Country Profile: ZAMBIA

Scientific basis for zoonosis education program (as of January 2023)

In situ project partner: Game Rangers International

Location: Across Zambia ☑ **urban** ☑ **rural**

Outreach to (area): The cities of Lusaka and Ndola, Luangwa and Itezhi-Tezhi towns, plus the surrounding rural communities

Structure

1. National characteristics

- Zambia is said to have over 70 languages, although many of these may be considered dialects; all of Zambia's major languages are members of the Bantu family; Chewa and Nyanja are mutually intelligible dialects (World Factbook 2022). English is the Official Language of Zambia. We will use English plus the localized language of each target area:
    - Itezhi-Tezhi: Ila
    - Luangwa: Nyanja
    - Lusaka: Nyanja
    - Ndola: Bemba
- With 46.3 % Zambia has one of the highest levels of urbanization in Africa, high density in the central area, particularly around the cities of Lusaka (3.2 million), Ndola, Kitwe (763,000 people), and MufuZamlira (World Factbook 2022). However, according to Africapolis (undated) Zambia is - unusually for the continent - characterised by few small cities: agglomerations of fewer than 50 000 inhabitants represent less than 19% of the urban population. In contrast, the capital, Lusaka (2.2 million inhabitants), is home to 35% of its urban population.
- Zambia is listed at position 102 (out of 113 countries) in the Global Food Security Index 2022 (The Economist 2022) and Position 108 (out of 121 countries) in the Global Hunger Index (Welthungerhilfe & Concern Worldwide 2022)

1.1. National legislation

- **Zambia Wildlife Act No. 12 of 1998**: https://faolex.fao.org/docs/pdf/zam50734.pdf
- National Parks and Wildlife (Licences and Fees) Regulations of 1994 (???)
- **National Parks and Wildlife (Game Animals) Order, 2015** (S.I. No. 10 of 2015): https://faolex.fao.org/docs/pdf/zam144989.pdf

1.2. Human population

19,642,123 Mio people (2022 est.; World Factbook 2022)

Population growth rate: 2.9% (2022 est.; World Factbook 2022)

Religion (2010 est.; World Factbook 2022):

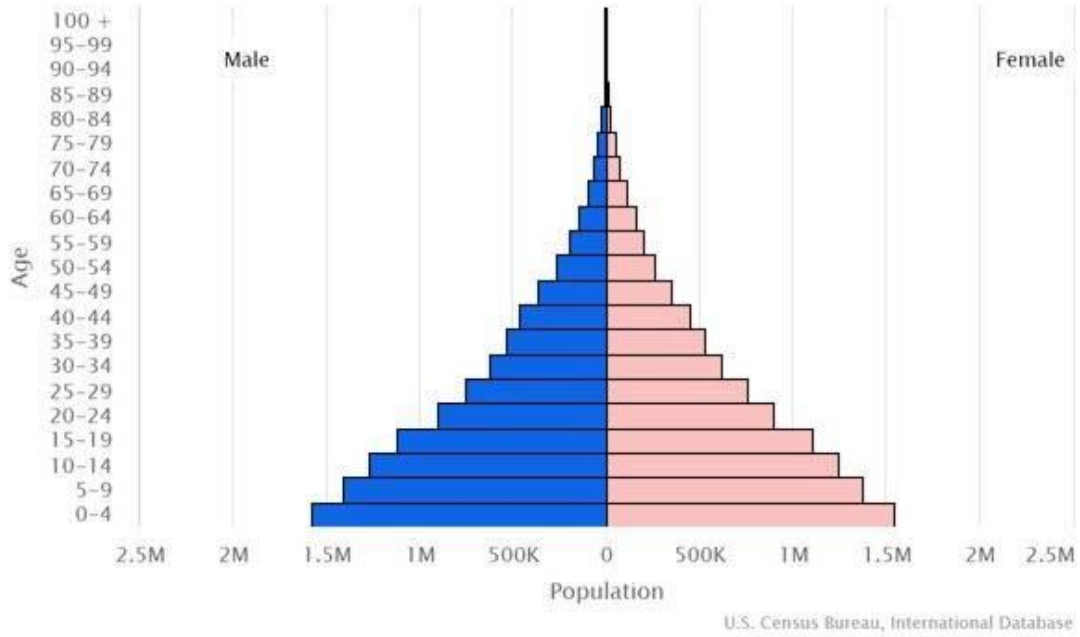
- Christianity: 98.2% (subgroups: Protestants 75.3%; Roman Catholics 20.2%; Other Christian 2.7%)
- other groups: 2.7% (includes Muslim Buddhist, Hindu, and Baha'i)
- none: 1.8%

Ethnic groups:

Percentage estimation of the main tribes by 2010 (World Factbook 2022):

Bemba 21%; Tonga 13.6%; Chewa 7.4%; Lozi 5.7%; Nsenga 5.3%; Tumbuka 4.4%; Ngoni 4%; Lala 3.1%; Kaonde 2.9%; Namwanga 2.8%; Lunda (north Western) 2.6%; Mambwe 2.5%; Luvale 2.2%; Lamba 2.1%; Ushi 1.9%; Lenje 1.6%; Bisa 1.6%; Mbunda 1.2%; other 13.8%; unspecified 0.4%.

Age structure (2020 est.; World Factbook 2022):



- 0-14 years: 45.74% (male 4,005,134/female 3,964,969)
- 15-24 years: 20.03% (male 1,744,843/female 1,746,561)
- 25-54 years: 28.96% (male 2,539,697/female 2,506,724)
- 55-64 years: 3.01% (male 242,993/female 280,804)
- 65 years and over: 2.27% (male 173,582/female 221,316)

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2. Relevant zoonotic diseases

2.1. Key points on zoonotic diseases

In a nutshell

- **About 75% of all novel infectious diseases are zoonoses** (i.e. diseases transmitted from animals to humans).
- **More than 70% of zoonoses originate from wild animals.**
- Legal AND illegal wildlife trade promote spreading of pathogens and zoonotic spillover events.
- While zoonotic diseases have their origin in animals, human-to-human transmission may become the dominant pathway (e.g. COVID-19, AIDS). Nevertheless, the original source has been in animals (mostly wildlife) and **risks for new spillover events should be reduced to a minimum.**
- **While so far there was no Ebola outbreak in Zambia, but WHO classified it high risk for importing disease from DRC**. Also, for Mpox and Marburg disease Zambia needs to be prepared against outbreaks, including prevention.
- While several zoonotic diseases in Zambia, such as Rift Valley Fever and Bovine Tuberculosis, are mainly associated with livestock as origin, they can also be transmitted by wildlife.
- Zambia had several fatal Anthrax cases; however, awareness is low, risks are neglected and diagnosis poor.
- **According to WHO the number of zoonotic outbreaks in the African region increased by 63% in the decade from 2012-2022**, compared to the decade before.
- **New zoonotic diseases to come**: Probability for the emergence and spread of new diseases increases (e.g. Nipah Virus Disease).
- **Reptile-associated salmonellosis** globally increases in countries. In some of the most poverty-afflicted regions of Africa, the burden of this neglected disease may be alarming (Pulford *et al*. 2019).
- In neighboring DRC, ~ 90% of snakes sold as bushmeat were infected with the endoparasitic worm *Armillifer armillatus*, causing Human visceral pentastomiasis.

2.2. Table: Zoonotic health risks relevant for Zambia

- So far no cases of Ebola recorded (CDC 2022)

Zoonosis	**Type of pathogen**	**Symptoms**	**Means of trans-mission**	**Outbreaks** (when?)	**Extent** (how many felt ill / died)	**Measures by the Government** (e.g., hunting ban, closure of bushmeat markets, education campaigns)	**References**
Ebola	Virus (Filovirus)	**Incubation time**: 2-21 days **Symptoms**: e.g. life-threatening **haemorrhagic fever**, malaise, fatigue, aching limbs, pain in abdomen, nausea, diarrhoea, internal and external bleeding (haemorrhages), delirium, shortness of breath	**Spillover from wildlife to humans**: bushmeat and contact to bats (primary hosts) as well as primates, rodents & duikers (secondary hosts) **Human to human**: Direct contact, blood, body liquids, faeces, vomit	No cases in Zambia so far…	**… but WHO classified it high risk for importing disease from DRC.** average case fatality rate is approximately 50% Assessment of potential risks of outbreaks in humans recommended for Zambia	In 2018, Zambia started training of Rapid Response Teams	CDC 2022a Changula et al. 2021 WHO 2021a WHO Africa 2018 Judson *et al.* 2016
Rabies (caused by Lyssa virus)	Virus	Fever, headache, vomiting, agitation, confusion, hyperactivity, excessive salivation, hallucinations, insomnia, partial paralysis	**Spillover from wildlife to humans**: Bites or scratches mainly from dogs, but also from wild animals (e.g. bats, monkeys, warthogs)		**Zambia considered a high-risk country**	Selected for pilot screening of zoonotic diseases in Zambia, notifiable	Public Health England (2020) University of Zambia et al. 2017 Hoffman et al. 2017
Marburg Disease	Virus (Filovirus)	**Incubation time**: 2-21 days **Symptoms**: bleeding from nose and mouth, high fever, severe headache, severe malaise, muscle aches and pain,	**Spillover from wildlife (e.g. bats, primates) to humans**: spread by body fluids, such as blood and saliva	Not yet in Zambia	average case fatality rate is approximately 50%	Not yet, but assessment of potential risks of outbreaks in humans recommended for Zambia	Changula et al. 2021 WHO 2021b Kajihara et al. 2019

Zoonosis	Type of pathogen	Symptoms	Means of trans-mission	Outbreaks (when?)	Extent (how many felt ill / died)	Measures by the Government (e.g., hunting ban, closure of bushmeat markets, education campaigns)	References
		diarrhoea, abdominal pain and cramping, nausea, and vomiting	**Human to human**: direct contact with blood or body fluids of sick persons				
Mpox (formerly Monkey pox)	Virus	e.g. fever, headache, muscle pain, skin lessons, pustules	**Spillover from wildlife to humans**: Direct contact with infected wildlife (rodents a primary host), persons, saliva droplets, sexual contact	No cases yet, but…	… WHO expects more cases in non-endemic countries	In reaction to WHO warning Ministry of Health issued an alert in May 2022	WHO 2022i Xinhua 2022 Doty et al. 2017
Avian Influenca (H5N1, H3N6)	Virus	**Incubation period**: 1 … **Symptoms**: high fever and cough, followed by symptoms of lower respiratory tract involvement including difficulty breathing; diarrhoea, vomiting, abdominal pain, encephalitis. Complications: e.g. severe pneumonia, hypoxemic respiratory failure, multi-organ dysfunction, septic shock. Case fatality rate much higher than that of seasonal Influenca	**Spillover from wildlife:** direct contact with infected animals (primary host aquatic birds, but also found in parrots) or contaminated environments **Human to human**: no transfers yet documented	Outbreaks in poultry in Nigeria, Togo, Benin and others	case fatality rate is approximately 60%	treated as priority due to large poultry stocks in Zambia National strategic prevention plan of 2005; however, limited capacities & coordination prevalence in poultry stocks 2.8% in southern Africa (including Zambia)	WHO 2018b, 2006 Phiri 2016 Mwacalimba & Green 2015 Wertheim et al. 2012 Simulundu et al. 2009
Rift Valley Fever	Virus (Bunyavirus)	**Incubation period**: 2-6 days **Symptoms**: feverish syndrome with sudden onset of flu-like fever, muscle pain, joint pain and headache. In severe cases retinal lesions, decreased vision or even blindness (“ocular	**Spillover from livestock to humans**: handling of infected carcasses (livestock, but also African buffalo and warthog), also vector-borne	Irregular events in Zambia spreading in Africa (2003: Egypt, 2006: East Africa,	Case-fatality rate in patients with haemorrhagic fever up to 50%		Chambaro et al. 2022 WHO 2021d Hoffman et al. 2017 LaBeaud et al. 2011

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		form"), **haemorrhagic fever**, Meningoencephalitis (loss of memory, hallucinations, confusion, disorientation, vertigo, convulsions, lethargy and coma), potentially fatal	**Human to human**: not documented	2007 Sudan, 2010 South Africa, 2012 Mauritania, 2016 Niger)			
Nipah Virus	Virus *(Henipavirus nipahense)*	**Incubation period**: usually 4-14 days (sometimes even up to 45 days) **Symptoms**: Infections in humans range from asymptomatic infections to acute respiratory infections (e.g. atypical pneumonia) and fatal encephalitis.	**Spillover from wildlife:** excreted in urine and saliva off bats >> transmitted to other animals (especially pigs), which then pass it on to humans.	No reports yet in Africa, but …	… Henipaviruses were detected in several bat species in Zambia		Markotter et al. 2020
Anthrax	Bacteria (*Bacillus anthracis*)	**Incubation period**: 1 day – 2 months **Symptoms (3 forms of Anthrax):** a) **skin anthrax:** itchy blisters and bumps, ulcers, black sore; headache, muscle aches, fever and vomiting **b) inhalation anthrax**: fever, chest pain, confusion, shortness of breath, extreme tiredness **c) gastrointestinal anthrax**: diarrhoea (evtl. with blood), abdominal pains, vomiting of blood, severe diarrhoea	**Spillover from wildlife:** Direct contact with herbivorous wildlife & livestock, consumption, handling of hides **Human to human**: no transfers yet documented	2011	31 cases (related to hippopotamus meat) Highly toxic (used as military weapon)	Selected for pilot screening of zoonotic diseases in Zambia, notifiable	Milbank & Vira 2022 Katani et al. 2021 University of Zambia et al. 2017 WHO 2016

Zoonosis	Type of pathogen	Symptoms	Means of trans-mission	Outbreaks (when?)	Extent (how many felt ill / died)	Measures by the Government (e.g., hunting ban, closure of bushmeat markets, education campaigns)	References
Brucellosis	Bacteria (*Brucella* sp.)	**Incubation period**: 1 week – 2 months **Symptoms:** flu-like symptoms, including fever, weakness, malaise and weight loss	**Spillover from wildlife:** Contact with infected herbivorous wildlife (e.g. buffalo, black lechwe) & livestock, consumption, floodwaters >> **Human to human**: rare transmission	(No systematic records)	Seropositivity among herdsmen and abattoir workers in Zambia was 14.4% and 46.4%, respectively; highest rate in Namwala	Neglected zoonoses, hardly studied and recorded	Mubanga et al. 2021 Simpson et a. 2021 Katani et al. 2021 Muma et al. 2010
Reptile-associated Salmonellosis	Bacteria (*Salmonella enterica* and *Salmonella typhimurium*)	**Incubation period**: 12-72 h **Symptoms:** diarrhoea, abdominal cramps, fever, occasionally nausea and vomiting. Bloodstream infections can be life threatening, especially in children under 5 yrs, the elderly, or in persons with weakened immune systems.	**Spillover from animals:** direct or indirect contact with faecal material from reptiles; handling of reptiles; touching surfaces/objects that were in contact with a reptile	(No systematic records)	Remains often undiagnosed >> underestimated		Zajac et al. 2021 Pulford et al. 2019 Pawlak 2014 Gumpenberger 2000
Bovine tuberculosis	Bacteria (*Mycobacterium bovis*)	**Incubation period**: months to years **Symptoms:** fever, night sweats, and weight loss, abdominal pain and diarrhoea. Can be fatal if untreated	**Spillover from animals:** direct or indirect contact with infected animals (mainly cattle, but also in many wildlife species of southern Africa); **Human to human**: inhalation of aerosol droplets of infected persons	(No systematic records)	BTB prevalence of 27.7% in the Kafue lechwe, but not assessed for many other wildlife species, regional differences	Although BTB is a notifiable disease, there is no official control program for the disease in Zambia, as t BTB is not seen as a disease of national economic importance	Lakin et al. 2022 Malama et al. 2019 Hoffman et al. 2017

Zoonosis	**Type of pathogen**	**Symptoms**	**Means of trans-mission**	**Outbreaks** (when?)	**Extent** (how many felt ill / died)	**Measures by the Government** (e.g., hunting ban, closure of bushmeat markets, education campaigns)	**References**
Human visceral pentastomiasis (caused by *Armillifer armillatus*)	Endoparasite (worm) endemic to West Africa	**Symptoms**: Most human infections are asymptomatic (sometimes even over decades), but serious or even fatal infections are described. Calcifications, caused by died and calcified parasites, can accumulate in liver, lung, pleura or abdomen, causing pain.	Contact with snake secretions (e.g. as bushmeat), consumption of uncooked bushmeat Rodents and small primates as secondary host	(No systematic records)	Outbreak in neighbouring Ivory Coast in 2022 infection rate in West Africa may be as high as 23%; numbers of infections increasing. In DRC, ~ 90% of snakes sold as bushmeat were infected with *A. armillatus*	greatly underestimated public health relevance; Pictured brochures on risks and hygienic measures are recommended	Milbank & Vira 2022 Blundell *et al.* 2020 Hardi *et al.* 2017 Tappe *et al.* 2016

2.3. Scientific background

2.3.1. General information

- **About 75% of all novel infectious diseases are zoonoses** (i.e. diseases transmitted from animals to humans) (WOAH 2022).
- **More than 70% of zoonoses originate from wild animals** (Jones *et al.* 2008).
- Legal AND illegal wildlife trade promote spreading of pathogens and zoonotic spillover events (IPBES 2020; Nijman 2021; Travis 2011).
- **New zoonotic diseases to come**: Probability for the emergence and spread of new diseases increases (Warren et al. 2022). According to WHO there has been a 63% increase in the number of zoonotic outbreaks in the African region in the decade from 2012-2022 compared to 2001-2011, e.g. Ebola, Mpox and corona viruses (UN Africa Renewal 2022).
- *Infections originating in animals and then jumping to humans have been happening for centuries, but the risk of mass infections and deaths had been relatively limited in Africa. Poor transport infrastructure acted as a natural barrier*," said Dr. Matshidiso Moeti WHO Regional Director for Africa (UN Africa Renewal 2022).
- Human zoonotic disease risk can be defined as a function of several factors, including transmission of infection and transition to disease. These components of disease risk rely on several factors (e.g. extrinsic factors, such as urbanization, agriculture, socioeconomic standing and intrinsic factors, such as life history, behaviour, and rapid evolutionary changes in animal hosts and pathogens) that are external to the host–pathogen system (Han et al. 2016).
- **Mammals and birds alone are thought to host an estimated 1.7 million undiscovered viruses and, of these, 540,000–850,000 viruses could have the ability to infect humans** (Shivaprakash et al. 2021; Carroll et al. 2018). For example, researchers recently discovered a family of viruses that can cause fatal haemorrhagic fever in African primate populations. Since humans have a similar form of the receptor responsible, the researchers concluded that transmission of this disease to humans is very likely (Mbenywe 2022; Warren et al. 2022).
- **Ungulates, primates, and bats are the major zoonotic reservoirs in wildlife trade.** Primates, ungulates, carnivores, and bats pose a high zoonotic risk, harbouring 132 (58%) of the 226 known zoonotic viruses in the current wildlife trade. Bats, rodents, and marsupials pose a significant zoonotic risk in future wildlife trade (Shivaprakash et al. 2021).
- Until recently, the role of wildlife as reservoir host for Rift Valley Fever remained unclear (Rostal et al. 2017). However, according to Lakin et al. (2022), African buffalos in South Africa have been proven to be infected.

2.3.2. Country-specific information

- In the absence of any national law, plan, or equivalent strategy document, on zoonotic disease the GHS Index Report (2021d) recommends that Zambia creates plans and strategies for the control and prevention of zoonotic diseases, including a priority zoonotic disease list. The report also notes that there is no publicly available evidence that Zambia conducts surveillance of zoonotic disease in wildlife (e.g. wild animals).

- **Anthrax:** A survey in different Zambian districts demonstrated low knowledge levels of outlining signs and symptoms of Anthrax (University of Zambia et al. 2017), which is a probable cause for the low numbers reported during that survey. However, in 2008 many wildlife animals including 14 lions died from anthrax, which has made Luangwa district to remain at high risk. In 2014 and 2016 several people in the district suffered and died from Anthrax in Chiawa. Therefore, with Luangwa district being located downstream of Chiawa put it at high risk (University of Zambia et al. 2017).
- According to Malama et al. (2019) **bovine tuberculosis** (BTB) is one of the major infectious diseases of cattle and Kafue lechwe (*Kobus leche kafuensis*) in Zambia. Other wildlife species are also infected (Hoffman et al. 2017), and the disease has also been diagnosed in humans.
- **Avian influenca**: The H3N6 avian influenza virus was isolated from a wild white pelican in Zambia (Simulundu et al. 2009). Mwacalimba & Green (2015) criticized that the priority plan for avian influence in resource constrained settings such as Zambia, which is not at the epicentre of avian influenza outbreaks, a narrow focus on infectious disease risk downplays the more pressing needs for public health, including those related to trade and development. Indeed, Phiri (2016) noted that from 2010 to date, influenza surveillance activities have been very limited, not effective and not coordinated due to lack of funding – and that surveillance remains a key as an early warning system in the control of possible influenza outbreak.
- Zambia has recorded high numbers of cases of **trypanosomiasis**, which is a priority for the Government, while other zoonotic diseases are neglected (Mulenga et al. 2022); however, trypanosomiasis is transmitted by vectors (tsetse fly) and not related to bushmeat, which is why this disease is not covered in our project.

3. Relevant wildlife species (or subspecies)

(e.g.; bats, which primate species? …):

3.1. Key points on most relevant wildlife species

- …

In a nutshell:

- **Ungulates, primates, carnivores and bats are the major zoonotic reservoirs in wildlife trade**, as they host 132 (58%) of 226 known zoonotic viruses in present wildlife trade (Shivaprakash *et al.* 2021).
- The relative risk of disease emergence was found highest for bats, followed closely by primates, then ungulates and rodents (Cleaveland *et al.* 2007).
- Duikers and other ungulates have a central role in Zambia's wildlife meat production (Lindsey et al. 2013c; Barnett 1997).
- **As the closest relatives of humans, primates pose a particularly high risk of zoonotic transmission to humans** (Mossoun *et al.* 2017).
- In mammals and birds alone, the number of undetected viruses is estimated at 1.7 million, of which 540,000 to 850,000 may have the potential to infect humans (Carroll *et al.* 2018).
- **Reptiles**: With the vast majority showing no symptoms, 12-85% of tortoises and freshwater turtles, 16-92% of snakes and 36-77% of lizards are carrying Salmonella pathogens.
- Theoretically any wildlife species harvested for bushmeat could be a potential source of zoonotic disease.
- In southern Africa, a broad range of wildlife species is used for **traditional medicine**, including primates and ungulates**.**

3.2. Table: Relevant wildlife species traded in Zambia

Species	IUCN Red List	Taxonomic group	Relevance in trade	Pathogens / zoonoses	References
Yellow Baboon *Papio cynocephalus*	LC stable	Primates	Bushmeat?? Traded for traditional practices, as pet	Rabies Marburg Disease Human yaws Rickettsial diseases? (e.g. Typhus)	Changula et al. 2021 Wallis 2020c Kurpiers et al. 2016 Nakayima et al. 2014
Chacma baboon *Papio ursinus*	LC decreasing	Primates	Hunted and body parts diversly utilized in traditional medicine (e.g. fat, paws, skin pieces, head, oil, ash, bones, testes)	Rabies Rickettsial diseases (e.g. Typhus)	Sithaldeen 2019 Nieman et al. 2019 Hoffman et al. 2017

Species	IUCN Red List	Taxonomic group	Relevance in trade	Pathogens / zoonoses	References
				Bovine tuberculosis	Nakayima et al. 2014
Kinda baboon *Papio kindae*	LC stable	Primates	Some hunting for food, killed for crop-raiding	Human jaws? (closely related to syphilis)	Wallis et al 2021
Vervet monkey *Chlorocebus pygerythrus*	LC stable	Primates	Intensely hunted for bushmeat & traded as pets At least in South Africa also used for traditional medicine (skin pieces and as oil)	Rabies Marburg Disease Rickettsial diseases (e.g. Typhus) (*Strongyloides fulleborni* also found in this species in Uganda)	Changula et al. 2021 Nieman et al. 2019 Kurpiers et al. 2016 Nakayima et al. 2014
Malbrouck monkey *Chlorocebus cynosuros*	LC	Primates	Hunted as pest; offspring sold as pets		Wallis 2019
Red-tailed Monkey *Cercopithecus ascanius*	LC decreasing	Primates	Hunted for bushmeat and as pest; offspring sold as pets		De Jong & Butynski 2019
Vervet monkey *Cercopithecus aethiops*	LC Decreasing		Hunted as pest (for crop-raiding), sometimes kept as pets		Butynski & De Jong 2022 Sakala 2016
Blue monkey *Cercopithecus mitis*	LC Decreasing	Primates	Hunted for bushmeat and as pest; offspring sold as pets		Butynski & de Jong 2019
Southern lesser galago *Galago moholi*	LC stable	Primates	Sold in the pet trade and used in traditional folk medicine in Zambia		Bearder et al. 2021 Svensson et al. 2015 Alves et al. 2010
African straw-colored fruit bat *Eidolon helvum*	NT decreasing	Bats (fruit bats)	Consumed as bushmeat by local people in western Zambia	Ebola, Marburg, **Henipavirus** (Zaire Ebolavirus and Lagos Bat Virus also detected in this species in Ghana, Kenya, Nigeria & Senegal); paramyxoviruses, filoviruses, lyssaviruses, pegiviruses, hepaciviruses, more than 60 different viruses	WHO 2021a WHO 2021b Kurpiers et al. 2016 Mildenstein et al. 2016 Luis et al. 2013 Quan et al. 2013 Mickleburgh et al. 2009 Towner et al. 2007

Species	IUCN Red List	Taxonomic group	Relevance in trade	Pathogens / zoonoses	References
				were identified in bats	
Egyptian fruit bat *Rousettus aegyptiacus*	LC stable	Bats		Marburg (virus proven in Zambian bats)	Markotter et al. 2020 Kajihara et al. 2019 Korine 2016
Hippopotamus *Hippopotamus amphibius*	**VU** stable	Ungulates	Intensely hunted for bushmeat and teeth (ivory) At least in South Africa also partially used for traditional medicine (fat)	Anthrax	Milbank & Vira 2022 Nieman et al. 2019 Lewison & Pluháček 2017
Duikers (unspecific)		Ungulates		Ebola	Leroy et al. 2004a
Common duiker *Sylvicapra grimmia*	LC Decreasing	Ungulates	Intensely hunted, among the most confiscated bushmeat species in Zambia Skull, skin pieces, horn and hooves also used in traditional medicine		Nieman et al. 2019 IUCN SSC Antelope Specialist Group. 2016e Sakala 2016
African buffalo *Syncerus caffer*	NT Decreasing	Ungulates	A favoured target for bushmeat hunters, among the most confiscated bushmeat species in Zambia A leading species on Zambia's game ranches Also used for traditional medicine in South Africa (fat, bones, horn)	Bovine tuberculosis Brucellosis Rift Valley Fever Bovine tuberculosis (all 4 diseases at least proven for buffalos in South Africa; RVF also in Botswana)	IUCN SSC Antelope Specialist Group. 2019 Nieman et al. 2019 Hoffman et al. 2017 Caron et al. 2016 Sakala 2016 Jori et al. 2015 Lindsey et al. 2015a; 2013c LaBeaud et al. 2011 Barnett 1997
Black lechwe *Kobus leche*	NT Decreasing	Ungulates	Intensely hunted, among the most confiscated bushmeat species in Zambia	Brucellosis Bovine tuberculosis (proven in South Africa)	Malama et al. 2019 Hoffman et al. 2017 Sakala 2016 Muma et al. 2010
Puku *Kobus vardonii*	NT Decreasing	Ungulates	highly desired source of meat; skin is used for drums and furniture		IUCN SSC Antelope Specialist Group. 2016f

Species	IUCN Red List	Taxonomic group	Relevance in trade	Pathogens / zoonoses	References
			A leading species on Zambia's game ranches		Lindsey et al. 2015a; 2013c Barnett 1997
Common eland *Tragelaphus oryx*	LC Stable	Ungulates	Intensely hunted for its high-priced meat A leading species on Zambia's game ranches Horns used in traditional medicine for exorcism	Bovine tuberculosis (proven in South Africa)	Nieman et al. 2019 Hoffman et al. 2017 IUCN SSC Antelope Specialist Group 2016g Lindsey et al. 2015a; 2013c
Greater Kudu *Tragelaphus strepsiceros*	LC Stable	Ungulates	Among the most hunted species in Zambia, sought for their high-quality meat; A leading species on Zambia's game ranches Horns used in traditional medicine for exorcism	Bovine tuberculosis (proven in South Africa)	Nieman et al. 2019 IUCN SSC Antelope Specialist Group 2020b Hoffman et al. 2017 Lindsey et al. 2013c Barnett 1997
Impala *Aepyceros melampus*	LC Stable	Ungulates	Among the most hunted species in Zambia A leading species on Zambia's game ranches	Bovine tuberculosis (proven in South Africa)	Hoffman et al. 2017 IUCN SSC Antelope Specialist Group 2016p Lindsey et al. 2013c Barnett 1997
Common warthog *Phacochoerus africanus*	LC Decreasing	Ungulates	Among the most hunted species in Zambia, skins also traded A leading species on Zambia's game ranches	Bovine tuberculosis (proven in South Africa)	Hoffman et al. 2017 De Jong et al. 2016 Lindsey et al. 2013c Barnett 1997
Plains zebra *Equus quagga, = Equus burchelli*	NT	Ungulates	Among the most hunted species in Zambia; trade in skin in some countries (including for traditional medicine) A leading species on Zambia's game ranches		Sakala 2016 King & Moehlman 2016 Lindsey et al. 2013c
		Carnivores?			

Species	IUCN Red List	Taxonomic group	Relevance in trade	Pathogens / zoonoses	References
Cape porcupine *Hystrix africaeaustralis*	LC Stable	Rodents	Hunted for food In South Africa also used for traditional medicine (oil, muscle tissue, viscera, bones, skin pieces, stomach contents, head)	Mpox?	Nieman et al. 2019 Cassola 2016c Sakala 2016
Boehm's squirrel *Paraxerus boehmi*	LC Trend unknown	Rodents	potentially harvested as bushmeat		Cassola 2016d Amori & Gippoliti 2002
Smith's bush squirrel *Paraxerus cepapi*	LC stable	Rodents	potentially harvested as bushmeat		Cassola 2016e Amori & Gippoliti 2002
Gambian sun squirrel *Heliosciurus gambianus*	LC Stable	Rodents	Hunted for food and medical purpose	Mpox	Doty et al. 2017 Cassola 2016f Amori & Gippoliti 2002
Puff adder *Bitis arietans*	LC Stable	Reptiles	Large specimens hunted for bushmeat, also exported as pets also used for traditional medicine	Salmonellosis visceral pentastomiasis	Pulford et al. 2019 Nieman et al. 2019 Hardi et al. 2017 Wagner et al. 2014 Marshall 1998
African rock python **Python sebae**	NT Decreasing	reptiles	Not native to Zambia, but carcasses, skin and bones used in traditional medicine	Salmonellosis visceral pentastomiasis	Alexander et al. 2021 Nieman et al. 2019 Pulford et al. 2019 Hardi et al. 2017 Marshall 1998
Monitor lizards *Varanus sp.*	Unclear	Reptiles	Second most used reptile species in traditional medicine in Sout Africa	Salmonellosis visceral pentastomiasis	Nieman et al. 2019 Pulford et al. 2019 Hardi et al. 2017

3.3. Scientific Background

- Although research has focused largely on mammals and, to a lesser extent, birds, theoretically any wildlife species harvested for bushmeat could be a potential source of zoonotic disease that can spillover during the hunting, butchering, and preparation process (Kurpiers et al. 2016; Karesh & Noble 2009).

- **Mammals and birds alone are thought to host an estimated 1.7 million undiscovered viruses and, of these, 540,000–850,000 viruses could have the ability to infect humans** (Shivaprakash *et al.* 2021; Carroll *et al.* 2018).
- In their assessment of the risk of disease emergence by taxa, Cleaveland *et al.* (2007) found that the relative risk of disease emergence was highest for bats, followed closely by primates, then ungulates and rodents – all of them heavily exploited for wildlife trade. Primates, ungulates, carnivores, and bats pose a high zoonotic risk, harbouring 132 (58%) of the 226 known zoonotic viruses in the current wildlife trade. Bats, rodents, and marsupials pose a significant zoonotic risk in future wildlife trade (Shivaprakash *et al.* 2021).

3.3.1. Primates

- As the closest relatives of humans, primates pose a particularly high risk of zoonotic transmission to humans (Mossoun et al. 2017). Nevertheless, parasite sampling is still too low, especially for arboreal and nocturnal species – and Zambia is among the countries with the lowest sampling levels, leaving large gaps of knowledge (Cooper & Nunn 2013).
- Researchers recently discovered a family of viruses that can cause fatal haemorrhagic fever in African primate populations. Since humans have a similar form of the receptor responsible, the researchers concluded that transmission of this disease to humans is very likely (Mbenywe 2022; Warren *et al.* 2022).
- Nakayima et al. (2014) highlight that the **continuously increasing contacts between humans and primate populations in Zambia raise concerns about transmission of pathogens** between these groups. They screened zoonotic pathogens in free-ranging baboons and vervet monkeys from Zambia and detected *Rickettsia* spp. in 33.3% of tested baboons and 47,5% of tested vervet monkeys.
- Changula et al. (2021) detected **Ebola viruses and Marburg viruses in wild baboons and vervet monkeys**. From 243 samples tested, 39 NHPs (16%) were found to be seropositive either for ebolaviruses or Marburg viruses. The authors note that baboons showed a significantly higher positive rate for Marburg viruses.

3.3.2. Ungulates

- According to Barnett (1997) larger ungulates make 77.8% of all species used as bushmeat in the rural areas of Luangwa Valley.
- Wildlife ranches in Zambia have significantly increased since the 1990s. In 2013, ~ 295,000 kg of venison was produced annually on wildlife ranches, 37.2% from trophy hunting (see table, taken from Lindsey et al. 2013c). In terms of produced meat, impala, eland, kudu, waterbuck, puku, zebra, African buffalo, and warthog were among the most relevant species (Lindsey et al. 2013c, see table below).

	Hunted as trophies	Meat produced from trophy hunting	Hunted for meat*	Meat produced from meat hunting	Total hunted	Total meat produced	Population on game ranches	% harvested (animals hunted plus captured live)	Max potential off-take	Maximum potential meat production
Buffalo	34	11,900	2	586	36	12,486	2,107	1.71%	16.6%	13,003
Bushbuck	106	3,498	244	6,344	350	9,842	6,015	5.82%	44.1%	70,008
Bushpig	61	2,340	142	4,729	203	7,069	5,589	3.63%	35.6%	65,987
Duiker Blue	0	0	0	0	0	0	5,572	0.00%	84.0%	0
Duiker Com	62	579	42	364	104	943	936	11.09%	62.5%	6,107
Eland	42	13,944	101	28,583	143	42,527	1,558	9.17%	18.4%	81,108
Elephant	2	3,300	0	0	2	3,300	1,710	0.12%	10.3%	458,101
Giraffe	0	0	1	586	1	586	321	0.31%	13.8%	26,015
Grysbok	15	30	0	0	15	30	2,130	0.70%	91.1%	9,894
Hartebeest	60	5,008	24	1,783	84	6,791	2,051	4.11%	26.4%	40,036
Hippo	8	4,080	1	784	9	4,864	1,530	0.59%	12.5%	149,704
Impala	186	5,766	2,075	63,080	2,261	68,846	27,998	8.08%	39.8%	335,001
Klipspringer	0	0	0	0	0	0	560	0.00%	64.8%	2,178
Kudu	76	12,464	226	24,422	302	36,885	6,287	4.80%	25.6%	173,544
Lechwe	56	3,441	98	5,341	154	8,782	1,513	10.18%	34.3%	28,287
Nyala	2	122	0	0	2	122	95	2.10%	30.0%	1,340
Oribi	21	164	0	0	21	164	730	2.81%	64.6%	3,626
Ostrich	0	0	5	620	5	620	378	1.32%	?	?
Puku	104	4,363	368	13,653	472	18,016	4,904	9.62%	34.5%	62,686
Reedbuck	51	1,869	125	3,988	176	5,857	2735	6.42%	39.8%	34,682
Roan	31	4,619	0	0	31	4,619	1,647	1.88%	21.5%	48,902
Sable	84	10,329	6	726	90	11,055	3,682	2.45%	22.9%	102,052
Sitatunga	17	1,087	0	0	17	1,087	328	5.27%	38.9%	4,099
Steenbok	0	0	0	0	0	0	117	0.00%	63.0%	450
Tsessebe	8	639	5	323	13	962	410	3.24%	29.7%	7,871
Warthog	82	3,300	228	8,618	310	11,918	4,831	6.42%	38.1%	69,576
Waterbuck	67	9,514	87	10,467	153	19,981	2,987	5.12%	24.1%	87,236
Wildebeest	7	966	27	3,194	34	4,160	630	5.40%	26.5%	19,722
Zebra	38	6,308	38	6,688	76	12,996	2,060	3.69%	22.3%	80,757
	1,220	109,630	3,845	184,879	5,064	294,508	91,411			1,981,972

*Including animals shot on unguided hunts, and those culled by ranch management to produce meat.
doi:10.1371/journal.pone.0081761.t003

3.3.3. Others

- Barnett (1997) reported **rodents and birds** also being sold at urban markets in Zambia.
- **Reptiles**: With the vast majority showing no symptoms, 12-85% of tortoises and freshwater turtles, 16-92% of snakes and 36-77% of lizards are carrying *Salmonella* pathogens. Under stressful unhygienic conditions risk of spillover to humans increases (Zajac et al 2021; Gumpenberger 2000). Pulford *et al*. (2019) examined wild-caught snakes originating from eight African countries and found 91% of them carrying *Salmonella*.
- In 2019, former **President Lungu made headlines by publicly eating meat of a puff adder**. He was criticized for showcasing snakes as alternative food and stimulating their consumption (Lusaka Times 2019).

4. Most relevant potential spillover pathways

4.1. Key findings on spillover pathways

In a nutshell:

- **Legal AND illegal wildlife trade are contributing to the spreading of zoonotic diseases.**
- **Bushmeat**-related activities (hunting, butchering, cooking, consumption) have been linked to numerous EID outbreaks, such as Ebola, HIV, and SARS.
- **Bushmeat hunting is the greatest threat to native wildlife in Zambia** (Tan 2020).
- **Zambia is facing rapid population growth in rural communities and urbanization.**
- **Bushmeat is increasingly consumed by high-income urban groups, where meat consumption rates and preference for wild meat rise with income.**
- Of 58 species of bushmeat globally investigated, 48 species were found to host one or more pathogens (Peros et al. 2021).
- Bushmeat is often smoked, dried or salted. But medical experts estimate that these processes are insufficient to kill viruses and other pathogens in the meat.
- **Increasing demand and commercialization of bushmeat is exposing more people to pathogens and facilitating the geographic spread of diseases** (Kurpiers *et al.* 2016).
- **Wildlife as pets:** Bites, scratches and contact with urine, saliva and feces pose a risk for disease transmission (such as rabies) from e.g. pet monkeys to keepers.
- **Wildlife use in Traditional Medicine and religious rituals is common in southern African countries and is obviously on its rise.**

4.2. Scientific background

- **Legal AND illegal wildlife trade are contributing to the spreading of zoonotic diseases.** Since the outbreak of COVID-19 wildlife markets are often seen as synonymous with illegal wildlife trade, but Nijman (2021) stresses that most of the wildlife offered at Wuhan wet market was legally offered. Stressful, unhygienic conditions during wildlife trade are fuelling pathogen levels in the animals.

4.2.1. Bushmeat

- **Poaching, e.g. with snares, is massive in Zambia** (Becker et al. 2013) **and illegal hunting for bushmeat is considered to be the most serious threat to wildlife in Zambia's protected areas** (Lindsey et al. 2015b).
- **Increased bushmeat hunting is indicated by declining ungulate populations in over 25% of Mozambican, Angolan, Zambian and Zimbabwean National Parks** (Sosnowski et al. 2021).

- Lindsey et al. (2013b) noted widespread bushmeat poaching and habitat encroachment; reasons include, among others, rapidly expanding human populations, poverty, open-access systems in Game Management Areas and underfunding of enforcement authorities.
- King (2014) estimates a 20-fold increase of bushmeat use in the area around North Luangwa National Park over the last 30 years.
- Utilization of bushmeat occurs throughout the rural and urban areas of Zambia and affects a wide range of species (Barnett 1997). The author noted that prices for bushmeat were higher in urban areas, e.g. Lusaka, and entices supplies of bushmeat from rural areas all over Zambia.
- According to Sakala (2016) main reasons for bushmeat hunting in the Mukungule Game Management Area were need for income (44%) and protein (33%), cultural aspects (23%), human-wildlife conflict (11%) and "misapplication of traditional knowledge" (11%).
- Hunters in rural societies in Zambia are respected as courageous individuals; individuals who can be helpful in times of trouble and also dangerous because of their knowledge of medicines associated with witchcraft (Sakala 2016).
- As part of their lease agreements with the Zambia Wildlife Authority, sport hunting operators in Zambia are required to provide annually to local communities free of charge i.e., provision a percentage of the meat obtained through sport hunting. White & Beland (2015) estimate that ~ 129,771 kgs of fresh game meat is provisioned annually by the sport hunting industry to rural communities in Zambia at an approximate value for the meat alone of >US$600,000 exclusive of distribution costs.

4.2.2. Wildlife as pets

- The Zambia Primate Project rescued over 750 vervet monkeys and baboons since 2002, from the illegal exotic pet trade in Zambia – and those injured or orphaned through the actions of humans, such as illegal snaring for bush meat and the persecution and stoning of primates in local communities where they are often perceived as pests (Zambia Primate Project, own data).

4.2.3. Traditional medicine & magic-religious rituals

- In the 1990s, traditional medicine was extremely popular in both rural and urban areas of Zambia (Marshall 1998). It continues to be popular today. Whiting & Williams (2013) report that the **trade in animal parts in southern Africa is still thought to be extensive.** During their survey at Faraday market in South Africa they found 147 different vertebrate species (60 mammals, 53 birds, 33 reptiles and 1 frog).
- According to Alves *et al*. (2010) 25 primate species are used in traditional folk medicine and magic-religious rituals in Africa: For example, *Galago moholi* is used in Zambia as charm for love and athletes and against baby crying and epilepsy.
    - In South Africa, leopard, chacma baboon, cape porcupine, genets and black-backed jackal were the mammal species most used in traditional medicine trade (Nieman et al. 2019). Chacma baboons are used to protect against bullets, fertilize crop fields, for black magic, or to protect livestock from evil; vervet monkeys for protection against evil spirits. Owls and vultures (*Gyps* sp.) were the most common birds (said to help against evil spirits, arthritis and

to prevent material theft). Puff adder, African rock python, Nile crocodile, Cape cobra, and Mamba the most common reptiles used for traditional medicine.

- "For the bats when they die, they don't rot instead they just dry up, so that's where the healer will say bring that to heal your problem" GRI Community Outreach Ranger
- Wildlife products are sometimes used in traditional medicine: in some instances, you will be told to look for some specific snake fats, crocodile fats, etc. Sometimes, the healer would have in stock, but if the healer doesn't have it, then he will ask the patient to source" GRI Community Outreach Ranger
- **According to Green et al. (2022) the traditional healing market in South Africa is rapidly expanding.** The authors name birds (vulture), reptiles (mamba and python) and mammals (eland, monkey, lion, leopard, giraffe, zebra, porcupine, pangolin, anteater, mole, hippo, buffalo, bushbuck, and bat), and one invertebrate (cowrie shell) as wildlife used for traditional medicine.
- The number of people handling wild animals and their parts and derivatives in the traditional medicine industry, including (but not limited to) poachers, breeders, middlemen, practitioners and consumers, **puts a large number of people at increased risk of contracting zoonotic diseases** (Green et al. 2022).
- Williams & Whiting (2016) highlight that animals in traditional medicine were mostly used for 'strength' (physical or overcoming fear), but also as love charms, warding off bad luck or bad spirits or improving one's luck. Only 36% of use categories were medicinal (e.g., headaches, skin problems, swollen feet, etc.).

5. Information relevant for awareness campaigns & programs

(contacts, lessons to learn, illustrations…)

5.1. Key points for awareness campaigns

In a nutshell:

- **Longstanding cultural beliefs and livelihood and food security challenges** mean that research findings alone would not have been successful in changing practices.
- **3 building blocks are needed for successful awareness campaigns**: 1) trust building – 2) awareness raising – 3) evidence through research (Machalaba 2022)
- **Skepticism /opposition against information on zoonotic diseases and measures to reduce risk for spillover events:** Traders and consumers may argue that wildlife was eaten for generations without ever having caused, or been associated with, an epidemic in humans.
- **Possible counterarguments must be collected and debunked to best persuade.**
- **Promotion of the One Health approach:** Interconnection between humans, wildlife and environment. In the long-term human health can only been assured together in a healthy environmental and with healthy animals.
- **Wildlife must not be blamed for zoonotic diseases** (see Turcios-Casco & Gatti 2020). Living with wildlife, not destroying them, and wildlife conservation (including habitat conservation) as part of the solution!
- **Explain probabilities and statistical incidents!** Most events of bushmeat consumption or contact with wildlife will not lead to zoonotic diseases, but risks are significantly rising with increasing deforestation & intrusion into remote habitats as well as commercialization of bushmeat trade (incl. long transport routes to cities). Increased human density in cities and increased mobility of people support outbreaks and spreading of diseases as soon as a spillover event has occurred.
- **Communication of human health risks, combined with demystification of bushmeat (e.g. primate is no more nutritious than other meat) caused strongest demand reduction**
- **Best arguments:** In demand reduction campaigns on wildlife as pets the aspects of illegality and human health risks have been proven more efficient than species conservation or animal welfare issues.
- **Messaging**: Positive messages are easier acceptable than negative; involve influential and credible actors; present appropriate alternatives
- **Enforcement AND persuasion are key to ensure long-term change of behavior**
- **Urban citizens are a major consumer group and should be prioritized in awareness campaigns.**

5.2. Scientific background

- **3 building blocks are needed for successful awareness campaigns**: 1) trust building – 2) awareness raising – 3) evidence through research (for details see Machalaba 2022)
- **Ideal-reality gap**: Although many people are concerned about a problem (a stated preference, which can be triggered by education), this does not always translate into taking practical steps to perform an environmental behaviour (revealed preferences).

5.2.1. Awareness & Skepticism

- According to a 2017 survey by Zambia's Department of National Parks and Wildlife **63% of Zambian adults believe that it is legal to keep primates as pets, while 46% of adults believe that it is legal to eat baboon meat**.
- Given the lack of awareness and precautionary measures taken among people who come into contact with bushmeat, the opportunity for new zoonotic pathogens to spillover into humans remains high. This is especially true, since the current rate of hunting wild animals will likely continue — at least until domestic animal production increases and can support the protein needs of the local people (Kurpiers *et al.* 2016; LeBreton *et al*. 2006).
- In December 2017, the Wildlife Crime Prevention (WCP) project launched the **"This Is Not A Game" public awareness campaign to help end the illegal bushmeat trade** (Graham & Ferguson 2020). However, the project focuses on conservation and legal aspects, while increased public awareness on zoonotic pathogens is still required.
- In conclusion of his study "Enhancing health campaigns through environmental education: A case of the Keep Zambia clean and healthy programme" Chileshe (2018) highlights the need of continuous education, changing the audience's attitudes and social norms, and cultivation the spirit of "Umuganda" (working together, including ngos, political parties and other stakeholders).
- Given the lack of awareness and precautionary measures taken among people who come into contact with bushmeat, the opportunity for new zoonotic pathogens to spillover into humans remains high. This is especially true, since the current rate of hunting wild animals will likely continue—at least until domestic animal production increases and can support the protein needs of the local people (Kurpiers *et al.* 2016; LeBreton *et al*. 2006).
- Bonwitt *et al.* (2018) underline that the **epistemic dissonance** between health risks (in the context of Ebola) and long-term experiences consuming bushmeat without personal incident would radically undercut the effectiveness of the bushmeat ban, which merely served to proliferate informal networks of wild animal trade and sale— hampering the development of acceptable, evidence-based surveillance and mitigation strategies for zoonotic spillovers. "*People simply refused to believe that wild meat could pose any health risk. Informants argued that wild animals were hunted and eaten for generations without ever having caused, or been associated with, an epidemic in humans. The same argument was commonly heard in rural areas of Guinea*." Other argument for suspicion was the government would try to consolidate power and weaken villages in areas supporting opposition party (as wild meat is considered an important source of physical strength and energy) – or the rumour that conservationist introduced the ban to prevent poaching.

5.2.2. Ecology and One Health Approach

- **Major reasons behind the emergence and spread of zoonotic pandemics are related to activities such as habitat fragmentation, deforestation, biodiversity loss,** intensive agriculture and livestock farming, uncontrolled urbanization, pollution, climate change and wildlife trade, including wild meat markets (Mishra et al. 2021; Dobson et al. 2020).
- People **need to understand the role of different wildlife species in the ecosystems** and that deforestation, agricultural and infrastructure expansion even into formerly remote habitats, biodiversity loss bring people and livestock into closer contact with wildlife which significantly increases the risk of spillover events (Machalaba 2022; Keesing & Ostfeld 2021; Everard 2020; IPBES 2020).
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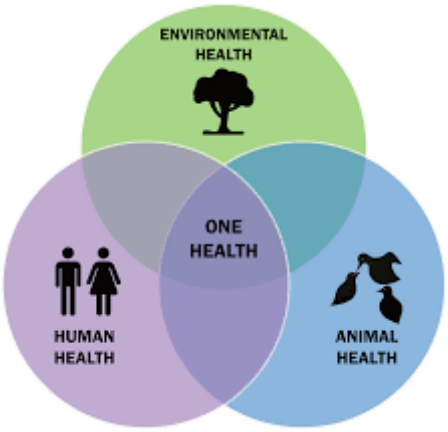
- The **One Health approach** - considering the health of people, animals and the environment – has been already promoted since the 2010s (Karesh & Vora 2010; Travis *et al.* 2011; Mackenzie *et al.* 2014). Since the COVID-19 this approach received much more attention (Zowalaty & Järhult 2020, Everard *et al.* 2020; Mishra *et al.* 2021; Berthe *et al.* 2022, Schwensow *et al.* 2022).



- ODI 2004: "*While many people are unaware of which animals are being protected by Liberian law, most (61%) recognised that bushmeat should not be purchased if it is protected. Few respondents (24%) knew of any unique animals in West Africa, and the majority (65%) did not believe that species can become extinct. Respondents recognised that Liberia has protected species and felt that not enough was being done to conserve Liberia's wildlife. Most (63%) believe they have a role to play in conserving Liberia's forests and wildlife. However, of the top 15 most preferred bushmeat species, five are protected under Liberian law. Variations in ranked preferences from different locations were likely to be related to availability of the species in the local markets. Only one primate species, the sooty mangabey, appeared in the top 15 taste preferences. Public awareness efforts, focused on selected species and habitats, could therefore be effective*."
- A study in Zambia found that the One Health approach was severely hampered by the non-existing exchange and cooperation between human health and veterinary authorities (Mwinyi et al. 2015).

5.2.3. Role of urban consumers / food alternatives

- Africa has the fastest urban growth in the world. The continent's population is projected to double between 2020 and 2050; with 2/3 will be living in urban areas (OECD/SWAC 2020).
- Urban population in Zambia is ~44%, with an urban growth rate of 4.23%. An estimated 70% of urban population lives in informal settlements which are characterized by significant social, economic and environmental problems (UN Habitat 2012-2023).
- Urban citizens are a main consumer group. Lusaka is described as a well-known bushmeat trading hub. According to the Young African Leaders Initiative "bushmeat consumption in Lusaka and across Zambia is primarily preference-based, and historically there are public perceptions that

bushmeat consumption is acceptable and healthy (under the guise of being free-range) and that it supports local communities. Residents of Lusaka consume tens of thousands of kilograms of bushmeat each year" (Nguluka 2018).

- Sosnowski et al. (2021) describe a **rapid population growth in rural communities and urbanization. Bushmeat is increasingly consumed by high-income urban groups, where meat consumption rates and preference for wild meat rise with income.** "*High-income groups can afford the costs associated with longer supply chains and a larger number of intermediaries and facilitators. That may lead to specialization of bushmeat hunting and supply and can involve organized criminal gangs*."

5.2.4. Demand reduction strategies

- **Ideal-reality gap**: Although many people are concerned about a problem (a stated preference, which can be triggered by education), this does not always translate into taking practical steps to perform an environmental behaviour (revealed preferences).
- **Arguments for demand reduction:** According to Moorhouse et al. (2017) human health risks (via zoonotic diseases) and legal aspects (protection status of a species and potential legal consequences) were more convincing for potential clients not to buy, compared to conservation (rarity of a species) or animal welfare aspects.
- During a survey around the North Luangwa National Park, 11.5 % of interview respondents suggested domestic meat and livestock (e.g. pigs, goats, chickens) as alternatives to bushmeat (King 2014).
- According to King (2014) attitudes in Luangwa Valley have changed over the past decade, to the extent that **hunting and trading bushmeat no longer command respect** and many people would like to stop. Reasons are e.g. increased fear to be arrested, but also an increased awareness of the benefits that wildlife bring with regards to tourism and related income.
- Campbell et al. (2021) from TRAFFIC highlight main factors for the success of demand reduction strategies, e.g.:
    - "*In general, target audiences respond better to **positive social messages** than to negative environmental messages. This is in line with the experience from communications targeting climate change deniers, which have proved more effective when focusing on the social welfare improvements of mitigating climate change, rather than the risks and realities of climate change."*
    - ***"The perceived credibility and pick-up of behaviour change messaging are influenced by who presents the message.** Locally influential actors and institutions should be engaged as messengers to change perceptions and bring about effective behaviour change. These messengers can have a strong voice in promoting alternative products or forms of consumption. In the Republic of the Congo, for example, Protestant Christian groups are growing in influence, and have significant social and political influence to connect with target audiences" (see also https://changewildlifeconsumers.org/toolkit/choosing-the-right-messenger/).*
    - *"**Proposing suitable alternative options** is important for any behaviour change intervention, and the right alternative product for wildlife consumers will vary based on local preferences and local availability. In the Republic of the Congo, imported frozen meats are seen as poor quality and unsafe, often making consumers sick. Local organic*

poultry and livestock and locally caught fish are seen as fresh, tasty, and healthy, satisfying the main motivators for why people consume wild meat in this area. Fresh fish may be a good alternative protein source in similar urban coastal areas if fish can be sustainably sourced.

- For the WWF, Nicolas (2021) also noted that "demand reduction campaigns that focus on diminishing the purchase of specific wildlife products work best when they target consumers and develop messaging based on research of consumer motivations. This allows campaigns to target consumers more effectively and develop appropriate messaging."
- MacFarlane *et al.* (2022) highlight: "*In light of the devastation caused by the current coronavirus pandemic, and the aforementioned associated risks, there may be a* ***moral responsibility for conservationists to incorporate factual health-risk warnings into communications that concern many wildlife trade activities…*** *Thus, by communicating that consuming primate meat is both high in risk (e.g., of contracting disease) and low in benefit (no more nutritious than other forms of protein) we can use both elements combined to reduce people's perception of its value.* ***Indeed, a recent experiment found that while the perceived value of an ineffective health remedy could be reduced by communicating either its lack of benefits (by 23%) or its potential health risks (by 30%), communicating both produced the greatest reduction in perceived value (by 50%).***

6. Relevant stakeholders & potential partners

(e.g., religious leaders / government / authorities / celebrities…):

- **University of Zambia, Department of Disease Control (Dr Musso Munyeme)**
- **Wildlife Crime Prevention (WCP) project**: "This Is Not A Game" public awareness campaign was launched in 2017.
  Awareness programs manager: Luwi Nguluka (https://www.linkedin.com/in/luwi-nguluka-8b850a158/)
  >> website of the campaign: http://www.thisisnotagame.info/ (presently under construction…)
  >> Facebook account of the campaign: https://www.facebook.com/ThisIsNotAGameZm/
- **Traditional Healers and Practitioners Association of Zambia** (THPAZ): Traditional healers in Zambia are consulted by people in communities for health problems such as Malaria, Tuberculosis, HIV and AIDS, mental health and many others (Green et al. 2022). The THPAZ had been involved in prevention campaigns against COVID-19 (WHO Africa 2020).

6.1. Role of stakeholders

- Religious leaders in Africa can have a central role in awareness campaign (e.g. vaccination, prevention of diseases, climate change), but also have the potential to undermine awareness or vaccination campaigns (Nche & Agbo 2022; Jegede 2007). Therefore, they need to be convinced first before becoming an active and helpful player (Nche 2020; Agbo & Nche 2020; Remes et al. 2012).
- In northern Nigeria, a **coalition campaign involving imams, Islamic school teachers, traditional rulers, doctors, journalists, and polio survivors** was gradually turning the tide against polio vaccine rejection (Nasir *et al.* 2014).
- During the COVID-19 pandemic religious leaders (Christians and Muslims) in several African countries were involved in Governments' public health education campaigns – including spots on TV and speaking on radio (WHO Africa 2020).

6.2. Health Alliance partners

Who:	**End Wildlife Crime**
What:	**"Preventing future zoonotic pandemics: strengthening national legal frameworks and international cooperation"**
Contacts:	Alice Pasqualato (pasqualato.alice@gmail.com)
Link:	https://alliance-health-wildlife.org/projects/preventing-future-zoonotic-pandemics-strengthening-national-legal-frameworks-and-international-cooperation/

Who:	**GIZ Zambia**
What:	eventually helpful for networking with authorities?
Contacts:	GIZ Office Zambia, Kariba Road, Plot 6469, Lusaka, Zambia giz-zambia@giz.de; +260-211-291918-20; +260-211-291946
Link:	https://www.giz.de/en/worldwide/338.html

7. Studies on national use of (social) media tools

7.1. Key findings on media tools

In a nutshell:

- **Radio remains by far the dominant news source in Zambia,** with 68% of households owning a radio (compared to 47% with TV). However, internet coverage and use has rapidly developed.
- There were 5.47 million **internet users** and 2.9 million **social media** users in Zambia in January 2022. Facebook is by far the most popular social media channel, followed by LinkedIn, Instagram, Facebook Messengers and Twitter.
- Social Media have been proven to help spread the word in public health campaigns.
- **Problem for several media tools is the difficult evaluation of impact**, of e.g. radio spots or billboards. While social media may reach only some target groups, evaluation is much easier, as outreach data are provided by the channels.
- A nun's radio show (by Astridah Banda) successfully shared COVID-19 information in different languages and dialects – and might be a good partner for our project.

7.2. Scientific background

- **Radio remains the dominant news source in Zambia,** especially as more than fifty percent of the population is in rural areas and can hardly afford a television set that today comes with a levy. Even more, the growing misinformation on social media networks has worked against the penetration of mobile telephoning that put internet enabled communication in the hands of many young people. Community Radio stations are critical key players in this regard as they broadcast predominantly in languages of the communities they serve (UNESCO 2022).
- Astridah Banda, a Dominican nun in Zambia, is hosting a radio show 15 minutes a week and used this show to spread COVID-19 awareness. English is Zambia's official language, but the country's 17 million citizens speak more than 70 languages and dialects. A radio show in English would not serve the whole country's needs, so Banda saw an **opportunity to share COVID-19 information in local languages and dialects — particularly those of the Bantu family — in both urban and rural areas** (Baskar 2020).
- GRI broadcast a weekly conservation education radio program from three community radio stations – reaching 75,000 households. It is recorded in both English and the relevant local languages and includes live call-in sessions
- Radio and television programs were proven to create awareness for AIDS prevention (Van Rossem & Meekers 2007). However, the results suggest that future reproductive **health communication campaigns that invest in radio programming may be more effective than those investing in television programming**.
- **Internet**: Up from 4.1 percent in 2012, about 20% of the population in Zambia accessed the internet in 2020 and even 28.5% in 2022 (Statista 2022; World Bank Group 2023).
- There were 5.47 million internet users in Zambia in January 2022. Kepios analysis indicates that internet users in Zambia increased by 279 thousand (+5.4 percent) between 2021 and 2022. For

perspective, these user figures reveal that 13.72 million people in Zambia did not use the internet at the start of 2022, meaning that 71.5 percent of the population remained offline at the beginning of the year (Kepios 2023).

- There were 2.90 million **social media** users in Zambia in January 2022, which is equivalent to 15.1 percent of the total population, but it's important to note that social media users may not represent unique individuals. According to Kepios (2023), **Facebook** had 2.60 million users in Zambia in early 2022, **Facebook Messengers** 245,200 users, **Instagram** 391,000 users, **Twitter** 114,800 users and **LinkedIn** 520,000 users. For more details see https://datareportal.com/reports/digital-2022-zambia.
- Facebook and WhatsApp are the most commonly used social media platforms
- A **YouTube video spot series in Zambia on HIV prevention** had only very limited outreach, as shown by the numbers of viewers (240 – 1800 views within 2 years: https://www.prepwatch.org/resources/zambia-ending-aids-campaign-materials/).
- A survey among journalists in Zambia (and Tanzania) found that **most reporters place more value on Facebook than any other social platform (67%)** such as WhatsApp (51.2%) and Twitter (40%) as it relates to professional practice. Individual journalists' value perception suggests that, unlike Facebook, the value of other social media platforms such as WhatsApp and Twitter were respectively tied to their usage in querying friends and sharing 'fake news' for entertainment purposes (Wanda & Gondwe 2021).

8. Other relevant information

- In neighbouring Tanzania (Tabora District), primates and carnivores are killed because they destroyed crops or preyed on domestic animals, but are not consumed as food, except for the African civet (*Civettictis civetta*), and food taboos are assumed as reason (Carpaneto & Fusari 2000).

Cultural and social taboos

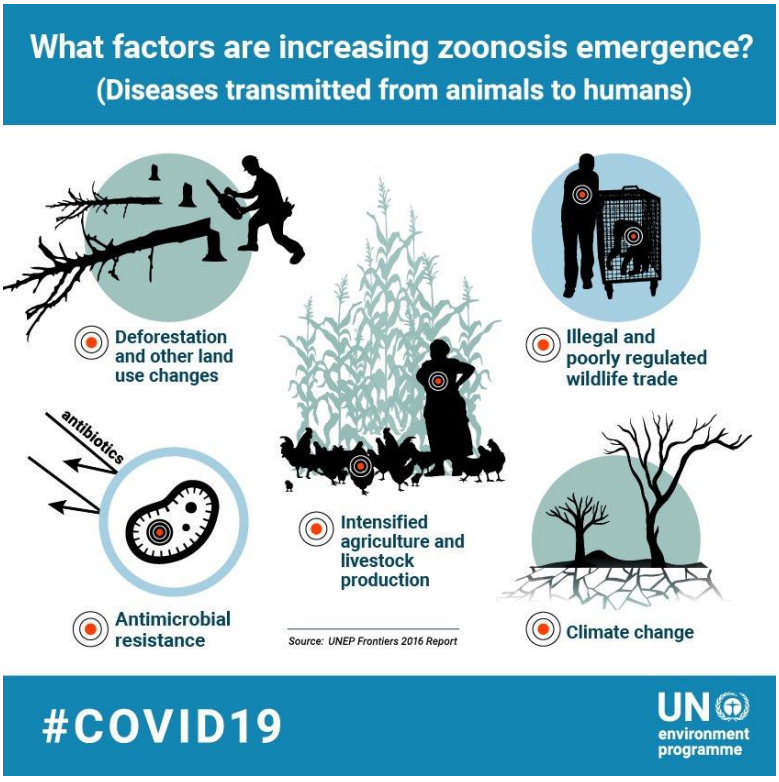
- In the past, the Bisa people of Luangwa Valley avoided to kill zebras (as their black colour was associated with witchcraft) and hippos, which were the major taboo species. But since the 1990s, hunting on these species increased, indicating an erosion of their cultural "totem", linked to increasing commercialization of the bushmeat trade (Barnett 1997).
- Hyenas are not consumed because they look creepy/sinister.
- Carnivores are not consumed because they feed on other animals (includes small and large carnivores)
- Chameleons are associated with witchcraft and are not consumed
- Bats are not consumed due to superstition

9. Examples for Visualization and Graphics (internal use only)

One Health concept

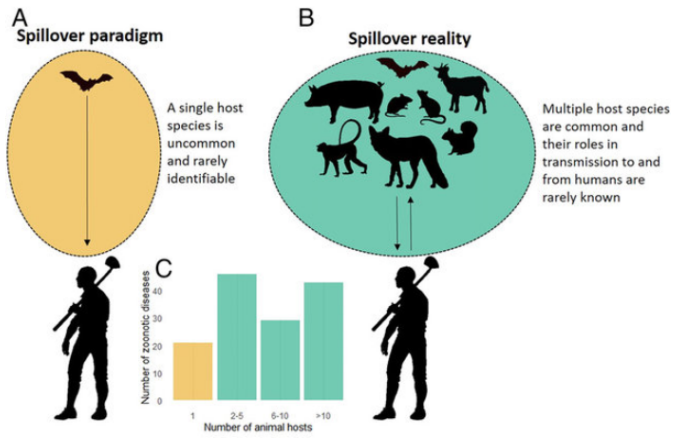
>> GIZ: https://www.giz.de/en/worldwide/95590.html

Biodiversity loss & zoonosis emergence
(https://twitter.com/GlobalGoalsUN/status/1251562406624374784/photo/1)



Complexity of hosts

(https://www.researchgate.net/publication/350665803_Impacts_of_biodiversity_and_biodiversity_loss_on_zoonotic_diseases/figures?lo=1)



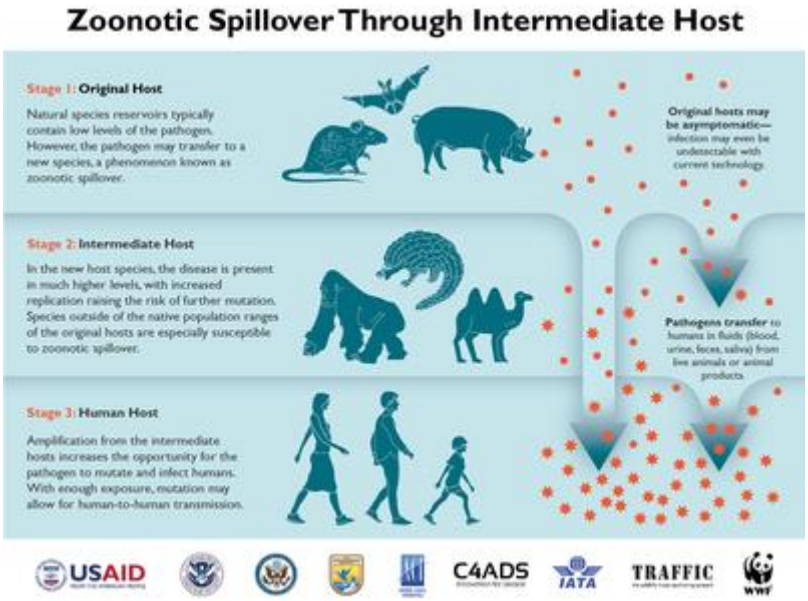
Figure

Caption

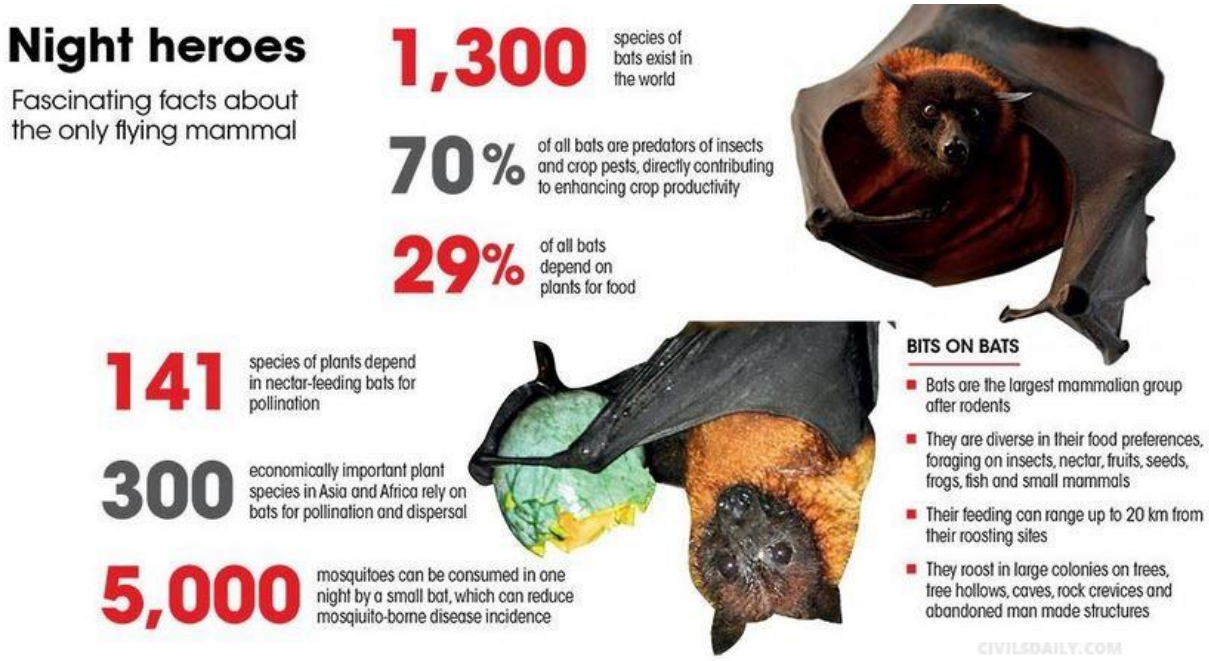
Fig. 4. The paradigm and the reality for research on spillover of zoonotic pathogens into humans. (A) The paradigm emphasizes a single animal host species for a zoonotic pathogen and an original spillover event, though the event and the species are rarely identified. (B) In reality, most zoonotic pathogens have multiple host species whose specific roles in transmission to and from humans are rarely known. (C) The number of viral zoonotic diseases that have 1, 2 to 5, 6 to 10, or 11+ known animal host species other than humans. Plotted from data made available in supplementary materials from Johnson et al. (21); see caveats about these and similar data in SI Appendix.

Zoonotic spillover through intermediate hosts

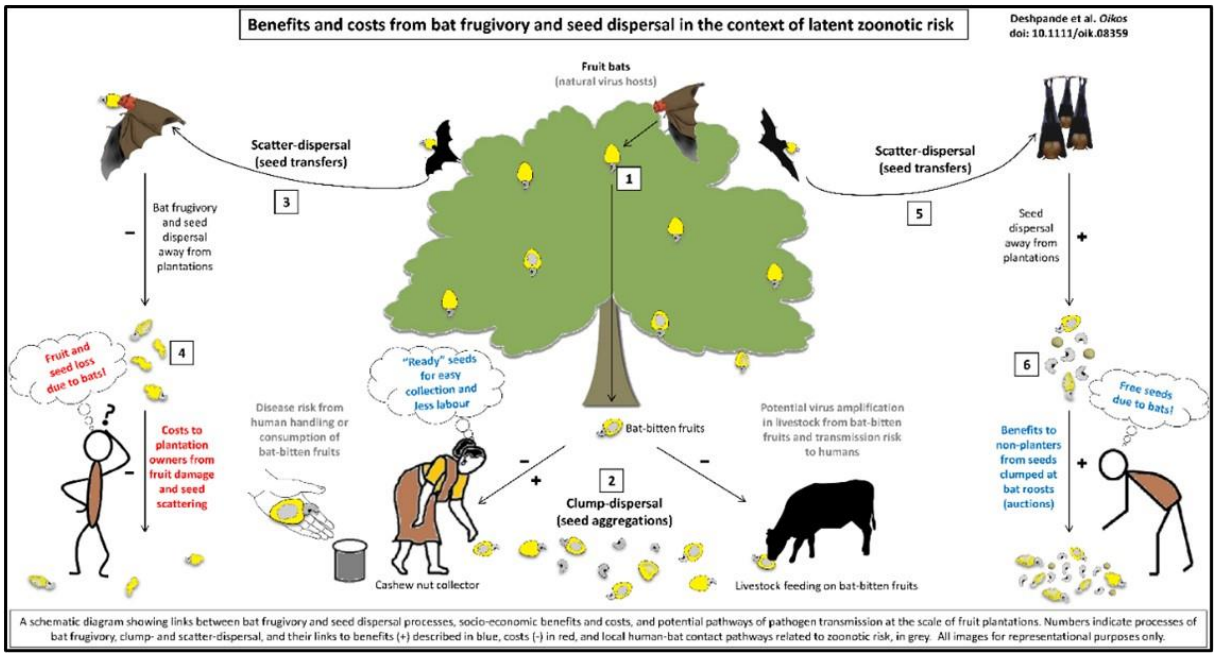
(https://routespartnership.org/news-room/covid-19-underscores-global-need-to-combat-animal-smuggling-in-aviation)



Ecological role of bats: https://www.civilsdaily.com/news/bats-and-their-ecological-significance/



https://www.oikosjournal.org/blog/fruit-bat-people-interactions



10. References

Africapolis (undated). Zambia – country report. https://africapolis.org/en/country-report/Zambia [accessed 27 Jan 2023]

Agbo, U. & G. Nche (2022). Suspecting the figures: What church leaders think about Government's commitment to combating COVID-19 in Nigeria. *Journal of Asian and African Studies* OnlineFirst, January

Alexander, G.J., Tolley, K.A., Penner, J., Luiselli, L., Jallow, M., Segniagbeto, G., Niagate, B., Howell, K., Beraduccii, J., Msuya, C.A. & Ngalason, W. (2021). *Python sebae*. The IUCN Red List of Threatened Species 2021: e.T13300572A13300582. https://dx.doi.org/10.2305/IUCN.UK.2021-2.RLTS.T13300572A13300582.en. Accessed on 30 January 2023.

Alves, R.; Souto, W. & R. Barboza (2010). Primates in traditional folk medicine: a world overview. *Mammal Rev* 40(2): 155–180.

Amori, G. & S. Gippoliti (2002). Rodents and the bushmeat harvest in Central Africa. In: *Links between biodiversity conservation, livelihoods and food security.* S. Mainka & M. Trivedi (eds). IUCN The World Conservation Union, pp. 95-100.

Barnett, R. (1997). Food for thought: The utilization of wild meat in eastern and southern Africa. TRAFFIC East/Southern Africa (ed), Nairobi, Kenya, 283 pp.

Baskar, P. (2020). Who do people trust for Coronavirus info? In Zambia, it's nuns on the radio. NPR, Online article 4th June 2020. https://rb.gy/iw0mwf, [accessed 27th January 2023]

Bearder, S.; Svensson, M.; Butynski, T. & Y. de Jong (2021). *Galago moholi*. The IUCN Red List of Threatened Species 2021: e.T8788A206563837. https://dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.T8788A206563837.en. Accessed 14 Jan 2023.

Becker, M.; McRobb, R.; Watson, F.*et al*. (2013). Evaluating wire-snare poaching trends and the impacts of by-catch on elephants and large carnivores. *Biol. Conserv*. 158: 26–36.

Berthe, F.; Bali, C.; Rameshwari, S. & G. Bartmanian (2022). Putting pandemics behind us: Investing in One Health to reduce risks of emerging infectious diseases. World Bank (ed.), Washington, Report, 52 pp. https://documents1.worldbank.org/curated/en/099530010212241754/pdf/P17840200ca7ff098091b7014001a08952e.pdf [retrieved 3rd January 2022]

Blundell, S.; Contopoulou, E. & A. McGregor (2020). A 62-year-old male with multiple calcified abdominal lesions. *Clinical Infectious Diseases* 71(9): 2533–2535.

Bonwitt, J.; Dawson, M.; Kandeh, M. *et al.* 2018. Unintended consequences of the 'bushmeat ban' in West Africa during the 2013–2016 Ebola virus disease epidemic. *Social Science & Medicine* 200: 166-173.

Butynski, T. & Y. De Jong (2022). *Chlorocebus aethiops*. The IUCN Red List of Threatened Species 2022: e.T4233A214886892. https://dx.doi.org/10.2305/IUCN.UK.2022-1.RLTS.T4233A214886892.en. Accessed on 30 January 2023.

Campbell, S.; Burgess, G.; Watson, S. & J. Compton (2021). Situation analysis: Social and behaviour change messaging on wildlife trade and zoonotic disease risks. TRAFFIC International (ed.), Cambridge, UK, 68 pp. https://www.traffic.org/site/assets/files/16541/traps_situation_analysis_full-vfinal.pdf

Carpaneto, G. & A. Fusari (2000). Subsistence hunting and bushmeat exploitation in central-western Tanzania. *Biodiversity and Conservation* 9: 1571–1585

Caron, A.; Cornelis, D.; Foggin, C. et al. (2016). African buffalo movement and zoonotic disease risk across Transfrontier Conservation Areas, Southern Africa. *Emerg Infect Dis*. 22(2):277-80.

Carroll, D.; Daszak, P.; Wolfe, N. et al. (2018). The Global Virome Project – Expanded viral discovery can improve mitigation. Science 359 (6378): 872-874.

Cassola, F. (2016c). *Hystrix africaeaustralis* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T10748A115099085. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T10748A22232321.en. 31 January 2023.

Cassola, F. (2016d). *Paraxerus boehmi* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T16204A115131686. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T16204A22242582.en. 31 January 2023.

Cassola, F. (2016e). *Paraxerus cepapi* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T16205A115131842. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T16205A22243078.en. 31 January 2023.

Cassola, F. (2016f). *Heliosciurus gambianus (*errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T9830A115094544. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T9830A22260303.en. 31 January 2023.

CDC (2022a). History of Ebola Virus Disease (EVD) Outbreaks. https://www.cdc.gov/vhf/ebola/history/chronology.html#anchor_1526565114626 [retrieved 12th Dec 2022]

Chambaro, H.; Hirose, K.; Sasaki, M. et al. (2022). An unusually long Rift valley fever inter-epizootic period in Zambia: Evidence for enzootic virus circulation and risk for disease outbreak. *PLoS Negl Trop Dis* 16(6): e0010420.

Changula, K.; Simulundu, E.; Lombe, B. *et al.* (2021). Serological evidence of filovirus infection in nonhuman primates in Zambia. *Viruses* 13: 1283.

Chileshe, B. (2018). Enhancing health campaigns through environmental education: A case of the 'Keep Zambia clean and healthy' programme. Thesis, University of Zambia, Lusaka, 314 pp.

Cleaveland, S.; Haydon, D. & L. Taylor (2007). Overviews of pathogen emergence: which pathogens emerge, when and why? In: *Wildlife and emerging zoonotic diseases: the biology, circumstances and consequences of cross-species transmission*. Childs, J; Mackenzie, J & J. Richt (eds). Springer, Berlin, pp 85–111.

Cooper, N. & C. Nunn (2013). Identifying future zoonotic disease threats: Where are the gaps in our understanding of primate infectious diseases? *Evolution, Medicine, and Public Health* 1: 27–36.

de Jong, Y. & T. Butynski (2019). *Cercopithecus ascanius*. The IUCN Red List of Threatened Species 2019: T4212A17947340. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T4212A17947340.en. Accessed on 14 January 2023.

de Jong, Y.; Cumming, D.; d'Huart, J. & T. Butynski (2016). *Phacochoerus africanus* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T41768A109669842. https://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T41768A44140445.en. Accessed on 31 January 2023.

Dobson, A.; Pimm, S.; Hannah, L. *et al.* (2020). Ecology and economics for pandemic prevention. *Science* 369: 379–381.

Doty, J.; Malekani, J.; Kalemba, L. *et al.* (2017). Assessing monkeypox virus prevalence in small mammals at the human–animal interface in the Democratic Republic of Congo. *Viruses* 9: 283.

Everard, M., Johnston, P., Santillo, D., *et al.* (2020). The role of ecosystems in mitigation and management of Covid-19 and other zoonoses. *Environmental Science & Policy* 111: 7-17.

GHS Index (2021d). Country Score Justifications and References – Zambia. 92 pp. https://www.ghsindex.org/wp-content/uploads/2021/12/Zambia.pdf. [accessed 31st January 2023]

Graham, J. & Y. Ferguson (2020). The case of the "This Is Not A Game" campaign in Zambia: An analysis of the messaging strategies used to deter illegal bushmeat consumption. *Psychology and Marketing* 37(12): 1696-1702

Green, J.; Hankinson, O.; de Waal, L. et al. (2022). Wildlife trade for belief-based use: Insights from traditional healers in South Africa. *Front. Ecol. Evol*. 10: 906398.

Gumpenberger, M. (2000). Reptilien und Salmonellen aus veterinärmedizinischer Sicht. *Mitt. Österr. Ges. Tropenmed. Parasitol*. 22: 55 -58.

Han, B. A., Kramer, A. M., & Drake, J. M. (2016). Global patterns of zoonotic disease in mammals. *Trends Parasit* 32(7): 565-577.

Hardi, R.; Babocsay, G.; Tappe, D. *et al.* (2017). *Armillifer*-infected snakes sold at Congolese bushmeat markets represent an emerging zoonotic threat. *EcoHealth* 14: 743–749.

Hoffman, L.; Swanepoel, M. & A. Leslie (2017). African game meat and the safety pertaining to free-ranging wildlife: example of a wild suid in South Africa: Food safety and security. In: *Game meat hygiene – Food safety and security*. P. Paulsen, A. Bauer and F.J.M. Smulders (eds.), Wageningen Academic Publishers, pp. 17-50.

IPBES (2020). Workshop on biodiversity and pandemics. Executive Summary. https://ipbes.net/sites/default/files/2020-11/20201028%20IPBES%20Pandemics%20Workshop%20Exec%20Summ%20Laid%20Out%20Final.pdf [8 Jan 2023]

Ishii, A.; Thomas, Y.; Moonga, L. *et al*. (2011). Novel arenavirus, Zambia. *Emerg Infect Dis*. 17(10): 1921–1924.

IUCN SSC Antelope Specialist Group (2020b). *Tragelaphus strepsiceros* (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2020: e.T22054A166487759. https://dx.doi.org/10.2305/IUCN.UK.2020-1.RLTS.T22054A166487759.en. Accessed on 31 January 2023.

IUCN SSC Antelope Specialist Group (2019). *Syncerus caffer*. The IUCN Red List of Threatened Species 2019: e.T21251A50195031. https://dx.doi.org/10.2305/IUCN.UK.2019-1.RLTS.T21251A50195031.en. Accessed 30 Jan 2023.

IUCN SSC Antelope Specialist Group (2017). *Kobus leche*. The IUCN Red List of Threatened Species 2017: e.T11033A50189021. https://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T11033A50189021.en. Accessed 30 Jan 2023.

IUCN SSC Antelope Specialist Group (2016e). *Sylvicapra grimmia*. The IUCN Red List of Threatened Species 2016: e.T21203A50194717. https://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T21203A50194717.en. Accessed 30 Jan 2023.

IUCN SSC Antelope Specialist Group (2016f). *Kobus vardonii*. The IUCN Red List of Threatened Species 2016: e.T11037A50189881. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T11037A50189881.en. Accessed 30 Jan 2023.

IUCN SSC Antelope Specialist Group (2016g). *Tragelaphus oryx* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T22055A115166135. https://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22055A50196938.en. Accessed on 30 January 2023.

IUCN SSC Antelope Specialist Group (2016p). *Aepyceros melampus*. The IUCN Red List of Threatened Species 2016: e.T550A50180828. https://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T550A50180828.en. Accessed on 31 January 2023.

Jones, K.; Patel, N.; Levy, M. *et al.* (2008). Global trends in emerging infectious diseases. *Nature* 451(7181): 990-993.

Jori, F.; Alexander, K.; Mokopasetso, M. *et al*. (2015). Serological evidence of Rift Valley Fever Virus circulation in domestic cattle and African buffalo in northern Botswana (2010–2011). *Front. Vet. Sci.* 2: 63.

Judson, S.; Fischer, R.; Judson, A. & V. Munster (2016). Ecological Contexts of Index Cases and Spillover Events of Different Ebolaviruses. *PLoS Pathog* 12(8): e1005780.

Kajihara, M.; Hang'ombe, B.; Changula, K. et al. (2019). Marburgvirus in Egyptian fruit bats, Zambia. *Emerg. Infect. Dis.* 25(8): 1577–1580.

Karesh, W. & Noble, E. (2009). The bushmeat trade: Increased opportunities for transmission of zoonotic disease. *Mount Sinai Journal of Medicine* 76(5): 429-434.

Karesh, W. & N. Vora (2010). One world – one health. *Clinical Medicine* 9(3): 259–260.

Katani, R.; Schilling, M.; Lyimo, B. *et al*. (2021). Identification of *Bacillus anthracis*, *Brucella* spp., and *Coxiella burnetii* DNA signatures from bushmeat. *Scientific Reports* 11: 14876.

Keesing, F. & R. Ostfeld (2021). Impacts of biodiversity and biodiversity loss on zoonotic diseases. *PNAS* 118(17): e2023540118.

Kepios (2023). Digital 2022 – Zambia. https://datareportal.com/reports/digital-2022-zambia. [accessed 27th January 2023]

King, E. (2014). Hunting for the Problem: An investigation into bushmeat use around North Luangwa National Park, Zambia. Thesis, Imperial College London, 94 pp. https://www.iccs.org.uk/wp-content/uploads/2011/10/Emily-King-Thesis-Amended-for-Website.pdf [accessed 30th January 2023]

King, S. & P. Moehlman (2016). *Equus quagga*. The IUCN Red List of Threatened Species 2016: e.T41013A45172424. https://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T41013A45172424.en. Accessed on 30 January 2023.

Korine, C. (2016). *Rousettus aegyptiacus*. The IUCN Red List of Threatened Species 2016: e.T29730A22043105. https://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T29730A22043105.en. Accessed on 31 January 2023.

Kurpiers, L.; Schulte-Herbrüggen, B.; Ejotre, I. & Reeder, D. (2016). Bushmeat and emerging infectious diseases: Lessons from Africa. In: *Problematic Wildlife*. Angelici, F. (eds), Springer, Cham, pp. 507-551.

LaBeaud, A.; Cross, P.; Getz, W. *et al*. (2011). Rift Valley Fever virus infection in African buffalo (*Syncerus caffer*) herds in rural South Africa: Evidence of interepidemic transmission. *Am. J. Trop. Med. Hyg.* 84(4): 641–646.

Lakin, H.; Tavalire, H. ; Sakamoto, K. et al. (2022). Bovine tuberculosis in African buffalo (*Syncerus caffer*): Progression of pathology during infection. *PLOS Neglected Tropical Diseases* 16(11): e0010906.

LeBreton, M., Prosser, A. T., Tamoufe, U., *et al*. (2006). Patterns of bushmeat hunting and perceptions of disease risk among central African communities. *Animal Conservation* 9(4): 357-363.

Leroy, E. M., Rouquet, P., Formenty, P., et al. (2004a). Multiple Ebola virus transmission events and rapid decline of central African wildlife. *Science* 303(5656): 387-390.

Lewison, R. & J. Pluháček (2017). *Hippopotamus amphibius*. The IUCN Red List of Threatened Species 2017: e.T10103A18567364. https://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T10103A18567364.en. Accessed 26 Jan 2023.

Lindsey, P., Balme, G., Becker, M., Begg, C. *et al.* (2015a). Illegal hunting and the bushmeat trade in savanna Africa: drivers, impacts and solutions to address the problem. Panthera/Zoological Society of Lon FAO, don/Wildlife Conservation Society report, New York. 74 pp.

Lindsey, P.; Taylor, W.; Nyirenda, V. & J. Barnes (2015b). Bushmeat, wildlife-based economies, food security and conservation: Insights into the ecological and social impacts of the bushmeat trade in African savannahs. FAO/Panthera/Zoological Society of London/SULi Report, Harare. 58 pp. https://www.fao.org/3/bc610e/bc610e.pdf

Lindsey, P.; Nyirenda, V.; Barnes, J. *et al.* (2013b). Underperformance of African protected area networks and the case for new conservation models: Insights from Zambia. *PLoS ONE* 9(5): e94109.

Lindsey, P.; Barnes, J.; Nyirenda, V. et al. (2013c). The Zambian wildlife ranching industry: Scale, associated benefits, and limitations affecting its development. *Plos One* 8(12): e81761.

Luis, A. D., Hayman, D. T., O'Shea, T. J., et al. (2013). A comparison of bats and rodents as reservoirs of zoonotic viruses: are bats special? *Proceedings of the Royal Society B: Biological Sciences* 280(1756): 20122753.

Lusaka Times (2019). President Lungu's snake eating antics send tongues wagging. Online article 30th September. https://www.lusakatimes.com/2019/09/30/president-lungus-snake-eating-antics-send-tongues-wagging/ [31 Jan 2023]

MacFarlane, D.; Hurlstone, M.; Ecker, U. *et al.* (2022). Reducing demand for overexploited wildlife products: Lessons from systematic reviews from outside conservation science. *Cons. Sci. Pract*. 4(3): e627.

Machalaba, C. (2022). Integrating biodiversity and health messaging and tackling superstition with communities in Liberia. https://panorama.solutions/en/solution/integrating-biodiversity-and-health-messaging-and-tackling-superstition-communities-liberia Published 24th October 2022. [retrieved on 5th January 2023]

Mackenzie, J.; McKinnon, M. & M. Jeggo (2014). One Health: From concept to practice. In: *Confronting Emerging Zoonoses: The One Health Paradigm*; Yamada, A.; Kahn, L.; Kaplan, B. et al. (eds); Springer: Tokyo, Japan, pp. 163–189.

Malama, S.; Munyeme, M. & J. Muma (2019). Bovine tuberculosis in Zambia. In: *Tuberculosis in Animals: An African Perspective*. Dibaba, A., Kriek, N., Thoen, C. (eds), Springer, Cham.

Markotter, W.; Coertse, J.; De Vries, L. *et al.* (2020). Bat-borne viruses in Africa: a critical review. *J. Zool.* 311: 77–98.

Marshall, N. (1998). Searching for a cure; Conservation of medicinal wildlife resources in East and southern Africa. TRAFFIC International, Cambridge, UK, 136 pp.

Mbenywe, M. (2022). Ebola-like African primate viruses 'poised for spillover' to humans, study finds. Mongabay. https://news.mongabay.com/2022/12/ebola-like-african-primate-viruses-poised-for-spillover-to-humans-study-finds/ [retrieved at 22nd Dec 2022]

Mickleburgh, S.; Waylen, K. & P. Racey (2009). Bats as bushmeat: A global review. *Oryx* 43(2): 217-234.

Milbank, C. & B. Vira (2022). Wildmeat consumption and zoonotic spillover: contextualising disease emergence and policy responses. *Lancet Planet Health* 6: e439–48.

Mildenstein, T.; Tanshi, I. & P. Racey (2016). Exploitation of bats for bushmeat and medicine. In: *Bats in the Anthropocene: Conservation of bats in a changing world*. C. Voigt and T. Kingston (eds.), pp. 325-375.

Mishra, J.; Mishra, P. & N. Arora (2021). Linkages between environmental issues and zoonotic diseases: with reference to COVID-19 pandemic. *Environmental Sustainability* 4: 455–467.

Moorhouse, T; Balaskas, M; Cruz, N. & D. MacDonald (2017): Information could reduce consumer demand for exotic pets. *Conservation Letters* 10(3): 337-345.

Mossoun, A.; Calvignac-Spencer, S.; Anoh, A. *et al.* (2017). Bushmeat Hunting and Zoonotic Transmission of Simian T-Lymphotropic Virus 1 in Tropical West and Central Africa. *J Virol*. 91(10): e02479-16.

Mubanga, M.; Mfune, R.; Kothowa, J. et al. (2021). Brucella seroprevalence and associated risk factors in occupationally exposed humans in selected districts of Southern Province, Zambia. *Front Public Health* 9:745244.

Mulenga, G.; Namangala, B.; Chilongo, K. et al. (2022). Policy and linkages in the application of a One Health system for reporting and controlling African Trypanosomiasis and other zoonotic diseases in Zambia. *Pathogens* 11: 30.

Muma, J.; Lund, A.; Siamudaala, V. et al. (2010). Serosurvey of *Brucella* spp. infection in the Kafue lechwe (*Kobus leche kafuensis*) of the Kafue flats in Zambia. *J Wildlife Dis* 46: 10639.

Mwacalimba, K. & J. Green (2015). 'One health' and development priorities in resource-constrained countries: policy lessons from avian and pandemic influenza preparedness in Zambia. *Health Policy and Planning* 30(2): 215–222.

Mwinyi, M.; Muma, J.; Kayunze, K. & M. Simuunza (2015). Policy concerns, opportunities, challenges, and attitude towards One Health practice in Zambia. *Journal of Health, Medicine and Nursing* 15: 30-38.

Nakayima, J., Hayashida, K., Nakao, R. et al. (2014). Detection and characterization of zoonotic pathogens of free-ranging non-human primates from Zambia. *Parasites Vectors* 7: 490.

Nasir, S.; Xa'u, I.; Gadanya, M. *et al.* (2014). From intense rejection to advocacy: How Muslim clerics were engaged in a Polio eradication initiative in Northern Nigeria. *PLoS Med* 11(8): e1001687.

Nche, G. (2020). Beyond spiritual focus: Climate change awareness, role perception, and action among church leaders in Nigeria. *Weather, Climate, and Society* 12(1): 149-169.

Nche, G. & U. Agbo (2022). The campaign against COVID-19 in Nigeria: exploring church leaders' role perception and action. Religion, Brain & Behavior April 2022.

Nguluka, L. (2018). YALI voices: This is not a game: illegal bushmeat in Zambia. Online article of 11th June 2018. https://yali.state.gov/this-is-not-a-game-illegal-bushmeat-in-zambia/ [accessed 31st January 2023]

Nicolas, A. (2021). Understanding consumer behavior to reduce wildlife demand. WWF, online article of 9 Sep 2021. https://www.worldwildlife.org/stories/understanding-consumer-behavior-to-reduce-wildlife-demand [27 Jan 2023]

Nieman, W.A., Leslie, A.J. & A. Wilkinson (2019). Traditional medicinal animal use by Xhosa and Sotho communities in the Western Cape Province, South Africa. *J. Ethnobiology Ethnomedicine* 15(1): 34.

Nijman, V. (2021). Illegal and legal wildlife trade spreads zoonotic diseases. *Trends in Parasitology* 37(5): 359-360.

OECD/SWAC (2020). Africa's urbanization Dynamics 2020: Africapolis, mapping a new urban geography. West African Studies. OECD Publishing, Paris, 204 pp. https://doi.org/10.1787/b6bccb81-en

Pawlak, A. (2014). Reptile-associated salmonellosis as an important epidemiological problem. *Postepy Hig Med Dosw* (Online) 68:1335-42.

Phiri, B. (2016). Challenges of avian influenza surveillance in Zambia and the way forward. Poster at 2nd International Conference on Flu, October 31-November 02, 2016, San Francisco, USA.

Peros, C.; Dasgupta, R.; Kumar, P. & B. Johnson (2021). Bushmeat, wet markets, and the risk of pandemics: Exploring the nexus through systematic review of scientific disclosures. *Environmental Science and Policy* 124: 1–11.

Public Health England (2020). Guidance – Rabies risks in terrestrial animals by country. https://www.gov.uk/government/publications/rabies-risks-by-country/rabies-risks-in-terrestrial-animals-by-country#l [retreived 4th January 2023]

Pulford, C.; Wenner, N.; Redway, M. *et al*. (2019). The diversity, evolution and ecology of *Salmonella* in venomous snakes. *PLoS Negl Trop Dis* 13(6): e0007169.

Quan, P. L., Firth, C., Conte, J. M., et al. (2013). Bats are a major natural reservoir for hepaciviruses and pegiviruses. *PNAS* 110(20): 8194-8199.

Remes, P.; Selestine, V.; Changalucha, J. *et al.* (2012). A qualitative study of HPV vaccine acceptability among health workers, teachers, parents, female pupils, and religious leaders in northwest Tanzania. *Vaccine* 30(36): 5363-5367.

Rostal, M.; Liang, J.; Zimmermann, D. et al. (2017). Rift Valley Fever: Does Wildlife Play a Role? *ILAR Journal* 58(3): 359–370.

Sakala, M. (2016). Wildlife resource utilisation and rural livelihoods in Mukungule game management area, Mpika, Zambia. Dissertation, University of Zambia, Lusaka, 109 pp.

Schwensow, N.; Heni, A.; Schmid, J. *et al*. (2022). Disentangling direct from indirect effects of habitat disturbance on multiple components of biodiversity. *Journal of Animal Ecology* 91:2220-2234.

Shivaprakash, K. N., Sen, S., Paul, S., Kiesecker, J. M., & Bawa, K. S. (2021). Mammals, wildlife trade, and the next global pandemic. *Current Biology* 31(16): 3671-3677.

Simpson, G.; Thompson, P.; Saegerman, C. *et al.* (2021). Brucellosis in wildlife in Africa: a systematic review and meta-analysis. *Scientific Reports* 11: 5960.

Simulundu, E.; Mweene, A.; Tomabechi, D. *et al.* (2009) Characterization of H3N6 avian influenza virus isolated from a wild white pelican in Zambia. *Arch. Virol.* 154: 1517–1522.

Sithaldeen, R. (2019). *Papio ursinus* (errata version published in 2020). The IUCN Red List of Threatened Species 2019: e.T16022A168568698. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T16022A168568698.en. Accessed 14 Jan 2023.

Sosnowski, M.; Everatt, K.; Pickles, R. *et al.* (2021). Illegal and unsustainable hunting of wildlife for bushmeat in Sub-Saharan Africa. Wilderness problem specific guide No. 2. Center for Problem-Oriented Policing, Arizona State University. Phoenix, AZ, 47 pp.

Statista (2022). Share of internet users in Africa as of January 2022, by country. https://www.statista.com/statistics/1124283/internet-penetration-in-africa-by-country/ [retrieved 4th Jan 2023]

Svensson, M.; Ingram, D.; Nekaris, A. & V. Nijman (2015). Trade and ethnozoological use of African lorisiforms in the last 20 years. *Hystrix, the Italian Journal of Mammalogy* 26(2): 151-161.

Tan, J. (2020). Bushmeat hunting: The greatest threat to Africa's wildlife? Article at *Mongabay*, dated 26 October. https://news.mongabay.com/2020/10/bushmeat-hunting-the-greatest-threat-to-africas-wildlife/

Tappe, D.; Sulyok, M.; Riu, T. *et al.* (2016). Co-infections in Visceral Pentastomiasis, Democratic Republic of the Congo. *Emerg Infect Dis.* 22(8):1333-9.

The Economist (2022). Global Food Security Index 2022. https://impact.economist.com/sustainability/project/food-security-index/reports/Economist_Impact_GFSI_2022_Global_Report_Sep_2022.pdf [accessed on 18th January 2023]

Towner, J. S., Pourrut, X., Albariño, C. G., et al. (2007). Marburg virus infection detected in a common African bat. *PloS one* 2(8): e764.

Travis, D.; Watson, E. & A. Tauer (2011). The spread of pathogens through trade in wildlife. *Rev. sci. tech. Off. int.* Epiz. 30 (1): 219-239.

Turcios-Casco, M. & R. Gatti (2020). Do not blame bats and pangolins! Global consequences for wildlife conservation after the SARS-CoV-2 pandemic. *Biodiversity and Conservation* 29: 3829-3833.

UN Africa Renewal (2022). In Africa, 63% jump in diseases spread from animals to people seen in last decade. Online Article of 14th July. https://www.un.org/africarenewal/magazine/july-2022/africa-63-jump-diseases-spread-animals-people-seen-last-decade (retrieved 13th Dec 2022).

UNESCO (2022). Celebrating radio and trust in Zambia. Press release 21st February 2022. https://www.unesco.org/en/articles/celebrating-radio-and-trust-zambia [accessed 27th January 2023]

UN Habitat (2012-2023). Zambia. https://unhabitat.org/zambia [accessed 31st January 2023]

University of Zambia, Ministry of Health & Ministry of Livestock and Fisheries (2017). REPUBLIC OF ZAMBIA – Report on pilot screening of Zoonotic Diseases and of Systems Capacity for their Surveillance and Control. 22 pp.

Van Rossem, R. & D. Meekers (2007). The reach and impact of social marketing and reproductive health communication campaigns in Zambia. *BMC Public Health* 7: 352.

Wagner, P.; Wilms, T.; Luiselli, L. *et al.* (2021). *Bitis arietans*. The IUCN Red List of Threatened Species 2021: e.T197461A2485974. https://dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.T197461A2485974.en. Accessed 26 Jan 2023.

Wallis, J. (2020c). *Papio cynocephalus*. The IUCN Red List of Threatened Species 2020: e.T92250442A92251260. https://dx.doi.org/10.2305/IUCN.UK.2020-2.RLTS.T92250442A92251260.en. Accessed on 31 January 2023.

Wallis, J. (2019). *Chlorocebus cynosuros*. The IUCN Red List of Threatened Species 2019: e.T136291A17957592. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T136291A17957592.en. Accessed on 14 January 2023.

Wallis, J.; Petersdorf, M.; Weyher, A. & C. Jolly (2021). *Papio kindae* (amended version of 2020 assessment). The IUCN Red List of Threatened Species 2021: e.T136848A190319676. https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T136848A190319676.en. Accessed on 14 January 2023.

Wanda, J. & G. Gondwe (2021). Social Media use among journalists in Zambia and Tanzania: Examining prospects and challenges. *African Communication Research* 9(1): 27-38.

Warren, C. J., Yu, S., Peters, et al. (2022). Primate hemorrhagic fever-causing arteriviruses are poised for spillover to humans. *Cell* 185(21): 3980-3991.

Welthungerhilfe & Concern Worldwide (2022). Global Hunger Index – Food systems Transformation and Local Governance. Boon, Dublin. https://www.globalhungerindex.org/pdf/en/2022.pdf. [accessed on 18th January 2023]

Wertheim, H. F., Horby, P., & Woodall, J. P. (Eds.). (2012). Atlas of human infectious diseases. *John Wiley & Sons.*

White, P. & J. Belant (2015). Provisioning of Game Meat to Rural Communities as a Benefit of Sport Hunting in Zambia. *PLoS ONE* 10(2): e0117237.

Whiting, M.; Williams, V. & T. Hibbitts (2013). Animals traded for traditional medicine at the Faraday Market in South Africa: Species diversity and conservation implications. In: Animals in Traditional Folk Medicine. R. Alves and I. Rosa (eds.), Springer-Verlag Berlin Heidelberg, pp. 421-473.

WHO (2022i). Multi-country monkeypox outbreak in non-endemic countries. https://www.who.int/emergencies/disease-outbreak-news/item/2022-DON385 [accessed 8th January 2023]

WHO (2021a). Ebola virus disease. https://www.who.int/news-room/fact-sheets/detail/ebola-virus-disease [retrieved 6th Dec 2022]

WHO (2021b). Marburg virus disease. https://www.who.int/news-room/fact-sheets/detail/marburg-virus-disease [retrieved on 12th Dec 2022]

WHO (2021d). Riff Valley Fever. https://www.afro.who.int/health-topics/rift-valley-fever [retrieved 14th Dec 2022]

WHO (2018b). Influenza (Avian and other zoonotic). Factsheet, 13th November 2018. https://www.who.int/news-room/fact-sheets/detail/influenza-(avian-and-other-zoonotic)#:~:text=Common%20initial%20symptoms%20are%20high,or%20coryza%20are%20less%20common. [accessed 31st January 2023]

WHO (2006). Avian influenza in Africa: statement by the Director-General of WHO. Press release 9th February 2006. https://www.afro.who.int/news/avian-influenza-africa-statement-director-general-who [accessed 5th January 2023]

WHO Africa (2020). WHO supports the Ministry of Health to train members of the Traditional Health Practitioners' Association of Zambia on COVID -19. Press release of 11th December 2020. https://www.afro.who.int/news/who-supports-ministry-health-train-members-traditional-health-practitioners-association-zambia [accessed on 31st January 2023]

WHO Africa (2018). Zambia heightens its capacity for preventing and responding to the threat of an outbreak of Ebola Virus Disease. Press release of 2nd November 2018. https://www.afro.who.int/news/zambia-heightens-its-capacity-preventing-and-responding-threat-outbreak-ebola-virus-disease [accessed 30th January 2023]

Wildlife Crime Prevention (undated). This is not a Game. The illegal bushmeat trade. http://www.thisisnotagame.info/index.php/the-illegal-bushmeat-trade-in-zambia.

Williams, V. & M. Whiting (2016). A picture of health? Animal use and the Faraday traditional medicine market, South Africa. *Journal of Ethnopharmacology* 179: 265-273.

WOAH - Word Organisation for Animal Health (2022). One Health – Controlling global health risks more effectively. https://www.oie.int/en/what-we-do/global-initiatives/one-health/ [retrieved 8th Jan 2023]

World Bank Group (2023). Individuals using the Internet (% of population) – Zambia. https://data.worldbank.org/indicator/IT.NET.USER.ZS?locations=ZM [assessed 27th January 2023]

World Factbook (2022). Zambia: People and Society. https://www.cia.gov/the-world-factbook/countries/zambia/#people-and-society [retrieved 6th Dec 2022]

Xinhua (2022). Zambia issues alert over threat on monkeypox outbreak. Online article of 23rd May 2022. https://english.news.cn/africa/20220523/72ee04f4c4ed41139d08ebb32346c87e/c.html [accessed 30th January 2023]

Zając, M.; Skarżyńska, M.; Lalak, A. *et al*. (2021). *Salmonella* in captive reptiles and their environment - Can we tame the dragon? *Microorganisms* 9(5):1012.

Zowalaty, M. & J. Järhult (2020). From SARS to COVID-19: A previously unknown SARS- related coronavirus (SARS-CoV-2) of pandemic potential infecting humans – Call for a One Health approach. *One Health* 9: 100124.