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Bushmeat and human health: Assessing the Evidence in tropical and sub-tropical forests

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ABSTRACT

The importance of bushmeat as source of food and medicine for forest peoples calls for an appropriate benefit/risk analysis in terms of human health. In this systematic review, we compiled information on the linkages between bushmeat and health, with a particular focus on the nutritional content, the zoo-therapeutic uses and the zoonotic pool of bushmeat species in tropical and sub-tropical forest regions. Despite the scarcity of data on the nutritional content of most common bushmeat species, the available studies demonstrate that bushmeat is an important source of fats, micro and macro-nutrients and has a diversity of medicinal uses. However, bushmeat may have detrimental health impacts where hunting, transportation, handling and cooking practices do not follow food safety practices. There is evidence that some bushmeat carcasses may be contaminated by toxic metals or by polycyclic aromatic hydrocarbons. Moreover, several pathogens carried by bushmeat are found to be zoonotic and potentially transmissible to humans through consumption or through exposure to body fluids and feces. We stress the need for more in-depth studies on the complex links between bushmeat and human health. The development of innovative handling, conservation and cooking practices, adapted to each socio-cultural context, should help reduce the negative impacts of bushmeat consumption on human health.

Keywords: Ethnozoology, systematic review, bushmeat, nutrient, zoonosis, zootherapy, health

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INTRODUCTION

There is growing evidence that points to the importance of wildlife as a source of nutrition, medicine and spiritual values in many human cultures in tropical and subtropical areas worldwide (Scoones et al. 1992; Nasi et al. 2008). The meat of wild animals in particular, commonly referred to as bushmeat, has formed a part of the staple diet of forest dwelling peoples for millennia (Elliott et al. 2002) and remains a primary source of animal protein, micro-nutrients and fat (Wilkie et al. 2005; Nasi et al. 2011, Siren and Machoa 2008; Golden et al. 2011; Mori et al. 2015, Alves et al. 2016). Bushmeat is also a significant source of revenue for many forest families (Milner-Gulland et al., 2003). Consumers often consider bushmeat a wholesome, safe alternative to commercially produced meat on sale at grocery stores. In some regions, it is preferred to farm-raised meats for its taste or based on the perception that industrial meats contain chemicals and additives (van Vliet and Mbazza 2011). Moreover, bushmeat also plays a special role in the cultural and spiritual identity of indigenous peoples (Siren 2012). Cawthorn and Hoffman (2015) have provided an extensive review of the nexus between bushmeat and livelihoods, emphasizing the contributions of bushmeat to food security, nutrition and well-being. In some communities, human ailments are treated with products derived from animals, also known as zootherapy (Alves et al. 2013a; Begossi and Braga 1992; Johns 1996; Martinez 2013). Such animal-based preparations constitute a plethora of medicinal solutions employed by numerous cultures since ancient times, and are still being used in different parts of the world as primary or complementary treatments (Alves and Rosa 2013).

However, it is also well established that all sorts of animal-derived foods and remedies are capable of producing adverse reactions (Alves et al. 2013b) and the consumption of animal products as food or medicine also facilitates the transmission of serious and widespread zoonoses. Thus, it is essential that traditional foods and drug therapies be submitted to an appropriate benefit/risk analysis. Increased research efforts in the last decade, further spurred by recent zoonotic disease epidemics (Kurpiers et al. 2016), have focused attention on the potential for bushmeat to act as a reservoir for pathogen transmission and spread into at-risk human populations.

To date, the role of wild meats in the provision of human nutrition and remedies and the emergence of human diseases presents something of a paradox and requires an assessment of its costs and benefits: “is bushmeat healthy or the opposite?”. However, because nutritionists, ethno-zoologists and epidemiologists often work in isolation from one another, there is no compiled evidence of the links between bushmeat and health that can assist policy makers in setting benchmarks of what is currently known and further allow researchers to better assess the importance of the resource. To respond to this need, we systematically reviewed all available information on: 1) the nutrient composition of bushmeat 2) its use in curative or preventive medicine and 3) the zoonotic pool present in bushmeat species.

METHODOLOGY

Our review provides a posteriori comparison of published case studies dated up to November 2016 that illustrate the links between bushmeat and health. We performed a systematic search on Google Scholar, Web of Science and CAB Direct (Figure 1).

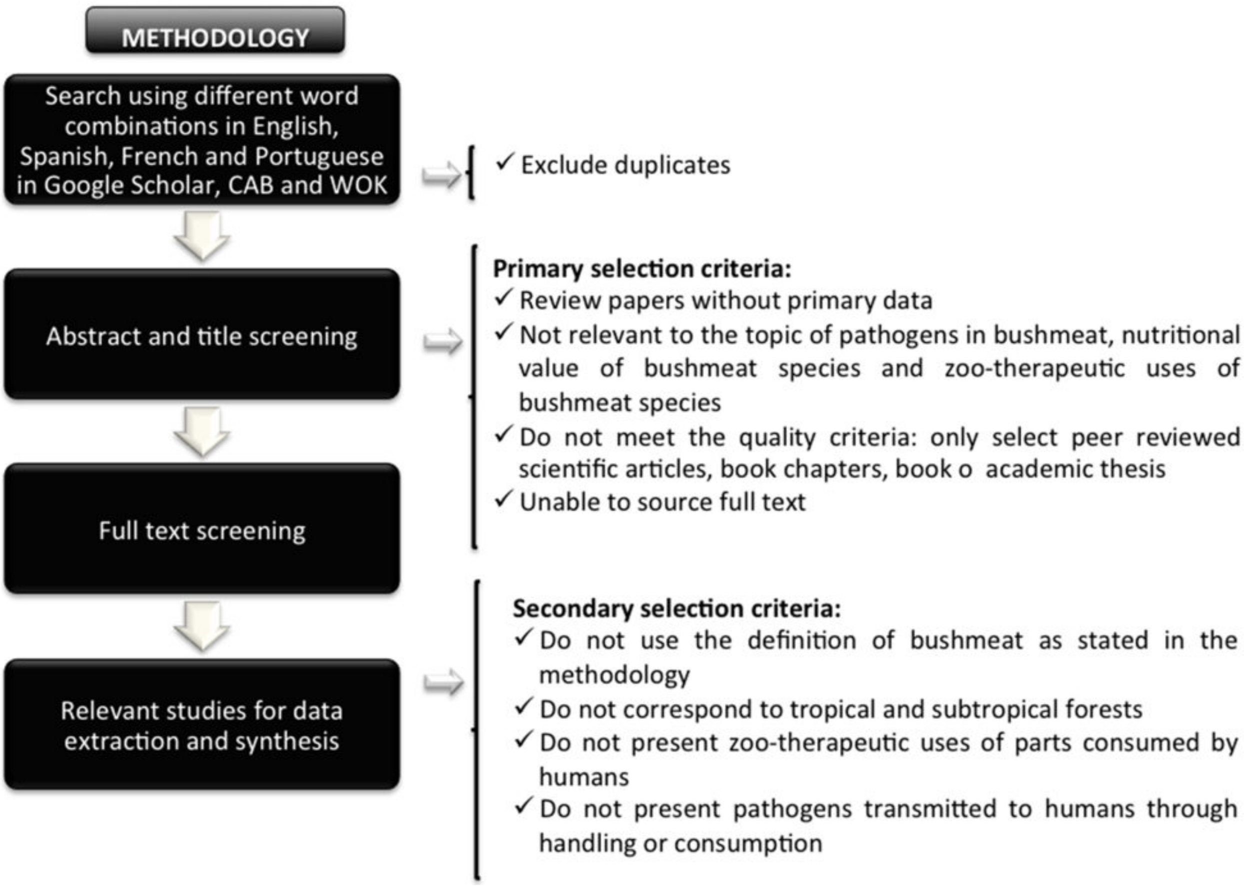

Figure 1. Methodology used for the systematic review process

In Google Scholar we searched using 40 combinations of words in English, Spanish, Portuguese and French (Table1). The search yielded 13827 results, excluding duplicates.

In the Web of Science database, we used the following search string, with language limits for articles in English, Spanish, Portuguese, and French, and retrieved 1105 additional results: ("game meat" OR "wild game" OR bushmeat OR "wild meat") AND (nutri* OR protein* OR calori* OR diet* OR consum* OR zoono* OR pathogen* OR disease* OR illness* OR infectio* OR medicin* OR therap* OR health OR treatment* OR "traditional medicine*" OR "folk medicine*" OR "alternative medicine*").

In CAB Direct, we used the following search string to yield 122 additional results ("game meat" OR "wild game" OR "bush meat" OR bushmeat OR "wild meat") AND (nutri* OR "nutritive value" OR protein* OR calori* OR diet* OR consum* OR zoono* OR pathogen* OR disease* OR illness* OR infectio* OR medicin* OR "medicinal properties" OR therap* OR health OR treatment* OR "traditional medicine*" OR "folk medicine*" OR "alternative medicine*").

The search strings were developed and validated among the authors, which together constitute a group of experts on bushmeat, zootherapy, nutrition and health.

The references were first screened by title and abstract according to the primary inclusion criteria below:

1. ONLY studies for which we were able to source the full text. Sixteen studies were eliminated because their PDFs could not be found.

Table 1. Results of the google scholar search using several key word combinations in Spanish, Portuguese, French and English

Combinations for search in english	***Results***	***Number of selected papers after 1st and 2nd selection criteria***
Bushmeat + health + nutrition	4.140	8
Bushmeat + health + zoonosis	2.140	19
Bushmeat + health + zootherapy	44	0
Bushmeat + health + "traditional medicine"	1090	9
Bushmeat + health + "medicinal animals"	38	4
"Wild meat" + health + nutrition	1.530	1
"Wild meat" + health + zoonosis	221	0
"Wild meat" + health + zootherapy	12	0
"Wild meat" + health + "traditional medicine"	326	0
"Wild meat" + health + "medicinal animals"	17	0
Combinations for search in spanish	**Results**	**Total references**
"carne de monte" + salud + nutrición	204	2
"carne de monte" + salud + zoonosis	20	0
"carne de monte" + salud + zooterapia	1	2
"carne de monte" + salud + "medicina tradicional"	153	1
"carne de monte" + salud + "animales medicinales"	0	0
"carne de animales silvestres" + salud + nutrición	81	0
"carne de animales silvestres" + salud + zoonosis	34	0
"carne de animales silvestres" + salud + zooterapia	1	0
"carne de animales silvestres" + salud + "medicina tradicional"	47	0
"carne de animales silvestres" + salud + "animales tradicionales"	0	0
Combinations for search in portuguese	**Results**	**Total references**
"carne de caça" + saúde + nutrição	299	1
"carne de caça" + saúde + zoonose	46	2
"carne de caça" + saúde + zoo terapia	9	1
"carne de caça" + saúde + "medicina tradicional"	65	0
"carne de caça" + saúde + "animais medicinais"	8	0
"carne de animais selvagens" + saúde + nutrição	12	0
"carne de animais selvagens" + saúde + zoonose	10	0
"carne de animais selvagens" + saúde + zoo terapia	3	0
"carne de animais selvagens" + saúde + "medicina tradicional"	1	0
"carne de animais selvagens" + saúde + "animais medicinais"	9	0
Combinations for search in french	**Results**	**Total references**
"viande de brousse" + santé + nutrition	158	1
"viande de brousse" + santé + zoonose	84	2
"viande de brousse" + santé + zoothérapie	1	0
"viande de brousse" + santé + "médecine traditionelle"	72	0
"viande de brousse" + santé + "animaux médicinaux"	0	0
Gibier + santé + nutrition	2150	0
Gibier + santé + zoonose	407	0
Gibier + santé + zoothérapie	13	0
Gibier + santé + "médecine traditionelle"	376	0
Gibier + santé + "animaux médicinaux"	5	0
TOTAL	3266	1
Snow ball		20
TOTAL	**13827**	**73**

2. ONLY studies containing information on the topics of interest to our research: We selected studies only if they provided primary information on one or more of the following topics: nutritional or toxic content of bushmeat, pathogens found in bushmeat species with potential transmission to humans (“zoonotic pool” in bushmeat species), and zoo-therapeutic uses of bushmeat.

3. Scientific merit: To ensure the scientific quality of the information reported, we only selected peer-reviewed documents such as scientific journal articles, book chapters, theses for an academic degree, or books.

4. ONLY studies providing primary information: Studies that used secondary data generated by other studies were not included. As far as possible, we tried to search for the primary source when it was cited in studies found through the word combination search.

The references that passed this first filter were then screened by their full text and selected using the secondary criteria below:

1. ONLY case studies from tropical and sub-tropical forests: We selected studies on bushmeat in tropical and sub-tropical forests as defined by Olson et al. (2001). Tropical forests are restricted to land area between the latitudes 23.5° North and 23.5° South of the equator, or in other words between the Tropic of Capricorn and the Tropic of Cancer. Tropical and Sub-tropical forests can be split into four areas: 1) Neotropical region, 2) Central Africa/ Afrotropical region, 3) Oriental or Indomalayan/Asian region and 4) Australasian region. We also included the Caatinga region in Brazil as several humid forest remnants are found in this ecosystem. Studies conducted in other parts of the world but referring to species that also occur in tropical and sub-tropical regions were also taken into account.

2. ONLY studies on bushmeat species hunted in the wild: We did not include studies that examined meat from wild species raised in domesticated environments.

3. ONLY studies referring to bushmeat species as defined by the Bushmeat Working Group from CITES: Bushmeat is defined as “meat for human consumption derived from wild animals” (CITES 2000). In addition, the CBD working group on bushmeat restricts the definition to mammals, birds, reptiles and amphibians (Nasi et al. 2008). This definition excludes aquatic animals, insects and molluscs. As such, the definition of bushmeat used here refers to mammals, birds, reptiles and amphibians consumed by humans for food or medicinal purposes.

4. Our focus is on bushmeat or the use of wild animals consumed for their meat, and not on wild animals in general. As such, for studies that reported on presence or prevalence of zoonotic diseases, we selected ***ONLY those that referred to zoonosis transmitted to humans through the handling or consumption of bushmeat.*** For studies on the zoo-therapeutic uses of bushmeat, we selected ***ONLY those that described the use of parts of the animal that are consumed for therapeutic purposes*** (meat, intestine, head, penis, fat, anus, bones etc.). Several studies on the zoonotic use of animals did not describe any consumptive use and were therefore not included. For example, studies on the use of snakes to produce creams for external use or objects used for witchcraft were not included in this study. Papers that only described a given species as being used for medicinal purposes without detailing the particular animal part(s) and its

specific use were also considered ineligible.

For each of the studies that passed our filter (N=112), we extracted the following information:

- For studies on the nutritional content or toxic contamination of bushmeat species: species, part of animal tested, micronutrients (Iron, Zinc, Potassium, Phosphorus, Calcium, Sodium, Manganese), lipids, fiber, protein, ash, carbohydrates, moisture, toxic content

- For studies on the zoo-therapeutic uses of bushmeat species: species, part of the animal used, preparation, target population, illness prevented, illness cured, ethnic origin of the users.

- For studies on the zoonotic pool of bushmeat species: species, part of the animal sampled, disease agent.

The information was organized in a structured database. Each of the studies was recorded in the database with information on authors, publication date, title, publication type, geographic position of study site, country.

RESULTS

General description of the data:

Among the 112 studies selected, 72 describe the zoonotic pool in bushmeat species, 21 report on the nutritional content of bushmeat and 19 report on the zoo-therapeutic uses of bushmeat (Figure 2).

Over the last 5 years, there has been an exponential increase in the number of studies on the zoonotic potential and nutritional value of bushmeat species. Studies on the zoo-therapeutic use of bushmeat have remained rather constant over the last 10 years.

Within the tropical and sub-tropical forests biome, the geographic distribution of case studies shows a concentration of studies in Africa (n=67) (Figure 3). A few studies report on Asia and the Pacific (India, Bangladesh, Australia, Malaysia, Thailand, China and Papua New Guinea, n=14). In Latin America and Caribbean (n=32), studies were conducted in Brazil, Peru, Ecuador, Saint Kitts, Colombia, Mexico, French Guiana and Venezuela. Studies on the zoonotic potential of bushmeat species are concentrated in Central Africa and West Africa, while studies on the nutritional content of bushmeat originate mainly from South America and West Africa. The zoo-therapeutic uses of bushmeat have seen greater research emphasis in Latin America and particularly Brazil compared to any other region.

Nutritional content and toxic contamination of bushmeat

Studies on the nutritional content of bushmeat vary in terms of the variables analyzed (vitamins, fat, moisture, carbohydrates, minerals, proteins, ash, fiber, metal element contaminations), in terms of the samples used (cooked, dried, salted, fresh, and smoked meat) and part of the animal used (meat, muscle, liver, kidney) (Annex 1). Some studies did not mention the species used for the analysis and the sample was only categorized as bushmeat.

Several studies conducted in sub-tropical and tropical forests of Africa analyzed the nutritional content of bushmeat. Malaisse and Parent (1982) concluded that rodents from the Miombo forest form an important subsidiary food whose nutritive value places them on the same level as beef or chicken. According to the authors, wild rodents, while not included in the F.A.O. Food Balance Sheets because they are not accounted for in national surveys, make a significant contribution to the quantity and quality of

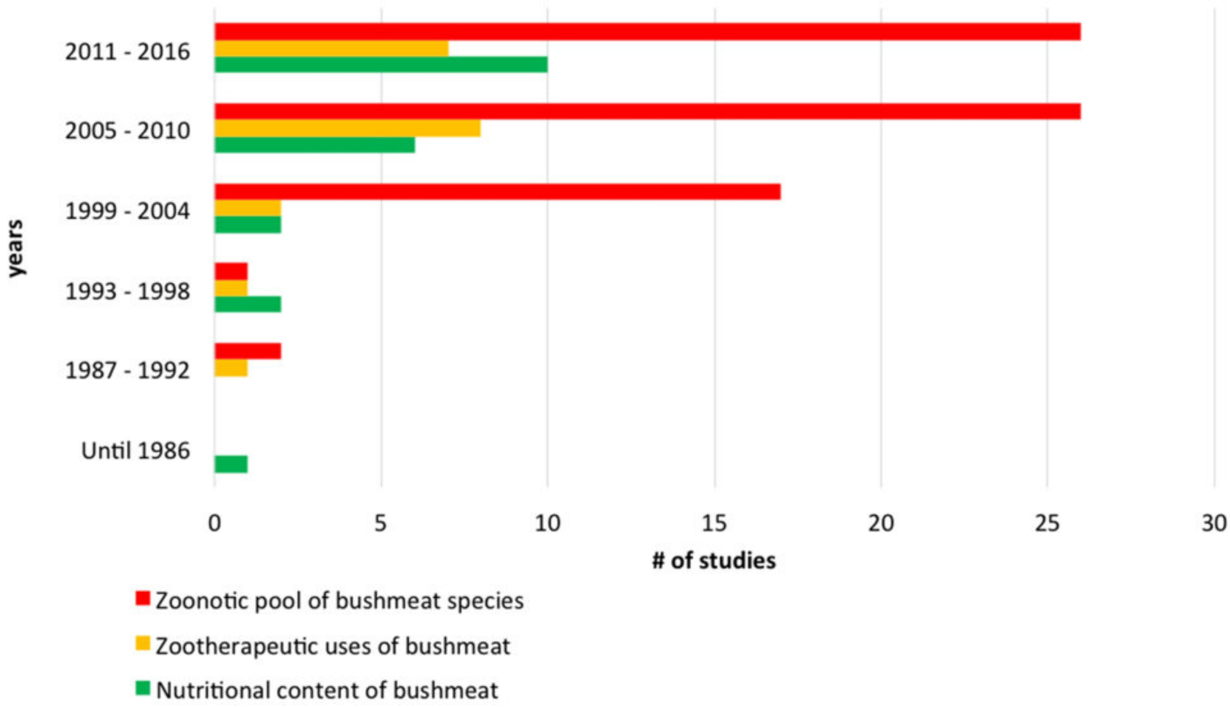

Figure 2. Number of studies per topic and year published

foods eaten by communities in rural areas. Olawale-Abulude (2007) analyzed the nutritional content of fresh bushmeat from a variety of species in Nigeria (including rodents, snakes, birds, bats and squirrels), and concluded that their use as sources of food was to be encouraged given their nutritional values in terms of protein and minerals and their good digestibility. Adei and Forson (2008) analyzed the livers of grass cutters and found higher concentrations of iron compared to the livers of domestic animals present in the market in Ghana. Similarly, Oyarekua et al. (2010) analyzed the nutrient composition of the African rat and concluded that the limb muscle was the more desirable in terms of nutritive value, due to its high iron, protein, potassium, magnesium and zinc content. Adeyeye and Jegede (2010) and Adeyeye et al. (2012) analyzed the amino acid profile of the greater cane rat and found that its muscle, liver and skin have high levels of most of the essential amino acids and phospholipids, although the skin and liver also contained high levels of cholesterol. Onadeko et al. (2011) analyzed the nutritional value of frogs (*Hoplobatrachus occipitalis, Xenopus muelleri* and *Ptychadena pumilio*) in Nigeria and concluded that the amino acid composition of frog meat can be compared to those of the *Clarias* sp. and *Tilapia* sp. and are valuable sources of protein for low-income consumers. Roger et al. (2012) analyzed the nutritional value of cooked bushmeat in Northern Cameroon with each sample representing a different bushmeat recipe. Niyi (2014) analyzed the nutritional content for the African wild antelope, *Antilocapra americana* in Nigeria and concluded that the meat was a positive source of protein, minerals and essential amino acids and had no negative health implications on the consumers since it had low levels of anti-nutrients (compounds that interfere with the absorption of nutrients). A

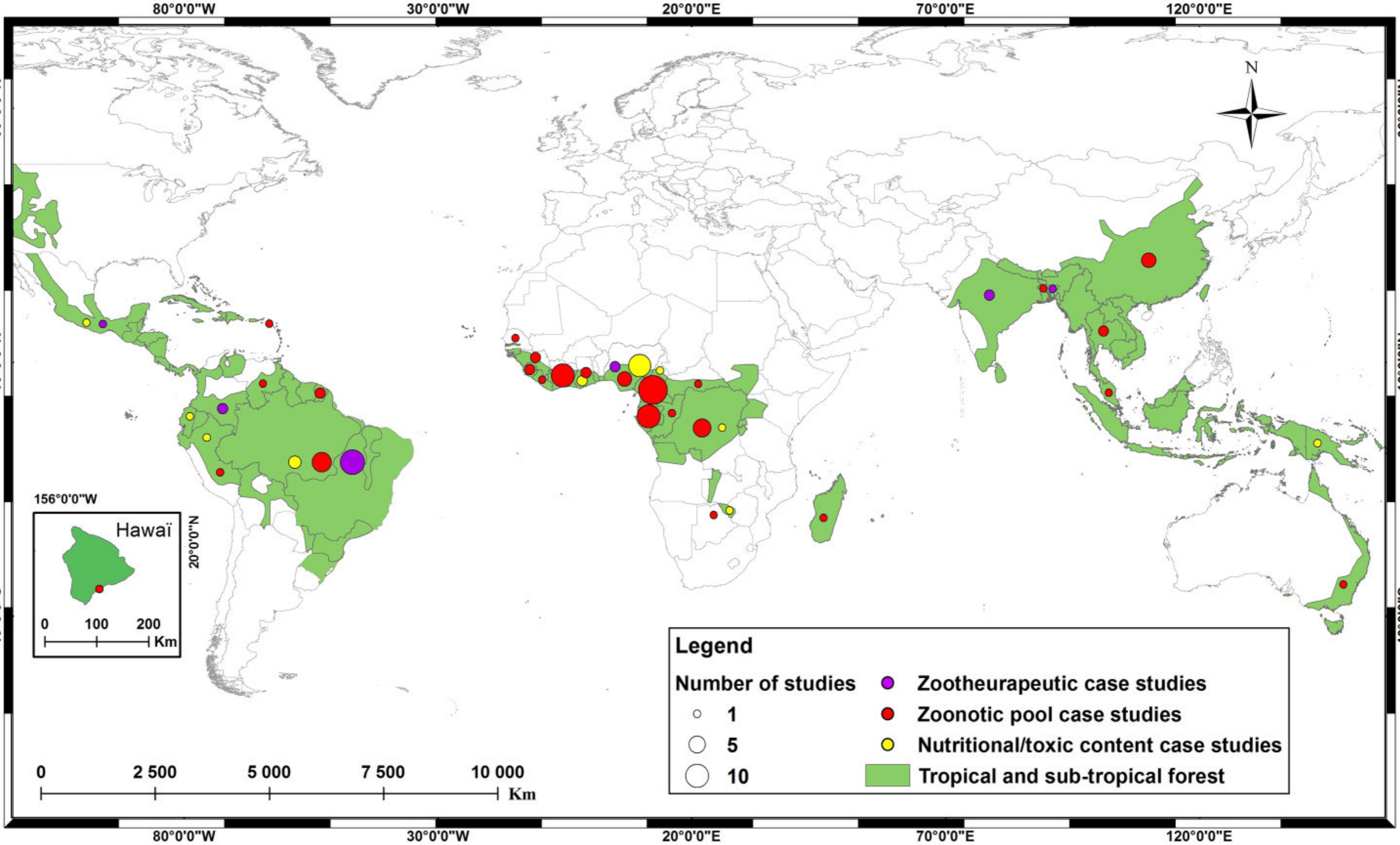

Figure 3. Location of case studies

recent study in Congo analyzed the fatty acid profile of blue duiker's meat and porcupine meat (Mananga et al. 2015) and concluded that the consumption of those two species provides essential linoleic and arachidonic fatty acids, which contribute to the plasticity of the organism, and oleic fatty acid which favors the development of the good cholesterol to prevent cardiovascular diseases.

Additional studies in Nigeria and Ghana analyzed the presence of toxic elements in bushmeat. Adei and Forson (2008) examined the livers of grass cutters in Ghana and concluded that livers can be a significant source of heavy metals (Cd, Hg, Pb) in the diet. Igene et al. (2015) and Soewu et al. (2014) analyzed metal contamination on fresh and dried grass cutter (Thryonomys swinderianus) in Nigeria and found the meat unsafe for consumption given their high concentration of nickel and chromium. The authors hypothesize that these concentration levels might come from contaminated water and soils due to mining or smelting waste-water production, cooking with nickel–steel alloy utensils, and eating from nickel-pigmented dishes. Yemi et al. (2015) found a high concentration of heavy metals in *Cephalophus* spp. hunted in an agricultural landscape from Nigeria that may be caused by acute or chronic contamination of their diet and habitat. Abdul et al. (2014) analyzed the polycyclic aromatic hydrocarbons (PAH) in smoked bushmeat in Ghana and found that bushmeat smoked with gas produced smaller PAH values compared to bushmeat smoked using wood mixed with spent oil, plastics mixed with refuse, and discarded car tires.

For Latin America, only six studies reported on the nutritional content of bushmeat. Aguiar (1996) analyzed the nutrient composition of several bushmeat species in the Brazilian Amazon and concluded that bushmeat species are generally low in fat content. The meat with the highest concentration of proteins was that of capybara (24,58g/100g). The meat with highest concentration of energy was that of tapir (127,34g/100g) and the meat with the highest content in fat was that of a Six-tubercled Amazon River turtle (*Podocnemis sextuberculata*, 5.56g/100g). Cordón and Salazar de Ariza (1999) analyzed the nutritional content of cooked meat from five species in Mexico (*Mazama americana, Pecari tayacu, Tayassu pecari, Crax* sp., *Cuniculus paca*), using a different recipe for each species, taking into account local culinary traditions. The study concluded that bushmeat consumption (every 15 days as observed in the studied communities) contributed significantly to healthy diets due to the high values of protein and minerals contained in the bushmeat species. Galvez et al. (1999) analyzed the nutritional content of the four most commonly consumed species in Iquitos, Peru (*Tayassu pecari, Geochelone denticulata, Agouti paca* and *Mazama americana*) and concluded that bushmeat contained a higher value of proteins and a lower fat content as compared to alternative proteins of domestic origin (beef, mutton, rabbit, etc). Siren and Machoa (2008) analyzed the nutrient content on bushmeat in Ecuador and found that if the availability of wild meat and fish decreases, the most serious effect would be a decrease in the already low intake of fat. Felix (2012) analyzed the nutritional quality of capybara meat in Brazil and found that it presented nutritional characteristics similar to those of farmed capybara, and that the meat from sustainably used capybara was suitable for commercialization based on its nutritional qualities. The study from Lemire et al. (2010) analyzed the content of selenium in various foods consumed by Amazonian riverside populations and found that paca (1,06 μg/g) and armadillo (0,52 μg/g) meat had a higher concentration of selenium than chicken and beef. Trace amounts of selenium are usually necessary for cellular function and may be important to counteract mercury (Hg) toxicity.

Only one study was found from Asia and the Pacific. Smith et al. (1993) analyzed the relationship between dietary composition and the height of children in Papua New Guinea and found that the consumption of bushmeat (together with fresh fish) had the strongest association with increased heights, and also contained the highest protein to energy ratios and high fat to energy ratios.

Zootherapeutic uses of bushmeat

Nineteen studies report on the zoo-therapeutic uses of bushmeat to either treat or prevent illnesses, and were conducted in India, Bangladesh, Nigeria, Brazil and Colombia (Annex 2). Different parts of the animals were used (e.g. the entire animal, its meat, intestines, penis, placenta, tail, anus, head, bill, gizzard), and their preparation with other ingredients (plant or animal products) were used in medicinal recipes to treat multiple diseases. In total, seventy-six bushmeat species were mentioned as having zoo-therapeutic purposes through their consumption.

In Nigeria, Adeola et al, (1992) described the use of 10 species by Nigerian farmers: the use of the intestines of *Cephalophus grimmia* (grey duiker) to cure stomach ache; the use of *Kinixys belliana* (a tortoise) to cure chest pain, the use of the intestines from *Crocodilus niloticus* (Nile crocodile) to prevent poisoning, the legs of *Phacochoerus africanus* (warthog) to prevent from lameness, the penis from *Gorilla gorilla* (gorilla) to prevent from poison, the head of *Manis tricuspis* (tree pangolin) to stop bleeding, the anus from *Civettictis civetta* (African civet) to prevent against convulsions, the intestines of *Atherurus africanus* (bush tailed porcupine) to cure stomach ache, the squirrel to prevent convulsions in children and python fat to cure rheumatism. The meat from African giant snail (*Achatina achatina* and *Achatina marginata*) is used to cure whooping cough, anemia, ulcer, asthma, hypertension, bone fracture and infertility in women (Agbogidi 2010). In addition, a certain number of species are used as aphrodisiacs (the penis of the chimpanzee, baboon, squirrel, warthog, buffalo, mona monkey, tree hyraz; the entire body of the tree hyrax, tortoise, parrot; the foot of the guinea fowl; the heart or tail of the cobra, the cane rat, and the puff adder) or to increase fertility in women (the flesh of the warthog, African civet, python, baboon, tortoise; the whole body of the bat, African giant rat, cane rat, African giant snail, squirrel and giant fowl; the placenta of the chimpanzee and mona monkey; the intestine of the cobra, puff adder and python).

In India, Solavan et al. (2014) described the use of *Varanus salvator* prepared with the skeleton and mixed with 3 liters of coconut milk, 50g of ganja leaf, administered twice a day for 40 days to cure arthritis, and the use of the meat from *Presbytis johnii* cooked with the seeds of *Piper nigrum*, the stem of *Zingiber officinale*, root of the *Allium sativum*, cow's ghee and the natural honey to cure asthma in children below 11 years old. In Assam, India, Hanse and Teron (2012), described the use of cooked meat from *Pteropus medius* (flying fox) to cure joint pain, the use of *Cervulus muntjac*, (barking deer) which legs are used to cook a soup that relieves chest pain, rheumatic pain and fever, and the use of *Vulpes* sp., fox, which flesh is cooked and eaten to relieve joint pain and fever. The Mro in Bangladesh cook the meat of *Sus scrofa*

(Eurasian wild pig) and *Canis aureus* (Asian Jackal) to relieve arthritis and rheumatism (Chowdhury et al., 2014).

In Brazil, fifty one species and different parts of the animals are consumed to treat or prevent diseases (see the long list in Annex 2) (Costa-Neto 2004; Alves and Filho 2006; Alves and Rosa 2007; Alves and Santana 2008; Alves et al. 2009; Ferreira et al. 2009; Alves et al. 2010; Barros et al. 2011; Ferreira et al. 2012; Pinto et al. 2012; Barros and Azevedo, 2014). The categories of illnesses most frequently mentioned were diseases of the respiratory tract (asthma, sore throat, and cough) and the musculoskeletal system and connective tissue. In Mexico, Morales-Mavíl and Villa-Cañedo (1998) report the use of dried meat from *Crotalus durissus* to prevent cancer, the meat from *Didelphis virginiana* cooked in a soup or smoked to cure skin problems and anemia, the use of the bone from the penis of *Nasua narica* consumed as aphrodisiac and the meat from *Conepatus semistriatus* as a remedy against acne. In Colombia, the Cofnes (an indigenous group from the Putumayo region) use the whole animal of *Didelphis marsupialis* to cure acne and purify blood (Camacho-Martínez 2013). The Pastos (another indigenous group from the Putumayo region) use *Cavia porcellus* for a variety of illnesses including stress, cold, weakness of the brain and headache, weakening of the uterus in women and avoid excessive salivary flow among children (Camacho-Martínez 2013). In the Pacific region of Colombia, rural populations use the fat from *Caiman crocodilus fuscus* to cure asthma, the biliary vesicle of *Cuniculus paca* as an analgesic, the liver from rodents (*Proechimys semispinosus, Hoplomys gymnurus, Didelphys marsupialis* and *Metachirus nudicaudatus*) as a hormonal stimulant to give birth, the fat from *Tamandua mexicana* to cure arthritis, the penis and testicles from *Potos flavus* as an aphrodisiac (Cuesta-Rios 2007).

Zoonotic pool in bushmeat species with potential spillover to humans

Because the study of reservoir systems and how infectious agents move between and within them can be complex, only a few cases provide evidence of the transmission of pathogens from wildlife to humans (Kurpiers et al. 2016). Several pathogens found in bushmeat species are zoonotic and may potentially be transmitted to humans. However, not all of them are transmitted through the consumption of bushmeat itself. Many viruses are actually transmitted to humans through exposure to body fluids and feces during the handling and butchering of bushmeat prior to cooking.

Tropical and sub-tropical forest areas in Africa

A detailed description of pathogens in bushmeat species from Africa is also available in Kurpiers et al. (2016). Here, we specifically report on the tropical and subtropical forests of Africa, where a total of 50 studies describe the existence of viruses, bacteria, protozoa and parasites in small primate species in particular, but also in ungulates, birds, reptiles, rodents and apes (see Annex 3). Twenty-five types of parasites were evidenced in bushmeat species from Africa. The most abundant parasites in bushmeat species were *Trichuris* sp., *Ancylostoma* sp., *Ascaris*, *Toxoplasma gondii* and *Strongyloides fulleborni,* most frequently transmitted from simians, rodents or ungulates to humans through a fecal-oral route (Annex 3: Zoonotic Parasites in bushmeat species from Africa).

The literature available provides records for nine main types of viruses (SIV; HTLVs, Foamy viruses, Monkey pox, Marburg virus, Lassa virus, Ebola, Nipah virus and Herpes) that can be transmitted to humans (Wolfe et al, 2004) and is hosted mainly by small primates, apes and Chiroptera (Annex 3: Zoonotic viruses present in bushmeat of species in Africa). Eight types of bacteria were reported in rodents, ungulates and apes (Annex 3: Zoonotic bacteria and other diseases present in bushmeat of species in Africa). The most common bacteria are *Escherichia coli*, *Salmonella* spp., and *Campylobacter* spp.

Latin America and Caribbean

In Latin America and Caribbean, thirteen studies describe the presence of parasites and bacteria in 19 bushmeat species (Annex 3: Zoonotic parasites in bushmeat of species in Latin America and Caribbean). *Toxoplasma gondii*, a ubiquitous protozoan parasite capable of infecting all warm-blooded animals, was found in several terrestrial mammals (Carme et al. 2002; Thoisy et al. 2003; Da Silva 2006; Truppel et al. 2010; Hamilton et al. 2014). Toxoplasmosis has a wide spectrum of clinical responses following infection, which ranges from acute fatal disease, congenital disease, behavioural changes and no obvious clinical signs (Innes 2010). *Echinococcus vogeli* was found in *Cuniculus paca* (Mayor et al. 2015), which is among the most hunted species in the Amazon region. The high prevalence of polycystic echinococcosis in pacas confirms that pacas are intermediate hosts. Because bushmeat viscera are usually used to feed dogs, humans might be consequentially infected through contact with feces from infected dogs. *Capillaria hepatica* was found in *Tayassu peccary* and *Ateles paniscus* (Pereira-Soares et al. 2011) and can be transmitted to humans if they consume the viscera of infected animals. *Tripanosoma cruzi*, responsible for Chagas disease, was found in porcupine (*Coendou* spp.), grey four eyed opossum (P*hilander opossum*) and nine-banded armadillo (*Dasypus novemcinctus*) (Coura et al. 2002). *Echinococcus vogeli*, responsable for echinococcosis disease and *Calodium hepaticum*, was found in paca (*Cuniculus paca*) (Almeida et al. 2013; Mayor et al. 2015).

Several bacteria responsible for gastroenteritis and enteric diseases were found in the raw meat of peccaries and capybara (Sarkis 2002; Annex 3: Zoonotic bacteria in bushmeat of species in Latin America and Caribbean) with possibilities for transmission to humans through the consumption of bushmeat species in rural and urban areas. *Brucella suis*, a type of bacteria that can cause diseases in humans and domestic animals of economic importance alike, was found in collared peccaries from Venezuela (Lord and Lord et al. 1991). Mycobacterium leprae was found in the nine-banded armadillo as well as in the six-banded armadillo (Cunga-Frota et al. 2012). The exact mode of transmission of leprosy between humans and armadillos is not known, but several studies have shown an association between the hunting, cleaning and eating of armadillos and the development of leprosy in human populations (Clark et al. 2008; Deps et al. 2008; Truman 2008). Armadillos are widely used in folk medicine and are a natural reservoir of etiological agents of several zoonotic diseases that affect humans such as leprosy, trichinosis, coccidioidomycosis or Valley Fever, Chaga's disease, typhus, and pulmonary micosis (Silva et al. 2005).

Asia and the Pacific

Very little data is available regarding the zoonotic pool of bushmeat species from Asia and the Pacific. *Escherichia coli* and *Salmonella* were found in kangaroo meat (Holds et al., 2007). Madar et al. (2012) found the presence of salmonella in Axis Axis in Hawai (see Annex 2: Zoonotic bacteria and parasites in bushmeat of species in Asia and Pacific). Four viruses were found in bushmeat species from Asia (Nipah virus, SARS coronavirus, Ebola, A/H5N1), particularly in bat species from South East Asia and China (see Annex 3: Zoonotic viruses present in bushmeat of species in Asia and Pacific).

DISCUSSION

Our findings are constrained by the type and nature of the collected information. For example, we were limited by not being able to select studies that did not make an explicit link between bushmeat and outcomes of interest (should they not make reference to the words bushmeat, game meat, or wild meat in the different languages used for the search). Studies on the nutritional content, zoo-therapeutic uses or zoonotic pool of wild animals that did not make explicit mention of consumptive use were excluded from this search to avoid collecting information on wild animals more broadly without consideration of their use as bushmeat. An alternative approach to find relevant studies would have been to conduct a species-by-species search based on the list of harvested animals for food in each of the geographical regions. However, this methodology would have expanded search efforts far beyond our capacity. Indeed, about 301 species for mammals alone, are known to be used for food (Ripple et al. 2016).

Despite these limitations, a striking result of this systematic review is the paucity of available data concerning the nutritional content of the most important bushmeat species, particularly from the tropical forests of Central and West Africa. Indeed, none of the nutritional studies provide data on species such as duikers, bush tailed porcupine and primates, which are among the most hunted species for food in the tropical forests of Africa (Nasi et al. 2011). Another striking result is the lack of standard methodology for the analysis of the nutritional content of bushmeat (part of the animal, state of the sample, variables measured, units used), which makes comparison between studies difficult. However, the majority of studies on the nutritional content of bushmeat species conclude that bushmeat contributes positively to overall dietary intake. These results are corroborated by other studies that have analyzed the nutritional status of bushmeat consuming populations. In traditional societies, bushmeat provides the greatest amount of daily calories (Smith et al. 1993), is a crucial source of micronutrients (Golden et al. 2011; Sarti et al. 2015) and fat (Siren and Machoa 2008) and continues to play an important role in terms of dietary diversity for modern forest societies (van Vliet et al. 2015). In their literature review, King and Furgal (2014) provided strong arguments for the consumption of wild meats based on their high nutritional content, especially in contexts where the incidence of obesity, diabetes, cardiovascular disease and their associated adverse health outcomes are increasing (e.g. among indigenous groups in the Artic). On the other hand, other studies also show that many tropical forest societies have been able to substitute bushmeat with other domestic protein sources in their dietary intake (Byron (2003) in Ecuador; Vega et al., (2013) in Equatorial Guinea).

Concerning the zoonotic pool of

bushmeat species, the collected studies clearly suggest that bushmeat does not constitute a health risk if strict hygiene and food safety practices with respect to the handling, butchering and preparation of bushmeat are followed. However, given current practices in forest regions, hunters may face risk of transmission if injured by an animal that is still alive, or when they carry their prey back home, or when they cut themselves during butchering (Subramanian 2012), facilitating the transfer of body fluids (LeBreton et al. 2006). The highest risk of disease transmission actually occurs during the butchering of animals, which includes women who engage in butchering at market and in food preparation. Very few precautions are taken by bushmeat users to avoid contact with bodily fluids (LeBreton et al. 2006; Yang et al. 2007; Kamins et al. 2014). For example, they do not typically use protective measures such as gloves (Kamins et al. 2014). According to Calvignac-Spencer et al. (2012), increased surveillance for zoonotic transmission of bushmeat pathogens to humans in areas where such transmission is more likely will contribute to a better understanding and prevention of risk factors. However, other factors besides hunting have also facilitated the spread of retroviruses (e.g deforestation, increased urbanization, travel, increased unsafe injections and transfusions) and their impact should also be carefully monitored to reduce transmission risks (Mouinga-Ondémé and Kazanji 2013). On the consumption side, bushmeat may represent a risk if the meat is inadequately cooked. Roasted bushmeat constitutes a high risk if only superficially roasted (Sidorowicz 1974). However, bushmeat is traditionally cooked for several hours before consumption, which reduces such risk, including the transmission of anthrax spores (Spotts Whitney et al. 2003) and monkeypox virus (Hahon and Kozikowski 1961). Bushmeat can also be contaminated by metals if the water, cooking utensils, and type of fuel used are not suitable for human consumption (Abdul et al. 2014; Igene et al. 2015). The means of transportation packing methods used during bushmeat transportation are other factors that may cause the contamination of bushmeat by pathogens. Food safety risks stemming bushmeat handling practices from tropical and sub-tropical forest areas is nonetheless comparable to deficiencies in domesticated meat handling practices in the same regions due to a lack of safe water, waste management, adequate infrastructure and knowledge with regards to food safety practices (King and Furgal 2014).

Concerning the zoonotic pool of bushmeat species, the available literature highlights the significant attention paid to viral infections linked to bushmeat handling practices (particularly that of primates) following the recent pandemics caused by zoonotic diseases (HIV and Ebola). On the other hand, bacterial and parasite infections have received less attention but constitute a major cause for the deaths of millions of users across tropical and sub-tropical forest areas. These common diseases deserve closer attention. Improving access to safe water, gloves, and modern tools for butchering and cooking could be envisaged among the strategies to reduce such disease transmission. Given the likely increase in consumption of non-traditional meats in the future (Hoffman and Cawthorn 2013), issues that would require further research include all facets of production and processing following the best and most culturally accepted food safety practices.

Several studies also report that a large number of animal species are used for medicinal purposes in rural and urban areas worldwide, particularly in African, Asian, and Latin American countries. In these areas, the trade of wildlife-based medicinal products is concentrated in local and traditional markets, where various species of medicinal plants and animals are commercialized (Alves et al. 2013b). The hygiene of medicinal products sold at markets is unknown, but probably varies enormously between traders and traditional healers (Mander et al. 2007). In Brazil, for example, Alves and Rosa (2007) ranked the sanitary conditions of the zoo-therapeutic products as poor. Alves et al. (2013b) highlights the need for further assessments of the sanitary conditions of commercialized medicinal products, as well as the need for the implementation of measures to address the sanitary aspects of the trade in animals and their parts for medicinal or nutritional purposes.

Another dimension of health that was not addressed in this study but that requires further consideration is the role of mental health. Indeed, hunting and its associated social and cultural forms have shown to contribute to the mental health and cultural continuity in traditional communities (Samson Pretty 2006). Thomas (1987) used the term "meat hunger" to refer to the mental health problems (complaints of tiredness, loss of vital strength and depression), related to the occasional lack of meat among nomadic hunter-gatherers like African Pygmies and Punan (Thomas 1987). As such, bushmeat is essential for health not only because it is a vital source of nutrients, but also because it contributes the vitality of hunters and communities at large (Motte-Florac et al. 1993). According to Dounias and Froment (2011), mental diseases like stress and depression are increasingly observed among former forest foragers, partly because sedentism has decreased their access to meat from the forest.

"Is bushmeat healthy or the opposite?" is not a simple question. Despite the importance of this question, the existing literature appears to have approached this question in a fragmented manner. This paper demonstrates the need for more in-depth studies in tropical and sub-tropical forest regions about the complex links between bushmeat and human health, particularly concerning the nutritional content of bushmeat, the pathogens that may see zoonotic transmission and the zoo-therapeutic uses of bushmeat. The results generated should help the development and testing of innovative approaches to reduce the negative impacts of bushmeat consumption on human health through better food handling and conservation practices, and further acknowledge the positive nutritional and medicinal values of bushmeat use. Further studies should also take into consideration that hunting and bushmeat consumption are not practiced in isolation of culture, society, economics, environment, politics or technology. A balance needs to be struck between the quantitative perspectives of epidemiology, and the powerful qualitative information derived from other disciplines. Bushmeat management will depend on understanding and working with people, with any approach based too narrowly in one or the other disciplines running the risk of failure in the long term (Cawthorn Hoffman, 2015). The reviewed literature also demonstrates the importance of understanding hunting and bushmeat consumption practices within the changing environments in which they are occurring (van Vliet et al. 2015). As such, trans-disciplinary approaches (including ethnozoology, epidemiology, anthropology, sociology, food technology, biology and ecology, etc) need to be integrated to recognize that the links between bushmeat and human health arise from highly complex interactions.

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Annex 1. Nutritional content of bushmeat species from tropical forest regions (cells highlighted in bold correspond to cooked or smoked meat): moisture, ash, protein, energy, fibre, lipid, carbohydatres and some essential minerals

	Phosphorus (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)	Magnesium (mg/100g)	Sodium (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)	Manganese (mg/100g)	Carbohydrates g/100G	Lipids g/100G	Fibre g/100G	Energy Kcal	Protein g/100G	Ash g/100G	Moisture g/100G	Source
Atherurus africanus										2.16						Mananga, 2015
Antelocapra americana	96	292	198	142	261	15.0	39	ND	57.17	5.32	ND		24.76	4.67	8.08	Niyi, 2014
Aethomys kaiseri		270	400			15				3		109	19.1	2	73.1	Malaisse and Parent, 1982
Bubulus ibis		555	407	481	518	5.1	3.3	4.30	9.83	2.14	0.14		76.72	6.41	4.79	Olawale-Abudule, 2007
Caiman yacare									0	0.56		91.62	21.87	0.74	76.93	Aguiar, 1996
Cephalophus sp.			**2.1**	**1.2**		**4.2**	**7.2**	**23.3**	**0.6**	**12**	**0.1**		**36.9**	**2.4**	**48**	**Roger et al., 2012**
Cephalophus sp.			**2.4**	**3.1**		**5.2**	**7.2**	**23.2**	**0.1**	**14**	**0**		**42.3**	**5.1**	**38.5**	**Roger et al., 2012**
Cephaluphus monticola										2.6						Mananga, 2015
Columba guinea G		194	507	538	611	5.0	1.0	5.70	0.84	13.38	2.68		60.63	15.54	7.05	Olawale-Abudule, 2007
Cricetomys gambianus		610	532	620	490	9.8	1.4	2.80	2.44	6.94	1.04		48.64	16.76	3.26	Olawale-Abudule, 2007
Cricetomys gambianus	750	1387	50			73	175	260	1	11.4			20.1	2	65.4	Orayekua and Keticu, 2010
Cricetomys gambianus						44.9	4.9									Adei and Forson-Adaboh, 2008
Cricetomys gambianus		**360**	**400**			**10**		**2.1**		**4.7**		**224**	**42.6**	**2.6**	**49.1**	**Malaisse and Parent, 1982**
Cuniculus paca	**2**		**59**										**45**	**5**	**74.7**	**Galvez et al., 2001**
Cuniculus paca	**48.**	**593**	**90**	**38**		**5**	**4**					**205**	**28.3**	**3.8**		**Cordon and de Ariza, 2001**

	5															
Cuniculus paca									2.29	2.66		112.78	19.92	0.63	74.5	Aguiar, 1996
Dasyprocta punctata									1.40	1.21		93.93	19.30	0.82	77.21	Aguiar, 1996
Eidolon helron		473	489	488	640	5.2	1.2	4.80	19.50	6.42	1.62		56.12	10.22	6.12	Olawale-Abudule, 2007
Epicrates anquifer		38	248	489	714	3.8	3.5	2.50	5.97	3.77	2.53		63.50	20.11	3.38	Olawale-Abudule, 2007
Estrilda astrild			**3.1**	**0.7**		**5.2**	**1.2**	**17.2**	**0.7**	**8.7**	**0.2**		**24.1**	**1.3**	**65**	**Roger et al., 2014**
Geochelone denticulata	**2**		**51**										**44**	**2.9**	**74.6**	**Galvez et al., 2000**
Hoplobatrachus occipitalis										1.06			19.45	1.28	77.85	Ondeko et al., 2011
Hydrochoerus hydrochaeris	204		31			0				1.48			20.65	1.2	74.75	Aparecida-Felix, 2012
Hydrochoerus hydrochaeris									1.53	0.62		110.02	24.5	13.64	59.63	Aguiar, 1996
Hyemoschus aquaticus			**0.1**	**3.7**		**2.1**	**17.4**	**14.1**	**0.3**	**11**	**0.2**		**70.5**	**13**	**5**	**Roger et al., 2016**
Leptopogon amaurocephalus									**1.44**	**3.54**		**104.77**	**16.82**	**1.04**	**77.82**	**Aguiar, 1996**
Lophuromys flavopunctatus		170	300			7				2.9		144	27.5	2.6	66.7	Malaisse and Parent, 1982
Mazama americana	**2**		**65**										**46.5**	**3.8**	**73.9**	**Galvez et al., 2002**
Mazama americana	**49.2**	**509**	**40**	**43**		**4**	**5**					**179**	**28.8**	**3.9**		**Cordon and de Ariza, 2000**
Mazama americana									1.10	1.08		110.02	23.95	0.86	73.01	Aguiar, 1996
Pecari tayacu	**49.8**	**540**	**33**	**40**		**4.3**	**4**					**201**	**37.8**	**4**		**Cordon and de Ariza, 2003**
Pecari tayacu									0.74	1.46		92.62	19.45	0.74	77.93	Aguiar, 1996
Phasianus colchicus	**47.6**	**42**	**103**	**28**		**18**	**8**					**171**	**32.0**	**2.7**		**Cordon and de Ariza, 1999**
Potamochoerus porcus			**1.9**	**1.7**		**4,6**	**5.1**	**19.5**	**0.3**	**12.8**	**0**		**63.1**	**3.8**	**20**	**Roger et al., 2007**
Podocnemis expansa									0	1.10		94.58	21.17	0.85	76.88	Aguiar, 1996
Podocnemis unifilis									0	1.68		96.32	20.30	0.77	77.25	Aguiar, 1996
Praomys tullbergi		260	482	578	275	7.6	1.2	2.50	11.56	6.51	ND		48.59	24.63	8.53	Olawale-Abudule, 2007

Ptychadena pumilio										0.97			19.79	1.26	78.96	Onadeko et a., 2011
Python regius		428	419	480	699	4.2	4.2	4.60	22.13	3.62	1.84		47.99	19.20	5.22	Olawale-Abudule, 2007
Python sebae			**3.5**	**7.8**		**2.4**	**3.5**	**32.4**	**0**	**14**	**0**		**56**	**10**	**20**	**Roger et al., 2012**
Scicurus carolinensis		625	475	560	655	6.8	2.4	2.40	35.08	7.21	1.25		28.72	10.64	10.10	Olawale-Abudule, 2007
Tapirus terrestris (salted)									1.72	3.54		127.34	22.15	9.01	63.49	Aguiar 1996
Tayassu tajacu	**2**		**64**										**46**	**5**	**75**	**Galvez et al., 1999**
Tayassu tajacu	**49.4**	**663**	**15**	**33**		**4**	**5**					**198**	**18.8**	**2.6**		**Cordon and de Ariza, 2002**
Thryonomys swinderianus		730	549	607	624	11.1	4.4	4.00	19.90	4.20	ND		22.70	0.90	52.30	Olawale-Abudule, 2007
Thryonomys swinderianus						57.2	5.4	23.8								Adei and Forson-Adaboh, 2008
Thryonomys swinderianus		**380**	**300**			**7**				**16.8**		**271**	**28**	**2.9**	**52**	**Malaisse and Parent, 1982**
Udagenthuss bengalus			**1.1**	**0.2**		**7.3**	**2.2**	**21.2**	**0.4**	**7.5**	**0**		**29.2**	**0.9**	**62**	**Roger et al., 2012**
Varanus exanthematicus			**3.1**	**1.3**		**7.2**	**2.9**	**14.3**	**0**	**10.4**	**0**		**68.6**	**5**	**16**	**Roger et al., 2012**
Xenopus muelleri										1.81			19.53	1.17	75.6	Onadeko et al., 2011
Wistar rat		625	486	574	600	7.2	1.8	2.60	34.88	4.00	1.00		28.00	6.42	25.70	Olawale-Abudule, 2007

Annex 2. Zootherapeutic uses of bushmeat

Species	Part of the animal	Target population	illness cured	ethnical origin of the users	Country	Source
Achatina achatina and Achatina Marginata	meat	All population	Used to cure whooping cough, aneamia, ulcer, asthma, hypertension, bone fracture, infertility in women	NA	Nigeria	Agbogidi, 2010
Atherurus africanus	intestine	All population	Used for stomach ache	Nigerian farmers	Nigeria	Adeola, 1992
Cephalophus grimmia	Intestine	all population	Stomach ache	Nigerian farmers	Nigeria	Adeola, 1992
Squirrel	whole	children	Prevention for convulsion in children	Nigerian farmers	Nigeria	Adeola, 1992
Python	fat	All population	Ingredient to cure rheumatism	Nigerian farmers	Nigeria	Adeola, 1992
Crocodilus niloticus	Intestine	all population	Prevention against poison	Nigerian farmers	Nigeria	Adeola, 1992
Gorilla gorilla	penis	All population	Drug for prevention against poison	Nigerian farmers	Nigeria	Adeola, 1992
Manis tricuspis	head	All population	Use in stopping bleeding	Nigerian farmers	Nigeria	Adeola, 1992
Phacochoerus africanus	legs	All population	Prevention of lameness	Nigerian farmers	Nigeria	Adeola, 1992
Kinixys belliana	Whole	all population	Chest pain	Nigerian farmers	Nigeria	Adeola, 1992
Agouti paca	penis	All population	Sexual impotence	Afrodescendant s	Brazil	Ferreira *et al.*, 2012
Boa constrictor	fat	All population	Rheumatism, backache	NA	Brazil	Alves *et al.*, 2010
	Skin, tail, head, fat	All population	Asthma, ulcer, stomach ache, infection, crysipelas, inflammation, rheumatism, luxation, diabetes, heart disease, leprosy	Afrodescendant s	Brazil	Alves and Filho, 2006
Bothrops sp.	fat	All population	Rheumatism, pain relief in injuries caused by sting of insect or snkae bites	Afrodescendant s	Brazil	Alves and Filho, 2006
Bradypus variegatus	Claw, skin, bones	All population	Asthma	NA	Brazil	Alves *et al.*, 2009
	Leather, fat	All population	Ulcer, asthma	NA	Brazil	Alves *et al.*, 2010
Caiman corcodilus acutus	skin	All population	Asthma, allergies, epilepsy	NA	Brazil	Alves *et al.*, 2009
	fat	All population	Asthma	Afro-descendants	Colombia	Cuesta-Rios, 2007
Callithrix sp.	meat	NA	Asthma	NA	Brazil	Alves and Rosa, 2007
Cathartes sp.	meat	NA	Tuberculosis	NA	Brazil	Costa-Neto, 2004
Caudison durissa	Fat, rattle, bone, skin	All population	Asthma, sore throat, earache, toothache, cough, bronchitis, snake bites, stroke, muscular pain, epilepsy, cancer, tuberculosis	Afrodescendant s	Brazil	Ferreira *et al.*, 2012
Cayman latirostris	Leather, fat	All population	Asthma, thrombosis, rheumatism	NA	Brazil	Alves *et al.*, 2010
Cerdocyon thous	Fat and liver	All population	Rheumatism and bronchitis	NA	Brazil	Ferreira *et al.*, 2009

	Fat, bone	All population	Earache, asthmatic bronchitis	NA	Brazil	Alves *et al.*, 2010
	fat	All population	Snake bites, sore throat, rheumatism	Afrodescendants	Brazil	Ferreira *et al.*, 2012
Chelonia mydas	fat	All population	Asthma, arthritis, backache, stroke, eryspelas, stomach ache	Afrodescendants	Brazil	Ferreira *et al.*, 2012
Chelonoides sp.	fat	All population	Sore throat cough, asthma, backache, inflammations	Afrodescendants	Brazil	Ferreira *et al.*, 2012
Chelonoidis denticulata	Whole animal	All population	Hemorrhage	NA	Brazil	Alves *et al.*, 2009
Civectis civetta	anus	All population	Prevention against convulsions	Nigerian farmers	Nigeria	Adeola, 1992
Cnemidophorus ocellifer	Whole animal	All population	Stroke, thrmbosis, cancer, hemorrhoids	Afrodescendants	Brazil	Ferreira *et al.*, 2012
Coendou prehensilis	spine	All population	Asthma and stroke	NA	Brazil	Alves *et al.*, 2009
	spine	All population	Ulcer, asthma	NA	Brazil	Alves *et al.*, 2010
	spine	All population	Asthma, bronchitis, cough, thrombosis, cancer, eczema, acne, toothache, stroke, earache	Afrodescendants	Brazil	Ferreira *et al.*, 2012
Conepatus semistriatus	meat	All population	Acne	NA	Mexico	Morales-Mavíl and Villa-Cañedo,1998
	Bones	All population	Cough and osteoporosis	NA	Brazil	Alves *et al.*, 2009
Coragyps atratus	Meat and whole animal	All population	Asthma, cought and alcoholism	NA	Brazil	Ferreira *et al.*, 2009
	liver	All population	alcoholism	NA	Brazil	Alves *et al.*, 2009
Coralus canirus	Whole animal	All population	Pain, relief in injures caused by sting of insect and snake bites	Afrodescendants	Brazil	Alves and Filho, 2006
Crotalus durissus	meat	All population	Against cancer	NA	Mexico	Morales-Mavíl and Villa-Cañedo,1998
	meat	NA	Rheumatism	NA	Brazil	Costa-Neto, 2004
	fat	All population	Snake bites, bruises, rheumatism, inflammations, arthritis, alleviate tremor	NA	Brazil	Ferreira *et al.*, 2009
	Fat, skin, rattle, head, eye	All population	Gastritis, rheumatism, spine, kidney disease, swelling, asthma, cancer, osteoporosis, boils,thrombosis	Afrodescendants	Brazil	Alves and Filho, 2006
	Rattle and fat	All population	Epilepsy, backache, asthma, osteoporosis, arthritis, variocele, edema, earache	NA	Brazil	Alves *et al.*, 2009
	fat, leather oil	All population	Rheumatism, backache	NA	Brazil	Alves *et al.*, 2010
Cuniculus paca	bill	All population	Analgesic	Afro-descendants	Colombia	Cuesta-Rios, 2007
Dasypus novemcinctus	Fat meat and tail	All population	Rheumatism, burns, inflammmations, pain in bones, ear aches and deafness	NA	Brazil	Ferreira *et al.*, 2009
	Paw, tail, fat, skin	All population	Asthma, headache, inflammation and stomach ache	NA	Brazil	Alves *et al.*, 2009
	Fat and tail	All population	Deafness, earache, asthma, burns, sinusitis, cough, pain, inflammation, urinary infection, strain, rheumatism	Afrodescendants	Brazil	Ferreira *et al.*, 2012
Desmodus rotundus	Whole animal	All population	Asthma, stroke, rheumatism	Afrodescendants	Brazil	Ferreira *et al.*, 2012

Didelphis albiventris	bones	All population	Cough and osteoporosis	NA	Brazil	Alves *et al.*, 2009
	Fat	All population	Inguinal bubo, furuncles	NA	Brazil	Alves *et al.*, 2010
Didelphis Marsupialis	meat	All population	rheumatism, asthma, sore throat, and inflammation	NA	Brazil	Barros and Azevedo, 2014
	Whole	all population	acne and blood purification	Cofanes	Colombia	Camacho-Martínez, 2013
	liver	women	Hormonal stimulant to give birth	Afro-descendants	Colombia	Cuesta-Rios, 2007
Didelphis virginicana	meat	All population	To cure skin problems and anemia	NA	Mexico	Morales-Mavíl and Villa-Cañedo,1998
Epicrates cenchria	fat	All population	Rheumatism, sore throat	Afrodescendant s	Brazil	Alves and Filho, 2006
	fat	All population	Sore throat, rheumatism, swelling, backache, arthrosis, burns, and toothache	Afrodescendant s	Brazil	Ferreira *et al.*, 2012
	Fat	All population	Rheumatism	NA	Brazil	Alves *et al.*, 2010
Eunectes murinus	fat	All population	Rheumatism, infection, erysipelas, inflammation, asthma, thrombosis	Afrodescendant s	Brazil	Alves and Filho, 2006
	fat	All population	Erysipelas	NA	Brazil	Alves *et al.*, 2009
Euphractus sexcinctus	Fat, meat and tail	All population	Rheumatism, burns, inflammmations, pain in bones, ear aches and deafness	NA	Brazil	Ferreira *et al.*, 2009
	Fat, skin, tail, paw	All population	Arthritis, asthma, stroke, loss of hearing, headache	NA	Brazil	Alves *et al.*, 2009
	Fat, tail, and legs	All population	Deafness, earache, asthma, burns, sinusitis, cough, pains, inflammations,rheumatism, sexual impotence, tuberculosis, infections, and osteoporosis	Afrodescendant s	Brazil	Ferreira *et al.*, 2012
Hoplomys gymnurus	liver	Women	Hormonal stimulant to give birth	Afro-descendants	Colombia	Cuesta-Rios, 2007
Iguana iguana	fat	All population	Ear aches, score throat and inflammations	NA	Brazil	Ferreira *et al.*, 2009
	Fat and tail	All population	Earache, deafness, sore throat, inflammations, swelling	Afrodescendant s	Brazil	Ferreira *et al.*, 2012
	fat	All population	Festering inflamation	NA	Brazil	Alves *et al.*, 2010
Lacheris muta	fat	All population	Rheumatism	Afrodescendant s	Brazil	Alves and Filho, 2006
Leopardus pardalis	eyes	All population	Asthma, sexual impotence	Afrodescendant s	Brazil	Ferreira *et al.*, 2012
Leptodactylus labyrinthicus	fat	All population	Sore throat, cough asthma, arthritis, backache	Afrodescendant s	Brazil	Ferreira *et al.*, 2012
	fat	All population	Score throat	NA	Brazil	Ferreira *et al.*, 2009
Leptodactylus vastus	fat	All population	Sore throat, cough, asthma, arthritis, backache	Afrodescendant s	Brazil	Ferreira *et al.*, 2012
Leptophis ahaetula	whole	All population	Pain relief in injuries caused by sting of insect or snkae bites	Afrodescendant s	Brazil	Alves and Filho, 2006
Mazama americana	Tibia	All population	Asthma	NA	Brazil	Alves *et al.*, 2010
Mazama gouazoubira	Tail, tibia	All population	Asthma, sore throat, rheumatism, arthritis	Afrodescendant s	Brazil	Ferreira *et al.*, 2012
Metachirus nudicaudatus	liver	women	Hormonal stimulant to give birth	Afro-descendants	Colombia	Cuesta-Rios, 2007

Micrurus ibiboboca	fat	All population	Rheumatism, asthma, toothache, sore throat, cough, osteoporosis, swelling, inflammations, arthritis	Afrodescendants	Brazil	Ferreira *et al*., 2012
Micrurus sp.	Whole, fat	All population	Rheumatism, sting of the snakes and insects	Afrodescendants	Brazil	Alves and Filho, 2006
Myrmecophaga tridactyla	skin	All population	Stroke	Afrodescendants	Brazil	Ferreira *et al*., 2012
Oxyrhopus trigeminus	whole	All population	Sting of the snakes and insects	Afrodescendants	Brazil	Alves and Filho, 2006
	fat	All population	Asthma, thrombosis, rheumatism	NA	Brazil	Alves *et al*., 2010
Paleosuchus palpebrosus	leather, fat	All population	Asthma, thrombosis, rheumatism	NA	Brazil	Alves *et al*., 2010
Pauxi tuberosa	bill	All population	Insect or snake bite	Colono and ingenous population	Brazil	Barros *et al*., 2011
	gizzard	All population	Pneumonia, bleeding, indigestion, stroke	Colono and ingenous population	Brazil	Barros *et al*., 2011
	gizzard	children	Cure the lack of appetite	Colono and ingenous population	Brazil	Barros *et al*., 2011
Philodryas olfersii	Whole animal	All population	Stroke	Afrodescendants	Brazil	Ferreira *et al*., 2012
Phrynops geoffroanus	fat	All population	Erysipelas, arthrities, rheumatism, eczemas, skin problems, bruises	NA	Brazil	Alves *et al*., 2009
	fat, hoof	All population	Vitiligo, asthma, earache, tonsillitis	NA	Brazil	Alves *et al.*, 2010
Phrynops tuberosus	Fat and blood	All population	Score throat, rheumatism, inflammations, asthma	NA	Brazil	Ferreira *et al.*, 2009
Podocnemis expansa	fat	All population	Fat is mostly used externally but also consumed to cure diversity of illnesses	NA	Brazil	Alves and Santana, 2008
Proechimys semispinosus	liver	women	Hormonal stimulant to give birth	Afro-descendants	Colombia	Cuesta-Rios, 2007
Cavia porcellus	Whole	all population	stress, cold, weakness of the brain and headache	Pastos	Colombia	Camacho-Martínez, 2013
	Whole	women	weakening of the matrix	Pastos	Colombia	Camacho-Martínez, 2013
	Whole	children	avoid excessive salivary flow	Pastos	Colombia	Camacho-Martínez, 2013
Progne chalybea	Whole animal	All population	Alcoholism	NA	Brazil	Ferreira *et al*., 2009
Pteropus medius	meat	All population	Join pain	Karbi, Dimasa, Bodo, Assamese, Bengoli, Nepali, Kuki, Garo	India	Hanse and Teron, 2012
Rhea americana	fat	All population	Cough	NA	Brazil	Alves *et al.*, 2010
Rhinella jimi	fat	All population	Bruises, inflammations, arthritis	NA	Brazil	Ferreira *et al.*, 2009
	Skin and fat	All population	Sore throat, asthma, flu, cough, rheumatism, inflammation, backache, osteoporosis, arthrosis, arthritis, diarrhea, toothach, infections, earache		Brazil	Ferreira *et al.*, 2012
Spilotes pullatus	whole	All population	Pain relief in injuries caused by sting of insect or snkae bites	Afrodescendants	Brazil	Alves and Filho, 2006
	Bone and fat	All population	Sore Throat, cancer, and inflammations	Afrodescendants	Brazil	Ferreira *et al.*, 2012
Tamandua mexicana	fat	All population	Arthritis	Afro-descendants	Colombia	Cuesta-Rios, 2007

Tamandua tetradactyla	fat	All population	Clean blood and cure asthma	NA	Brazil	Pinto *et al.*, 2012
Tropidurus hispidus	Whole animal	All population	Sore throat	NA	Brazil	Alves *et al.*, 2010
Tropidurus semitaeniatus	Whole animal	All population	Pharyngitis, asthma, “throat cyst”	NA	Brazil	Alves *et al.*, 2010
Tupinambis merianae	Fat and tail	All population	Score throat, coughs, asthma, headache, bruises, inflammations, rheumatism, flu, bronchitis, arthritis, arthrosis, back ache, tooache, healing, deafness and earches	NA	Brazil	Ferreira *et al.*, 2009
	Fat and skin	All population	Earache, kidney pain, loss of hearing, backache, skin problems, inflammation, sore throat, asthma	NA	Brazil	Alves *et al.*, 2009
	Fat, skin, and tail	All population	Burns, osteoporosis, healing, headache	Afrodescendant s	Brazil	Ferreira *et al.*, 2012
	fat	All population	Catarrh, asthma, throat, furuncle, tonsillitis, earache	NA	Brazil	Alves *et al.*, 2010
Varanus salvator	meat	all population	Arthritis	Irular, Kanikaran, Kattunayakan, Kota, Kurimbas, Palliyan, Paniyan, Sholaga and Toda	India	Solavan *et al*, 2004
Vulpes sp.	meat	All population	Relieves pain and fiever	Karbi, Dimasa, Bodo, Assamese, Bengoli, Nepali, Kuki, Garo	India	Hanse and Teron, 2012
Presbytis johnii	meat	children below 11 years	Asthma	Irular, Kanikaran, Kattunayakan, Kota, Kurimbas, Palliyan, Paniyan, Sholaga and Toda	India	Solavan *et al*, 2004
Canis aureus	meat	All population	Relieves arthritis and reumathism	Mro	Bengladesh	Chowdhury *et al.*, 2014
Cervulus muntjac	meat	All population	Chest pain, rheumatic pain and fever	Karbi, Dimasa, Bodo, Assamese, Bengoli, Nepali, Kuki, Garo	India	Hanse and Teron, 2012
Sus Scrofa	meat	All population	Relieves arthritis and reumathism	Mro	Bengladesh	Chowdhury et al., 2014

Annex 3. Zoonotic agents in bushmeat species from Africa, Latin America/Caribbean and Asia/Pacific

AFRICA

Zoonotic parasites in bushmeat species from Africa.

Order	*Common name*	*Species*	*Part of the animal*	*Pathogen or Disease agent*	*Disease*	*Reference*
Reptile	Python	*Python sp.*	meat	*Armillifer*	Snakeborne *Armillifer* pentastomiasis	Tappe *et al.*, 2016
	Ornate monitor lizards	*Varanus ornatus*	Faeces	*Strongyloides papillosus*	Enteric disease, gastroenteritis, others	Okoye *et al.* 2015
				Trichuris trichiura		
				Ascaris lumbricoides		
				Entamoeba histolytica		
	African savannah monitor lizards	*Varanus exanthematicus*	Faeces	*Capillaria bursata*	Enteric disease, gastroenteritis, others	Okoye *et al.* 2015
				Trichuris trichiura		
				Ascaris lumbricoides		
				Dicrocoelium hospes		
				Entamoeba histolytica		
Rodent	Brush tailed porcupine	*Atherurus africanus*	meat	*Toxoplasma gondii*	Toxoplasmosis	Lussac, 2010
	Cane rat	*Thryonomys swinderianus*	meat	*Toxoplasma gondii*	Toxoplasmosis	Lussac, 2010
			Faeces	Strongyle ova	Gastrointestinal disease	Adejinmi and Emikpe, 2011
			feaces	Strongyloides	Gastrointestinal disease	Adejinmi and Emikpe, 2011
			feaces	Trichuris	Gastrointestinal disease	Adejinmi and Emikpe, 2011
			feaces	Cestode	Gastrointestinal disease	Adejinmi and Emikpe, 2011
			feaces	Ascaris	Gastrointestinal disease	Adejinmi and Emikpe, 2011
			Faeces	*Trichuris trichiura*	Enteric disease, gastroenteritis, others	Okoye *et al.* 2015
				Ascaris lumbricoides		
				Metastrongylus elongates		
				Globocephalus diducta		
				Oesophagostomum columbianum		
				Moniliformis moniliformis		
	Wild rabbits	*Oryctolagus cuniculus*	Faeces	*Trichostrongylus retortaeformis*	Enteric disease, gastroenteritis, others	Okoye *et al.* 2015
				Enterobius vermicularis		
				Ancylostoma sp.		
				Taenia saginata		
				Dicrocoelium hospes		

	Striped land squirrels	*Xenus erythropus*	Faeces	*Trichuris trichiura*	Enteric disease, gastroenteritis, others	Okoye *et al.* 2015
				Ascaris lumbricoides		
				Heligmosomoides polygyrus		
				Hymenolepsis nana		
				Moniliformis moniliformis		
Ungulate	Bay duiker	*Cephalophus dorsalis*	meat	*Toxoplasma gondii*	Toxoplasmosis	Lussac, 2010
	Grey duiker	Sylvicapra grimmia	feaces	Strongyle ova	Gastrointestinal disease	Adejinmi and Emikpe, 2011
			feaces	Trichuris	Gastrointestinal disease	Adejinmi and Emikpe, 2011
			feaces	Ascaris	Gastrointestinal disease	Adejinmi and Emikpe, 2011
			feaces	Cestode	Gastrointestinal disease	Adejinmi and Emikpe, 2011
			feaces	*Strongyloides papillosus*	Enteric disease, gastroenteritis, others	Okoye *et al.* 2015
				Ascaris lumbricoides		
				Trichostrongylus retortaeformis		
				Metastrongylus elongatus		
				Oesophagostomum columbianum		
	Blue duiker	*Cephalophus monticola*	meat	*Toxoplasma gondii*	Toxoplasmosis	Lussac, 2010
	Maxwell's Duikers	*Philantomba maxwellii*	Faeces	*Strongyloides papillosus*	Enteric disease, gastroenteritis, others	Okoye *et al.* 2015
				Ascaris lumbricoides		
				Metastrongylus elongatus		
	Chevrotain	*Hyemoschus aquaticus*	meat	*Toxoplasma gondii*	Toxoplasmosis	Lussac, 2010
Bird	Yellow billed turaco	*Tauraco macrorhynchus*	meat	*Toxoplasma gondii*	Toxoplasmosis	Lussac, 2010
	Bush fowls	*Francolinus bicalcarutus*	Faeces	*Strongyloides papillosus*	Enteric disease, gastroenteritis, others	Okoye *et al.* 2015
				Capillaria bursata		
				Ascaridia galli		
				Eimeria tenella		
	Guinea fowls	*Numida meleagris*	Faeces	*Capillaria bursata*	Enteric disease, gastroenteritis, others	Okoye *et al.* 2015
				Ascaridia galli		
				Ascaris lumbricoides		
				Eimeria tenella		
	Senegal coucal	*Centropus senegalensis*	meat	*Toxoplasma gondii*	Toxoplasmosis	Lussac, 2010
Primates	Mustached monkeys	*Cercopithecus cephus*	meat	*Entamoeba coli*	Gastrointestinal disease	Pourrut *et al.* 2011
				Strongyloides fulleborni		
				Ancylostoma sp.		
				Trichuris sp.		
				Ascaris sp.		
				Bertiella sp.		
	Mona monkey	*Cercopithecus mona*	meat	*Entamoeba coli*	Gastrointestinal disease	Pourrut *et al.* 2011
				Strongyloides fulleborni		

				Ancylostoma sp.		
				Trichuris sp.		
				Capillaria sp.		
	De Brazza's monkey	*Cercopithecus neglectus*	meat	*Entamoeba coli*	Gastrointestinal disease	Pourrut *et al.* 2011
				Strongyloides fulleborni		
				Ancylostoma sp.		
				Trichuris sp.		
				Capillaria sp.		
				Ascaris sp.		
	Greater spot-nosed monkey	*Cercopithecus nictitans*	meat	*Entamoeba coli*	Gastrointestinal disease	Pourrut *et al.* 2011
				Endolimax histolitica		
				Strongyloides fulleborni		
				Ancylostoma sp.		
				Trichuris sp.		
				Capillaria sp.		
				Enterobius sp.		
				Ascaris sp.		
	Crested mona	*Cercopithecus pogonias*	meat	*Entamoeba coli*	Gastrointestinal disease	Pourrut *et al.* 2011
				Strongyloides fulleborni		
				Ancylostoma sp.		
				Trichuris sp.		
				Capillaria sp.		
				Ascaris sp.		
	Agile mangabey	*Cercocebus agilis*	meat	*Entamoeba coli*	Gastrointestinal disease	Pourrut *et al.* 2011
				Strongyloides fulleborni		
				Ancylostoma sp.		
				Trichuris sp.		
				Enterobius sp.		
				Ascaris sp.		
	Mantled guereza	*Colobus guereza*	meat	*Strongyloides fulleborni*	Gastrointestinal disease	Pourrut *et al.* 2011
				Ancylostoma sp.		
				Trichuris sp.		
	Grey-cheeked mangabey	*Lophocebus albigena*	meat	*Ancylostoma sp.*	Gastrointestinal disease	Pourrut *et al.* 2011
				Enterobius sp.		
				Ascaris sp.		
	Northern Talapoin Monkey	*Miopithecus ogouensis*	meat	*Entamoeba coli*	Gastrointestinal disease	Pourrut *et al.* 2011
				Strongyloides fulleborni		
				Ancylostoma sp.		
				Ascaris sp.		
	Chimpanzee	*Pan troglodytes*	meat	*Entamoeba coli*	Gastrointestinal disease	Pourrut *et al.* 2011
				Strongyloides fulleborni		
				Ancylostoma sp.		
	Greater bamboo Lemur	*Prolemur simus*	Feaces	*Cryptosporidium*	Enteric disease, gastroenteritis, others	Rasambainarivo, 2013
	Brown mouse Lemur	*Microcebus rufus*	Feaces	*Cryptosporidium*	Enteric disease, gastroenteritis, others	Rasambainarivo, 2013
Carnivore	African palm civet	*Nandinia binotata*	Tissue	*Trichinella britovi*	Trichinosis disease	Pozio *et al.*, 2005
	True civet	*Viverra civette*	Tissue	*Trichinella britovi*	Trichinosis disease	Pozio *et al.*, 2005

Zoonotic viruses present in bushmeat of species in Africa.

Order	Common name	Species	Part of the animal	Pathogen or Disease agent	Disease	Reference
Ungulate	Duiker	*Cephalophus sp.*	blood	*Ebola virus*	Ebola virus disease	Leroy *et al.*, 2004a
Primate	Agile mangabey	*Cercocebus agilis*	meat	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Peeters *et al*. 2002
			blood	*Simian T-lymphotropic virus type 1*	*adult T-cell leukemia, neurological disorders such as HTLV-1- associate myelopathy (HAM) also known as tropical spastic paraparesis (TSP), and has also been associated with inflammatory diseases*	Liégeois *et al*. 2008
			blood	*Simian T-lymphotropic virus type 2*	*Neurological disease*	Liégeois *et al*. 2009
	Sooty mangabey	*Cercocebus atys*	meat	*Simian T-lymphotropic virus type 1*	Plethora of Simian Immunodeficiency Viruses	Apetrei *et al*. 2005
			meat	*Orthopox virus*	Monkey pox disease	Apetrei *et al*. 2005
			blood	*Simian T-lymphotropic virus type 1*	*T-cell leukemia or lymphoma and HTLV- 1–associated myelopathy or tropical spastic paraparesis*	Calvignac-Spencer *et al*. 2012
			muscle	*Simian foamy virus*	Plethora of Simian Immunodeficiency Viruses	Smith *et al.*, 2012
			blood	*Simian Immunodeficiency virus*	Plethora of Simian Immunodeficiency diseases	Ayouba *et al*., 2013
			blood	*Ebola virus*	Ebola virus disease	Leroy *et al.*, 2004
	Red-capped mangabey	*blood*	blood	*Simian T-lymphotropic virus type 2*	*Neurological disease*	Liégeois *et al*. 2008
			blood	*Simian T-lymphotropic virus type 3*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al*. 2012
			blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Aghokeng *et al*., 2010
			blood	*Simian T-lymphotropic virus type 1*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al*. 2013
			blood	*Simian Foamy Virus*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé *et al*. 2012
			blood	*Simian T-lymphotropic virus type 1*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé and Mirdad Kazanji 2013
	Red tailed monkey	*Cercopithecus ascanius*	blood	*Simian T-lymphotropic virus type 3*	Plethora of Simian Immunodeficiency Viruses	Ahuka-Mundeke *et al*. 2012
	Mustached guenon	*Cercopithecus cephus*	Meat and blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Peeters *et al*. 2002 Courgnaud *et al*. 2003 Aghokeng *et al*., 2007
			meat	*Simian T-lymphotropic virus type 2*	*adult T-cell leukemia, neurological disorders such as HTLV-1- associate myelopathy (HAM) also known as tropical spastic paraparesis (TSP), and has also been associated with inflammatory diseases*	Liégeois *et al*., 2008

		meat	*Simian T-lymphotropic virus type 1*	Neurological disease	Liégois *et al*., 2008
		blood	*Simian T-lymphotropic virus type 1*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al*. 2012
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al*. 2013
		meat	*Simian Foamy Virus*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé *et al*. 2012
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency viruses	Aghokeng *et al*., 2010
Mona monkey	*Cercopithecus mona*	meat	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Peeters *et al*. 2002
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Courgnaud *et al*. 2003
De Brazza's monkey	*Cercopithecus neglectus*	meat	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Peeters *et al*. 2002
		blood	*Simian Foamy virus*	Plethora of Simian Immunodeficiency Viruses	Wolfe *et al*., 2004
		blood	*Simian T-lymphotropic virus type 3*	Plethora of Simian Immunodeficiency Viruses	Ahuka-Mundeke *et al*. 2012
		blood	*Simian T-lymphotropic virus type 1*	Plethora of Simian Immunodeficiency Viruses	Ahuka-Mundeke *et al*. 2012
		meat	*Simian Foamy Virus*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé *et al*. 2012
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Aghokeng *et al*., 2010
Greater spot-nosed monkey	*Cercopithecus nictitans*	meat	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Peeters *et al*. 2002
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Aghokeng *et al*., 2010
		blood	*Simian immunodeficiency virus*	*No reports transmission to humans*	Courgnaud *et al*. 2002
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Courgnaud *et al*. 2003
		blood	*Simian T-lymphotropic virus type 1*	*adult T-cell leukemia, neurological disorders such as HTLV-1- associate myelopathy (HAM) also known as tropical spastic paraparesis (TSP), and has also been associated with inflammatory diseases*	Liégeois *et al*. 2008
		blood	*Simian T-lymphotropic virus type 1*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al*. 2012
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al*. 2013
		meat	*Simian Foamy Virus*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé *et al*. 2012
		blood	*Simian Foamy Virus*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé and Mirdad Kazanji 2013
		muscle	*Betha herpes virus*	Herpes	Smith *et al*., 2012

Primate	Crested mona	*Cercopithecus pogonias*	meat	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Peeters *et al*. 2002
			blood	*Simian T-lymphotropic virus type 1*	*adult T-cell leukemia, neurological disorders such as HTLV-1- associate myelopathy (HAM) also known as tropical spastic paraparesis (TSP), and has also been associated with inflammatory diseases*	Liégeois *et al*. 2008
			blood	*Simian T-lymphotropic virus type 1*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al*. 2012
	Sun-tailed monkey	*Cercopithecus solatus*	blood	*Simian Foamy Virus*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé *et al*. 2012
				Simian immunodeficiency virus	Plethora of simian immunodeficiency viruses	Beer *et al*., 1999
	Wolf's monkey	*Cercopithecus wolfi*	blood	*Simian Foamy Virus*	Plethora of Simian Immunodeficiency Viruses	Ahuka-Mundeke *et al*. 2012
	Green monkey	*Chlorocebus sabeus*	Bone marrow	*Betha herpes virus Gamma herpesvirus*	Herpes	Smith *et al*., 2012
			blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Aghokeng *et al*., 2010
			Bone marrow	*Simian foamy virus*	Plethora of Simian Immunodeficiency Viruses	Smith *et al*., 2012
	Angola pied colobus	*Colobus angolensis*	blood	*Simian T-lymphotropic virus type 1*	Plethora of Simian Immunodeficiency Viruses	Ahuka-Mundeke *et al*. 2012
	Mantled guereza	*Colobus guereza*	meat	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Peeters *et al*. 2002
			blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Aghokeng *et al*., 2010
	Gorilla	*Gorilla gorilla*	blood	*Simian Foamy virus*	Plethora of Simian Immunodeficiency Viruses	Wolfe *et al*., 2004
			blood	*Simian Foamy virus*	Plethora of Simian Immunodeficiency Viruses	Calattini *et al*., 2007
			blood	*Ebola virus*	Ebola virus disease	Leroy *et al*., 2004
			meat	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Peeters *et al*. 2002
	Grey-cheeked mangabey	*Lophocebus albigena*	blood	*Simian T-lymphotropic virus type 2*	*adult T-cell leukemia, neurological disorders such as HTLV-1- associate myelopathy (HAM) also known as tropical spastic paraparesis (TSP), and has also been associated with inflammatory diseases*	Liégeois *et al*. 2008
			blood	*Simian T-lymphotropic virus type 1*	*Neurological disease*	Liégeois *et al*. 2009
			blood	*Simian Foamy Virus*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé *et al*. 2012
			blood	*Simian T-lymphotropic virus type 1*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé and Mirdad Kazanji 2013
			blood	*Simian Foamy Virus*	Plethora of Simian Immunodeficiency Viruses	Ahuka-Mundeke *et al*. 2012
	Black mangabey	*Lophocebus aterrimus*	meat	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Peeters *et al*. 2002
	Grey-cheeked mangabey	*Lophocebus albigena*	blood	*Simian T-lymphotropic virus type 2*	*adult T-cell leukemia, neurological disorders such as HTLV-1- associate myelopathy (HAM) also known as tropical spastic*	Liégeois *et al*. 2008

				paraparesis (TSP), and has also been associated with inflammatory diseases	
		blood	*Simian T-lymphotropic virus type 1*	*Neurological disease*	Liégeois *et al*. 2009
		blood	*Simian Foamy Virus*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé *et al.* 2012
		blood	*Simian T-lymphotropic virus type 1*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé and Mirdad Kazanji 2013
		blood	*Simian Foamy Virus*	Plethora of Simian Immunodeficiency Viruses	Ahuka-Mundeke *et al.* 2012
Black mangabey	*Lophocebus aterrimus*	blood	*Ebola virus*	Ebola virus disease	Leroy *et al*., 2004
Drill	*Mandrillus leucophaeus*	blood	*Simian Foamy virus*	Plethora of Simian Immunodeficiency Viruses	Wolfe *et al*., 2004
Mandrill	*Mandrillus sphinx*	blood	*Simian Foamy virus*	Plethora of Simian Immunodeficiency Viruses	Wolfe *et al*., 2004
		blood	*Ebola virus*	Ebola virus disease	Leroy *et al*., 2004
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Ndembi *et al*. 2007
		blood	*Simian T-lymphotropic virus type 1*	*adult T-cell leukemia, neurological disorders such as HTLV-1- associate myelopathy (HAM) also known as tropical spastic paraparesis (TSP), and has also been associated with inflammatory diseases*	Liégeois *et al*. 2008
		blood	*Simian T-lymphotropic virus type 3*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al*. 2012
		blood	*Simian T-lymphotropic virus type 1*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al*. 2013
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al*. 2014
		meat	*Simian Foamy Virus*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé *et al.* 2012
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Mouinga-Ondémé and Mirdad Kazanji 2013
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Aghokeng *et al*., 2010
		meat	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Tsujimoto *et al*., 1989 Peeters et al. 2002
		meat	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Tsujimoto *et al*., 1989 Peeters et al. 2002
		blood	*Ebola virus*	Ebola virus disease	Leroy *et al*., 2004
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Ndembi *et al*. 2007
		blood	*Simian T-lymphotropic virus type 1*	*adult T-cell leukemia, neurological disorders such as HTLV-1- associate myelopathy (HAM) also known as tropical spastic paraparesis (TSP), and has also been associated with inflammatory diseases*	Liégeois *et al*. 2008
		blood	*Simian T-lymphotropic virus type 3*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al*. 2012
		blood	*Simian T-lymphotropic*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al*. 2013

			virus type 1		
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al.* 2014
		meat	*Simian Foamy Virus*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé *et al.* 2012
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Mouinga-Ondémé and Mirdad Kazanji 2013
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Aghokeng *et al.*, 2010
		meat	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Peeters *et al.* 2002 Liégeois *et al.*, 2006
Gabon talapoin	*Miopithecus ogoouensis*	blood	*Simian T-lymphotropic virus type 1*	*adult T-cell leukemia, neurological disorders such as HTLV-1- associate myelopathy (HAM) also known as tropical spastic paraparesis (TSP), and has also been associated with inflammatory diseases*	Liégeois *et al.* 2008
		blood	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Aghokeng *et al.*, 2010
		blood	*Ebola virus*	Ebola virus disease	Leroy *et al.*, 2004
Chimpanzee	*Pan troglodytes*	blood	*Ebola virus*	Ebola virus disease	Formenty *et al.*, 1999
		blood	*Simian Foamy virus*	Plethora of Simian Immunodeficiency diseases	Calattini *et al.*, 2007
		blood	*Simian imunodeficiency virus*	Plethora of Simian Immunodeficiency diseases	Vanden Haesevelde *et al.*, 1996
		blood	*Simian imunodeficiency virus*	Plethora of Simian Immunodeficiency diseases	Corbet *et al.*, 2000
		blood	*Simian imunodeficiency virus*	Plethora of Simian Immunodeficiency diseases	Etienne *et al.*, 2011
		blood	*Simian Foamy Virus*	Plethora of Simian Foamy Virus and Prototype foamy virus	Mouinga-Ondémé *et al.* 2012
		blood	*Simian T-lymphotropic virus type 1*	T-cell leukemia or lymphoma and HTLV- 1–associated myelopathy or tropical spastic paraparesis	Leenderz *et al.*, 2004b Calvignac-Spencer *et al.* 2012
	Pan troglodytes verus	muscle	*Simian Foamy virus*	Plethora of Simian Immunodeficiency diseases	Smith *et al.*, 2012
	Pan troglodytes eliotti	blood	*Ebola virus*	Ebola virus disease	Leroy *et al.*, 2004
Olive baboon	*Papio anubis*	Spinal nerce	*Simian Foamy virus*	Plethora of Simian Foamy and Prototype foamy virus	Smith *et al.*, 2012
Baboon	*Papio papio*	Optic nerve, eye	*Betha herpes virus* *Gamma herpes virus*	Herpes	Smith *et al.*, 2012
		Blood, tissue	*Simian T-lymphotropic virus type 1*	*T-cell leukemia or lymphoma and HTLV- 1–associated myelopathy or tropical spastic paraparesis*	Calvignac-Spencer *et al.* 2012 Leendertz *et al.*, 2010
Red colobus monkey	*Piliocolobus badius badius*	Blood, tissue	*Simian immunodeficiency virus*	Plethora of Simian Immunodeficiency Viruses	Liégeois *et al.*, 2009 Locatelli *et al.*, 2008 Locatelli *et al.*, 2008a

						Leendertz *et al*., 2010
			Blood, tissue	*Simian Foamy Virus*	Plethora of Simian Immunodeficiency Viruses	Leendertz *et al.*, 2010
			blood	*Simian Foamy Virus*	Plethora of Simian Immunodeficiency Viruses	Ahuka-Mundeke *et al.* 2012
	Thsuapa red colobus	*Piliocolobus tholloni*	Blood and tissue	*Simian immunodeficiency viruses*	Plethora of simian immunodeficiency viruses	Liégois *et al*., 2009
	Olive colobus	*Procolobus verus*	Animal tissue	Orthopoxvirus	*Human monkey pox*	Reynolds *et al*., 2010
Rodent	Pouched rat	*Cricetomys* sp.	blood	*Nipah virus*	*acute encephalitis and respiratory illness*	Pernet *et al.*, 2012
Chiroptera	Straw colour fruit bat	*Eidolon helvum*	blood	Ebola virus	*Ebola virus disease*	Hayman *et al*., 2010
			blood	*Ebola virus*	*Ebola virus disease*	Pourrut *et al*., 2009
	Franquet's Epauletted	*Epomops franqueti*	Animal tissue	Orthopoxvirus	*Human monkey pox*	Reynolds *et al.*, 2010
	Dormouse	*Graphiurus* sp.	Animal tissue	Orthopoxvirus	*Human monkey pox*	Reynolds *et al.*, 2010
	Sun Squirrel	*Heliosciurus sp.*	blood	*Ebola virus*	*Ebola virus disease*	Pourrut *et al.*, 2009
	Hammer headed bat	*Hypsignathus monstrosus*	blood	*Ebola virus*	*Ebola virus disease*	Pourrut *et al.*, 2009
	Peter's dwarf epauletted fruit bat	*Micropteropus pusillus*	blood	*Ebola virus*	*Ebola virus disease*	Pourrut *et al*., 2009
	Angolan free tailed bat	*Mops condylurus*	blood	*Ebola virus*	*Ebola virus disease*	Pourrut *et al*., 2009
	Little collared fruit bat	*Myonycteris torquata*	blood	*Marburg virus*	Marburg virus disease	Swanepoel *et al.*, 2007
	Eloquent horseshoe bat	*Rhinolophus eloquens*	blood	*Marburg virus*	Marburg virus disease	Swanepoel *et al.*, 2007
	Egyptian fruit bat	*Rousettus aegyptiacus*	blood	*Ebola virus*	*Ebola virus disease*	Pourrut *et al*., 2009

Zoonotic bacteria and other diseases present in bushmeat of species in Africa.

Order	***Common name***	***Species***	***Part of the animal***	***Pathogen or Disease agent***	***Pathogen Type***	***Disease***	***Reference***
Rodent	African-crested porcupine	*Atherurus africanus*	bushmeat	*Sallmonella spp.*	Bacteria	*Enteric disease, gastroenteritis*	Bachand *et al.* 2012
	Gambian Pouched Rat	*Crycetomys gambianus*	Tongue, biceps, muscles	Trichinella	Bacteria	Trichinellosis	Mbaya *et al.*, 2010
Ungulate	African buffalo	*Syncerus caffer*	smoked game meat	*Escherichia coli*	Bacteria	Enteric disease, gastroenteritis	a Mpalang *et al.* 2013
				Salmonella spp.			
				Campylobacter spp.			
	Warthog	*Phacochoerus aethiopicus*	smoked game meat	*Escherichia coli*	Bacteria	Enteric disease, gastroenteritis	a Mpalang *et al.* 2013
				Salmonella spp.			
				Campylobacter spp.			
	common duiker	*Sylvicapra grimmia*	smoked game meat	*Escherichia coli*	Bacteria	Enteric disease, gastroenteritis	a Mpalang *et al.* 2013
Primate	Chimpanzee	*Pan troglodytes verus*	Lung tissue Tissue and bones	*Bacillus anthracis*	Bacteria	Respiratory and gastro-intestical diseases	Leendertz *et al.*, 2004 Leendertz *et al.*, 2006
	Gorilla	*Gorilla gorilla*	Tissue and boes	*Bacillus anthracis*	Bacteria	Respiratory and gastro-intestical diseases	Leendertz *et al.*, 2006
	Broad nose gentle Lemur	*Prolemur simus*	NA	*Cryptosporidium sp.* *Giardia sp.*	protozoa	Cryptosporidiosis	Rasambainarivo 2013
	Brown mouse Lemur	*Microcebus rufus*	NA	*Cryptosporidium sp.* *Giardia sp.*	protozoa	Cryptosporidiosis	Rasambainarivo 2013
Carnivore	Banded mangoose	*Mungos mungo*	kidney	*Leptospira interrogans*	bacteria	Leptospirosis	Jobbins *et al.*, 2014

Latin America and Caribbean

Zoonotic parasites in bushmeat of species in Latin America and Caribbean

Order	*Common name*	*Species*	*Part of the animal*	*Pathogen or Disease agent*	*Disease*	*Reference*
Primate	Wild-caught Caribbean green monkey	*Chlorocebus sabaeus*	Blood	*Toxoplasma gondii*	Toxoplasmosis	Hamilton *et al.* 2014
	Howler monkey	*Alouatta seniculus*	Serum	*Toxoplasma gondii*	Toxoplasmosis	Carme *et al*, 2002
	Howler monkey	*Alouatta seniculus*	Serum	*Toxoplasma gondii*	Toxoplasmosis	Thois et al., 2003
	Spider monkey	*Ateles paniscus*	liver	*Capillaria hepatica*	*hepatic fibrosis of varying degree and granulomatous inflammation*	Pereira-Soares *et al.* 2011
Rodent	Porcupine	*Coendou spp*	Serum	*Trypanosoma cruzi*	Chagas disease	Coura *et al.*, 2002
	Kinkajou	*Potos flavus*	Serum	*Toxoplasma gondii*	Toxoplasmosis	Thois *et al.*, 2003
Carnivore	Tayra	*Nasua nasua*	Serum	*Toxoplasma gondii*	Toxoplasmosis	Thois *et al.*, 2003
Pilosa	Anteater	*T.tetradactyla*	Serum	*Toxoplasma gondii*	Toxoplasmosis	Carme *et al*, 2002
			Serum	*Toxoplasma gondii*	Toxoplasmosis	Thois *et al.*, 2003
Didelphimorphia	Opossum	*Didelphis marsupialis*	Serum	*Toxoplasma gondii*	Toxoplasmosis	Carme *et al*, 2002
			Serum	*Toxoplasma gondii*	Toxoplasmosis	Thois *et al.*, 2003
	Grey for eyed opossum	*Philander opossum*	Serum	Trypanosoma cruzi	Chagas disease	Coura *et al.*, 2002
	White eared opossum	*Didelphis albiventris*	Serum	*Toxoplasma gondii*	Toxoplasmosis	Thois *et al.*, 2003
Ungulate	Collared peccary	*Tayassu tayacu*	Serum	*Toxoplasma gondii*	Toxoplasmosis	Carme *et al*, 2002
			Serum	*Toxoplasma gondii*	Toxoplasmosis	Thois *et al.*, 2003
	White leaped peccary	*Tayassu pecari*	liver	*Capillaria hepatica*	*hepatic fibrosis of varying degree and granulomatous inflammation*	Pereira-Soares *et al.* 2011
	Deer	*Massama spp.*	serum	*Toxoplasma gondii*	Toxoplasmosis	Carme *et al*, 2002
			serum	*Toxoplasma gondii*	Toxoplasmosis	Thois *et al.*, 2003
	Agouti	*Dasyprocta puntata*	serum	*Toxoplasma gondii*	Toxoplasmosis	Carme *et al*, 2002
			serum	*Toxoplasma gondii*	Toxoplasmosis	Thois *et al.*, 2003
	Acouchy	*Myoprocta acouchy*	serum	*Toxoplasma gondii*	Toxoplasmosis	Thois *et al.*, 2003
	Paca	*Cuniculus paca*	Thoracic, abdominal organs, liver	*Echinococcus vogeli*	*Polycystic echinococcosis*	Mayor *et al.* 2015 Almeida *et al.*, 2013
			liver	Calodium hepaticum	focal necrosis	Almeida *et al.*, 2013

			serum	*Toxoplasma gondii*	Toxoplasmosis	Carme *et al,* 2002
			serum	*Toxoplasma gondii*	Toxoplasmosis	Thois *et al.,* 2003
	Capybara	*Hydrochaeris hydrochaeris*	blood	*Toxoplasma gondii*	Toxoplasmosis	Truppel *et al.* 2010
Cingulata	Nine-banded armadillo	*Dasypus novemcinctus*	serum	*Toxoplasma gondii*	*Toxoplasmosis*	da Silva *et al.* 2006
			serum	*Toxoplasma gondii*	Toxoplasmosis	Carme *et al,* 2002
			serum	*Toxoplasma gondii*	Toxoplasmosis	Thois *et al.,* 2003
			serum	Trypanosoma cruzi	Chagas disease	Coura *et al.* 2002
	Six-banded armadillo	*Euphractus sexcinctus*	serum	*Toxoplasma gondii*	*Toxoplasmosis*	da Silva *et al.* 2006

Zoonotic bacteria in bushmeat of species in Latin America and Caribbean

Order	Common name	Species	Part of the animal	Pathogen or Disease agent	Disease	Reference
Ungulates	Capibara	*Hydrochaeris hydrochaeris*	raw meat	*Staphylococcus aureus*	*Food poisoning con nausea, vomiting, abdominal pain and prostration*	Sarkis 2002
				Clostridium	*Gastroenteritis*	
				Fecal coliforms	*Enteric disease, gastroenteritis*	
	Collared peccary	*Tayassu tajacu*	raw meat	*Staphylococcus aureus*	*Food poisoning con nausea, vomiting, abdominal pain and prostration*	Sarkis 2002
			raw meat	*Clostridium*	*Gastroenteritis*	Sarkis 2002
				Fecal coliforms	*Enteric disease, gastroenteritis*	
			spleen, liver, mesenteric and retropharyngeal lymph nodes, sera, eyes and blood	*Brucella suis*	Several infections	Lord *et al.* 1991
	Javali	*Sus scrofa scrofa*	raw meat	*Staphylococcus aureus*	*Food poisoning con nausea, vomiting, abdominal pain and prostration*	Sarkis 2002
				Clostridium	*Gastroenteritis*	
				Fecal coliforms	*Enteric disease, gastroenteritis*	
Cingulata	Nine-banded armadillo	*Dasypus novemcinctus*	ear, nose, liver and spleen	*Mycobacterium leprae*	*Leprosy*	Cunga-Frota et al. 2012
	Six-banded armadillo	*Euphractus sexcinctus*	ear, nose, liver and spleen	*Mycobacterium leprae*	*Leprosy*	Cunga-Frota et al. 2012

Asia and Pacific region

Zoonotic bacteria and parasites in bushmeat of species in Asia and Pacific

Order	Common name	Species	Part of the animal	Pathogen or Disease agent	Disease	Reference
Ungulate	Axis deer	Axis Axis	Raw meat	Salmonella	Salmonella gastroenteritis	Madar *et al.*, 2012
	Wild boar	Sus scrofa	Raw meat	*Trichinella*	Trichinellosis	Marva *et al.*, 2005
Diprotodontia	Kangoroo	Macropus rufus, M. Giganteus and M. Fuliginosus	Raw meat	Salmonella	Gastroenteritis	Holds *et al.*, 2008
	Kangoroo	Macropus rufus, M. Giganteus and M. Fuliginosus	Raw meat	*Escherichia coli*	Gastroenteritis	Holds *et al.*, 2008

Zoonotic viruses present in bushmeat of species in Asia and Pacific

Order	*Common name*	*Species*	*Part of the animal*	*Pathogen or Disease agent*	*Disease*	*Reference*
Bird	Crested Hawk-Eagles	*Spizaetus nipalensis*	lungs	A/H5N1 virus	Avian Influenza	van Borm *et al.*, 2005
Rodent	Chinese ferret-badger	*Melogale moschata*	Nasal, fecal and blood	SARS coronavirus	Severe Acute respiratory syndrom	Guan *et al.*, 2003
	Chinese hare	*Lepus sinensis*	Nasal, fecal and blood	SARS coronavirus	Severe Acute respiratory syndrom	Guan *et al.*, 2003
Ungulate	Chinese muntjac	*Muntiacus reevesi*	Nasal, fecal and blood	SARS coronavirus	Severe Acute respiratory syndrom	Guan *et al.*, 2003
Carnivore	Hog-badger	*Arctonyx collaris*	Nasal, fecal and blood	SARS coronavirus	Severe Acute respiratory syndrom	Guan *et al.*, 2003
	Himalayan palm civet	*P. larvata*	Nasal, fecal and blood	SARS coronavirus	Severe Acute respiratory syndrom	Guan *et al.*, 2003
Chiroptera	Horseshoe bats	Rhinolophus pearsoni,	Serum, fecal, throat samples	SARS coronavirus	Severe Acute respiratory syndrom	Li *et al.*, 2005
	Horseshoe bats	Rhinolophus pussilus	Serum, fecal, throat samples	SARS coronavirus	Severe Acute respiratory syndrom	Li *et al.*, 2005
	Horseshoe bats	Rhinolophus macrotis	Serum, fecal, throat samples	SARS coronavirus	Severe Acute respiratory syndrom	Li *et al.*, 2005
	Horseshoe bats	*Rhinolophus sinicus*	Nasopharyngeal and anal swabs and blood samples	SARS coronavirus	Severe Acute respiratory syndrom	Lau *et al.*, 2005
	Horseshoe bats	*Rhinolophus sinicus*	Throat and faecal swabs or fresh faecal samples	SARS coronavirus	Severe Acute respiratory syndrom	Ge *et al.*, 2013
	Bats	*Roussetus spp*.	Blood samples	Ebola Zaire and Reston viruses	Ebola hemorrhagic fever	Olival *et al.*, 2013
	Island flying fox	*Pteropus hypomelanus*	Urine	Nipah virus	Encephalitis and respiratory disease	Chua *et al.*, 2003
	Large flying fox	*Pteropus vampyrus*	Urine	Nipah virus	Encephalitis and respiratory disease	Chua *et al.*, 2003