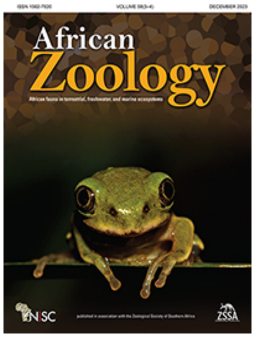

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Short Communication

A new record of a chick falling from a nest in Limpopo province, South Africa, adds to the known causes of Hooded Vulture *Necrosyrtes monachus* mortality

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For all species, causes of mortality, both anthropogenic and natural, should be recorded. In Critically Endangered species these records are even more important, owing to their potential impacts on small and/or declining populations. Here we present a case of natural mortality that occurred when a 20-day old Hooded Vulture nestling fell from its nest in Limpopo province, South Africa, which is a new cause of mortality for the Critically Endangered Hooded Vulture *Necrosyrtes monachus* throughout its range. We also compile all known causes of mortality for Hooded Vultures from the scientific and grey literature. The carcass of this nestling was found on the ground below the nest some 25 days later. This cause of mortality is previously undocumented for this vulture species, and it was recorded on a series of photographs taken by a camera trap in the nest tree. We believe this cause of mortality to be uncommon when compared to other threats faced by this species.

Keywords: anthropogenic mortality, natural mortality, Hooded Vulture, nestling falling from nest, camera trap, South Africa

Globally, most species of vultures are highly threatened (IUCN 2023). While the anthropogenic threats to vultures are well studied (Ogada et al. 2012; Ives et al. 2022), non-anthropogenic (hereafter referred to as 'natural') causes of mortality are not as well known, and are likely to be underreported (De Pascalis et al. 2020). Natural causes of mortality to vultures and other raptors include, inter alia, predation, disease and nests falling to the ground due to inclement weather (Thompson et al. 2013; Adhikari et al. 2022). Knowledge of natural causes of mortality in raptors is important to better understand species population dynamics (Klaassen et al. 2014) and to refine models that predict population persistence (e.g., Murn and Botha 2018; Aresu et al. 2021).

One way of recording instances of natural raptor mortality is with camera traps, which have certain advantages over direct behavioural observations; camera traps can be set to operate continually in all weather conditions, without the risk of observer fatigue or the possibility of an observer influencing focal animal behaviour (Fern et al. 2022). Thus, camera traps at raptor nests may yield more information than notes recorded during direct observation (Gil-Sánchez et al. 2021). Camera traps placed at Hooded Vulture *Necrosyrtes monachus* nests have recorded the predation of an egg (by a Chacma Baboon *Papio ursinus*) and a nestling (by a Martial Eagle *Polemaetus bellicosus*) (Thompson et al. 2017b), but there are few additional accounts of camera trapping at Hooded Vulture nests in the scientific literature (Thompson et al. 2017a), and, to our knowledge, no studies that have focused on causes of mortality in this species.

There are previous cases of Hooded Vulture nestlings being rescued after falling from their nests in South Africa. These chicks would otherwise likely have died from starvation, dehydration or predation. In one case, a Hooded Vulture nestling fell to the ground when its nest was destroyed during a storm in Mpumalanga province. The grounded nestling was rescued on 4 December 2018 and raised in captivity, before being released on 20 August 2020 (LJT, JPD and GJT, unpublished data). The data from this young vulture's tracking device showed that it survived for at least 1 year and 8 months after release, until 22 April 2022 when its tracking device went offline (Endangered Wildlife Trust, unpublished data). A second Hooded Vulture chick with a broken leg was found below its nest in November 2018 in Balule Game Reserve, Limpopo province, and taken into captivity (Vulpro 2018), and a third was reportedly taken into captivity on 17 December 2022 after falling from its nest in Marloth Park, Mpumalanga province (Vulpro 2023). The oldest known case of a Hooded Vulture nestling being rescued after falling from its nest is from Nigeria, where a chick, about 73 days old, that had fallen from its nest was taken into captivity on 14 February 1972 and successfully raised for 91 days (CD, unpublished data).

Here we present a case of natural mortality that occurred when a 20-day old Hooded Vulture nestling fell from its nest in Limpopo province, South Africa. We also compile a list of all known causes of Hooded Vulture mortality from the scientific and grey literature.

This particular observation was recorded at a Hooded Vulture nest in a Matumi tree (*Breonadia salicina*) growing on an island in the Mohlatse (Blyde) river in BlyOlifant Nature Reserve in Limpopo province, South Africa. On 9 May 2020, LJT used the doubled-rope technique, as described in Thompson et al. (2017b), to access the canopy and fixed a SkyPoint Solar-dark camera trap to a branch approximately 2 m from the nest using cable ties. The camera was set to take two pictures in quick succession whenever movement was detected, with an interval of 3 min after these two pictures. At night, the camera used a black flash (also called a 'no-glow' or 'covert' flash) to illuminate the subject with 940 nm infrared LED lights, which are less visible to humans and wildlife than xenon flashes, white LEDs or low-glow infrared flashes (Rovero et al. 2013; Apps and McNutt 2018). When the camera was installed, there were already a few green Jackalberry (*Diospyros mespiliformis*) leaves lining the nest, but the nest was still under construction and egg laying had not yet occurred. On 14 October 2020, JPD used the single-rope technique to access the nest tree and remove the camera trap.

Between 9 May 2020 and 14 October 2020, the camera trap took 8 812 photographs. The photographs revealed that the Hooded Vultures returned to their nest on the morning of 11 May 2020 and continued building it with Matumi twigs and lining it. The lining mainly comprised sprigs of green Matumi leaves with some sprigs of green Jackalberry leaves. The adult Hooded Vulture pair was observed mating on their nest eight times between 15 May and 9 July 2020; six times in the morning (between 06:55 and 08:43) and twice in the afternoon (at 16:22 and 16:46).

Prior to egg-laying, the other animals recorded in camera trap photographs of this nest included a species of dormouse, captured in the nest at 23:33 on 13 May 2020. Based on the riparian forest habitat in which this nest tree was located, this was probably a Woodland Dormouse (*Graphiurus murinus*) (Cassola and Child 2016). Thick-tailed Bushbabies (*Otolemur crassicaudatus*), either alone or in pairs, were recorded visiting the nest six times from 11 May to 5 July 2020, when the nest was lined but before egg laying, and only at night (from 20:05 to 03:06). The Thick-tailed Bushbaby is a nocturnal primate species which is capable of building nests to use as sleeping sites, and it is known to use a range of sites depending on their availability (Bearder et al. 2003). Both these species (the Woodland Dormouse and Thick-tailed Bushbaby) were previously recorded as visitors to Hooded Vulture nests in South Africa (Thompson et al. 2017b).

The Hooded Vulture egg was first photographed on 10 July 2020 at 17:59. The adult vultures continued adding sprigs of green leaves to the nest throughout July and August. On 28 August 2020, the egg was seen pipping (Pettit and Whittow 1982) and the newly hatched nestling was first seen, completely emerged from its eggshell, on 30 August 2020. On 19 September 2020 (a night that did not seem to be windy judging from the lack of movement of branches in subsequent photographs), a sequence of photographs taken from 23:06 to 23:30 show the chick slipping down the side of the nest, while an adult stood on the nest, facing the chick (Figures 1 and 2). By 23:36 the chick was no longer visible in the nest and the adult was still standing on the nest, leaning over the rim, facing in the direction in which the chick had fallen.

The following morning (20 September 2020), an adult was seen bringing green leaves to the nest and rearranging old nesting material, after which the nest remained empty until 29 September, when the adult pair returned to the nest around midday. On 8 October, one adult briefly returned to the nest (for <3 min). When removing the camera from the nest tree, JPD and LJT found the desiccated carcass of the Hooded Vulture nestling below the nest.

The IUCN Red List of Threatened Species lists various threats to Hooded Vultures, some of which are ecosystem stresses (causing conversion or degradation of ecosystems), while others are species stresses (causing indirect species effects or species mortality) (BirdLife International 2022). On 9 September 2023, we used Scopus to search for scientific literature that mentioned causes of mortality in Hooded Vultures, using the following search terms anywhere within the paper or its reference list: ('hooded AND vulture' OR 'necrosyrtes AND monachus') AND (mortality OR death OR killed OR kill OR threat). Our search revealed 107 results and we used these sources, and the references contained therein, to compile a list of anthropogenic threats known to cause mortality in Hooded Vultures (Table 1). We provide examples of each threat, with guidance from the IUCN Conservation Measures Partnership Unified Classification of Direct Threats (IUCN 2022) (Table 1). McClure et al. (2018) previously used this IUCN Threat Classification in relation to raptors, and Gore et al. (2020) summarized the IUCN Threats for some African vulture species. Here, we provide specific examples of each of the Direct Threats, in relation to Hooded Vultures, to assist researchers in using the IUCN Threat Classification for raptors (Table 1).

We also list various natural causes of mortality to Hooded Vultures, again with specific examples (Table 2). These examples were gleaned from the scientific literature and our own observations. It is also worth noting an unsuccessful predation attempt of an adult Hooded Vulture by a Martial Eagle (*Polemaetus bellicosus*) in the Kruger National Park, South Africa (Mafuta 2018). We consulted various other sources, including seminal works on vultures in general and on Hooded Vultures in particular (Attwell 1963; Ogada and Buij 2011; Allan 2015; Ogada et al. 2016; Botha et al. 2017; Ives et al. 2022), but found no additional causes of mortality to Hooded Vultures, other than those already listed in Tables 1 and 2.

Here we described a cause of mortality that has not been previously recorded for Hooded Vultures; a nestling falling out of the nest. We did not observe any predators in the photographs from this nest, nor did the evening of the

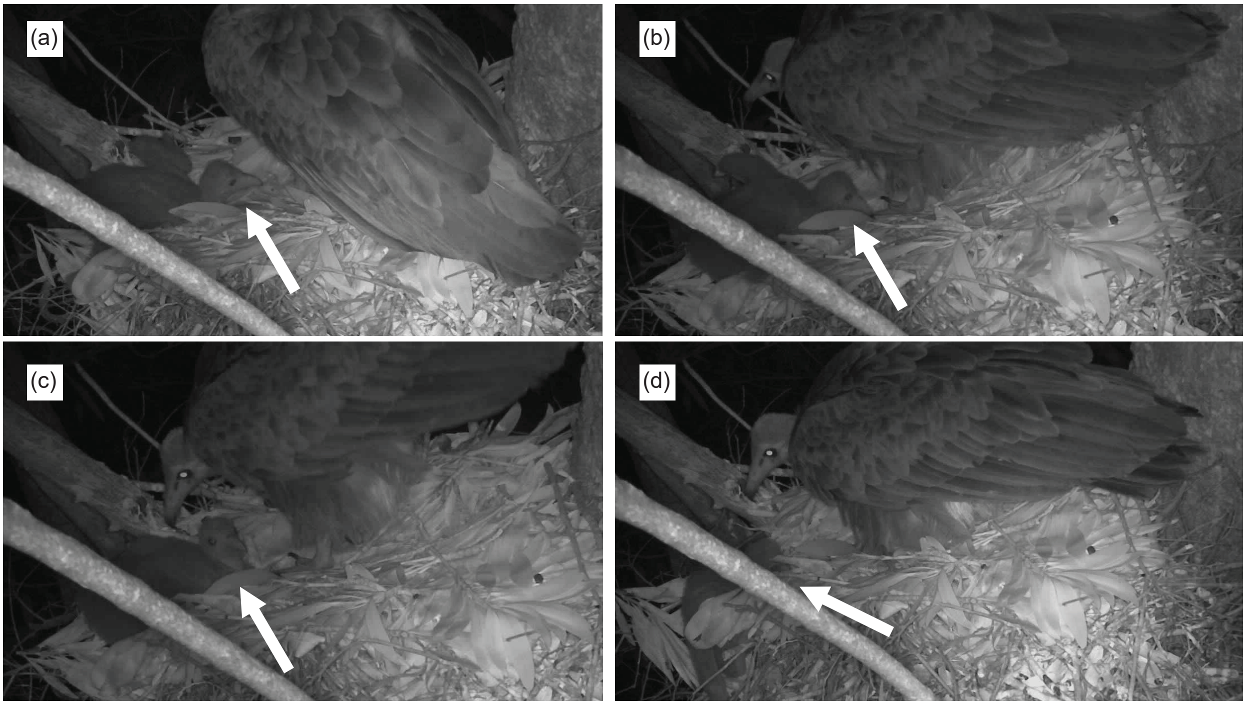

Figure 1: The camera trap was programmed to take two photographs in quick succession whenever movement was detected, with an interval of 3 min before it could be triggered again. The head of the Hooded Vulture nestling is indicated with a white arrow (a–d): (a) The first in the series of photographs in which the Hooded Vulture nestling is seen slipping out of its nest. The nestling is located to the side of the nest, instead of being in the middle of the nest bowl. Picture taken at 23:06 on 19 Sept 2020. (b) The first of two photographs taken at 23:20 on 19 Sept 2020. (c) The second of two photographs taken at 23:20 on 19 Sept 2020. (d) The nestling has moved closer to the side of the nest in this photograph taken at 23:23 on 19 Sept 2020

event seem to be windy. Thus, we believe the chick falling from its nest was purely accidental, and not provoked by the presence of a predator or by strong winds. We presume the chick died from injuries sustained in the fall, or from dehydration, because adult vultures generally do not feed their chick on the ground (B. Jones, pers comm.).

Human-induced mortality of vultures may always be higher than natural mortality (De Pascalis et al. 2020). However, because Hooded Vultures are Critically Endangered, and have slow reproductive rates and long regeneration times, all causes of mortality (both anthropogenic and natural) are potentially important for this species, particularly in South Africa, where the population size is estimated at 100–200 mature individuals (Allan 2015). If not for the installation of a camera trap at this nest, the cause of this mortality event could not have been confirmed, and we therefore encourage researchers to publish their observations of mortalities gleaned from camera traps at raptor nests (Keran 1981).

We suspect this cause of mortality to be uncommon in this species, as this is the first time that we have observed it and, although we have monitored Hooded Vulture nests for ten years, we have never found a whole (not predated) Hooded Vulture nestling carcass below a nest before. Furthermore, Hooded Vultures in north-eastern South Africa usually build their bowl-shaped nests in large Jackalberry trees, lodged in a secure position against the main trunk (JPD and LJT pers obs.), and this should limit the chances of nestlings falling out of nests.

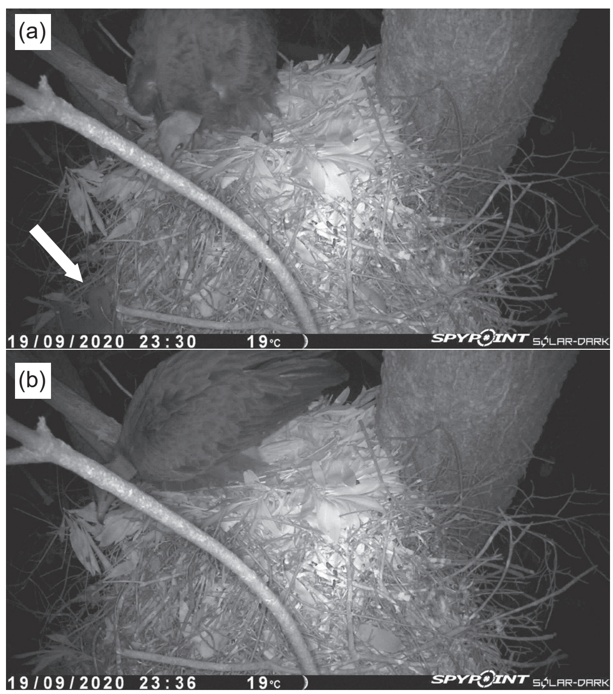

Figure 2: (a) The head and bill of the Hooded Vulture nestling (indicated with the white arrow) are visible in the bottom left corner of the photograph, at 23:30. (b) the nestling can no longer be seen in the photograph. The adult bird stands on the nest, facing in the direction in which the nestling fell, leaning over the edge of the nest

Table 1: All known anthropogenic causes of mortality to Hooded Vultures throughout their range, adapted from BirdLife International (2022), grouped into the corresponding IUCN Threat Categories

Cause of mortality	IUCN Threat Categories			Example(s)	Country	Refs[1]
Captive carnivores (surplus killing)	1. Residential & Commercial Development	1.3. Tourism & Recreation Areas	Type of development: a predator breeding tourist facility	Lions (*Panthera leo*) and leopards (*P. pardus*) kill vultures (surplus killing) at a predator breeding tourist facility, where big cats are housed in large camps without roofs and smaller feeding enclosures are not used. A nearby vulture feeding site attracts hundreds of vultures to the facility. This is listed as an anthropogenic threat because of poor management; better management could mitigate the threat.	South Africa	a
Baboons at poorly managed feeding sites	2. Agriculture & Aquaculture	2.3. Livestock Farming & Ranching	2.3.2. Small-holder Grazing, Ranching or Farming	At a small-scale piggery. Although this is listed as an ecosystem stress, in this case, it is indirectly a species stress, as the small-scale farming operation (breeding pigs), causes increased amounts of food, which attracts wild Chacma Baboon (*Papio ursinus*) and vultures, and the baboons repeatedly attack and kill Hooded Vultures.	South Africa	b
Electrocutions on powerlines	4. Transportation & Service Corridors	4.2. Utility & Service Lines	Electrical wires	A Hooded Vulture killed by electrocution in Balule Nature Reserve.	South Africa	b
Collisions with powerlines	4. Transportation & Service Corridors	4.2. Utility & Service Lines	Electrical wires	Two Hooded Vultures killed by collision in Balule Nature Reserve in 2020–2021.	South Africa	b
Collisions with motor vehicles	4. Transportation & Service Corridors	4.2. Utility & Service Lines	Motor vehicles	Hooded Vultures killed by motor vehicle collisions while trying to remove domestic animals previously hit by cars on the roads.	Burkina Faso	c
Poisoning – intentional (for African traditional medicine)	5. Biological Resource Use	5.1. Hunting & Collecting Terrestrial Animals	5.1.1. Intentional Use (species being assessed is the target)	Hooded Vultures are killed for this purpose using poisons (pesticides or ground tobacco powder), shotguns and traps. Particularly in West Africa (likely because of the vultures higher density) and to a lesser extent in southern Africa, with little evidence in East Africa.	Burkina Faso, Guinea-Bissau, Nigeria, South Africa	d–j
Poisoning – intentional (for food/bushmeat)	5. Biological Resource Use	5.1. Hunting & Collecting Terrestrial Animals	5.1.1. Intentional Use (species being assessed is the target)	Particularly in West Africa (again, likely because of their relatively higher density) and to a much lesser extent in southern Africa. Little evidence for this in East Africa.		e h j
Killing (method unspecified) – intentional (to sell as food/bushmeat)	5. Biological Resource Use	5.1. Hunting & Collecting Terrestrial Animals	5.1.1. Intentional Use (species being assessed is the target)	In West Africa, Hooded Vultures are killed and sold for meat. The use of vultures (of unknown species) for bushmeat has also been recorded (infrequently) in southern Africa.	Ghana, Ivory Coast, Niger, Nigeria, Sierra Leone, South Africa	k l m n
Removal of egg from nest by people	5. Biological Resource Use	5.1. Hunting & Collecting Terrestrial Animals	5.1.1. Intentional Use (species being assessed is the target)	During incubation, eggs were removed from nests, reportedly for use in African traditional medicine. In 2019, about 30 eggs were being sold in the fetish market in Ouagadougou.	Burkina Faso	c o p
Poisoning – unintentional (for food/bushmeat)	5. Biological Resource Use	5.1. Hunting & Collecting Terrestrial Animals	5.1.2. Unintentional Effects (species is not the target)	Offal is removed from carcasses of wildlife that were poisoned for bushmeat (using Furadan) and vultures feed on this offal, creating a new poisoning pathway.	Ghana	m
Poisoning – unintentional (possibly targeting crop raiding animals)	5. Biological Resource Use	5.1. Hunting & Collecting Terrestrial Animals	5.1.2. Unintentional Effects (species is not the target)	Hooded Vultures fed on poisoned bushpigs (*Potamochoerus larvatus*), in January 2023, in the Hoedspruit area.	South Africa	q
Poisoning – unintentional (targeting predators of livestock)	5. Biological Resource Use	5.1. Hunting & Collecting Terrestrial Animals	5.1.2. Unintentional Effects (species is not the target)	Targeting jackals, hyaenas, e.g., 27 dead Hooded Vultures found at the carcass of a poisoned cow.	Senegal	r s

Table 1: Cont.

Cause of mortality	IUCN Threat Categories			Example(s)	Country	Refs[1]
Poisoning – unintentional (targeting feral dogs)	5. Biological Resource Use	5.1. Hunting & Collecting Terrestrial Animals	5.1.2. Unintentional Effects (species is not the target)	Targeting feral and/or rabid dogs.	Kenya, Senegal	e r
Poisoning – unintentional (with pharmaceuticals and barbiturates)	5. Biological Resource Use	5.1. Hunting & Collecting Terrestrial Animals	5.1.2. Unintentional Effects (species is not the target)	Substances used to medicate and/or euthanise livestock; e.g., livestock is treated with diclofenac and carcasses are dumped, rather than buried.	Ghana	m
Poisoning – intentional (sentinel poisoning)	5. Biological Resource Use	5.1. Hunting & Collecting Terrestrial Animals	5.1.3. Persecution/Control	Twenty-eight Hooded Vultures were killed in Botswana in June 2019.	Botswana, Malawi	t u
Intentional destruction of an occupied nest	5. Biological Resource Use	5.1. Hunting & Collecting Terrestrial Animals	5.1.3. Persecution/Control	A hotel owner believed that Hooded Vultures caused the death of coconut palms (*Cocos nucifera*) that they slept in, so he intentionally destroyed an occupied nest in retaliation.	Senegal	r
Cutting or pruning of nest tree	5. Biological Resource Use	5.3. Logging & Wood Harvesting	5.3.3. Unintentional effects: subsistence/small scale (species being assessed is not the target) [harvest]	Nest trees cut/pruned for firewood or livestock fodder during incubation and the nestling stage.	Burkina Faso	o
Disease[2]	8. Invasive and Other Problematic Species, Genes & Diseases	8.5. Viral/Prion-induced Diseases	8.5.2. Named "Species" (Disease)	Highly pathogenic avian influenza (HPAI, subtype H5N1) was found in wild Hooded Vultures in West Africa. The birds could be sentinels or vectors of this disease.	Burkina Faso	v

[1] 'Refs' (References): a = Thompson et al. (2020b); b = LJT pers. obs.; c = CD pers. obs; d = Saidu and Buij (2018); e = Odino et al. (2015); f = Henriques et al. (2020); g = Mashele et al. (2021b); h = Mashele et al. (2021a); i = Daboné et al. (2023a); j = Jallow et al. (2022); k = Gbogbo et al. (2016); l = Thiollay (2006a); m = Deikumah (2020); n = Barlow and Kimbo (2023); o = Daboné et al. (2019); p = Daboné et al. (2023b); q = JPD pers. obs.; r = Mullié et al. (2017); s = Thiollay (2006b); t = Botswana Government (2019); u = Roxburgh and McDougall (2012); and, v = Ducatez et al. (2007).

[2] 'Disease' may normally be viewed as a natural cause of mortality in raptors (Nemeth et al. 2006, van den Brand et al. 2015). However, the IUCN – CMP Unified Classification of Direct Threats includes 'Diseases' along with other 'Direct Threats', which are defined as 'proximate human activities or processes that have impacted, are impacting, or may impact the status of the taxon being assessed' (IUCN 2022). The example provided for 'Diseases' (which falls under Category 8: 'Invasive & Other Problematic Species, Genes & Diseases'), states 'Threats from non-native and native plants, animals, pathogens/microbes or genetic materials that have or are predicted to have harmful effects on biodiversity following their introduction, spread and/or increase in abundance' (IUCN 2022). Thus, HPAI may presumably fall under this threat, as humans have undoubtedly played a part in the spread and increased abundance of this disease through the global poultry industry (Sun et al. 2018; van der Kolk 2019; Zhao et al. 2019).

Table 2: All known natural (non-anthropogenic) causes of mortality to Hooded Vultures throughout their range

Natural cause of mortality	Example	Country/Region	Reference(s)
Removal of egg from nest by predator	By a Chacma Baboon *Papio ursinus*	South Africa	Thompson et al. (2017b)
	By a Vervet Monkey *Cercopithecus aethiops*	South Africa	LJT and JPD, unpublished data
	By a Sykes Monkey *Cercopithecus albogularis*	East Africa	Van Someren (1956)
Egg fell from nest	Egg slipped out of nest	Burkina Faso	CD pers. obs.
Nest blown down by wind	NA[1]	Burkina Faso	Daboné et al. (2019)
Foot caught in tree, hung upside down	A young vulture's foot became wedged in the fork of a tree. It was found hanging in the tree, dead, with head down and wings outspread.	East Africa	Van Someren (1956)
Predation of nestling in nest	By a Martial Eagle *Polemaetus bellicosus*	South Africa	Thompson et al. (2017b)
	By a Verreaux's Eagle-owl *Bubo lacteus*	Not stated	Mundy et al. (1992)
Predators killing birds at feeding events	By a Black-backed Jackal *Canis mesomelas*[2]	South Africa	C Rowles, in litt.
	By a Lion *Panthera leo*[3]	South Africa	JPD and LJT, unpublished data
Nestling fell from nest	20-day old nestling slipped out of nest	South Africa	*This study*

[1] The nest in Burkina Faso was most likely blown down by the wind.
[2] The Hooded Vulture found dead at a feeding event was surrounded by the spoor (tracks) of a Black-backed Jackal and field rangers determined this bird had been bitten and killed by the scavenger.
[3] The Hooded Vulture was found dead at a lion kill and had puncture marks on its body consistent with having been bitten.

At raptor rehabilitation centres in KwaZulu-Natal and Limpopo provinces in South Africa, the annual admissions caused by raptor nestlings falling from their nests were reportedly as high as 8% and 12%, respectively (Thompson et al. 2013; Mashele et al. 2022). However, these admission records did not report whether the nestlings simply slipped out of their nests, or whether the entire nest was destroyed, for example by inclement weather or fire (Walker 2014). Our knowledge of these incidents may be improved with the increased use of camera traps at nests.

In cases where vulture nestlings are found on the ground, they can be returned to their nests immediately, if the nest is still intact or can be rebuilt (Walker 2014) and if the chick is uninjured (this should be determined by an experienced raptor rehabilitator and/or a wildlife veterinarian). Alternatively, vulture chicks whose nests have fallen can be raised in captivity and released after the post-fledging dependence period, as was done with a female Hooded Vulture at the Moholoholo Wildlife Rehabilitation Centre in South Africa (Endangered Wildlife Trust and Moholoholo Wildlife Rehabilitation Centre, unpublished data). The data from this individual's tracking device showed that she lived for at least 1 year and 8 months in the wild following her release, and that she travelled a cumulative 8 244 km from release to her last transmission date (Endangered Wildlife Trust, unpublished data).

We expect that the various causes of Hooded Vulture mortality may change in prevalence and intensity throughout this species' range, not least because of the behavioural plasticity of these birds, which adapt to differences in the attitudes of local people towards them (Deikumah 2020; Thompson et al. 2020a; Owolabi et al. 2021; Daboné et al. 2022). Furthermore, we acknowledge that there may be other causes of Hooded Vulture mortality than those listed in Tables 1 and 2. Some studies mention that Hooded Vultures were killed without explicitly stating how they were killed (Soewu 2008; Atuo et al. 2015; Williams et al. 2021), and other studies report that large numbers of Hooded Vultures died (Scholte 1998) or that populations declined (e.g., Buechley et al. 2022) without stating what caused these mortalities and declines. We therefore reiterate the suggestions of Ives et al. (2022) for the provision of funding for wildlife health, to allow for necropsies, disease investigation and toxicological analysis of vulture carcasses, as well as a publicly accessible database to store this information.

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Conflict of interest statement — The authors declare they have no conflicts of interest to report.

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