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Running header: Wild boar attacks and anti-rabies treatment

The nature of attacks by wild boar (Sus scrofa) and wild boar/domestic pig hybrids (´javaporcos´) and the conduct of anti-rabies care in Brazil

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ABSTRACT

Introduction: In Brazil, the wild boar is an exotic invasive species that has been reported as a disease reservoir in several parts of the world. The result of crossing a boar with a domestic pig is called, in Brazil, a ´´javaporco´´. In Brazilian territory, boars and javaporco have been recorded serving as food sources for blood-feeding bats (*Desmodus rotundus*), and the impacts of such interactions on human health are still unknown. **Objetive:** Characterize attacks by wild boar and javaporco on human, and anti-rabies treatment that follows such accidents. **Methods:** Reports and epidemiological investigation records of human rabies treatment from 2007 to 2017 stored in the National System of Notifiable Diseases database were analyzed by descriptive epidemiology. **Results:** 309 attacks - 271 (87%) by wild boar and 38 (12.3%) by javaporco were reported - an increase in the number of reports in the most recent years of the evaluated time series. Attacks occurred in all regions of the country, in 17 Federated Units and in 252 municipalities. Men were most commonly attacked sex (283 - 91.58%), with the most commonly attacked age group being 35 to 49 years (86 - 27.83%), and occupations being wire fence constructor (31 - 10.03%), retired or pensioner (15 - 4.85 %) and student (13 - 4.20%). Single lesions (197 - 63.75%), deep (248 - 80.25%), produced by bite (292 - 94.49%), in the lower limbs (159 - 51.45) were the most recorded. Most of the individuals attacked had no history of anti-rabies treatment (249 - 80.58%), and the treatment indicated was serum plus vaccine (162 - 52.42%). **Conclusion:** Given the rising profile of the attacks and the geographical expansion of the wild boar's range in Brazil, with the consequent risk of attacks this study has shown, the health authorities should be alert to episodes of aggression, which should be monitored and, after incidents the medical care guidelines of the National Rabies Control Program should be followed.

Keywords: zoonoses; epidemiological surveillance, animal rabies, wild rabies.

INTRODUCTION

The wild boar (*Sus scrofa*) (or *javali* in Brazil) is a species of wild pig native to Europe, Asia and North Africa, that was introduced into South America at the beginning of the 20th century [1]. The species began invading Brazil the boar invasion (Figure 1-A) in the 1990's where the species migrated in from Uruguay, resulting initially in a slow and limited expansion in municipalities in the extreme south of the country [2,3]. However, it was noticed that the dispersion to other regions of the Brazilian territory was accompanied economic interests, with a view to commercial breeding and crosses with domestic pigs (generating the javaporco), so that the species was intentionally transported to other regions of Brazil expanded its distribution more rapidly than if it had been dispersing naturally. Currently wild boar are present across a large part of the national territory, and occupy a variety of Brazilian ecosystems and biomes [4].

The wild boar is listed as one of the 100 most damaging exotic species in the world [5] and has been responsible for widespread damage to both biodiversity and agriculture. These animals cause damage to native flora, kill native fauna, impact agricultural production [6-8], and represent a serious health risk for livestock, as they act as reservoirs for several diseases [9,10].

In terms of health, the Brazilian government's great concern relates to the potential of the species to introduce and maintenance of diseases that may impact domestic swine populations (e.g. classical swine fever)

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and other livestock (e.g. foot-and-mouth disease), and so impact the country's agricultural economy. In this context, several studies have shown that the species is involved in enzootic cycles of zoonoses [11-16].

As a result, Brazil has instituted a National Plan for the Prevention, Control and Monitoring of Wild Boar with the aim to establish the necessary actions to contain the territorial and demographic expansion of the species within the country, and reduce its impacts, especially in priority areas of environmental, social and economic interest [3].

In addition, recent studies have found that species expansion and its abundance in some areas of Brazil are resulting in encounters between wild boars and hematophagous bats (Figure 1-B), for which they are serving as a food source [17] In some areas they have become the preferential prey of vampire bats, *Desmodus rotundus* [18].

Figure 1. A - Female wild boar with piglettes, recorded in Campo Belo do Sul municipality, Santa Catarina State, southern Brazil (Photo: Diego Küster Lopes). B - Javaporco serving as a food source for vampire bats, *Desmodus rotundus*, recorded by a photographic trap in of Campinorte municipality, Goiás State, central Brazil (Photo: Sidney Moreira). C - Injury produced by wild boar attack on a hunter's lower left limb, Lages municipality, Santa Catarina State Source: Allan Pyerre.

The consequences of sich events are still unknown and uncertain, however, there is currently a new cycle of wild rabies in the country, largely vectored by bats [19]. This could, potentially, favor boar and javaporco infections and the potential development of mutations of the rabies virus and the development of spillovers (that is, mutations of the virus that occur when adapting to a new host) [20]. Parallels exist elsewhere: there are known cases of rabid wild pigs attacking humans have been reported in several regions of India, where canine rabies is common, and interactions between pigs and dogs are frequent [21,22].

In Brazil, impacts caused by wild boar attacks and aggressive interactions with humans and the resulting risk of rabies virus infections are still unknown. Consequently, the objective of this study is to characterize the frequency and profile of wild boar and javaporco attacks in human populations, and record the epidemiological surveillance and human rabies treatment adopted.

MATERIALS AND METHODS

Study structure

A cross-sectional, descriptive, quantitative study based on secondary information from the official database of the National System of Notifiable Diseases (SINAN) was carried out, using information from the Notification form and epidemiological investigation (FNIE) (http://portalsinan.saude.gov.br/images/documentos/Agravos/Atendimento%20Anti-rabico/anti_rabico_v5.pdf) and records of human rabies control database from the Brazilian Ministry of Health. The study period was from January 2007 to December 2017, and the notifications database was accessed on 02/02/2018.

For the purposes of the analysis, notified accidents were considered to be reported as wild boar-related when the aggressor species [FNIE field 40] was reported as another species [category 7], and in the open field give aggressor species identify as: boar = [wild boar] [captive wild boar], [wild pig/wild boar], or as javaporco [wild boar/domestic pig], [wild boar/swine], [domestic pig/wild boar] or [cross between domestic pig and wild boar].

Information analyzed that related to victims were: [male/female], age [in years], municipality of residence, location of residence [urban, peri-urban, rural,] residence [information of the Federal Unit (state or district of Distrito Federal) where the individual resides], occupation [labor activity performed by the individual - according to the Brazilian occupation code 2002] [23].

Information analyzed related to the attack was: month [month in which the attack was reported], year [year in which the attack was reported], injury [single,

multiple, no injury], injury type [yes or no - if yes, bite or superficial lesion], wound type [yes, no - if yes, deep, superficial or tearing], and wound location [yes, no, unknown - if yes: head/neck, hands/feet, trunk, upper limbs, lower limbs].

Information analyzed in relation to anti-rabies treatment were: condition of the aggressor animal [healthy, suspect, rabid, dead/disappeared], patient history of anti-rabies treatment [yes (pre-exposure or post exposure)] and treatment indicated [treatment, animal observation, observation plus vaccine, vaccine, serum plus vaccine]. Ignored or blank entries have also been counted.

Data Analysis

After the qualitative review of the completed human rabies data sheets, the data were tabulated in Microsoft Office Excel® data sheets and submitted to descriptive statistical analysis using frequency and central tendency measures using Tabwin 3.2 software.

RESULTS

A total of 309 attacks were identified, of which 271 (87%) were by wild boar and 38 (12.3%) by javaporco. Ordering results by year of the accident show an ascending record profile (minimum of 17 attacks and maximum of 47 attacks/year - average of 51.5 attacks/year) (Figure 2 - A). Attacks were recorded in 17 federal units, in all regions of Brazil, though most frequently in the south and southeast (244 -78.96%). São Paulo State recorded 92 attacks (29.77%), followed by Paraná (49 - 15.85%), Minas Gerais (45 - 14.56%), Rio Grande do Sul (30 - 9.70%), Santa Catarina (28 - 9.06%), Goiás (21 - 6.79%), Mato Grosso (12 - 3.88%), Espírito Santo (8 - 2.58%), Mato Grosso do Sul (7 - 2.26%), Rio de Janeiro (7 - 2.26%), Distrito Federal (2 - 0.64%), Bahia (2 - 0.64%), Alagoas (2 - 0.64%), Sergipe (1 - 0.32%), Ceará (1 - 0.32%), Acre (1 - 0.32%) and Rondônia (1 - 0.32%) (Figure 3-A). Attacks occurred in 252 Brazilian municipalities (Supplementary Material 1), ranging from 1 to 4 records per municipality, based on municipality of residence of the victim of aggression.

The most frequent area of residence of attacked individuals was urban (162 - 52.42%), followed by rural (135 - 43.68%). Attacks occurred in all months of the year, though the highest frequencies were observed in June and November (31 attacks - 10.03% - in each month) (Figure 2 - B).

Among victims the most frequently reported occupations were: wire-fence constructor (31 - 10.03%), retired or pensioner (15 - 4.85%), student (13 - 4.20%), followed by occupations related to the agricultural and rural environment (Figure 2 - C). People most commonly attacked were, men (283 - 91.58%), between the ages of 35 to 49 (86 - 27.83%), with a median age of 44 years (Figure 3 - B).

Recorded wound types were: single lesions (197 - 63.75%), deep (248 - 80.25%) produced by bite (292 - 94.49%), on the lower limbs (159 - 51.45) (Figure 1-C and Table 1).

Most of the aggressor animals were classified as dead or missing (106 - 34.30%), the individuals attacked generally had no history of antirabies treatment (249 - 80.58%), and the treatment indicated was serum and antirabies vaccine (162 - 52.42%) (Table 2).

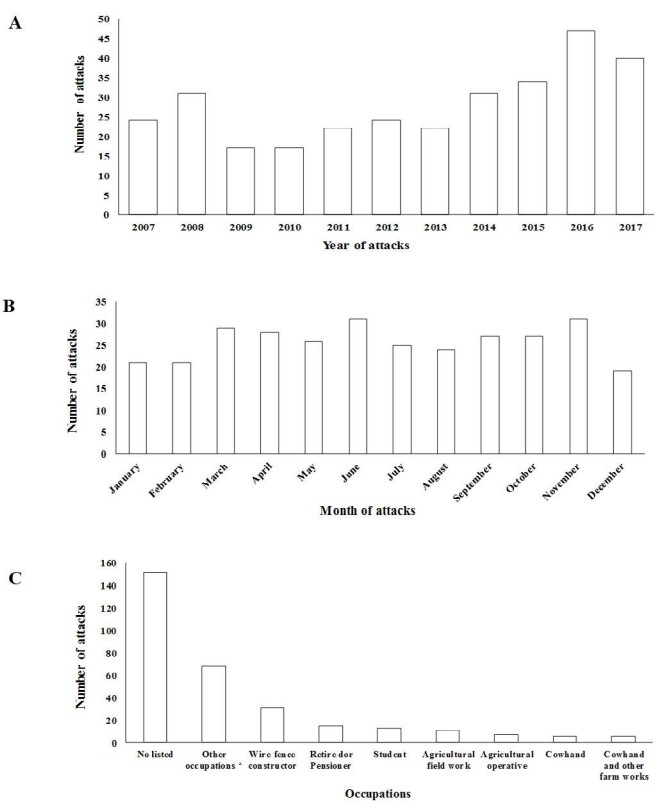

Figure 2. A - Distribution of attacks by wild boar and javaporco, according to notification year. B - Distribution of attacks wild boar and javaporco, according to notification month. C - Main occupations of the individuals attacked by wild boar and javaporco between 2007 and 2017 in Brazil. * Other occupations = <3 records per occupation.

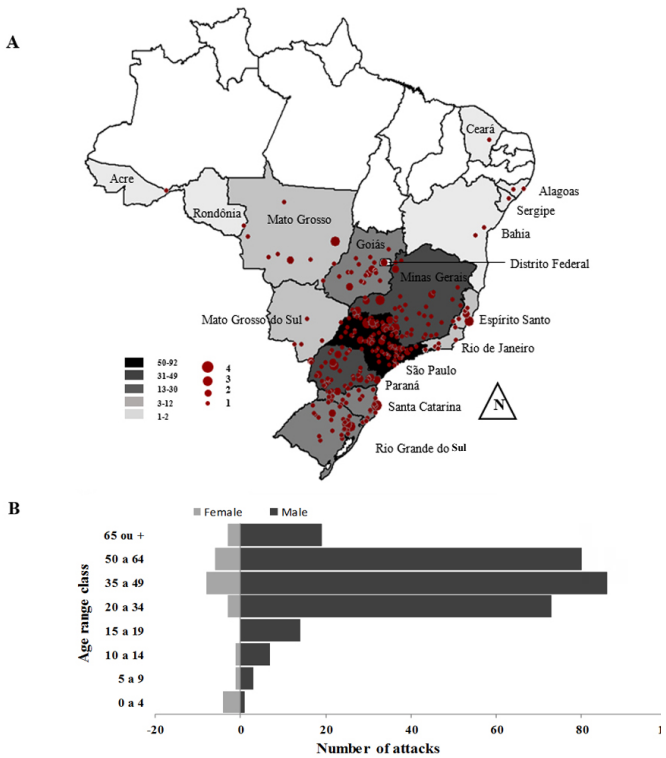

Figure 3. A - Geographical distribution of the attacks by wild boar and javaporco, in Brazil between 2007 and 2017, by reported municipality and Federated Unit of residence. Dark colors represent the Federated Units with the highest number of records. Red circles represent the municipalities where the attacks were reported to have occurred. The size of the circle represents the number of attacks per municipality of residence (ranging from 1 to 4 attacks per municipality). B - Distribution of wild boar and javaporco attacks according to sex and age group, 2007 to 2017, Brazil.

Table 1. Type and location of the wound, caused by attacks of wild boar and javaporco, 2007 to 2017, Brazil.

Wound Type	Yes		No		Ignored/ Empty Field	
	N	%	N	%	N	%
Single	197	63.75	109	35.27	3	0.98
Multiple	107	34.62	200	64.72	2	0.66
Superficial	37	11.97	263	85.11	9	2.92
Laceration	79	25.56	215	69.57	15	4.87
Deep	248	80.25	51	16.5	10	3.25
Bite	292	94.49	16	5.17	1	0.34
Superficial	25	8.09	283	91.58	1	0.33
Wound Type	Yes		No		Ignored/ Empty Field	
	N	%	N	%	N	%
Head or neck	8	2.58	299	96.76	2	0.66
Arms	67	21.68	240	77.66	2	0.66
Mucus membranes	4	1.29	303	98.05	2	0.66
Trunk	34	11	273	88.34	2	0.66
Feet/hands	102	33	205	66.34	2	0.66
Legs	159	51.45	149	48.22	1	0.33

Table 2. Condition of the aggressor animal, history of rabies treatment of the injured individual and treatment indicated in cases of the attack by wild boar and javaporco, 2007 to 2017, Brazil.

Animal status	N	%
Dead/Dissapeared	106	34.3
Healthy	98	31.71
Suspected	77	24.91
Rabid	2	0.64
Field ignored/empty	26	8.44
Previous anti-rabies treatment?	N	%
No	249	80.58
Yes	15	4.85
Field ignored/empty	45	14.57
Treatment Recommended	N	%
Serum + Vaccine	162	52.42
Vaccine	85	27.5
Additional vaccination	28	9.06
No treatment needed	9	2.91
Observation of animal	8	2.58
Preexposure	7	2.26
Field ignored/empty	10	3.27

DISCUSSION

The results presented show an increasing frequency of human attacks by wild boars in recent years. Men engaged in occupational activities in rural areas were the most frequently bitten. Bites were mostly single and deep and on the lower limbs. Half of the attacked individuals did not undertake the recommended course of anti-rabies treatment.

The density of attacks and the geographical distribution of occurrences coincide with the expansion of the species. In the most recent evaluation of the species distribution in the country, the National Plan for Prevention, Control and Monitoring of wild boar showed, that, since 2007, has been recorded in an increasing number of municipalities, so that current records include 5% of the national territory [3]. At the last count, the country had 563 municipalities with record of wild boar and javaporco, and the greatest part of this invasion of Brazilian territory has occurred in the last 10 years [3].

It is possible that some records are the result of mistaken identifications since, in some areas, wild

boar cohabit with native species that resemble them (Queixadas - *Tayassu pecari* and Catetos - *Pecari tajacu*), and victims may not be able to accurately differentiate the species. Likewise, it is possible that the data underestimated the true extent of the situation, since many accidents with javaporcos, characterized "pigs" as the aggressor, and such records were not included in this study. It is also likely that many health professionals are not recording wild boar accidents because FNIE human rabies care has historically been used for rabies surveillance transmitted by dogs and cats and there is still reluctance on the part of health professionals to report accidents in which wild species are involved.

In terms of anti-rabies treatment, it was observed that the recommended treatments were not followed-up in 50% of the recorded wild boar accidents [24]. In cases of attacks involving wild animals, it is recommended that serum and anti-rabies vaccination be administered, since it is not possible to monitor the animal and little is known about the pathogenesis of rabies in potential wild reservoirs of the virus [20, 24].

Another important aspect that could not be verified from the accessed database material was the victim´s tetanus vaccination status. Tetanus is another possible complication of lesions caused by pigs [25], as contaminated wounds may give access to *Clostridium tetani* spores. Thus physicians who treat victims of wild and domestic animal attacks should always take the opportunity to check the vaccination status of their patient and provide them with the vaccines they need [25]. Similarly, wounds caused by wild boars can lead to secondary infections since such bacteria as *Staphylococcus* sp, *Streptococcus* sp, *Pasteurella multocida*, *Flavobacterium* sp and other genera [26, 27] may have entered the wound. Such possibilities should be considered when treating such attacks.

Most studies documenting attacks by wild boars and javaporcos report one-off assaults and deaths [28-30]. In Turkey and India, significant soft tissue trauma and penetrating lacerations in the lower extremities (up to 10 cm in length and 4 cm in depth) were the most frequent results of such attacks, and deaths were rare [28, 29].

In a study conducted in India (1990-2008) of 309 human deaths and attacks by wild boar, most incidents occurred in forest areas to men aged 41-50 years, with a predominance of accidents in the month of November, in the morning, during work activities [31].

Mayer 27 compiled world-wide records of attacks by wild pigs, analyzed 412 attacks and found that these occurred in wild and rural areas. Occurrence was greater during winter months, and often involved injured animals or hunting situations with a predominance of solitary male animals that escaped without damage to themselves. The victims were mostly adult men, walking on foot, alone. Severity of resulting lesions ranged from mild to fatal, and the victims generally suffered a single injury in the form of laceration or puncture to the limbs. The deaths, when they occurred, were due to subsequent hemorrhagic events. This profile is in line with much of what has been recorded in Brazil, where men working in rural areas in the economically active age group are the most affected.

Ideally, what could increase the number of records for present study would be to access information from the mortality information system (SIM - which records deaths occurring Brazil), and data from the hospital information system (SIH - which registers hospital care) which are the databases supporting the public health policies of the Brazilian Ministry of Health. In any future studies, it would also be important to quantify the epidemiological burden of wild boar attacks, evaluating premature deaths (years of life lost), sequelae, temporary or full retirements, and the direct and indirect impacts on Brazilian government services.

Records obtained in this study did not show a specific seasonality for attacks, which were observed in all the months of the year, with a slight predominance in June and November. Aditionally, half the victims were urban residents. Due to the limitation of the database, we cannot divine the exact location of the accidents. Regional studies should evaluate these records, seeking to identify local risk factors and seasonal patterns of aggression, in order to achieve a more precise understanding of the magnitude of this problem, so allowing the development of suitable public prevention policies.

The highest frequencies of aggression were observed in states in the southeast and south of the country (regions with the highest demographic density in the country), especially in of São Paulo State, where attack events were recurrent in some municipalities. In such areas it is important to intensify the actions the wild boar control recommended by the National Plan for Prevention, Control and Monitoring of wild boar [3].

Wild boar population management actions depend as much on governmental command and

control mechanisms as on the collaboration of society in general. Cooperation of volunteers, such as land owners and rural workers, is essential to guarantee that government efforts dedicated to controlling this highly invasive species are effective [3].

Given the growing profile of the attacks and increasing geographical area occupied by wild boar, and with the consequent risk of attacks that the current work has shown, health authorities should pay strong attention to attacks on humans by wild boars, which should be followed up and follow the deploy medical care methods as given in the National Rabies Control Program guidelines [24].

It is also important that people who engage in occupational activities in the areas where the species occurs are aware of the risk of attack. Those who hunt wild boar should be made aware of the occupational risk in which the activity places them, as well as boar behaviors that indicate the imminence of an attack.

Supplementary material 1: List of municipalities (codes according to IBGE) where the wild boar and javaporco attacks occurred and the number of attacks per municipality, 2007 to 2017.

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