Frontiers in Conservation Science

TYPE Perspective
PUBLISHED 05 December 2024
DOI 10.3389/fcosc.2024.1488981

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OPEN ACCESS

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RECEIVED 31 August 2024
ACCEPTED 08 November 2024
PUBLISHED 05 December 2024

CITATION
Anderson CJ and Reaser JK (2024) Wildlife culling as a biophobic response to zoonotic disease risk: why we need a one health approach to risk communication.
Front. Conserv. Sci. 5:1488981.
doi: 10.3389/fcosc.2024.1488981

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Wildlife culling as a biophobic response to zoonotic disease risk: why we need a one health approach to risk communication

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Zoonoses – infectious diseases that are transmitted between people and other animals – are one of the foremost public health threats. Public health messaging is a critical tool for informing at-risk communities about zoonotic disease threats and effective mitigation measures. Unfortunately, when not carefully crafted, public health messaging can foster fear-based (biophobic) responses to wildlife that may carry zoonotic pathogens—enculturating fear, disgust, and other forms of aversion. In worst case scenarios, biophobia of zoonotic hosts can result in humans culling wildlife populations or destroying their habitat. To better understand how public health messaging can responsibly provide necessary information on zoonoses risks while also promoting an affinity (biophilia) for potential zoonotic pathogen hosts, we conducted a literature review to identify cases of zoonoses-initiated wildlife culls and evaluated patterns and trends. We found that culls are frequently of native wildlife species, rather than nonnative species, and often increase threats to human health rather than mitigate them. We further found that the cultural impetus behind culls is rarely evaluated or discussed in the literature. Clearly, more research is needed in this regard. Human, animal, and environmental health are intertwined, and thus zoonoses prevention and mitigation is best addressed through a One Health lens. There is a need for public health and conservation professionals to collaborate in the development of risk mitigation messaging that enculturates effective zoonoses preventative measures, including biodiversity conservation.

KEYWORDS

biodiversity, fear, messaging, public health, zoonoses

1 Introduction

Zoonoses – infectious diseases that are transmitted between people and non-human animals– are a driving force in human evolution and society (Ledger and Mitchell, 2022). As humans have expanded across the globe, increased to over eight billion in number (United States Census Bureau, 2024), and degraded ecological systems in the process of meeting societal demands, zoonotic disease outbreaks have also increased in frequency and severity (Debnath et al., 2021). At present, zoonoses lead to an estimated 2.5 billion cases of human illness and 2.7 million human deaths annually (Grace et al., 2012). While many zoonoses are transmitted to humans by domesticated animal hosts, most zoonotic pathogens are hosted by wildlife (Jones et al., 2008).

In contemporary culture, public understanding of zoonotic disease risk is largely based on information disseminated by public health agencies at local and national scales. These agencies have a mission to protect people. Typically, the goal of this public health messaging is to minimize the likelihood that zoonotic pathogens will be transmitted from wildlife or domesticated animals to people. For pathogens that have the potential for human-to-human spread, public health messaging also provides cautionary information and guidance (e.g., masking) to reduce the likelihood that an epidemic (localized outbreak) or pandemic (large-scale outbreak) will occur (e.g., CDC, 2024).

Undoubtedly, public health messaging aimed at zoonoses prevention safeguards human lives, livelihoods, and various socio-cultural norms. It can be successful in enculturating risk-reducing human behaviors, such as washing hands before meals. Public health messaging can thus also facilitate the adoption of new cultural norms that improve human welfare and security.

Despite the positive intent and impacts of public health messaging to prevent zoonoses outbreaks, risk communication can have drawbacks from a biodiversity conservation perspective. Risk communication typically includes information on which wildlife or domestic animal species may transmit respective diseases. In response to this information, people may develop adverse relationships to these species out of a sense of self-protection. This is particularly true when the diseases of concern can have crippling or fatal outcomes (Decker et al., 2012; MacFarlane and Rocha, 2020; Shapiro et al., 2021). Public health messaging can thereby facilitate biophobia – a reaction to biological organisms encompassing "dark emotions" such as fear, disgust, and aversion (Soga et al., 2023; Soga and Evans, 2024).

A wide range of negative attitudes and behaviors have been reported in response to zoonoses-based biophobia, including killing animals that may host pathogens and destroying wildlife habitats. Biophobia-induced wildlife culling (killing animals at the population level) is an extreme reaction to public health risk communication wherein fear or other dark emotions drive humans to attempt to reduce or eradicate wildlife populations that are known or believed to transmit a specific zoonotic disease. In addition to potentially adversely impacting animal welfare, this practice is problematic from at least three perspectives: 1) wildlife culling to mitigate zoonoses risk is rarely effective in reducing pathogen prevalence or transmission rates among wildlife hosts (Olival, 2016; Miguel et al., 2020; Viana et al., 2023); 2) the culling activity may increase transmission risk to humans (e.g., if carcasses are handled by hunters; Keatts et al., 2021); and 3) there may be adverse impacts on wildlife populations and ecosystems more broadly, particularly when native species are targeted (Asprilla-Aguilar et al., 2007; MacFarlane and Rocha, 2020; Shapiro et al., 2021). These unintended adverse consequences of public health messaging largely arise from the focus of this messaging on people without sufficient regard to how human health is dynamically intertwined with the health of animals and the natural environment.

In this Perspective, we provide a brief review of biophobia in the zoonoses risk mitigation context and report on case studies wherein populations of wildlife hosts have been culled or their habitat destroyed in response to zoonoses (S1). In two of these case studies, we examine the social drivers and messaging that impacted culling efforts (Boxes 1, 2). We conclude with a call for a One Health approach to zoonoses risk communication that simultaneously promotes public health and biodiversity conservation messaging for situations in which native wildlife are known or suspected to be zoonotic pathogen hosts. To protect human, animal, and ecological health, there is a need to educate stakeholders about zoonotic disease risk, enculturate effective zoonoses risk mitigation strategies, and foster a lasting affinity for the natural world.

2 Biophobia

"Biophobia" emerged conceptually as the antonym of "biophilia," defined by ecologist E.O. Wilson as "the innate tendency to focus on life and lifelike processes" (Wilson, 1984). Biophilia is believed to be largely inherent, but can also be learned (Barbiero, 2011). It has numerous positive impacts at the individual level, including stress reduction and positive social behaviors (Olivos-Jara et al., 2020). Biophilia among humans also benefits biodiversity conservation through increases in pro-environmental behaviors and support of pro-environmental policies (Soga et al., 2016; Alcock et al., 2020).

Although the common definition of biophobia is "fear of nature or a specific organism" (Correia and Mammola, 2024), the experience of biophobia can also include feelings of panic, disgust, or other aversive emotions (Castillo-Huitrón et al., 2020). Biophobia is both innate and learned (Correia and Mammola, 2024). As an evolutionary adaptation, biophobia among early humans was requisite for survival. Threats such as large predators, toxic plants or fungi, or venomous animals likely led to the evolution of behavioral and physiological survival responses in humans (Castillo-Huitrón et al., 2020; Patuano, 2020; Correia and Mammola, 2024).

As a learned response, biophobia can manifest at the individual or community level. Phobias may result from personal experiences or information conveyed by others. For example, young children exhibit fear of snakes less often than older children or adults (Souchet and Aubret, 2016). Biophobia may be a shared response in communities and cultural groups to real or perceived threats (Gish et al., 2024; Soga and Evans, 2024). Ultimately, biophobia

BOX 1 Case Study: Marburg Virus Disease in Egyptian Fruit Bats.

The Kitaka Cave in southern Uganda was mined for lead and gold beginning in the 1930s (Towner et al., 2009). In July through September 2007, four miners in Kitaka Cave were infected with Marburg Virus Disease (MVD), one of whom died from the disease (Towner et al., 2009; Amman et al., 2014). The mine was inhabited by a population of >100,000 Egyptian fruit bats (Towner et al., 2009). This species is the natural host of Marburg virus and Ravn virus, the etiologic agents of MVD. The Ugandan Ministry of Health closed access to the mine in response to the MVD infections. There was no risk-mitigation response, and miners were not financially compensated for their lost income (Towner et al., 2024). Disease researchers from the U.S. Centers for Disease Control and Prevention provided informal information to district health authorities and miners cautioning that the mine should not be entered without personal protective equipment, which was cost-prohibitive to the miners, and that culling the bats would likely have negative public health and ecological impacts (Towner et al., 2024). In 2008, the miners initiated a cull of the bats. Using reed barriers and fishing nets, they prevented bat egress from the cave, then sealed cave entrances with sticks and plastic (Amman et al., 2014). A pile of dead bats was found in the forest in August 2008, and by November 2008 the cave appeared to be fully void of bats (Amman et al., 2014). In October 2012, an outbreak of MVD occurred in Ibanda, a town approximately 20km from the Kitaka Cave. An etiological investigation found only one population of Egyptian fruit bats in the region, located in the repopulated Kitaka Cave. The population in the cave was estimated to include 1–5% of the population observed prior to the cull (Amman et al., 2014). Subsequent evaluations indicated seroprevalence of MARV and RAVV among the Egyptian fruit bats was 5% prior to the cull and 13% after the cull. While the ecological driver behind the increase cannot be certain, it may be attributed to increased movement and contact between animals that survived the cull with the large number of susceptible (disease-naïve) animals that repopulated the mine after the cull. The colonizing bats, exposed to the virus for the first time, could have had higher levels of titers and antibodies than animals that had been long-infected. This is particularly relevant to human health risk, as elevated antibody levels can lead to higher spillover rates (Amman et al., 2014).

leads to nature-avoidance behaviors and increases likelihood of supporting or participating in actions aimed at eliminating nature (Soga and Evans, 2024). Demonstrated by humans at the community level, biophobia can have devastating impacts on native wildlife populations and ecosystems. Unfortunately, biophobia and the impacts thereof are increasing in scale and magnitude (Soga and Evans, 2024). People living in urban and economically developed communities demonstrate greater levels of biophobia than those living in rural areas (Soga et al., 2023). As the proportion of humans living in urban areas is expanding, so too is the proportion of humans disconnected with nature (Castillo-Huitrón et al., 2020). Public levels of zoonoses biophobia appear to be also increasing in tandem with greater misinformation and media coverage (Decker et al., 2012), which is often poorly-crafted and inadequately contextualized (MacFarlane and Rocha, 2020).

Like other forms of biophobia, biophobic response to pathogens and parasites is both inherent and learned. Humans and other animals have evolved preventative and reactive responses to avoid pathogens and parasites (Hart and Hart, 2018; Sarabian et al., 2023). Given the increasing occurrence of zoonotic spillover, it is perhaps unsurprising that humans are developing biophobia toward zoonotic hosts. Yet, these fears are often unmerited, as public fear can be centered upon a perceived zoonotic host rather than a confirmed host and, in many circumstances, the collective fear of zoonotic hosts likely outweighs actual risk (MacFarlane and Rocha, 2020). For example, in the wake of the COVID-19 pandemic, public fear and animosity towards bats increased, largely due to the misconception that bats have been demonstrated to be the reservoir host of the virus (Lu et al., 2021; Sasse and Gramza, 2021) and lack of understanding that it is exposure to infected humans and the human environment, rather than animal hosts, that poses the greatest risk (Mehraeen et al., 2021). There have been calls by the Australian government to cull fruit bats in response to Hendra virus (Olival, 2016), despite the fact that it is habitat loss (Eby et al., 2023) that fundamentally drives the spillover of the deadly virus to humans.

3 Culling as zoonoses risk mitigation

Although a considerable amount of wildlife culling is likely done as a fear-based reactionary measure without consideration for the broader implications, the strategic culling of animals by authoritative bodies to mitigate zoonoses risk is generally thought

BOX 2 Case Study: Suspected SARS-CoV-2 in Bats.

In February 2020, Zhou et al. (2020) published their findings that the novel coronavirus, now known as SARS-CoV-2, was 96% identical at the whole-genome level to a bat coronavirus previously identified in horseshoe bats (*Rhinolophus affinis*). This finding suggested that SARS-CoV-2 may have originated in bats (Mallapaty, 2020), although to date the reservoir host has not been identified. Following these findings, misinformation and media coverage associating bats with the pandemic were commonplace (MacFarlane and Rocha, 2020) and, consequently, negative attitudes towards bats among the public were strengthened (Lu et al., 2021).

In March and April 2020 alone, bat culls were reported in Cuba, South America, Africa, and Asia. Citizens in Cuba (ADNCuba, 2020) and Peru (RTE News, 2020) were documented killing bats with fire. In Rajasthan, a state in northwestern India, local citizens killed approximately 200 wild bats (Goyal, 2020). In some countries, governments intervened to protect bats. The Peruvian National Service of Wild Forests and Fauna released a statement calling for citizens to halt these culls (RTE News, 2020), and the federal government of India extended legal protection to bats under the Indian Wildlife Act (Goyal, 2020). Conversely, some governments were actively involved in efforts to cull bats or destroy bat habitat. Rwandan government employees shot roosting straw-colored fruit bats (*Eidolon helvum*) with water cannons in an effort to drive them away from the Kigali, the capital city (Bittel, 2020).

In Indonesia, bat culls were encouraged and implemented by local governments. The government in Subang, a regent in western Java, circulated a letter to the public with instructions to mitigate spread of COVID-19. Among guidelines including canceling large events and public school operations, residents received instructions to kill bats (Farhan and Assifa, 2020). In Surakarta, a city in central Java known colloquially as Solo, the local government gassed and burned bats that had been captured for sale in a local live animal market (CNN Indonesia, 2020). To stop these efforts, The Research Center for Biology, Indonesian Institute of Sciences – the national scientific authority – partnered with local conservation organizations. Together, they sent a letter to the local government in Subang and developed a public education flier, which they shared via social media. The letter and flier outlined the environmental and economic benefits of bats, explained that the strain of SARS-CoV-2 hosted by bats in Indonesia was non-infectious to humans, and elucidated the futility of culling bats as a disease mitigation strategy. Within days of these efforts, the governments stopped culling bats (Sigit Wiantoro, Museum Zoologicum Bogoriense – BRIN, *pers. comm.*; Ellena Yusti, CRC 990 EFforTS, *pers. comm.*)

to be underlain by two key assumptions. The first assumption is that the transmission rate of a given pathogen (R_0) correlates with wildlife population size (Guyton and Brook, 2015). This assumption is relevant for some density-dependent pathogens, but transmission is often independent of population size or density. The etiologic agent of plague, *Yersinia pestis*, can persist in relatively small rodent populations, resulting in occasional and sporadic human epidemics (Keeling and Gilligan, 2000). Pathogen transmission rates can also be dependent upon frequency of specific behavioral interactions, such as those that are sexually transmitted or vector-borne (Miguel et al., 2020). The second assumption is that culling decreases population size (Guyton and Brook, 2015). This is a flawed assumption, as many wildlife species compensate for decreased population density through increased immigration or increased reproductive output (Myers et al., 2000). The documented stability of fox population sizes despite culls in varied spatial and temporal settings is a prime example (Baker et al., 2002; Comte et al., 2017; Jiguet, 2020).

Culling can, in some circumstances, be an effective disease mitigation strategy (Geering and Penrith, 2001; Prentice et al., 2019; Miguel et al., 2020). In the case of livestock or other captive animals, the number of animals can be determined, movement restricted, and interactions with other species limited. In these circumstances, preemptive (Tildesley et al., 2009) and test-based (Lu et al., 2008) culling have effectively reduced disease prevalence and transmission. In contrast, culling free-ranging wildlife poses a myriad of challenges. Wildlife behavior and population dynamics are beyond human control and often unpredictable. Culling efforts of wildlife populations have resulted in altered spatial distribution and home range size (Woodroffe et al., 2006; Viana et al., 2023), transition to nocturnal activity patterns (More et al., 2015), increased immigration (Beasley et al., 2013; Lieury et al., 2015), increased reproductive output (Myers et al., 2000), and altered population age and sex structure (Miguel et al., 2020), all of which can influence disease dynamics, including potentially increasing transmission risk. Most wildlife culls implemented to mitigate zoonoses risk have lacked efficacy evaluation, have been found to be ineffective, or have counterproductively increased pathogen prevalence or transmission (Olival, 2016; Viana et al., 2023). Tragically, many wildlife culls for zoonoses mitigation have resulted in adverse consequences for animal welfare, greater species vulnerability, and cascading ecological impacts (Guyton and Brook, 2015).

4 Culling case study findings

Our literature review methodology and case study summaries are located in Supplementary Table S1. The majority of culls to mitigate zoonotic risk are likely localized, unauthorized, and undocumented and therefore unreported in publicly transparent sources. However, we identified 35 case studies of culling in the scientific literature, all of which targeted mammal hosts. The culls aimed to mitigate risk of 12 pathogens and parasites: five viruses, four bacteria, and three parasites. Over half of cases were for rabies (n = 11) or bovine tuberculosis (n = 8). The majority of cases (n = 30) were conducted or authorized by governments or another authoritative body.

In reviewing these case studies, we noted that the explicit socio-cultural impetus behind culls is rarely evaluated or discussed. Reports of culls conducted by the public simply state that the cull was implemented in response to a particular zoonotic threat, but do not investigate the knowledge or motivation of those initiating the cull. For example, it cannot be determined why the miners of Kitaka Cave culled the resident bats (Box 1). Towner et al. (2024) reported that the miners shared frustration they were unable to access the mine for financial reasons. Motivations for the cull may have also included retaliation or fear for their personal safety. Reports of culls conducted by governments or other authoritative bodies also rarely elucidate decision-making criteria or discussion of alternative techniques. Most notably, it's clear that empirical evaluations of culls as a risk mitigation measure are not standard practice in these scenarios (i.e., the culls are not demonstratively science-based), nor are animal welfare or socio-cultural values evaluated via social science investigations. The motivation for many culls conducted both by the public and by authoritative bodies is, therefore, largely unjustified ("irrational") from the perspective of standard scientific procedure. Although likely held unconsciously in many cases, it is apparent that the fear that a wild animal is a threat to human survival and should therefore be destroyed, despite the cost to the animal's life, is a driving force for many culls, rather than rigorous risk management evaluation.

The fact that culling has proven to be largely ineffective at zoonoses mitigation further underscores the lack of objective decision criteria and likelihood of fear-based bias ("irrationality") in many circumstances. Efficacy of the zoonoses-initiated culls in our review ranged from ineffective or counterproductive (e.g., increase in pathogen prevalence reported by Comte et al., 2017), to mixed results [e.g., decrease in skunk density but increase in pathogen geographic distribution reported by Gunson et al. (1978) and Fehlner-Gardiner (2018)], to effective (e.g., decrease in pathogen prevalence and pathogen geographic containment reported by le Roex, 2014). The means by which culling efficacy was evaluated varied across studies. While it was unsurprising that efficacy of culls conducted by the public is rarely evaluated, over half (n = 16) of the culls by authoritative bodies did not include an evaluation of pathogen prevalence in the targeted host species in response to the cull. Studies that incorporated multiple evaluation criteria outlined important dynamics. For example, in a cull of rodents to mitigate threat of Lassa fever, Mariën et al. (2024) found the rodent population decreased, but the virus spillover rate to humans increased. Had this study included only an evaluation of rodent population density, the cull likely would have been deemed successful. Cases wherein culling was effective included unique cultural, geographic, or ecological circumstances. For example, Denmark has been free of rabies since 1982, partially credited to the cull of red foxes (*Vulpes vulpes*) in the 1960s–1980s, but also due to the geographic isolation of the country and continued rabies management in northern Germany (Aubert, 1999).

At least 20 of the 35 of the culls in our review were of native wildlife species. This is particularly concerning, as culling native species is likely more ecologically detrimental than culling nonnative species. Culls of native species in our review resulted in reduction in populations of keystone species (Cocozza and Alba, 1962), increased pathogen prevalence rates (Lee et al., 2018), and altered community assemblages (Bourne, 2007), all of which compromise the integrity and sustainability of local ecological communities.

5 Discussion

Harrison et al. (2010) and Miguel et al. (2020) outlined necessary conditions for disease-focused wildlife culling to be attempted, including a thorough understanding of the pathogen transmission cycle, known response of target wildlife populations to culling, economic efficacy of the cull, and support among stakeholders. While these guidelines provide important decision criteria at multiple levels, they do not identify the need for risk communication that avoids instilling a biophobic response. Likewise, the literature that we reviewed provides few examples of risk communication conducted in concert with biodiversity protection goals. To avoid future biophobia-driven culls, there is a clear need to develop a One Health approach to zoonoses risk communication.

The One Health High-Level Expert Panel defines One Health as, "an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems," World Organisation for Animal Health (2021). Because zoonoses mitigation necessitates attentiveness to all three components of One Health, it is critical that zoonoses-focused public health messaging promotes zoonoses risk mitigation while also promoting biodiversity conservation and biophilia. There is, therefore, a need for collaboration between public health and biodiversity conservation practitioners, especially those working on the communication aspects of both fields. Studies of communication effectiveness indicate that messaging needs to be carefully crafted using consistent and clearly understood terminology (Shapiro et al., 2021), cautiously and intentionally communicated to the media (Tabbaa, 2010), and framed using evidence-based techniques to encourage pro-environmental behaviors (Jacobson et al., 2018; Niemiec et al., 2020). It is also important that "prevent zoonoses, promote biophilia" messaging is adapted to the local ecology, culture, language, and context (Reaser et al., 2024, this Research Topic).

A growing body of scientific literature demonstrates that wildlife culling to mitigate zoonotic risk is frequently ineffective at protecting human lives and can have dire impacts on native wildlife and ecological systems. Despite this, these culls continue, both as rogue endeavors by unauthorized citizens as well as coordinated efforts by local authorities. Although the culls may be well-intended to protect human lives, they are often futile efforts driven by biophobic response to zoonoses risk communication. There is an urgent need for scientific inquiry into the social drivers and decision criteria leading to these culls. Further, it is the responsibility of those in the public health and biodiversity communication fields to develop public health campaigns that provide guidance on effective zoonoses risk mitigation while simultaneously encouraging stewardship of the natural environment that is requisite for our survival.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding author.

Author contributions

CA: Conceptualization, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. JR: Conceptualization, Funding acquisition, Supervision, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. The publication of this paper was sponsored through an Interagency Agreement Between the US Fish & Wildlife Service and Smithsonian National Zoo & Conservation Biology Institute. It advances work on risk communication as a component of study directed by the American Rescue Plan Act. Additional in-kind partners in this sponsorship include the International Alliance Against Health Risks in the Wildlife Trade and the International Union for the Conservation of Nature (IUCN).

Acknowledgments

We thank Sigit Wiantoro and Ellena Yusti for providing information about their efforts to cease bat culls in Indonesia. We thank Daisy Gómez Ruiz, Gabriela Peña Bello, and Ana María Sánchez Zapata for providing information about bat culls in Colombia. We thank Isla Kirkey for pre-submission review of this manuscript.

Conflict of interest

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The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fcosc.2024.1488981/full#supplementary-material

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