Country Profile: CAMEROON

Scientific basis for zoonosis education program

(as of April 2023)

In situ project partner: Limbe Wildlife Centre

Location: Limbe, Southwest Province ☑ **urban** ☑ **rural**

Outreach to (area): The LWC education and outreach program reaches 1800 children and around 30,000 visitors per year (90% Cameroonian), with a focus on wildlife conservation. The program will be expanded to include zoonoses risks. Any outreach education program we undertake will concentrate in the South-West region due our location, which is rich in rainforest.

Structure

1. National characteristics

- There are 24 major African language groups; English and French are official languages; however, Pidgin is commonly used in several areas
- Level of urbanization: 5%
- population concentrated in the west and north, with the interior of the country sparsely populated (World Factbook 2022)
- Position 96 (out of 113 countries) in the Global Food Security Index 2022 (The Economist 2022) and Position 80 (out of 121 countries) in the Global Hunger Index (Welthungerhilfe & Concern Worldwide 2022)

1.1. National legislation

- National legislation, plans, or equivalent strategy documents on zoonotic disease exist, including the promotion of the "One Health Concept, but they are not open to public (GHS Index 2021; WHO 2017a). However, there is insufficient evidence that the plan addresses risk identification and mitigation measures for zoonotic disease transmission. Also, there is now evidence that Cameroon collaborates with the private sector to control and respond to zoonoses (GHS Index 2021).
- The wildlife and forestry law of Cameroon from 1994 forbids the sale and trafficking of endangered species. Penalties are ranging from fines of between 3 million francs CFA to 10 million francs CFA, or imprisonment from one to three years. Additionally, the Minister of Forestry and Wildlife issued an order to ban the transport of bushmeat for commercial purposes, in 2010 (Mbun & Nguemwo 2021, Tembang 2021).
- Order N° 0649/MINFOF of 18 December 2006 establishes the distribution of animal species whose killing is authorized as well as the margin of killing according to the type of sports hunting permit (Mbun & Nguemwo 2021).
- Order No 1425/A/MINEF/DFAP/SAN specifies the hunting seasons (Mbun & Nguemwo 2021):
    - Savannah: 1st December to 31st May (6 months)
    - Rainforest: 1st December to 31st July (8 months)
- In Cameroon there are four different types of hunting permits (Mbun & Nguemwo 2021):
    - Big game sports hunting
    - Medium game sports hunting
    - Small game sports hunting
    - Commercial harvest.
- In Cameroon, three protection classes are set forth in Order No 053/MINFOF of 1 April 2021 which replaces Order No. 0648/MINFOF of 18 December 2006 (Mbun & Nguemwo 2021):
    - Class A – Totally protected (no commercial/ sports hunting permitted)
    - Class B – partially protected list of animals opened for sports hunting for hunting permit holders, in authorized hunting areas and during hunting periods.
    - Class C – least protected list of animals allowed for sports hunting/commercial purposes under same conditions as Class B, but also open for subsistence hunting and consumption in grassroots community without other restrictions.

- Law no. 006 of 2001 identifies notifiable animal diseases and response procedures, including zoonoses (e.g. tuberculosis and anthrax) and non-zoonotic animal diseases. It requires animal keepers to submit a written report of notifiable diseases to the local administrative and veterinary authorities. (GHS Index 2021).
- According to Saylors et al. (2021), the government agency is responsible for the regulation of hunting and sale of bushmeat, and meat confiscation or requests for proof of permit documentation.
- According to GHS Index (2021), a MINEPIA policy document from 2013 allocates budgets for surveillance and response to specific zoonoses, including animal influenzas, Rift Valley fever, Lassa fever, Marburg and Ebola viruses, tuberculosis, brucellosis and rabies, without providing plans.
- Cameroon has a unit called the National Program for the Prevention Against Emerging and Re-Emerging Zoonoses (NPPCERZ) which is a zoonotic disease department which collaborates with other Ministries (GHS Index 2021).
- The Laboratory of the Research Center for Military Health (CRESAR) monitors zoonotic diseases in wildlife, for example Ebola (WHO 2017a).
- Cameroon established a ban on bat hunting and consumption after the Ebola crisis 2014 Akem & Permunta 2020).

1.2. Human population

29,321,637 Mio people (2022 est.; World Factbook 2022)

Population growth rate: 2.75% (2022 est.; World Factbook 2022)

Religion (2018 est.; World Factbook 2022):

In Cameroon, Christianity and Islam are widespread, but Animism is also widely practiced (Republic of Cameroon 2022).

- Christianity: 70.7% (subgroups: Roman Catholics 38.3%; Protestants 25.5%; Other Christian 6.9%)
- Islam: 24.4 %

  (⇨ In Islam consumption of primate meat is banned, see taboo)
- Animism: 2.2%
- other groups: 0.5%
- none: 2.2%

Ethnic groups:

Cameroon is home to more than 240 tribes which are found in three main ethnic groups: Bantus, Semi-Bantus and Sudanese (Republic of Cameroon 2022).

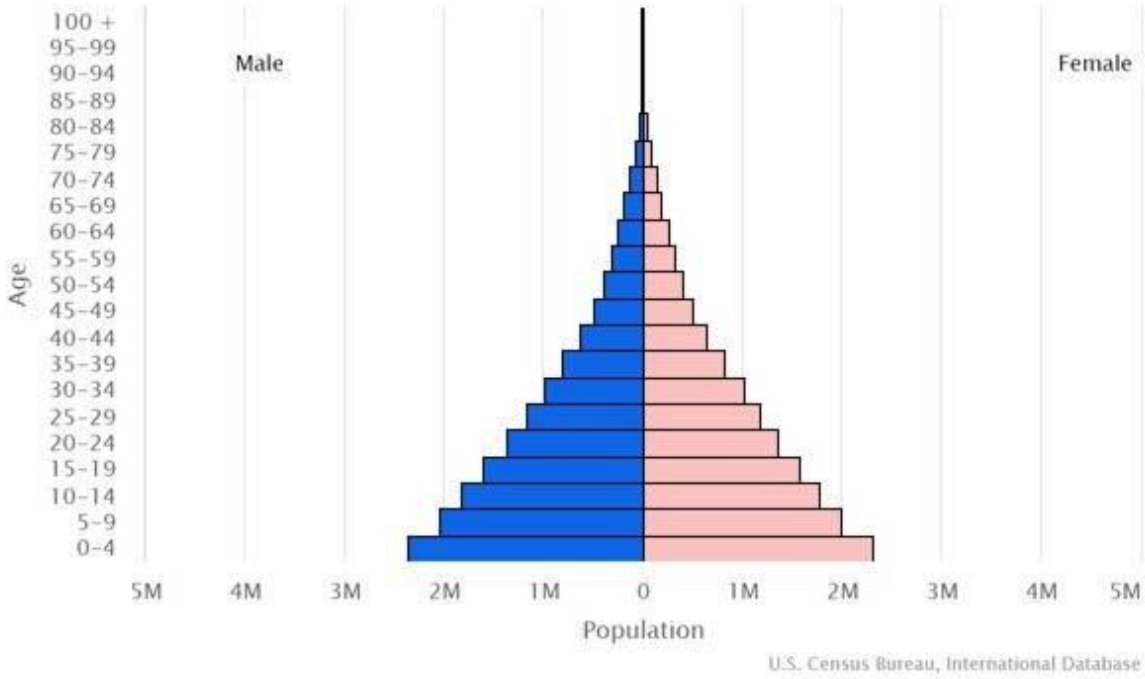
- Bantus: Beti, Bassa, Bakundu, Maka, Douala, Pygmies, etc
- Semi-Bantus: Bamileke, Gbaya, Bamoun, Tikar, etc.
- Sudanese: Fulbe, Mafa, Toupouri, Shoa-Arabs, Moundang, Massa, Mousgoum, etc.

Percentage estimation of the main tribes by 2018 (World Factbook 2022):

Bamileke-Bamu 24.3%, Beti/Bassa, Mbam 21.6%, Biu-Mandara 14.6%, Arab-Choa/Hausa/Kanuri 11%, Adamawa-Ubangi, 9.8%, Grassfields 7.7%, Kako, Meka/Pygmy 3.3%, Cotier/Ngoe/Oroko 2.7%, Southwestern Bantu 0.7%, foreign / other ethnic group 4.5%

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

- 0-14 years: 42.34% (male 5,927,640/female 5,820,226)
- 15-24 years: 20.04% (male 2,782,376/female 2,776,873)
- 25-54 years: 30.64% (male 4,191,151/female 4,309,483)
- 55-64 years: 3.87% (male 520,771/female 552,801)
- 65 years and over: 3.11% (male 403,420/female 460,248)



2. Relevant zoonotic diseases

2.1. Key points on zoonotic diseases

Some zoonotic diseases (such as yellow-fever and trypanosomiasis) are transferred to humans by insect bites. Those “vector-borne” diseases are not covered by this country profile, as this project aims raising awareness for consumption-linked spillover risks (e.g. via bushmeat, keeping of wildlife as pets).

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.**
- Viruses present the greatest zoonotic disease threat to humans because their fast rates of evolution will allow them to easily adapt to new hosts. However, other zoonotic diseases are caused by **bacteria or parasites**.
- During a workshop in December 2018, **ECOWAS agreed upon a list of seven priority zoonotic diseases for the region** – Anthrax, Rabies, Ebola and other viral haemorrhagic fevers (for example, Marburg fever, Lassa fever…), zoonotic influenzas, zoonotic tuberculosis, Trypanosomiasis* and Yellow fever*.
- More than 70% of the population is involved in small-scale agriculture, making them particularly vulnerable to zoonotic disease infections.
- **Cameroon's ecologically diverse landscape can give rise to a wide range of zoonotic diseases.** In the north, persistent zoonotic diseases associated with livestock losses are most prevalent, while new zoonotic diseases are also emerging in the forested south.
- The neighbouring country Nigeria is among the top ten countries with the highest burden of infectious and zoonotic diseases globally.
- An increasing number of Pentastomiasis infections are being reported in Congo, Nigeria, and Cameroon.
- **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.

2.2. Table: Zoonotic health risks relevant for Cameroon

CDC and USAID (2016) identified Rabies, Anthrax, Avian Influenza, Ebola, Marburg and Bovine Tuberculosis as the top zoonotic diseases of major public health concern in Cameroon. However, so far [as of Dec 2022] no cases of Ebola were documented (CDC 2022a).

Diseases present in Cameroon or surrounding countries were considered. Five different criteria were selected for ranking zoonotic diseases:

1. The state of the disease in humans, domestic animals, or wildlife in Cameroon
2. Mortality, morbidity, and disability in humans
3. The potential to spread rapidly amongst animals and humans
4. Economic, environmental, and social impacts
5. Capacity for detection, prevention, and control of the zoonoses in the country

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 human cases have been reported in Cameroon; Cameroon is considered to be an area at risk for future Ebola outbreaks	average case fatality rate is approximately 50%	**Priority for Government in Cameroon**	WHO 2021a CDC 2022 CDC & USAID 2016 Judson *et al.* 2016 Kurpiers et al. 2016 Wolfe et al. 2004a
Lassa Fever	Virus (Arena-virus)	**Incubation period**: 6-21 days, highly virulent **Symptoms**: **haemorrhagic fever**, general weakness, and malaise. After a few	**Spillover from wildlife to humans**: Contamination with excrement/secretions of rodents; consumption of uncooked rodent meat	No human cases have been reported in Cameroon; Cameroon is	About 80% of people who become infected with Lassa virus have no symptoms		WHO undated a,b WHO 2021c WHO 2019b

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
		days, headache, sore throat, muscle pain, chest pain, nausea, vomiting, diarrhoea, cough, abdominal pain. In severe cases facial swelling, general bleeding tendency, pleural & pericardial effusions, neurological symptoms, slowed heartbeat, low blood pressure. Death approx. 12 d after onset of disease in irreversible shock with organ failure, hypovolaemia and anuria.	**Human to human**: direct contact with blood, tissues, secretions and urine of infected persons, sexual contact	considered a risk country for the outbreak of Lassa Fever First discovered in Nigeria in 1969. Endemic in Nigeria. Incidences in at least 17 states since 2016.	case fatality ratio is 1-15% among hospitalized patients		WHO 2017b Mylne et al. 2015 Fichet-Calvet & Rogers 2009 Njouom et al. 2008
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, diarrhoea, abdominal pain and cramping, nausea, and vomiting	**Spillover from wildlife (e.g. bats) to humans**: spread by body fluids, such as blood and saliva **Human to human**: direct contact with blood or body fluids of sick persons	No human cases have been reported in Cameroon	average case fatality rate is approximately 50% 2005-outbreak in Angola: > 200 people died; 2 of 3 ill persons in Ghana died Nine people died and 16 are suspect to have contracted the disease (only one tested positive) in the eastern area of Equat. Guinea, in Feb 2023	**Priority for Government in Cameroon**	WHO 2023 Sah et al. 2022 WHO 2022f WHO 2021b Markotter et al. 2020 CDC & USAID 2016
Mpox (=Monkey pox)	virus	**Incubation time**: 3-17 days **Symptoms**: e.g. fever, headache, muscle pain, skin lessons, pustules,	**Spillover from wildlife to humans**: bushmeat (blood and secretions of infected primates, duikers & rodents)	Dec 2021-Feb 2022	25 cases, less than 5 dead		CDC 2022b Milbank & Vira 2022 WHO 2022i

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
		lymphadenopathy, back pain, myalgia, weakness	**Human to human**: Direct contact with infected persons, saliva droplets, sexual contact				CDC & USAID 2016 Wolfe et al. 2005
T-cell leukaemia	Virus (Simian retroviruses: STLV-1 / HTLV-1 and STLV-2 / HTLV-2)	**Incubation time**: 6 months – 20 years **Symptoms**: Often without symptoms; however, 5% of infected persons suffer from adult T-cell leukaemia / lymphoma and HTLV-1 associated myelopathy; higher risk for tuberculosis	**Spillover from wildlife to humans**: bushmeat, bites by non-human primates; blood, saliva **Human to human:** Blood, sexual contact, breast-feeding		High HTLV-1 prevalence given for Cameroon Prevalence rate of 0.9%, but up to 3% among pygmies 89% of bushmeat in Cameroon is infected with STLV		Milbank & Vira 2022 Anyanwu et al. 2018 Mousson et al. 2017 ECDC 2015 Gessain & Cassar 2012 Courgnaud *et al.* 2004 Wolfe et al. 2004a
Hendra Virus Disease	Virus (Henipa-virus-group)	**Incubation period**: 9-16 days **Symptoms** range from mild influenza-like illness to fatal respiratory or neurological disease.	Direct contact with infected bats (natural hosts) or other species (as secondary host, including livestock), contact with body fluids (blood, urine, saliva); consumption of contaminated food products; contact with infected persons		Although infection with Hendra virus is rare, the case fatality is high: 57%		WHO undated c Milbank & Vira 2022 Mbu'u *et al.* 2019 CDC & USAID 2016 Weiss *et al.* 2012
Nipah Virus Disease	Virus (Henipa-virus-group)	**Incubation period**: 4-14 days **Symptoms** range from asymptomatic infection	Direct contact with infected bats (natural hosts) or other species (as secondary host, including livestock), contact with body fluids	Not yet, but to be expected	considered one of the world's deadliest viruses with the heaviest mortality rates in some instances		Milbank & Vira 2022 Skowron *et al.* 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
		(subclinical) to acute respiratory infection, pneumonia and acute encephalitis; in severe cases progressing to coma within 24 to 48 hours and death.	(blood, urine, saliva); consumption of contaminated food products; contact with infected persons		case fatality rate is estimated at 40% to 75%; 20% of patients are left with neurological disorders		Soman Pillai *et al.* 2020 WHO 2018 CDC & USAID 2016 Kurpiers et al. 2016
Avian bird flu	Virus (Influenca virus: H5N1, H5N8 & H7N9)	**Incubation time**: up to 21 days **Symptoms**: pneumonia; stomach and intestinal complaints; increase in liver enzymes; severe reduction of leukocytes (leukopenia), erythrocytes (anaemia) and thrombocytes (thrombocytopenia), in severe cases renal failure, lung failure, multiorgan failure	**Spillover from wildlife:** wild aquatic birds as primary host, poultry as secondary host, direct contact with infected birds (blood, faeces, feathers)	Until now no human infections have been detected in Cameroon, but there have been several outbreaks among poultry first cases in animals in Africa in 2006 (in Nigeria), spreading within Africa	case fatality rate is approximately 60% Prevalence in humans in Cameroon: 29% Zoonotic spillover in East Asia, spreading by migrating wild birds and poultry (so far no human-to-human infections known, but first possible mammal-to-mammal infection noted among minks in a fur farm in Spain in October 2022)	**Priority for Government in Cameroon**	Spiegel 2023 Reuters 2022 GHS Index 2021 Ihekweazu et al. 2021 Monamele et al. 2019 CDC & US AID 2016 Wertheim et al. 2012 Gaidet *et al.* 2010 Cattoli *et al.* 2009 Njouom et al. 2008 Seck et al. 2007 WHO 2006
Rabies	Virus (lyssa virus)	**Incubation time**: 1-3 months **Symptoms**: Fever, headache, vomiting, agitation, confusion, hyperactivity, excessive salivation, hallucinations, insomnia, partial paralysis	Bites or scratches mainly from dogs, but also from wild animals (e.g. bats, monkeys)		Cameroon is considered a high-risk country Lyssa virus found in bats in Nigeria	**Priority for Government in Cameroon**	Markotter et al. 2020 Public Health England 2020 CDC & USAID 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
Corona / COVID-19	Virus (Corona virus: SARS-CoV-2)	**Incubation time**: 2-14 days **Symptoms**: fever or chills, cough, shortness of breath or difficulty breathing, fatigue, muscle or body aches, headache, loss of taste or smell, sore throat, congestion or runny nose, nausea or vomiting, diarrhoea	**Spillover from wildlife**: bats as primary host, wildlife (e.g. civets, bamboo rats, primates) sold at wet markets discussed as secondary host; **human to human**: respiratory uptake of virus-containing particles (aerosols)	2020-2023	Zoonotic spillover in China, but pandemic spreading by humans Corona viruses also found in wild bats in Cameroon and other African countries		Worobey *et al.* 2022 Xiao *et al.* 2022 Fischhoff *et al.* 2021 Markotter et al. 2020
AIDS	Virus (lentivirus: SIV-1/HIV-1)	**Incubation period**: After 1-6 weeks acute retroviral syndrome; development of AIDS within 10 years **Symptoms**: Diarrhoea for more than a week; dry cough; memory loss; depression & neurological disorders; pneumonia; profound, fatigue; rapid weight loss; recurring fever or profuse night sweats; blotches on or under skin or inside mouth, nose or eyelids; swollen lymph glands in the armpits, groin or neck; white spots or unusual blemishes on the tongue, in the mouth, or in the throat; weakened immune system. Opportunistic	**Spillover from wildlife**: bushmeat, blood and body fluids of chimpanzees **human to human**: blood, body fluids, sexual contact	ongoing	Zoonotic spillover early in 20th century from chimpanzees to humans, but further spreading by humans While HIV detection rates decreased over time overall, children less than 15 years of age showed an annual increase from 6.7% in 2014 to 12.3% in 2018. Data from the largest tertiary facility in Liberia shows broad HIV detection rates that are much higher than national prevalence estimates.		Kurpiers et al. 2016 Peeters et al. 2010 Wolfe et al. 2004a Hahn et al. 2000 Gao *et al.* 1999

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
		infections may lead to weakening, coma, death.					
Anthrax	Bacteria (*Bacillus anthracis*)	**Incubation period**: 1 day – 2 months **Symptoms (3 forms of Anthrax):** a) **skin anthrax** (most common form): 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 **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	Exact numbers of human infections in Cameroon are unknown. Skin and intestinal forms have been reported frequently in neighbouring countries.	Highly toxic (used as military weapon) Skin infections represent more than 95% of cases Without treatment the risk of death from skin anthrax is 23.7%, for intestinal infection 25-75%, respiratory anthrax: 50-80%	**Priority for Government in Cameroon**	Katani et al. 2021 WHO 2017a CDC & USAID 2016 WHO 2016 Wertheim et al. 2012
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 & livestock, consumption, floodwaters >> **Human to human**: rare transmission			**Priority for Government in Cameroon**	Katani et al. 2021 Simpson et a. 2021 WHO 2017a CDC & USAID 2016 Wolfe et al. 2005

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
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		BTB prevalence of 27.7% in the Kafue lechwe, but not assessed for many other wildlife species, regional differences	**Priority for Government in Cameroon**	Lakin et al. 2022 Hoffman et al. 2017 CDC & USAID 2016
Leptospirosis	Bacteria (*Leptospira borgpetersenii, L. Interrogans, L. kirschneri*)	**Incubation period:** 2-10 days **Symptoms:** Weil's syndrome characterized by jaundice, renal failure, haemorrhage and myocarditis with arrhythmias; meningitis/meningoencephalitis; pulmonary haemorrhage with respiratory failure (often lethal).	**Spillover from animals:** Mainly contact with infected livestock, but also rodents and other wildlife, consumption of bushmeat **Human to human**: rare (via body fluids)	One of the most widespread zoonosis worldwide	Neglected but widespread: 2.3-19.8% of hospital patients with fever in Africa Case-fatality rates of 5 – 70%		CDC & USAID 2016 Allan et al. 2015 Jobbins et al. 2014
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	**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 CDC & USAID 2016 Pawlak 2014 Gumpenberger 2000

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
		weakened immune systems.					
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)	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 Hardi et al. 2017 Vanhecke et al. 2016
Psittacosis	Bacteria	**Symptoms:** fever, respiratory signs	Inhalation of bird droppings infected with the bacteria	Not recorded	Unknown prevalence in birds, very few studies undertaken in African free-range birds (only two, one in Egypt and one in South Africa and not in parrots)		Limbe Wildlife Centre 2023 Stokes et al. 2021

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).
- During a One Health Zoonotic Disease Prioritization workshop in December 2018, Economic Community of West African States (**ECOWAS**), including Nigeria, **agreed upon a list of seven priority zoonotic diseases for the region** – Anthrax, Rabies, Ebola and other viral haemorrhagic fevers (for example, Marburg fever, Lassa fever), zoonotic influenzas, zoonotic tuberculosis, Trypanosomiasis* and Yellow fever* (**Vector-borne diseases, not relevant for this project (see below);* Goryoka et al. 2021).
- "*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 (Mactilda Mbenywe 2022; Warren *et al.* 2022).
- 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).
- **Reptile-associated salmonellosis** has become a globally important epidemiological problem, in many countries caused by the boom of exotic pets (Waltenburg *et al*. 2022; Pawlak 2014). In Africa, reptiles are also consumed as bushmeat or for traditional medicine.

- *Leptospira* infection was reported in a wide range of domestic and wild animal species from across Africa. **Leptospirosis** is a substantial cause of human illness in Africa, representing 2.3-19.8% of hospital patients with fever (Allan *et al.* 2015).

2.3.2. Country-specific information

- Researchers evaluated zoonotic disease risk perception in bushmeat markets found that " "risks associated with blood contact were not well understood, and most market actors demonstrated a lack of knowledge of risk infection and participants who did acknowledge disease transmission risk generally ignored risks due to economic circumstances or past experiences" (Saylors et al. 2021).
- More than 70% of the population is involved in small-scale agriculture, making them particularly vulnerable to zoonotic disease infections. Cameroon's ecologically diverse landscape can give rise to a wide range of zoonotic diseases. In the north, persistent zoonotic diseases associated with livestock losses are most prevalent, while new zoonotic diseases are also emerging in the forested south. (CDC & USAID 2016).
- The CDC and the USAID (2016) emphasized in a workshop that zoonotic diseases that occur in large numbers impact the society in three main ways:
    1. Threaten the health of animals resulting in illness, loss of productivity, and death.
    2. Threaten the livelihood of a large segment of the population dependent on livestock as a major source of income.
    3. Cause a large number of illness and death in people, which is associated with significant economic and societal loss.
- An increasing number of Pentastomiasis infections are being reported in Congo, Nigeria, and Cameroon (Vanhecke et al. 2016).
- According to Ihekweazu et al. (2021), the neighbouring country Nigeria is among the top ten countries with the highest burden of infectious and zoonotic diseases globally.

3. Relevant wildlife species

3.1. Key points on 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.
- At the same time duikers, primates, bats and pangolin were identified as the most frequently mentioned bushmeat species.
- The relative risk of disease emergence was found highest for bats, followed closely by primates, then ungulates and rodents.
- **Primates** represent the largest group of species hunted for bushmeat. **As the closest relatives of humans, primates pose a particularly high risk of zoonotic transmission to humans**.
- 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.
- **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.** While bats have been identified as major primary hosts for many pathogens, primates, racoon dogs, civets and other wildlife are potential secondary hosts.

3.2. Table: Relevant wildlife species traded in Cameroon

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic diseases	References
Chimpanzee *Pan troglodytes ellioti* *Pan t. troglodytes*	**EN** decreasing	Primates	Hunted for bushmeat and cultural traditions Hunted by specialized hunters; short supply chain, sold to restaurants and wealthy buyers Sold to Nigerians protected under protection Class A	Ebola multiple simian retroviruses STLV-1/ HTLV-1 SIV-cpz/HIV-1 AIDS Anthrax	Dipita et al. 2022 Mbun & Nguemwo 2021 Nguyen *et al.* 2021 WHO 2021a Tagg et al. 2018 Mossoun et al. 2017 Humle et al. 2016 Bobo et al. 2014 Alves et al. 2010 Peeters et al. 2010 Leroy et al. 2004a Hahn *et al.* 2000
Gorilla *Gorilla gorilla gorilla and Gorilla g. diehli*	**CR** decreasing	Primates	Hunted for bushmeat	Ebola STLV-1/ HTLV-1	Mbun & Nguemwo 2021

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic diseases	References
			Hunted by specialized hunters; short supply chain, sold to restaurants and wealthy buyers protected under protection Class A	SIV-gor/HIV-1 AIDS	Nguyen *et al.* 2021 WHO 2021a Maisels et al. 2018 Tagg et al. 2018 Bobo et al. 2014 Alves et al. 2010 Peeters et al. 2010 Rouquet *et al.* 2005 Leroy et al. 2004a Hahn *et al.* 2000 Oates et al. 2006 Courgnaud *et al.* 2004
Monkey **Guenons** *Cercopithecus* spp. **Galagos/ Bushbaby** Galagidae spp. **Old Worls monkey** Cercopithecidae spp. **West African Potto** *Perodicticus potto* **Preuss's red colobus** *Procolobus preussi* **Putty nosed Guenon** *Cercopithecus nictitans* **Mona guenon** *Cercopithecus mona* **Agile Mangabey** *Cercocebus agilis* **Red-tailed Monkey** *Cercopithecus ascanius* **Moustached Monkey** *Cercopithecus cephus* **De Brazza's Monkey** *Cercopithecus neglectus* **Crowned Monkey** *Cercopithecus pogonias* **White-throated guenon** *Cercopithecus erythrogaster* **Colobus guereza** *Colobus guereza* **Black Colobus** *Colobus satanas* **Grey-cheeked Mangabey** *Lophocebus albigena*	NT decreasing **CR** decreasing NT decreasing NT decreasing LC decreasing LC decreasing LC unknown LC unknown NT decreasing **EN** decreasing LC decreasing **VU** decreasing **VU** decreasing	Primates	Hunted for bushmeat and traditional medicine, pottos also sold as pets Guenons: second most hunted taxon Galagos: Position 5 of most hunted taxa in Lebialem, Cameroon Putty nosed Guenon: most frequently captured monkey species in Southeastern Cameroon	Ebola Marburg STLV-1/ HTLV-1 STLV-3 possible reservoirs for Mpox	Dipita et al. 2022 Mbun & Nguemwo 2021 WHO 2021a Abernethy & Maisels 2020 Cronin et al. 2020 Maisels et al. 2020a,b,c,d Matsuda Goodwin et al. 2020c Svensson et al 2020 Wallis 2020a Cronin et al. 2019 de Jong & Butynski 2019a,b Linder et al. 2019 Maisels et al. 2019 Mwenja et al. 2019 Svensson & Nekaris 2019 Okareh & Morakinyo 2018 Svensson et al. 2015 Bobo et al. 2015 Bobo et al. 2014 Alves et al. 2010

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic diseases	References
Tantalus Monkey *Chlorocebus tantalus* **Golden Angwantibo** *Arctocebus aureus* **Preuss's Monkey** *Allochrocebus preussi* **White-eyelid mangabeys** *Cercocebus spp.* **Red-capped mangabeys** *Cercocebus torquatus*	LC stable LC unknown **EN** decreasing **EN** decreasing				Wright & Priston 2010 Courgnaud *et al.* 2004
Drill *Mandrillus leucophaeus*	**EN** decreasing	Primates	Position 10 of most hunted taxa, in Lebialem, Cameroon Hunted for bushmeat and traditional medicine Sold to Nigerians		Dipita et al. 2022 Mbun & Nemo 2021 Gadsby et al. 2020 Bobo et al. 2014 Alves et al. 2010 Wright & Priston 2010 Courgnaud *et al.* 2004
Antelopes **Forest antelope** **Bay duiker** *Cephalophus dorsalis* **Peter's duiker** *Cephalophus callipygus* **Yellow back duiker** *Cephalophus sylvicultor* **Blue duiker** *Philantomba monticola* **Ogilby's duiker** *Cephalophus ogilbyi* **Black-fronted Duiker** *Cephalophus nigrifrons* **Bates' Pygmy Antelope** *Neotragus batesi* **Sitatunga** *Tragelaphus spekii* **Bongo** *Tragelaphus eurycerus* **Bushbuck** *Tragelaphus scriptus* **Gazelle** *Gazella spp.*	-- NT decreasing LC decreasing -- LC decreasing LC decreasing LC decreasing LC unknown LC decreasing NT decreasing LC stable	Ungulates	Hunted for bushmeat, prestige, and traditional medicine reported as the most commonly eaten species and most desirable animals Blue duiker: most frequently captured animal in Southeastern Cameroon Bay duiker: third most hunted bushmeat taxon, in Lebialem, Cameroon Bongo and Gazelle protected under protection Class B	Ebola Anthrax (?)	Dipita et al. 2022 Katani et al. 2021 Mbun & Nguemwo 2021 WHO 2021a IUCN SSC Antelope Specialist Group 2020 IUCN SSC Antelope Specialist Group 2016h,i,m,q,r,s,t,u Bobo et al. 2015 Bobo et al. 2014 Wright & Priston 2010 Rouquet et al. 2005 Leroy et al. 2004a
Red river hog *Potamochoerus porcus*	LC decreasing	Ungulates	Hunted for bushmeat and traditional medicine Position 9 of most hunted taxa, in Lebialem, Cameroon	Anthrax (?)	Katani et al. 2021 Mbun & Nguemwo 2021 D'Cruze et al. 2020 Reyna et al. 2016

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic diseases	References
			protected under protection Class B		Bobo et al. 2015 Bobo et al. 2014 Wright & Priston 2010
Buffalo *Syncerus caffer*	NT decreasing	Ungulates	Hunted for traditional medicine, bushmeat protected under protection Class A		Mbun & Nguemwo 2021 IUCN SSC Antelope Specialist Group. 2019 Bobo et al. 2014
Common warthog *Phacochoerus africanus*	LC decreasing	Ungulates	Hunted for bushmeat	Bovine tuberculosis (proven in South Africa)	Dipita et al. 2022 Hoffman et al. 2017 de Jong et al. 2016
Water chevrotain *Hyemoschus aquaticus*	LC decreasing	Ungulates	Hunted for traditional medicine, bushmeat		IUCN SSC Antelope Specialist Group. 2016[e] Bobo et al. 2015 Bobo et al. 2014
Hippopotamus *Hippopotamus amphibius*	**VU** stable	Ungulates	Hunted for bushmeat		Mbun & Nguemwo 2021 Lewison & Pluháček 2017
Bats **Straw-coloured fruit bats** *Eidolon helvum* **Hammer-headed Fruit Bat** *Hypsignathus monstrosus*	NT decreasing LC unknown	Bats	Hunted for bushmeat and traditional medicine occasional meat resource; strongly varies between regions; *Eidolon helvum* considered a delicacy in Bomboko area	Ebola, Marburg, Nipah virus, paramyxoviruses, filoviruses, lyssaviruses, pegiviruses, hepaciviruses, more than 60 different viruses were identified in bats	Milbank & Vira 2022 WHO 2021a WHO 2021b Akem & Permunta 2020 Cooper-Bohannon et al. 2020 D'Cruze et al. 2020 Baudel *et al.* 2019 Mildenstein et al. 2016 Tanshi 2016 Bobo et al. 2014 Luis et al. 2013 Quan et al. 2013 Mickleburgh et al. 2009 Towner et al. 2007
Porcupines Hystricidae		Rodents	Most hunted taxon, Hunted for bushmeat	possible reservoirs for Mpox nairoviruses	Dipita et al. 2022 Amori et al. 2021

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic diseases	References
African brush-tailed porcupine *Atherurus africanus* **Porcupine** *Hystrix indica*	LC unknown LC stable		favoured species in wild meat markets of Nigeria meat of this species is also often the most expensive meat in many African cities	anthrax Salmonella	Mbun & Nguemwo 2021 Nguyen *et al.* 2021 Peros et al. 2021 Hoffmann & Cox 2016 Bobo et al. 2015 Bobo et al. 2014 Wright & Priston 2010
Multimammate mice *Mastomys* spp.	--	Rodents	Hunted for bushmeat and traditional medicine	Lassa Fever	WHO undated a,b D'Cruze et al. 2020
Giant pouched rats *Cricetomys spp.* **Emin's pouched rat** *Cricetomys emini* **Gambian rat** *Cricetomys gambianus*	LC stable LC stable	Rodents	Hunted for bushmeat Position 6 of most hunted taxa	possible reservoirs for Mpox nairoviruses	Dipita et al. 2022 Kennerley 2019 Cassola 2016a Bobo et al. 2015 Wright & Priston 2010
Protoxerus stangeri	LC unknown	Rodents	Hunted for bushmeat		Cassola 2016k Bobo et al. 2015
Cane Rat *Thryonomys spp.* **Grass cutter** *Thryonomys swinderianus*	LC unknown	Rodents	Hunted for bushmeat Position 9 of most hunted taxa (Grass cutter)		Mbun & Nguemwo 2021 Child 2016 Wright & Priston 2010
Squirrels **Rope squirrels** *Funisciurus* spp. **Western Palm Squirrel** *Epixerus ebii* **Striped ground squirrel** *Xerus erythropus*	LC unknown LC stable	Rodents	Hunted for bushmeat and traditional medicine	possible reservoirs for Mpox	Dipita et al. 2022 Mbun & Nguemwo 2021 Okareh & Morakinyo 2018 Doty et al. 2017 Falendysz et al. 2017 Cassola 2016h,l Bobo et al. 2014
Hare Leporidae spp.	--	Lagomorpha	Hunted for bushmeat		Mbun & Nguemwo 2021
Hedgehog *Atelerix sp.* **Four-toed Hedgehog** *Atelerix albiventris*	LC stable	Hedgehogs	Hunted for bushmeat, medical purposes (in West Africa) and internationally sold as pet	Salmonellosis	Cassola 2016g Bobo et al. 2015 Nijman & Bergin 2015 Woodward et al. 1997
Mongooses **Marsh mongoose** *Atilax paludinosus*	LC decreasing	Carnivores	Hunted for bushmeat and traditional medicine		Dipita et al. 2022 Mbun & Nguemwo 2021

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic diseases	References
Black-legged Mongoose *Bdeogale nigripes* **Banded Mongoose** *Mungos mungo* **Flat-headed kusimanse** *Crossarchus platycephalus* **Common Cusimanse** *Crossarchus obscurus*	LC stable LC unknown LC unknown				Angelici & Do Linh San 2016 Gilchrist & Do Linh San 2016 Angelici & Do Linh San 2015a,b Bobo et al. 2015 Do Linh San et al. 2015 Bobo et al. 2014
Leopard *Panthera pardus*	**VU** decreasing	Carnivores	Hunted for cultural practices protected under protection Class A		Mbun & Nguemwo 2021 Stein et al. 2020 Bobo et al. 2014
Serval *Leptailurus serval*	LC stable	Carnivores	Hunted for bushmeat protected under protection Class B		Mbun & Nguemwo 2021 Thiel 2019
African civet *Civettictis civetta*	LC unknown	Carnivores	Hunted for bushmeat and traditional medicine protected under protection Class B		Dipita et al. 2022 Mbun & Nguemwo 2021 Do Linh San et al. 2019 Bobo et al. 2014
African palm civet *Nandinia binotata*	LC unknown	Carnivores	Hunted for bushmeat and traditional medicine		Dipita et al. 2022 Bobo et al. 2015 Gaubert et al. 2015 Bobo et al. 2014
African Golden Cat *Caracal aurata*	**VU** decreasing	Carnivores	Hunted for bushmeat		Bahaa-el-din et al. 2015 Bobo et al. 2015
Spotted hyena *Crocuta crocuta*	LC decreasing	Carnivores	Hunted for bushmeat protected under protection Class B		Mbun & Nguemwo 2021 Bohm & Höner 2015
Ichneumon *Herpestes ichneumon*	LC stable	Carnivores	Hunted for bushmeat		Dipita et al. 2022 Do Linh San et al. 2016
Servaline Genet *Genetta servalina*	LC unknown	Carnivores	Hunted for bushmeat		Dipita et al. 2022 Gaubert et al. 2016 Bobo et al. 2015
Rusty-spotted genet *Genetta maculata*	LC unknown	Carnivores	Hunted for bushmeat		Dipita et al. 2022 Angelici et al. 2016
Spotted-necked otter *Hydrictis maculicollis*	NT decreasing	Carnivores	Hunted for bushmeat		Mbun & Nguemwo 2021

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic diseases	References
			protected under protection Class B		Reed-Smith et al. 2021
Hyraxes **Beecrot's hyrax** *Dendrohyrax dorsalis*	LC unknown	Dassies	Hunted for cultural traditions and bushmeat		Bobo et al. 2015 Butynski et al. 2015b Bobo et al. 2014
African forest elephant *Loxodonta cyclotis*	**CR** decreasing	Proboscidea	Hunted for bushmeat and traditional medicine protected under protection Class A		Gobush et al. 2021 Mbun & Nguemwo 2021 Nguyen *et al.* 2021 Bobo et al. 2014
Pangolins Manidae **Tree pangolin/ White-bellied pangolin** *Phataginus tricuspis* **Long-tailed pangolin** *Phataginus tetradactyla* **Giant Pangolin** *Smutsia gigantea*	 **EN** decreasing **VU** decreasing **EN** decreasing	Pangolins	Hunted for taste, medicinal benefits, bushmeat White-bellied panoglin intensely used as bushmeat and in traditional medicine protected under protection Class A	coronaviruses	Dipita et al. 2022 Mbun & Nguemwo 2021 Nguyen *et al.* 2021 D'Cruze et al. 2020 Ingram et al. 2019 Nixon et al. 2019 Pietersen et al. 2019 Bobo et al. 2015 Bobo et al. 2014 Wright & Priston 2010
Snakes **Central African Rock Python** *Python sebae* **Ball Python** *Python regius* **Forst cobra** *Naja melanoleuca* **Jameson's mamba** *Dendroaspis jamesoni* **Eastern green mamba** *Dendroaspis angusticeps* **Rhinoceros horned viper** *Bitis nasicornis* **Egyptian cobra** *Naja haje* **Gaboon Viper** *Bitis gabonica*	 NT decreasing NT decreasing LC decreasing LC stable LC Unknown **VU** decreasing LC decreasing **VU** decreasing	Reptiles	Hunted for bushmeat and traditional medicine heavily exploited commercially for leather and food; also used in traditional medicine in Cameroon & Nigeria Sold to Nigerians Central African Rock Python protected under protection Class A	Salmonellosis visceral pentastomiasis (caused by *Armillifer armillatus*)	D'Cruze et al. 2022 Dipita et al. 2022 Alexander et al. 2021 Jallow et al. 2021b Luiselli et al. 2021a,d Mbun & Nguemwo 2021 Nguyen *et al.* 2021 Penner et al. 2021 Wagner et al. 2021b Wilms et al. 2021a D'Cruze et al. 2020 Alexander et al. 2019

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic diseases	References
					Pulford et al. 2019 Hardi et al. 2017 Bobo et al. 2014
Monitor Lizard *Varanus spp.* **Nile Monitor Lizard** *Varanus niloticus*	LC stable	Reptiles	Hunted for bushmeat and decorations protected under protection Class B		Mbun & Nguemwo 2021 Wilms et al. 2021b Bobo et al. 2015 Bobo et al. 2014
Crocodiles **Nile Crocodile** *Crocodylus niloticus* **Dwarf crocodile** *Osteolaemus tetraspis* **Slender-snouted Crocodile** *Mecistops cataphractus*	LC stable **VU** unspecified **CR** decreasing	Reptiles	Hunted for bushmeat and decorations Sold to Nigerians protected under protection Class A		Dipita et al. 2022 Mbun & Nguemwo 2021 Isberg et al. 2019 Bobo et al. 2014 Shirley 2014 Crocodile Specialist Group 1996
Turtles **African Softshell Turtle** *Trionyx triunguis* **Forest Turtle** *Pelusios gabonensis*	**VU** decreasing	Reptiles	Hunted for bushmeat protected under protection Class A		Mbun & Nguemwo 2021 van Dijk et al. 2017
Tortoise *Kinixys spp.*		Reptiles	Hunted for traditional medicine, bushmeat, and cultural practices Sold to Nigerians		Mbun & Nguemwo 2021 Bobo et al. 2015 Bobo et al. 2014
Parrots **African grey parrot** *Psittacus erithacus*	**EN** decreasing	Birds	Hunted to be sold in the international pet market, for belief-based use, traditional medicine, and decorations Sold to Nigerians protected under protection Class A		Limbe Wildlife Center 2022 Assou et al. 2021 Mbun & Nguemwo 2021 BirdLife International 2021a Bobo et al. 2014
Crowned eagle *Stephanoaetus coronatus*	NT decreasing	Birds	Hunted for cultural practices and decorations Sold to Nigerians		BirdLife International 2018 Bobo et al. 2014
Hornbills *Tockus spp.* **White-thighed Hornbill** *Bycanistes albotibialis*	-- LC decreasing	Birds	Hunted for bushmeat, cultural practices, and decorations Sold to Nigerians		BirdLife International 2016c Bobo et al. 2015 Bobo et al. 2014
Barn owl *Tyto alba*	LC stable	Birds	Sold to Nigerians		BirdLife International 2019b

Species	IUCN Red List	Taxonomic group	Relevance in trade	Related zoonotic diseases	References
					Bobo et al. 2014
Black kite *Milvus migrans*	LC stable	Birds	Hunted for cultural practices and decorations Sold to Nigerians		BirdLife International 2021b Bobo et al. 2014
Green sunbird *Anthreptes rectirostris*	LC decreasing	Birds	Sold to Nigerians		BirdLife International 2022b Bobo et al. 2014
African pygmy kingfisher *Ispidina picta*	LC stable	Birds	Hunted for decorations Sold to Nigerians		BirdLife International 2016b Bobo et al. 2014
African palm Swift *Cypsiurus parvus*	LC decreasing	Birds	Hunted for cultural practices and decorations		BirdLife International 2019a Bobo et al. 2014
Palmnut Vulture *Gypohierax angolensis*	LC stable	Birds	Hunted for cultural practices and decorations Sold to Nigerians		BirdLife International 2016a Bobo et al. 2014
Black guineafowl *Agelastes niger*	LC decreasing	Birds	Hunted for cultural practices, bushmeat, and decorations		BirdLife International 2022a Bobo et al. 2015 Bobo et al. 2014
Great blue turaco *Corythaeola cristata*	LC stable	Birds	Hunted for traditional medicine and decorations Sold to Nigerians		BirdLife International 2017 Bobo et al. 2014
Francolin *Francolinus spp.* **Forest Francolin** *Peliperdix lathami*	LC decreasing	Birds	Hunted for bushmeat		Mbun & Nguemwo 2021 BirdLife International 2016d Bobo et al. 2015

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).

- According to Fa et al. (2006) mammals represented more than 90% of the bushmeat carcasses sold in Nigeria and Cameroon followed by reptiles while birds and amphibians were relatively rare.
- The most common wildlife species consumed as bushmeat are porcupines (72%), pangolins (69%) and snakes (44%) (Nguyen *et al.* 2021). The least reported wildlife species consumed as bushmeat are elephants (8%), chimpanzees (4%) and gorillas (3%). Law enforcement and awareness-raising efforts play important roles in reducing consumer demand (Nguyen *et al.* 2021).
- Duikers, primates and pangolin were identified as the most frequently mentioned bushmeat species (Ordaz-Németh *et al.* 2017; Jeffrey 1977). Sooty mangabeys (being a carrier for the AIDS virus) ranked only at No. 13 of taste preference of urban consumers (ODI 2004; Hahn *et al.* 2000).
- According to Bobo et al. (2014), Obang and Ngunnchang clans have accumulated knowledge on the use of 51 wildlife species of which 50.9% represent mammals, 21.6% birds, 15.7% reptiles, 7.8% fish and 3.9% invertebrates. They identified four main use categories of wildlife (Bobo et al. 2014):
    - Food, medicine and sales values (41.2%)
    - Ethnomusical animals and parts used as trophy (29.2%)
    - Decoration and jewellery making values (21.9%)
    - Magico-religious and multipurpose values (7.8%)
- Local taboos, e.g., species-specific taboos, habitat taboos, method taboos, and segment taboos, still exist but are rarely respected among the youth, primarily because of the lack of wildlife (Bobo et al. 2014).

3.3.1. Primates

- Primates represent the largest group of species hunted for bushmeat (Kurpiers et al. 2016; Bobo et al. 2015). As the closest relatives of humans, they 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 (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 (Mactilda Mbenywe 2022; Warren *et al.* 2022).
- Due to population decline of larger primates now even smaller species, such as *Cercopithecus petaurista* are now hunted for commercial bushmeat markets, despite high costs for ammunition (Matsuda Goodwin et al. 2020a ,b; Svensson et al. 2020).
- Great apes are hunted for their meat despite being protected (Tagg et al. 2018).

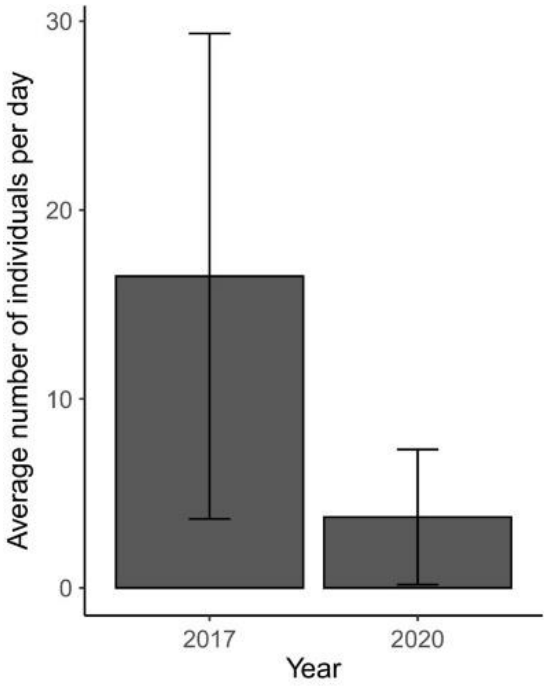
3.3.2. Bats

- **Bats** are heavily over-exploited since at least three decades; hunting is particularly prevalent among the large-bodied fruit bats (Mildenstein et al. 2016).

- Bats are identified as the most likely primary host for outbreaks of SARS, MERS and COVID-19 outbreaks, with other mammals, such as civets, racoon dogs etc. as secondary host, causing spillover events to humans via wildlife markets (Worobey *et al.* 2022; Markotter *et al.* 2020; Banerjee *et al.* 2019). Bats are also hosts for Marburg, Ebola and many other viruses (Kia *et al.* 2021; Kajihara *et al.* 2019; Hayman *et al.* 2012; Leroy *et al.* 2009).
- Cameroon is a home range of the fruit bats belonging to the Pteropodidae family which are considered to be natural hosts of Marburg virus (WHO 2021b).
- **Fruit bats are heavily consumed in West Africa: In southern Ghana only, about 128,000 *Eidolon helvum* are sold each year as bushmeat** (Kamins *et al.* 2011; Mickleburgh *et al.* 2009). Hunting of bats is often underrepresented in surveys, due to separate commodity chains, and therefore underestimated (Kamins et al. 2011).
- Bat meat as bushmeat has largely disappeared from sale in major cities such as Buea and Limbe due to fears of zoonotic pathogen risks associated with bushmeat, including bats. However, bat meat is still consumed in remote villages. The killing of bats with the mouth during hunting expose hunters (young men) while the preparation of bat carcasses for consumption also put women, (mostly young and unmarried) at risk (Akem & Permunta 2020).

3.3.3. Others

- **Ungulates**: Beside primates, ungulates were hunted most heavily (Bobo et al. 2015).
- **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 eight African countries and found 91% of them carrying *Salmonella*.
- **Pangolin**s: Between 2017 and 2020, the bushmeat trade in pangolins in Cameroon declined significantly, following national bans in the trade of the species and during the COVID-19 pandemic (see figure). However, even after the national bans, pangolins continued to be openly offered for sale, indicating that the law is not being adequately enforced (Harvey-Carroll *et al.* 2022). According to Mbun & Nguemwo (2021), White-bellied Pangolins were discreetly on sale in Cameroon. Also, some respondents said they could supply other Class A and Class B protected species that were not observed in the market surveys (Mbun & Nguemwo 2021).



- The emerging trade in feathers and skulls through Cameroon to West Africa for cultural and traditional medicinal uses appears to be less well regulated (Mbun & Nguemwo 2021).

4. Relevant potential spillover pathways

4.1. Key points 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.
- Of 58 species of bushmeat globally investigated, 48 species were found to host one or more pathogens.
- 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**.
- **Wildlife as pets:** Bites, scratches and contact with urine, saliva and feces pose a risk for disease transmission from e.g. pet monkeys to keepers.
- **Wildlife use in Traditional Medicine and religious rituals is common in West African countries**: 281 different wildlife species were recorded at a traditional medicine market in Togo, of which 140 were mammals, 33 were reptiles, 59 were bird species and 49 amphibians.
- At least 25 primate species are used in traditional folk medicine in Africa, in Nigeria for example *Pan troglodytes*. Use of pangolins in TM is reported from Ghana, Togo and Sierra Leone.
- **Be a model in your communication** (including social media): Don't post pictures holding wildlife, keep distance, wear masks and gloves)

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

- A review of global bushmeat studies (with a focus on Africa) found that of the 58 species of bushmeat investigated, 48 species were found to host one or more pathogens (Peros et al. 2021).
- Bushmeat-related activities (hunting, butchering, cooking, consumption) have been linked to numerous emerging infectious disease (EID) outbreaks, such as Ebola, HIV, and SARS. Increasing demand and commercialization of bushmeat is exposing more people to pathogens and facilitating the geographic spread of diseases (Kurpiers et al. 2016).

- Ebola-outbreak among chimpanzees after hunting and shared consumption of a red colobus monkey is proven; seropositive chimpanzees were found broadly throughout forested regions of Central Africa (Alexander et al. 2015).
- Bushmeat is often smoked, dried or salted. However, medical experts estimate that these processes are insufficient to kill viruses and other pathogens in the meat. For example, wildlife biltong may pose special challenges, given that the virus can survive over 50 days when dried and kept at 4°C (Alexander et al. 2015).
- Prices for bushmeat increased with distance from national park boundaries and were higher near the road network, as there were more opportunities for further trade. Trading sites closer to national parks acted more as wholesalers, with carcasses being smoked more frequently as they were not sold to end users (MacDonald et al. 2012).
- According to Nguyen *et al.* (2021), 91% of respondents claimed to consume bushmeat.
- The corona pandemic has also affected the bushmeat trade in a variety of ways. While some people have severely reduced their consumption of bushmeat, others have become more dependent on bushmeat as a food source. Before the pandemic, the bushmeat trade was thriving despite laws restricting capture and sale of wild animals (Tembang 2021).
- In Nigeria, bushmeat biomass extracted for sale (600 kg/km2 per year) was three times higher than in Cameroon. It is estimated that more than 900,000 reptiles, birds and mammals are sold each year by rural and urban populations in southeastern Nigeria and western Cameroon alone, equivalent to about 12,000 tons of terrestrial vertebrates (Fa et al. 2006).

4.2.2. Wildlife as pets

- In many parts of the primate distribution range, the practice of keeping primates as pets is common. However, keeping of primates as pets can result in close spatial proximity and may lead to physical contact, thereby creating opportunities for zoonosis (Lappan et al. 2020; Muehlenbein 2017).
- Primate infants, often survivors of bushmeat hunting, are sold as pets or to private and public zoos, providing additional income for the hunter (Marx et al. 1991).
- It is well known locally that bushmeat and other forest products cross the long, largely forested frontier from Cameroon to Nigeria every day, as well arriving on small private boats by sea. A substantial number of chimpanzees and monkey at the Drill Ranch in Nigeria were known to have been brought to Nigeria from Cameroon (PANDRILLUS 2023).

4.2.3. Traditional medicine and magic-religious rituals

- According to Alves et al. (2010) 25 primate species are used in traditional folk medicine and magic-religious rituals in Africa: In Cameroon, *Gorilla gorilla* is considered sacred and used as concoction for ailments, for charms or amulets, to obtain victory in competition. *Pan troglodytes* is claimed to help against male impotency and epilepsy and is used for amulets and as concoction for ailments ("regarded as a sacred totem and a reincarnation of ancestors, considered sacred, piece of the dried bone of chimpanzees is tied around the waist or wrist of infants in the belief that it makes them stronger as they grow into adulthood, chimpanzee's central incisors procured to be worn as amulet around the waist of infants to protect them and give them power over others in their cohort, magic rituals").

5. Information relevant for awareness campaigns & programs

5.1. Key points for awareness campaigns

In a nutshell:

- **Longstanding cultural beliefs, 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.
- **Scepticism /opposition against information on zoonotic diseases and related measures to reduce risk for spillover events (after Ebola outbreak 2014-2016):** Traders and consumers argued 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.**
- **Urban consumers see bushmeat as a local, natural, and healthy food compared to livestock ⇨ need to be refuted in awareness campaigns.**
- **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, instead highlighting a species' ecological role is needed. 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 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
- **Food alternatives: Urban bushmeat consumers have a key role, as they can create a deadly suction effect for wildlife up to distant areas – but have a better choice.**
- **Enforcement AND persuasion are key to ensure long-term change of behaviour.**
- **In 2012, Cameroon adopt a One Health National Strategy and therefore was one of the first countries in sub-Saharan Africa to do so.**

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 & Scepticism

- **!! Model safe and appropriate practices with primates in field settings, outreach, and social media materials:** Conservationists must follow safe distance and masking protocols when being observed or photographed. They should not be photographed holding primates (even in captive care settings) and should avoid sharing images showing close human–primate spacing in outreach materials, on social media accounts, or in public presentations. **Such images may create public perceptions that primates are appealing and tame, increasing the risks of inappropriate behaviour toward wild primates, and increasing demand for primates as pets** (Lappan et al. 2020).
- 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).
- Wirsiy et al. (2021) highlighted that the Baka Community in Cameroon had poor knowledge of Ebola but at the same time were at high risk of infection.
- 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.
- Gaubert et al. (in print) interviewed bushmeat vendors in three west African countries and found that vendors generally did not believe that pangolins were involved in the pandemic, as people have always been eating pangolins and have never been sick. The authors recommend that future awareness campaigns through television and social networks also include education on microbial evolution and host shift.
- Exploitation of wildlife for bushmeat is intense, with income generation being the main reason for hunting (Maurice et al. 2017a, Wright & Priston 2010).
- According to Randolph et al. (2022), improved access to employment and education for women and girls could play a major role in reducing the urge to join the urban wild meat trade. Their study showed that 74% of the wild meat vendors are woman and the majority of traders, meat cleaners and vendors originating from forest-based southern Cameroonian

ethnic groups. The decision to engage in this particular trade depended on livelihood benefits, ethnic ties, and low formal economic opportunities (Randolph et al. 2022).

- Despite national bans and the outbreak of the Coronavirus, Pangolins were still openly offered at a major bushmeat market in Cameroon. The persistence of the bushmeat trade in general is therefore likely due to socio-cultural factors. Additional measures are needed to reduce consumer demand for bushmeat and provide alternative income-opportunities for bushmeat traders. In addition, increased enforcement of protected species regulations in Cameroon is needed, especially in urban areas (Harvey-Carroll *et al.* 2022).
- Nguyen *et al.* (2021) documented a significant association between bushmeat consumption and religion. Muslim respondents were less likely to consume bushmeat than Christian respondents. People without religious affiliation all claimed to have eaten bushmeat. For many people who were born and raised in or near the forest, bushmeat was the primary source of protein and a tradition of their ethnic groups. Also, the findings of this study indicate a strong preference towards bushmeat in urban centres of Cameroon compared to livestock. The study showed no significant association between bushmeat consumption and gender, age or education level.
- Illegality (33%) was identified as the biggest barriers to bushmeat consumption, followed by high price (24%), unavailability (10%), pressure from family/children (4%), and not their social norm (3%). 26% claimed to not face any barriers while consuming and purchasing bushmeat (Nguyen *et al.* 2021).
- Nguyen *et al.* (2021) found six major reasons for bushmeat preference (sorted from most mentioned to at least mentioned).
    - **Taste** (most popular reason; over 70% of respondents)
    - **health** (including factors pertaining to the perception of bushmeat as healthy, nutritious, fat-free, rich in protein and vitamin, natural and clean meat, as well as perceived medical benefits such as being an aphrodisiac or antibiotic and curing cancer and other diseases)
    - **cultural influences** (including responses regarding local tradition, family tradition, and habit)
    - **affordability**
    - **prestige**
    - **availability**
- Bushmeat is essential source of meat for hundreds of millions of rural people living in poverty (Nguyen *et al.* 2021, Brashares *et al.* 2011). On the other hand, large-sized and/or protected bushmeat species are considered luxury products that are often bought by wealthier elites driven by status-seeking behaviour (Nguyen *et al.* 2021, Brashares *et al.* 2011). Therefore, wealthier households consume only slightly less bushmeat than others (Brashares *et al.* 2011). Conservation messages must therefore be tailored to the respective target groups and their sociocultural background (Nguyen et al. 2021).
- Hunters no longer adhere to the traditional norms that ensured protection from wildlife diseases. This is reflected in the dwindling of taboos and norms related to hunting and the consumption of bat meat. Due to society, strict gender roles, Ebola transmission routes tend to be gender- and age-specific. More urban men than villagers and hunters consume bat

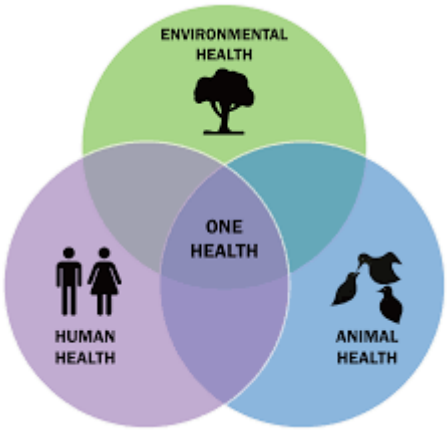
meat. Most bat hunters and sellers are young (22-33 men und 20-28 women), single, have little education and are otherwise jobless (Akem & Permunta 2020).

- Before the Ebola outbreak in 2020, the consumption of bat meat was common in big cities like Limbe, Muyuka and Tiko. This declined drastically with the outbreak of the Ebola virus in West Africa, which led to a ban on bat hunting and consumption in Cameroon. In contrast, hunting and trade in roasted bat meat was frequently observed in remote rural areas such as Bafia, Munyenge and Ekata. This seems to indicate that urban dwellers (who are wealthy compared to rural dwellers) are more likely to adapt to and cope with the perceived threat of disease infection, in contrast to (mostly poor) rural dwellers (Akem & Permunta 2020).
- Although consumption of primate bushmeat often leads to outbreaks of zoonotic diseases in parts of Africa, primate bushmeat is still considered a delicacy by many Cameroonians. Surveys on knowledge of the zoonotic disease Ebola shows that more than 80% of respondents had heard about Ebola. Among young people aged 15 to 25, knowledge of Ebola was highest with more than 30%. The study also shows that women have a higher awareness of Ebola disease. About 75% of respondents who consumed primate bushmeat knew that primates can transmit diseases to humans. Despite this, the acceptance of primate bushmeat was very high at around 70%. The results indicate that further education campaigns are needed to further raise awareness of zoonotic diseases and the consumption of primate bushmeat (Maurice et al. 2017a).
- Bushmeat serves as a buffer for food security for low-income families, is a preferred source of protein for the middle class and satisfies luxury demand for endangered species for wealthy consumers (Randolph 2016; Wolfe et al. 2005). According to the study, wealthy men in particular bought purchase prized species from the market, while women mainly bought bushmeat for resell (Randolph 2016). Randolph (2016) documented over 24 taxa in the primary bushmeat market, including rodents (31%), ungulates (17%), primates (13%), scaly anteaters (12%), and reptiles (11%). With the exception of cane rat, fresh bushmeat was more worth than smoked (Randolph 2016).

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 (Keesing & Ostfeld 2021; Everard 2020; IPBES 2020).
- For example, bats comprise the highest risk among all wildlife for harbouring emerging diseases; increased human encroachment in recent decades has driven some bat species to become peri-domestic, which increases the risk of zoonotic spillovers (Kurpiers *et al.* 2016).
- However, the **ecological benefit of bats is immense:** In their natural ecological roles they perform valuable ecosystem services beneficial to humans, seed dispersal maintaining local watersheds, all of which are reduced when bats are hunted. Reductions in bat populations as a result of hunting could have expensive ramifications on local communities' water supplies, agriculture, and eco-tourism industries (Mildenstein et al. 2016).

- In 2012, Cameroon adopt a One Health National Strategy and therefore was one of the first countries in sub-Saharan Africa to do so. They identified wildlife disease surveillance as one of the key areas where capacity building is needed (US AID 2020c).
- Furthermore, persecution of bats, including the destruction of their roosts and culling of whole colonies, has led not only to declines of protected bat species, but also to an increase in virus prevalence in some of these populations. Educational efforts are needed in order to prevent future spillovers and to further protect bats from unnecessary and counterproductive culling (Schneeberger & Voigt 2015).
- 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 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).



- Saylors et al. (2021) found that risks associated with bushmeat were poorly understood by most market actors.

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).
- During a survey in Nigeria, Togo, Burkina Faso, and Niger the proportion of persons not consuming any bushmeat was highest in urban areas, especially among young people. Nevertheless, existing demand from a large urban population can create an immense pull and support very long-distance wild meat trade (Luiselli et al. 2019).
- Urban consumption is now considered a key intervention point; urban citizens have a choice in their consumption behaviour (many other food items, such as fish and domestic meat, are available and may be even cheaper), which can contribute to demand reduction (Ingram et al. 2021).

Understanding motives and barriers:

- Ingram et al. (2021) underline: "*City dwellers may consume wildlife for many reasons, including a desire for traditional cuisines and to maintain a cultural connection to a rural heritage, or a perception of wild meat as fresh, healthy, tasty, exotic, and/or as a marker of status. Therefore, reducing demand in metropolitan areas is rarely a question of providing affordable and accessible substitutes, as these already exist. Instead, it is about changing consumer attitudes and practices*."
- Chausson et al. (2019) found that "*the perception of bushmeat as natural, tasty and healthy, and a rare luxury product functioning as a symbol of social status, underpins social norms to provide bushmeat. The main barriers to purchasing were cost and availability. Locally produced fish, meat, and poultry were positively perceived as organic and healthy, whereas frozen imported animal proteins were perceived negatively as transformed, of poor quality and taste, and unhealthy*."

- A survey by WCS found that "traditional" conservation campaigns and messages may be counterproductive and even reinforce negative perceptions of conservation, because perceptions held by urban African bushmeat consumers and those held by actors in the conservation sector are often incongruent: "*For example, in Pointe Noire (Kongo Brazzaville), bushmeat consumers associated bushmeat with their culture, status, and hospitality – and they don't want to give this part of their social life up. They were suspicious of conservation as a foreign preoccupation, putting more importance on animals than humans and imposed by outsiders who do not appreciate Congolese life and culture. They felt they were helping rural people and hunters make a living by buying bushmeat. … In Kinshasa (DRC), eating bushmeat was considered expression of status and cultural identity. … The limited supply, long transport and maintaining the bushmeat quality make it expensive and more desirable. …They resisted being told what to do by international conservation organizations. They had more immediate urban problems such as pollution, the pandemic, and the social and economic pressures of their daily lives*" (Yocum et al. 2022).
- WCS recognized that **for calls to reduce bushmeat consumption to be accepted by bushmeat consumers, behaviour change strategies such as communication campaigns needed to be oriented to how the intended audiences perceive conservation issues and bushmeat consumption** (Yocum et al. 2022).**:**
    - In Pointe Noire's pilot campaign, the new frame aimed to reorient audiences from resistance to acceptance and a sense of ownership about conservation. The campaign shared "good news" instead of bad news that denies the consumers' interests and pleasures and gave reasons for optimism and pride to positively reorient perceptions about conservation and reducing bushmeat consumption.
    - In Kinshasa, the new frame aimed to shift indifference to interest in conservation that has a closer connection to urban life. Small, feasible actions, and moments of success were offered as chances to make daily life better and at the same time be part of a conservation initiative… Reducing bushmeat consumption was offered as a way to enhance social life and feel more successful.

5.2.4. Demand reduction strategies

- **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.
- The need for education programs to include understanding of the risks of zoonotic diseases, and to stimulate behaviour change is obvious (MacFarlane et al. 2022; Veríssimo et al. 2018; Moorhouse et al. 2017).
- **Food preferences and habits are formed in large part through childhood experiences and actually persist throughout the course of an individual's life**, helping to maintain memories and strengthen connections with traditional origins and territory (van Vliet et al. 2015).
- Van Vliet (2018) warns that stigmatization of bushmeat may foster a "cultural backlash", accusing protectionist behaviours of "cultural imperialism" and recommends to analyse and consider the complex cultural dimension. Cawthorn & Hoffman (2015) also underline potential ethical collisions and the need to provide alternative sources for food and 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 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 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%).***
- Consumer demand for bushmeat can be changed by switching customers to alternative protein sources such as domestic meat, dispelling negative perceptions about domestic meat while promoting positive perceptions (Nguyen et al. 2021).

6. Relevant stakeholders

Various studies found that the following stakeholders are important to raise awareness and educate people (Nguyen et al. 2021, Nche 2020, Nasir et al. 2014, Jegede 2007):

- Political leaders
- Religious leaders, involving imams, Islamic school teachers, Catholics, Anglicans, and Pentecostals
- Traditional rulers
- Doctors
- Journalists
- influential celebrities
- ngos in Cameroon, e.g. WCS (https://www.cwcscameroon.org/), WWF…
- Ministry of Health
- Ministry of Environment, Nature Protection and Sustainable Development
- Ministry of Forestry and Fauna

6.1. Role of stakeholders

- Religious leaders in Africa can have a central role in awareness campaign, 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 (Agbo & Nche 2022; Nche 2020; Remes et al. 2012).
- During COVID-19 pandemic religious leaders in several African countries were involved in Governments' public health education campaigns (WHO Africa 2020).
- 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).

6.2. Health Alliance Partners

Who:	**Center for International Forestry Research**
What:	**"Mitigating risks of disease transmission in the wild meat food chain from forest to fork in Cameroon"**
Contacts:	Amy Ickowitz (a.ickowitz@cifor-icraf.org)
	Josef Mbane (J.Mbane@cgiar.org)
	Caleb Tata (calebyengo@gmail.com)
Link:	https://alliance-health-wildlife.org/projects/mitigating-risks-of-disease-transmission-in-the-wild-meat-food-chain-from-forest-to-fork-in-cameroon/
Who:	**GIZ Cameroon**
What:	eventually helpful for networking with authorities
Contacts:	Rue 1.820, Quartier Bastos, P.O. 7814 Yaoundé, Cameroon
	+237 222 20 94 40 / 222 21 52 70
	Country Director: Rico Langeheine rico.langeheine@giz.de
Link:	https://www.giz.de/en/worldwide/345.html

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

7.1. Key findings on media tools

In a nutshell:

- **Radio remains the most used mass-communication medium in Africa**.
- Studies show that education via social media is crucial for awareness and public health campaigns.
- 36.5-38% of Cameroonian citizens are using internet.
- There were 10.05 million **internet** users in Cameroon in January 2022, meaning that 63.5 percent of the population remained offline at the beginning of the year.
- The number of social media users in Cameroon was continuously increasing over the past years and were forecast to continuously increase between 2022 and 2028 by in total 9.9 million users.
- There were 4.55 million **social media** users in Cameroon in January 2022, which is equivalent to 16.5 percent of the total population.

7.2. Scientific background

- **Radio remains the most used mass-communication medium in Africa**. It has the widest geographical reach and the greatest audiences compared with the Internet, television and newspapers - reaching millions who have no access to the internet (UN 2022).
- **On COVID-19**: Adanlawo (2020) revealed that media, especially social media play critically role in curbing the spread of Coronavirus. The study concluded that crisis risk communication is an important step contributing to changing individual behaviour and control of Coronavirus. The study recommends the need for every stakeholder to indulge in the use of social media in communicating Coronavirus crisis to the public to achieve behavioural epidemiology control.
- **On COVID-19:** In the context of COVID-19, Porat et al. (2020) highlight an **infodemic — an over-abundance of information, of which some is accurate, and some is not, making it hard for people to find trustworthy and reliable guidance to make informed decisions**. The authors propose five practical guidelines for public health and risk communication that will cut through the infodemic and support well-being and sustainable behaviour change: (1) create an autonomy-supportive health care climate; (2) provide choice; (3) apply a bottom-up approach to communication; (4) create solidarity; (5) be transparent and acknowledge uncertainty.
- **On Ebola emergency**: In Nigeria, social media, including Facebook and Twitter, obviously helped to curtail the Ebola-outbreak in 2014 by disseminating accurate information about the disease and correcting hoax messaging (Fayoyin 2016; Carter 2014).
- **Role of social media campaigns**: A study by Duong et al. (2021) underscored the need to leverage the power of social media and interpersonal communication in public health

campaigns to prevent infectious outbreaks. They found that interpersonal communication mediated the effect of social media campaign exposure on risk-reducing behaviour.

- 36.5-38% of Cameroonian citizens are using internet (Statista 2022; World Bank Group 2023).
- There were 10.05 million **internet** users in Cameroon in January 2022. Kepios analysis indicates that internet users in Cameroon increased by 967 thousand (+10.6 percent) between 2021 and 2022. For perspective, these user figures reveal that 17.51 million people in Cameroon did not use the internet at the start of 2022, meaning that 63.5 percent of the population remained offline at the beginning of the year (Kepios 2023).
- The number of social media users in Cameroon was continuously increasing over the past years and were forecast to continuously increase between 2022 and 2028 by in total 9.9 million users (Degenhard 2022).
- There were 4.55 million **social media** users in Cameroon in January 2022, which is equivalent to 16.5 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 4.1 million users in Cameroon in early 2022, **Facebook Messengers** 789,400 users, **Instagram** 613,600 users, **Twitter** 145,300 users and **LinkedIn** 820,000 users (for details see https://datareportal.com/reports/digital-2022-cameroon).

8. Other relevant information

- Recent political and armed conflict in the Anglophone areas, including Limbe's South-West region, has weakened effective law enforcement. Indirectly, this encourages animal trafficking, the consumption of bushmeat and the transmission of zoonoses (Harvey-Carroll et al. 2022).

Cultural and social taboos

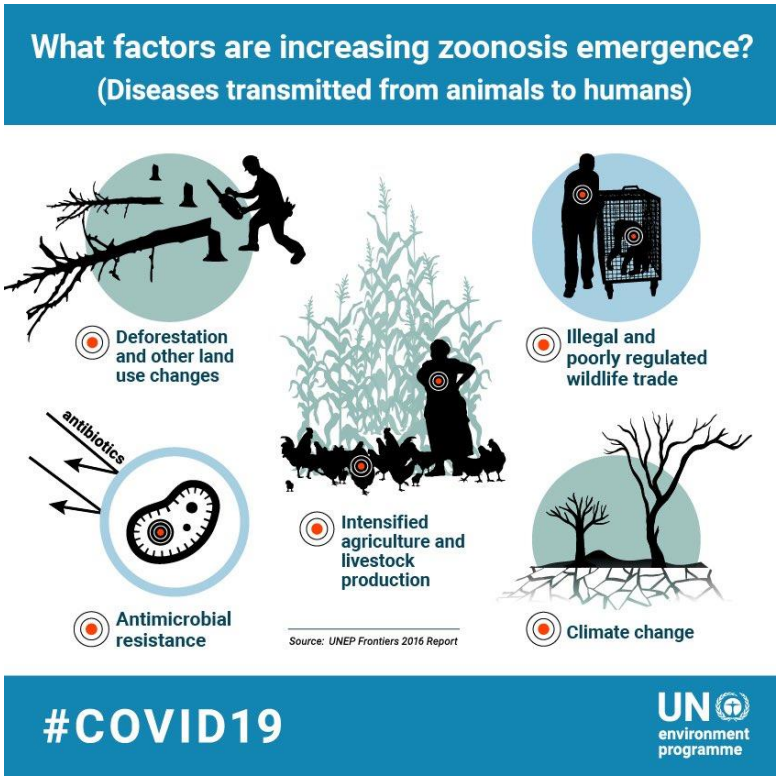
- **A critical explication of the functions and limits of taboos and customary practices attached to wildlife harvesting is needed to see what the society stands to gain from various taboos and how these taboos can be constructively repositioned to achieve ultimate wildlife conservation**, according to a study in Nigeria (Obioha et al. 2012). For example, the endangered sclater's monkey, endemic to Nigeria, is locally protected in a community complex by long-standing social taboos, which remained largely intact until nowadays (Baker et al. 2017).
- The Islam's prescribed method of slaughter for halal means de facto that all bushmeat species are prohibited for strict Muslims (van Vliet & Mbazza 2011), including the eating of primate meat. However, Nyanganji et al. (2010) note that, while eating of great ape meat is restricted by certain taboos, those traditional taboos are increasingly breaking down because of an influx of immigrants from non-Muslim areas, and because of a commercialization of the bushmeat trade.
- Bachmann et al. (2020) found that Muslims in Côte D'Ivoire consumed 86% less primate meat, 90.6% less duiker meat and 94.1% less rodents than Animists.
- Hunting pressure is unsustainable due (in part) to non-selective guns and traps placed around farms and forests. At present, hunters only avoid killing **totemic animals**. For instance, Nimba hunters, avoid killing of chimpanzees and some other primates, leopard, some species of mongoose and the yellow-backed duiker. These avoided species serve as totems, are considered dangerous, have mystical value (especially chimpanzees and leopards), are of known conservation value or are known to be rare (Conservation International undated).
- In central Ghana, two primate species (the ursine black and white colobus and the Campbell's monkey) are locally protected by a **hunting taboo**, thought to date back to the 1830s (Saj et al. 2013). The authors conclude from their research that the monkeys serve as a totemic mechanism to preserve the villagers' social world.
- According to a second study in Ghana, hunters are often more aware of existing **taboos and myths** than of legal aspects, such as closed hunting season and license requirements. However, existing rituals as a remedy for the violation, serving as an antidote against the intrigue, are undermining efficiency of taboos. Rather than integration of the myths and taboos into biodiversity management, increased efforts for enforcement of laws are needed (Emieaboe et al. 2014).
- **Local hunting practices, often accompanied by several taboos, were practiced for centuries, but this does not apply to commercial bushmeat trade into urban markets**, where new consumption aspects have been developed (Zhou et al. 2022).
- State-enforced quarantine, with a mandatory prohibition of movement, raised condemnation, strengthened stigmatization, created a climate of fear, mistrust and denial that did not help people to understand the causes, ways of transmission, and prevention strategies. An understanding of the drivers of fear and mistrust in the affected communities which ultimately result in behaviour that may increase disease transmission, appear to be a crucial and substantial part of an outbreak control (Arthur *et al.* 2022; Pellecchia *et al.* 2015).

9. Examples for Visualizations & Graphics (for internal use only)

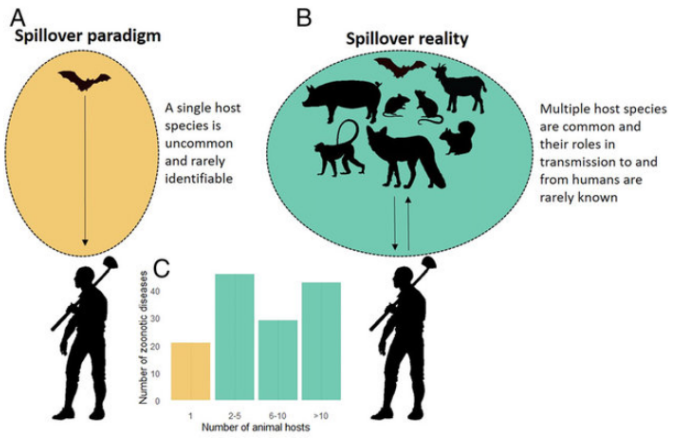
One Health concept

>> taken from 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)



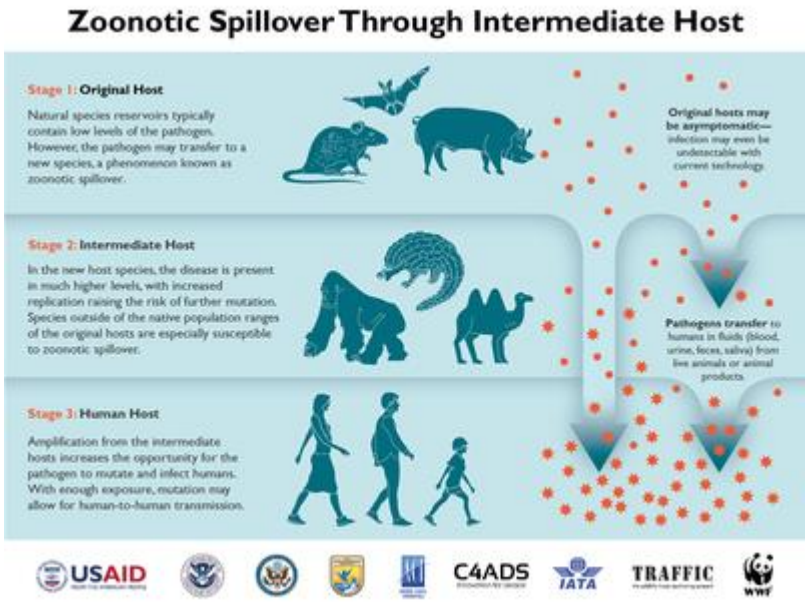
Figure

Caption

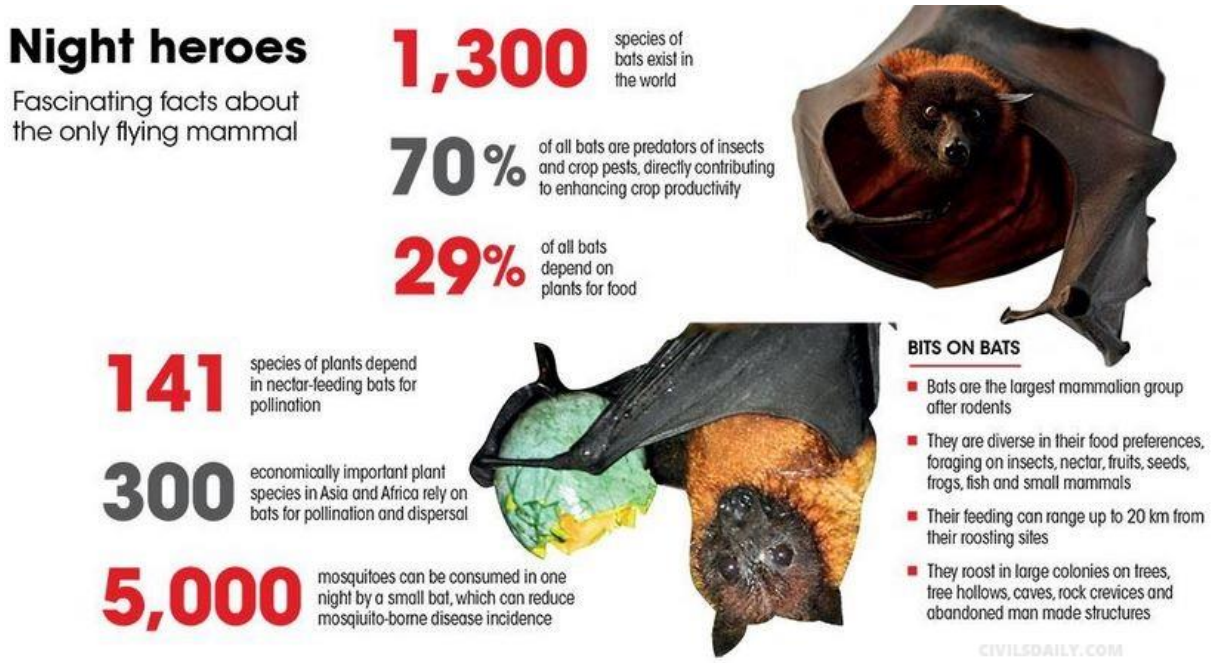
Fig. 4. The paradigm and the reality for research on spillover of zoonotic pathogens into humans. (A) The paradigm emphasizes a single animal host species for a zoonotic pathogen and an original spillover event, though the event and the species are rarely identified. (B) In reality, most zoonotic pathogens 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

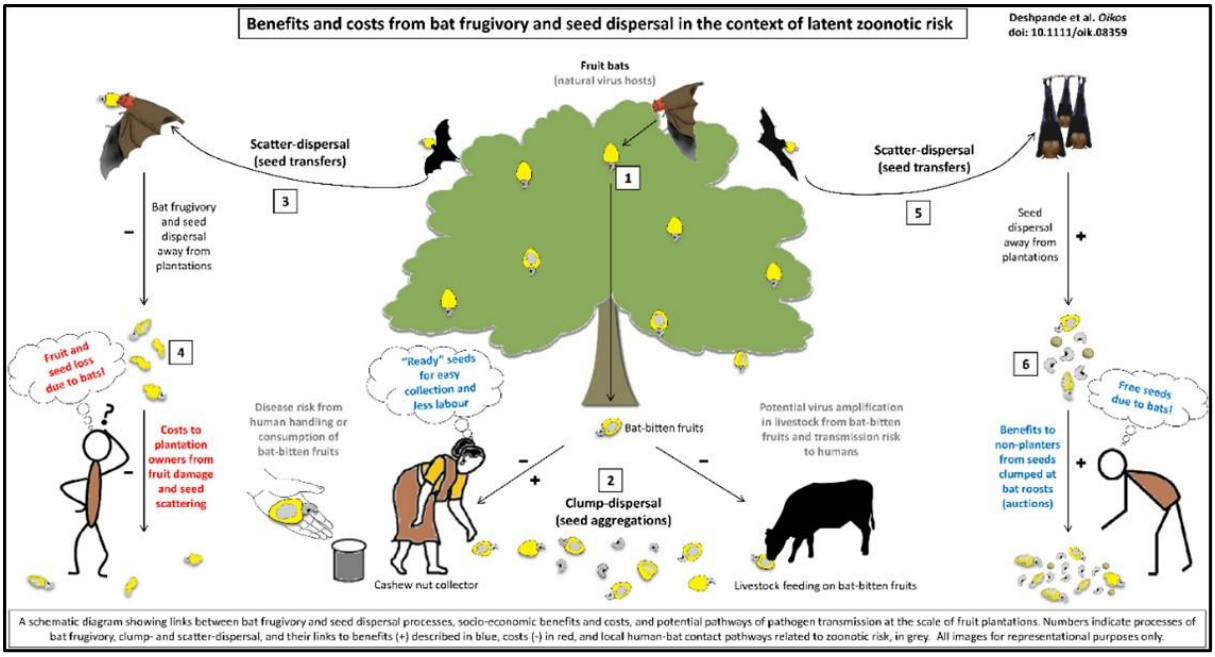
(https://routespartnership.org/news-room/covid-19-underscores-global-need-to-combat-animal-smuggling-in-aviation)



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



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



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