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# Lead ingestion as a potential contributing factor to the decline in vulture populations in southern Africa

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ABSTRACT

Vulture populations in southern Africa have been on the decline for years, which unlike the Asian vulture crisis, has no one specific cause. Reasons attributable are deliberate and secondary poisonings, drowning, power line injuries, electrocutions, traditional medicine ("muti" trade) and calcium deficiencies. However, lead toxicity as a potential causal factor is hardly mentioned. The potential for lead toxicity needs to be considered as substantial game hunting occurs in the region with little regulatory control on bullet types. In this study, we determined the whole blood lead concentrations of captive and wild vulture populations in South Africa and Namibia (n=185). Results were compared to previous published ranges indicative of background exposure ( < 10 μg/dL), non-toxic point exposure based upon the range established from captive birds and subclinical exposure. In general, whole blood lead concentrations were higher for wild African White-backed vultures (*Gyps africanus*)(AWBV) than Cape vultures (*G. coprotheres*)(CGV) at 15.54 ± 12.63 μg/dL vs 12.53 ± 8.88 μg/dL (non-significantly different), while in the Bearded vultures (*Gypaetus barbatus*) no indication of exposure was evident. Very similar exposures resulted irrespective of the birds being in captivity or under wild, free-roaming conditions. A proportion of wild birds did, however, appear to be exposed to another source of lead than purely environmental ( ± 12% and 30.6% for AWBV and CGV respectively). One bird, which had a whole blood concentration of 100 μg/dL, died soon after capture. To find the relationship between whole blood lead concentration and likely exposure factors, birds were compared by their rural/urban location, vicinity to mines and surrounding soil lead concentrations. With no relationship being present for the latter factors, we believe that this is evidence that the portion of southern African vultures being exposed to unknown source of lead, which we suggest arises from leaded ammunition remaining from hunting

## 1. Introduction

Vultures play an important role in their environment (i.e. ecosystem services) by disposing of carcasses which help not only in nutrient recycling, but also plays a role in reducing the spread of diseases like anthrax. Vulture populations could also indirectly affect population numbers of obligate scavengers (such as feral dogs) thereby mitigating the spread of zoonotic diseases like rabies and dangerous human-animal interactions (Sharp, 2006). Southern Africa is home to eight old-world vulture species (Mundy et al., 1992; IUCN, 2014). Despite being home to this many vulture species, most are endangered with no specific reason being readily evident for their decline when compared to the diclofenac-associated decline on the Asian subcontinent (Oaks et al., 2004; Pain et al., 2008) or the effects of illegal poisoning in Europe (Margalida, 2012). In contrast their endangered status is ascribed to a combination of factors such as poisoning (malicious, accidental and secondary), drowning, electrocutions, power line collisions, traditional medicine trade and poor chick development due to calcium deficiencies to name some of the documented threats (Richardson and Plug, 1986; Ogada et al., 2012; Ogada et al., 2016), with further concerns now being raised over wind turbines (De Lucas, 2012). However, strikingly absent on the probable list of hazards is any mention of lead exposure as a potential cause of vulture mortalities as occur in other European species (Hernández and Margalida, 2009). Despite an extensive literature search, only one study contained limited information on lead concentrations in six White-backed vultures (*Gyps africanus*) sampled near Kruger National Park, South African (Van Wyk et al., 2001).

While medical reports from South Africa indicate the most common sources of lead in people results from lead in the paints, soil and the

*Abbreviations:* AWBV, African White-backed vultures; CGV, Cape Griffon vultures; NZG, National Zoological Gardens; KD, Krugersdorp; PMB, Pietermaritzberg

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**Fig. 1.** Map of areas sampled in southern Africa (Map Data: ©AfriGIS Google). A - Etosha National Park; B - Otjiwarongo; C - Pilanesberg National Park; D - Krugersdorp; E - De Wildt; F - National Zoological Gardens (Pretoria Zoo); G - Moholoholo; H - Johannesburg Zoological Gardens; I - Kimberley; J - Dundee; K -Pietermaritzburg. The smaller map on the right, indicates ranging movements of 10 adult Cape Griffon vultures tagged with GPS trackers, as an indication of site selection (Naidoo, unpublished observations).

atmosphere (Mathee, 2014), lead poisoning in animals can additionally result through the ingestion of lead from sources such as motorcar battery plate; direct intake of lead ammunition and shot; the ingestion of plants growing in a highly polluted areas; or the consumption of meat contaminated with lead fragments (Osweiler et al., 1996). For the vulture, lead shot or bullets and tissue residues remain the likely source as the birds are predominantly carnivorous feeding on predator kills, hunter kills or natural deaths. In terms of residues this would result in exposure following the consumption of edible tissues and bone high in lead as evident in the tissues of cattle feeding on fields contaminated with lead (Alkmim Filho et al., 2014). However, the most important source could be the ingestion of lead ammunition in hunted carcasses, through the consumption of lead particles that remain in the bullet wound track or in contaminated and disposed offal (Dobrowolska and Melosik, 2008). A study by Hunt et al. (2006), concluded that 95% of the carcasses they sampled in the USA originating from rifle-killed deer (*Odocoileus* spp.), were positive for lead fragments, while 90% of offal piles discarded from these killed animals were also positive for lead fragments. The latter is extremely important in a South African context, as the game hunting industry forms a massive component of the local economy, with an estimated value of US$700million in 2010 in the provinces of North West, Eastern Cape, Limpopo, Northern Cape and Free State (Van der Merwe et al., 2014). An important feature of the hunting industry is that hunters usually leave behind portions of the carcass especially the gut piles for predator feeding. Also of importance is that South African legislation only limits the use of leaded ammunition, when the intended use is for the hunting of waterfowl (Avery and Watson, 2009).

Despite a large body of literature describing the clinical and subclinical effects of lead in various bird species, the actual tolerances of the wild African vultures is yet to be established. The closest indication of toxicity was described by Naidoo et al. (2012) in a captive Cape Griffon vultures (*G. coprotheres*) breeding colony, exposed to high lead concentrations within their enclosures at the South African National Zoological Gardens in Pretoria. In this case-study, they described signs of decreased egg hatchability, embryonic death and abnormal chick development concurrent with whole blood lead concentrations ranging between 50 and 100 μg/dL in the adult birds. Thus toxic effects were thus only non-lethal at these concentrations and no clinical signs were observed. This was similar to a model applied by Buekers et al. (2009), which predicted that the adult baseline non-toxic concentration would be in the region of 71 μg/dL based upon a no observable effect level of 20 μg/dL and the lowest observable effect level of 110 μg/dL in Turkey vultures (*Cathartes aura*) Furthermore, Garcia-Fernandez et al. (2005) reported that concentration between 20 and 50 μg/dL in the Griffon vultures (*Gyps fulvus*) would not cause physiological toxicity, while concentrations above 100 μg/dL would result in clinical signs of toxicity (neurological signs, muscle wasting, weakness, anaemia and weight loss).

In this study, we evaluated whole blood lead concentration of various African White-backed and Cape Griffon vulture colonies in South Africa from both captive and wild populations. All results obtained were compared to the whole blood lead concentrations obtained from wild birds sampled at the Etosha National Park in Namibia, which we considered to be a pristine site. To obtain an indication whether environmental exposure alone would explain the wild bird exposures, the distribution of wild bird individual lead concentrations were evaluated in relation to the 95% confidence intervals of the mean of whole blood lead concentrations obtained from the captive birds. Mean whole blood lead concentrations per area of sampling were also compared to previously published soil concentrations around the said area to ascertain if exposure could be explained by only exposure via the soil. In addition concentrations between rural and urban birds; as well as relations with mining activities were compared to ascertain if environmental lead exposure could explain the levels of exposure.