

COMMENTARY**Exposure to pesticides and zoonoses during procurement, trade, and consumption of vulture parts: an unexplored threat to human health.**

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Summary

Background: Examination into the origin of SARS-CoV-2 has shed further light on opportunities for broader zoonotic pathogen transmission stemming from the trade in living wildlife and animal parts, and in associated practices. In certain parts of the world (e.g., Africa), various bird species are illegally captured for both subsistence and non-subsistence purposes such as for belief-based use. The latter practice includes rare and declining vulture species and arises from the (relatively recent) belief that directly ingesting certain vulture body parts may impart powers of clairvoyance or bring good fortune. Among a variety of capture methods used by hunters, pesticide-poisoned or nicotine-laced baits are prevalent. In 2020, a mass mortality incident in Guinea Bissau involving over 2000 Critically Endangered Hooded Vultures was linked to belief-based practices, and to the use of a carbamate pesticide. This was to date the highest reported number of vultures killed by pesticide poisoning within a single event. Such deliberate, indiscriminate poisoning is now widely

acknowledged within conservation sectors as posing evident threats to vulture species and populations. However, the potential human health repercussions arising from the possibility for zoonotic pathogen transmission (e.g., anthrax, avian H5N1 influenza), and for secondary exposure to the range of toxic substances used to capture and prepare individual birds – whether to hunters, procurers and traders of vulture parts or to consumers – have remained unexplored.

Objectives: Our aims are to 1) generate awareness of these practice within human health risk assessment sectors; and 2) generate interest within the human health sector in examining the potential for zoonotic pathogen transmission and toxicity or poisoning risks to people that may stem from these practices.

Discussion: We briefly describe human behaviours associated with this belief-driven practice as they relate to potential exposure, and issue a plea for examination of the associated health risks, in collaboration with ongoing conservation and wildlife forensics efforts.

Commentary:**Exposure to zoonotic pathogens and poisons resulting from belief-based practices and consumption.**

Investigations into a likely wildlife origin of SARS-CoV-2 and the ensuing covid-19 pandemic have cast new scrutiny on the wildlife trade and the related practices, which can promote transmission of pathogens to humans that eventually can evolve in the human population and become a pandemic. In West and Southern Africa, belief-based use of vultures is the main driver of their trade (Nikolaus 2001, Beilis & Esterhuizen 2005, Saidu & Buij 2013), and vultures and their body parts are used to purportedly treat various ailments, or for good fortune, while their carcasses are also sold locally for meat (Nikolaus 2011, Buij *et al.* 2016).

Traders of live vultures in open markets often keep them in cages and handle them during business transactions (Figure 1), while their body parts are offered for sale alongside other wildlife products at open markets (Figures 2 and 3). Through contact with carrion and waste, vultures may retain pathogens of global public health significance on their feathers, head, and feet. While vultures have not yet been conclusively implicated as epidemiological transfer or transmission agents, they have been shown to carry zoonotic pathogens demonstrating antimicrobial resistance which could impact veterinarians and other staff involved in handling these species (Plaza *et al.* 2020, Suárez-Pérez *et al.* 2021). Similarly, handling and consumption of vultures and use of their parts may present a risk for human exposure to bacteria and viruses including anthrax, *Salmonella* spp, *Campylobacter* spp, and avian H5N1 influenza (Ducatez *et al.* 2007, Turnbull *et al.* 2008, Molina-Lopez *et al.* 2011, Marin *et al.* 2014). Because the belief-based vulture trade is primarily conducted in urban settings, there is higher risk for human exposure and subsequent spread of vulture-borne pathogens.

Among a variety of methods employed for capturing vultures for belief-based practice, the use of pesticide- or nicotine-laced baits is prevalent (Saidu & Buij 2013). In fact, indiscriminate and far-reaching, deliberate pesticide poisoning is one of the main drivers of vulture population declines (e.g., Ogada 2014, Plaza *et al.* 2019), making accipitrid vultures one of the fastest declining groups of birds globally (Ogada *et al.* 2012). Correspondingly, significant losses due to belief-based trade across Africa have been reported (e.g., McKean *et al.* 2013, Williams *et al.* 2014, Buij *et al.* 2016). In early 2020, over 2,000 Critically Endangered Hooded Vultures (*Necrosyrtes monachus*) in Guinea Bissau (in West Africa) were determined to have been poisoned after residues of methiocarb, a highly toxic carbamate insecticide, were detected in some of the carcasses recovered for testing (Henriques *et al.* 2020). This was to date the highest reported number of vultures killed by pesticide(s) within a single poisoning event. The observed number of decapitated vultures, among other gathered evidence, suggested belief-based trade was the driver of the mass killing.

Human health risks and risk demographic of the vulture trade.

The decline of accipitrid vultures is devastating to ecosystem health due to the loss of efficient scavengers (Buechley & Şekercioglu 2016). While further diminishing already imperilled populations, the trade in vultures and their parts also places humans at risk of direct exposure to poisons and zoonoses. Broadly speaking, three groups are involved: 1) hunters capture and handle birds; 2) traders handle, process, and sell birds or their parts; and 3) consumers and buyers process and ingest parts. Odino (2012) has detailed several exposure opportunities in hunters illegally using pesticides to capture birds for food (i.e., poaching). People ingesting and handling poisoned vultures captured through use of pesticides or other toxic substances



Figure 1: A man holding a captured Hooded Vulture for sale in a wildlife market in Ibadan, Nigeria, *ca.* March 2020. Photograph: SA.



Figure 2: Rüppell's and White-backed Vulture heads for sale at a wildlife market in Ibadan, Nigeria, *ca.* March 2020. Photograph: SA.

(as documented in Saidu & Buij 2013) risk direct exposure to residues on or in vulture products (Otieno *et al.* 2010, Richards *et al.* 2015, 2017). For instance, to treat an unhealing wound believed to be caused by witchcraft, a live vulture is killed and boiled and then burnt and the ashes are applied to the wound (S. Awoyemi, unpublished data). Those processing vulture carcasses for sale could also be exposed via inhalation and dermal contact, whether residues from toxic substances used for capture, or additives used for the processing itself. Moreover, weathering and loss of moisture can increase the concentration of poison residues to which people could be exposed (Richards *et al.* 2015, 2017). Although there is ample literature demonstrating the human health repercussions of chronic occupational exposure to subacute levels of certain pesticides (e.g., insecticides, fungicides, which may cause joint pain, reduced mobility, or modified body posture – among others), pesticide exposure has largely been documented by questionnaire rather than clinically or toxicologically (e.g., blood, urinalysis or hair) as a defining factor in any of these ailments (e.g., Kamel & Hoppin 2004, Marete *et al.* 2021). To our knowledge the human health impacts of pesticide exposure have never been specifically examined in the context of the trade in vultures, or their (or other animal) parts procured by capture via toxic substances.

Variation in health risks posed by the belief-based trade in vulture parts is likely to extend across members of society and encompass both men and women (Awoyemi 2014). For example, among the Yoruba in southwestern Nigeria, the trade in vultures or other wildlife is a matrilineal practice, passed from mothers to their daughters across generations (Awoyemi 2014). Although the majority of traders are women, a smaller number of men also inherit this trade from their mothers. At

present, there is no information on occupational exposure to health risks for the women and men involved in the trade, or for consumers. Direct assessment is the only way that the hazard posed by zoonotic pathogens or toxins can be determined, and a sense of urgency is required given the potential health and transmission risks. Importantly, however, religious and spiritual leaders within communities should be approached as allies in investigating risk factors for the exposure of consumers and traders to pathogens and toxins, because trust in consenting to the collection of biological samples (e.g., blood, hair and urine) would have to be established over time. To build trust, religious opinion leaders who are known and respected by traders and consumers could be enlisted to impart the importance of medical tests to determine the level of exposure to toxins and pathogens. Maintaining such engagement will be important so that once risk factors for exposure to pathogens and toxins have been identified, those involved in the trade are engaged in behavioural change to mitigate any risks. On the other hand, the potential health repercussions may be of such importance that precautionary principles to vulture consumption and trade should be applied, rather than to wait for the evidence to act upon it. To reach traders and consumers alike on the potential health risks that come with handling and consumption of vultures, educational messages would be conveyed through radio which is the most popular media in Nigeria (Broadcasting Board of Governors 2014) and shared during prayer meetings at places of worship. The context of the current coronavirus epidemic and past occurrences of Ebola are opportunities to propel these messages and convince traders of the need for their cooperation.



Figure 3: A section of an open wildlife market in Ibadan, Nigeria, *ca.* March 2020. Photograph: SA.

Conclusions

The trade in vultures poses an indisputable threat to vulture species and populations, with the use of indiscriminate pesticides and other toxic substances to kill vultures for the trade further magnifying the threat. Due to the use of these substances, there may be a public health risk of direct exposure and intoxication. Tandem assessment of the risk of transmission of pathogens of public health significance on vulture feathers, heads and feet – all of which people involved in the capture, processing, or consumption of vulture parts may come into contact with - is also warranted. Given that accipitrid vultures are protected by law, their critical conservation status, and the danger that belief-based trade in vultures may pose to human health, steps should be urgently taken to address these tandem concerns. We advocate for enhanced

protection and vigilance towards demand reduction through stopping trade of vultures and potential surrogate species, and call for multi-disciplinary approaches that increase understanding and awareness about the potential risks posed to humans. We also stress the need for identifying workable alternatives and solutions in acknowledgement that the rationale and drivers for partaking in the consumption of vulture parts will likely remain even if health risks are identified. Since these drivers are compelling to the people who believe in them, any alternatives provided have to be correspondingly meaningful. Finally, we urgently call for biological and toxicological screening of community members involved in the hunting or capture of birds and the trade and consumption of parts, to more definitively examine any potential threats to human health.

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