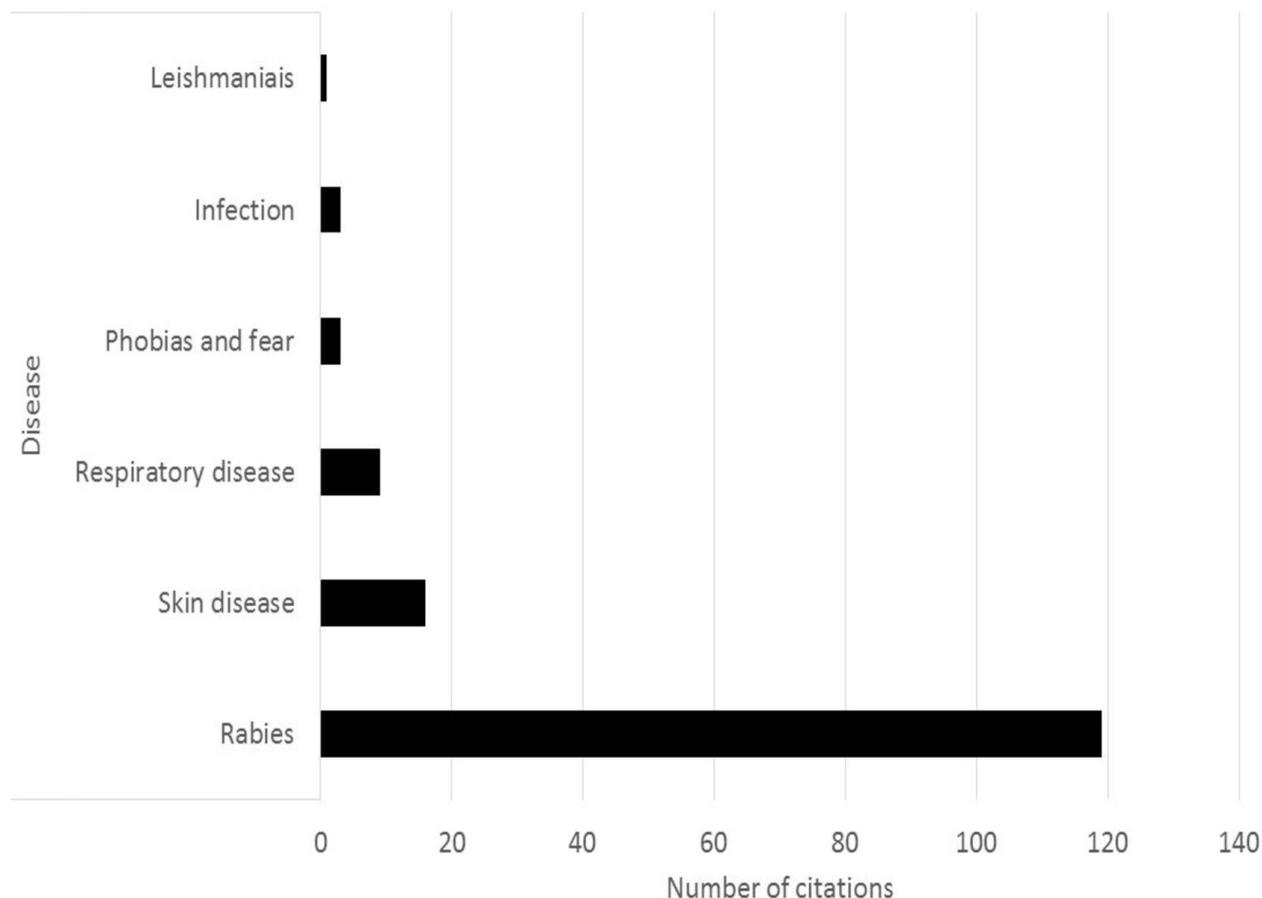


Figure 3. Diseases cited by interviewees related to crab-eating fox.

due to farming and livestock activities as well as the accumulation of trash, which attracts these animals to human settlements. According to Alexander et al. (2002), such contact further increases the participation of the crab-eating fox in the transmission of diseases. In a study conducted in the state of Sergipe by Antunes et al. (2018), the rabies virus circulates opening in the wild, leading to the spread of the disease to urban and rural environments. This situation imposes the need for a permanent, systematic epidemiological surveillance of rabies among key wild species, such as primates, bats and carnivores, in natural environments. In the present study, the crab-eating fox was commonly sighted in the areas surroundings agricultural activities for the raising of domesticated animals, especially birds, which explains the negative view that the interviewees had regarding the species, as such contact very often results in the predation of small farm animals besides the transmission of diseases.

In the reports of 7.77% of the interviewees, aggression toward domesticated dogs (*C. familiaris*) by the crab-eating fox caused conflictive relations that resulted in the death of foxes. According to Beisiegel et al. (2013), conflicts between dogs and *C. thous* are common, especially when the fox approaches homes in search of food. Lemos et al. (2011b) report aggression and the death of foxes by dogs on cattle farms in the state of Goiás and on a federal road in the state of Minas Gerais. A study conducted in India reports that domesticated dogs exert a negative impact on the spatial distribution of the fox *Vulpes bengalensis* and are an important cause of the mortality of the species (Vanak & Gompper 2010).

When asked what should be done in cases of a domesticated animal being attacked, 55.17% stated that the animal should be vaccinated, 20.69% would seek a veterinarian, 6.90% would

sacrifice the animal and 17.24% did not know what should be done. With regard to attacks against humans, 67.07% stated that the proper course of action would be a rabies vaccine, 22.16% state that they would seek a healthcare service, 5.99% did not know what should be done, 3.59% reported they would take medication and 1.20% would wash the bite wound. Although the majority of interviewees demonstrated knowledge on what should be done following aggression or an attack by *C. thous*, there is a need for prevention and control measures for this zoonosis in rural areas.

Attacks by crab-eating foxes should be carefully verified, as this animal is one of the main reservoirs of wild rabies (Kotait et al. 2007) and the fact that it lives in areas near human activities increases the odds of contact with humans and the possible transmission of this disease. The prevention of attack, together with vaccination programs and the birth control of domesticated dogs could potentially reduce the rate of contact between dogs and wild carnivores (Vanak & Gompper 2010, Lemos et al. 2011b). Moreover, environmental education programs directed at wildlife could orientate populations as well as assist in the conservation of the species in rural landscapes.

CONCLUSION

The present findings show that the residents of rural communities interviewed demonstrate knowledge regarding *C. thous* as well as its ecological, morphological and utilitarian characteristics. The findings also suggest that its adaptability and use of different resources enable *C. thous* to take advantage of rural landscapes.

According to the respondents, due to its negative roles as a wild animal, predator of

small domesticated animals and a threat to health, the crab-eating fox is the main carnivore that causes conflicts with rural communities by attacking domesticated animals that are a source of income and food for local families. However, the positive roles for *C. thous* cited were use for medicinal purposes, craftwork, mystical-religious activities and as a pet. Thus, it is important to understand the relationship between the population studied and *C. thous* used as a faunal resource, as this is a wild animal that is submitted to other pressures, taking into consideration biological, conservationist and cultural aspects.

The findings demonstrate a need for further information on this animal as well as adequate measures to reduce contact between the species and local communities in an effort to ensure the preservation of the species and diminish conflicts related to the predation of domesticated animals and the transmission of rabies. Environmental education actions should be implemented to inform local communities with regard to the importance of *C. thous* to the balance of the ecosystem and public health issues, serving as a useful tool for conservation programs and the achievement of sustainable societies.

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