

Causes of Cape Vulture *Gyps coprotheres* mortality at the Kransberg colony: a 17 year update

P. C. Benson

ABSTRACT

An assessment of natural and man-induced mortality factors was made at the Kransberg Cape Vulture colony from 1981 to 1998. Unhatched eggs accounted for the largest number of mortalities at this colony. Death at the nestling stage was the second highest age group affected. Nestling death was due to poisoning, predation, weather, traumatic injury and insufficient food. At the fledging stage, the juvenile's inability to return to the nest to be fed, collision with natural and man-made structures and drowning accounted for the mortalities observed. At the sub-adult and adult stage, poisoning was the only mortality factor observed. The two main factors affecting Cape Vultures at the Kransberg are food availability and poisoning. Increasing human densities, improved farming practices and changes in land-use will cause a decrease in food availability, resulting in an overall decline in Cape Vulture numbers. Total numbers of birds and reproductive output should stabilise at a level which can be supported by the available food. Total numbers could however be further affected by poisoning incidents, which can have a devastating impact on reduced numbers of birds. Eliminating poisoning incidents should be the highest conservation priority for Cape Vultures at the Kransberg.

INTRODUCTION

Documentation of bird mortality is difficult, as most carcasses go undiscovered. Of those found, there are biases toward man-induced factors (Newton 1976). The proximate and ultimate causes of death may differ and are often difficult to assess, leading to questionable conclusions. Though many causes of mortality have been suggested for Cape Vultures *Gyps coprotheres* (Benson & Dobbs 1984; Tarboton & Allan 1984; Mundy *et al.* 1997), little is known of the yearly variation in these factors or their relative importance to the total population or particular sub-populations.

This paper addresses some mortality factors documented at the Kransberg, the largest Cape Vulture breeding colony, where reproductive activities were monitored and carcasses collected as part of a long-term study of this bird's biology (Benson & Dobbs 1984; Dobbs & Benson 1984a, 1984b; Tarboton & Benson 1988; Benson *et al.* 1990). Breeding activities were followed and the pattern of nesting failures monitored over 17 seasons. A total of 464 carcasses of various age groups were collected from below the nesting cliff and surrounds. An evaluation of the cause of death for each was made and the importance of the different mortality factors are considered.

STUDY SITE

The Kransberg, 20 km northeast of Thabazimbi in the west of South Africa's Northern Province (24°28'S, 27°36'E), is on a 5.1 km section of the south-western corner of the Waterberg mountain range. A portion of the 200 m high south-facing nesting cliff is included in the recently proclaimed Marakele National Park and the remainder is on private land. Cattle and game farming are the main land-uses in the surrounding *Acacia* thornveld savanna.

METHODS

Reproductive activities

Over 2,800 sites have been identified and mapped on photos from aerial surveys of this cliff and each is assigned a unique alpha-numeric code (Tarboton & Benson 1988; Benson *et al.* 1990). From March 1981 to March 1984 the colony was monitored on a full-time basis. Subsequently, monthly ground surveys from 1-3 weeks in duration have been conducted throughout the breeding season and behavioural and/or reproductive activities documented at each site. Using the terminology of Postupalsky (1974), when an occupied site is where at least nest building behaviour is observed, and an active site is where at least an egg is laid (i.e. all active sites are occupied, but not all occupied sites are active) breeding success was determined.

The use of each site for breeding, timing of reproductive activities and nesting success has been monitored from 1981. Most sites were used for nesting in at least one season during this study. When possible, the cause of unsuccessful nesting attempts was determined. Over 14,000 nesting attempts have been documented.

Mortality factors

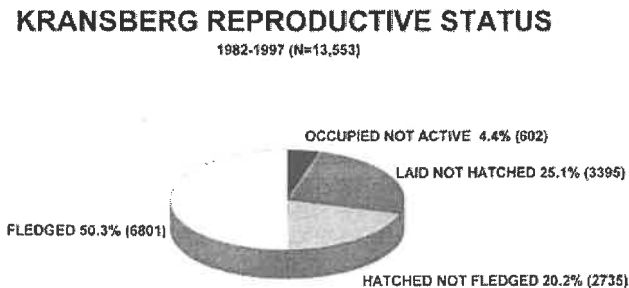
Carcasses of vultures have been collected from the base of the nesting cliff, the scree slope below the colony, under towers at the top of the nesting area and elsewhere around the colony. An assessment of these carcasses has been made, including chemical analyses when poisoning was suspected and conditions allowed it. Toxicological analyses were conducted at the Veterinary Research Institute - Onderstepoort. Remains of many of these carcasses are housed at the Department of Birds, Transvaal Museum, Pretoria.

RESULTS

Nesting success

During this study, the greatest number of breeding attempts occurred in 1984, when 977 occupied sites, of which 961 were active nests, were documented. The lowest number of breeding attempts occurred in 1995 when 725 occupied sites were observed, of which 697 were active. Fledging success from 1982 to 1997 ranged from 33.6% to 61.1% at occupied sites. In this period a total of 13,533 nesting attempts were monitored. The overall mean fledging success for this period was 50.3% (Fig. 1).

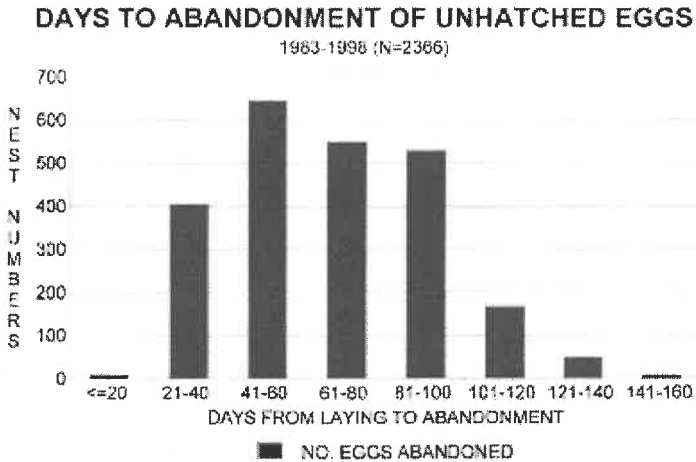
Figure 1. The fate of Cape Vulture nesting attempts at the Kransberg Colony (1982-1997).



Nesting mortalities

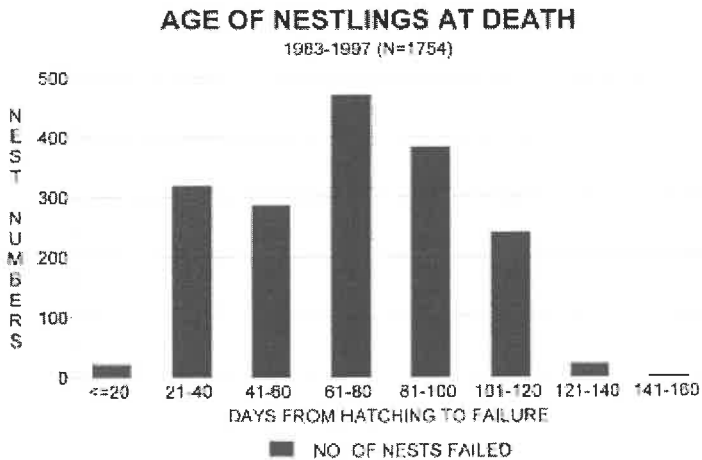
Generally, the highest period of nesting failure was during the egg stage (11 of 16 years), when 55.4% of failures occurred. The average duration of incubation of eggs which failed to hatch was 66.7 days (N = 2366). However, some birds continued to incubate for almost 5 months (Fig. 2). Normal hatching occurs at about 56-57 days after egg-laying.

Figure 2. Days from laying to abandonment of unhatched eggs by Cape Vultures at the Kransberg Colony (1983-1998).



The average age at death of nestlings which failed was 69.6 days. There was an increase in mortality during the period of 20-40 days of age, with the biggest loss of nestlings occurring between 60-100 days (Fig. 3). The average hatching date is 8 July (N = 6998). Days 20-40 are during the coldest period of the winter months, which may account for this increase in loss when chicks are still quite small, but are not receiving the close brooding from parents that occurs in the first weeks after hatching. The second and larger loss occurred during the period of greatest food demand by the nestlings, when they are growing at their fastest rate.

Figure 3. Days from hatching to failure of nestlings of Cape Vulture which died at the Kransberg Colony (1983-1997).



Predation

The main predator on Cape Vultures at the Kransberg is the Black Eagle *Aquila verreauxii*, which flies daily along the nesting cliff and soars in updrafts with vultures. Although only nine nestlings have actually been observed to be killed by Black Eagles at Kransberg (and two others at the Blouberg colony), many more unsuccessful predation attempts have been seen. Both adult and subadult eagles take young vultures. Adult eagles may act individually or in pairs. Subjectively, adult eagles seem more proficient than young birds at taking nestlings.

Eagles also scavenge vulture carcasses which have fallen to the base of the nesting cliff (pers. obs.). Of the carcasses found under nesting areas, 122 showed some evidence of scavenging or predation. Carcasses of poisoned adult vultures have been found scavenged, as well as nestlings which have died of poisoning or other causes. Generally it is impossible to be certain whether a carcass was scavenged or predated unless a predation event was observed. My feeling is that a predated carcass is usually fully consumed, while those scavenged are only partially eaten. Twenty-seven nestling carcasses were thus categorised as predation victims.

Depending on the vultures' reproductive state, their response to the eagles varies. During and prior to incubation there is no vocal response to the eagle's presence. When eggs begin to hatch, vultures respond to the eagles with a hoarse roar. This also varies, depending on the location of the eagle relative to the nesting areas. When the eagle is flying below the nesting areas vultures do not respond vocally, but when level with or above nest sites roaring occurs. Once fledging begins, roaring all but ceases.

Vultures attempt to defend their young by rushing at the eagle with wings spread and several birds may converge on the smaller predator. This can result in a rough and tumble event leading to the eagle being battered or the pulling from the nesting ledge of adult vultures. These latter observations occurred when young eagles attempted to take nestlings. Again, subjectively, young eagles appear less motivated than adults in their attacks on vultures. The young eagles may be more cautious or perhaps their intention is more harassment than predation.

A single event of a subadult eagle still-hunting a vulture chick was observed. The eagle landed on an unused vulture nest site, observed the potential prey and parent, then attacked successfully.

Benson & Dobbs (1984) reported on events of a lone male baboon consuming and/or destroying vulture eggs in 1982. Subsequent observations suggest that this is an uncommon occurrence. Baboon troops travelling through nesting areas generally avoid the vultures.

Traumatic injury

Bone abnormalities in nestling vultures are one source of mortality at the Kransberg and other colonies. Over 80% of the skeletal anomalies observed in live wild nestlings on the Kransberg cliff, between 1982 and 1997, were unilateral and in the wing ($N = 143$) (Benson in press a). The radius and ulna are often the bones affected. Though externally observable bone abnormalities may approach 3% of young at fledging stage, these birds represent about 1% or less of the annual reproductive attempts at the Kransberg.

Of the 143 nestlings with bone abnormalities, 27 (18.8%) were observed at 13 nest sites. At 12 of these sites, nestlings were observed with abnormalities in two years, at the 13th, nestlings were affected in three seasons. Though no formal assessment of nest sites has yet been conducted, some of the above are in relatively tight situations, with little space available for adults to land or stand without encountering the nestling. Others are in areas of high nesting density.

Weather

Benson & Dobbs (1983) reported weather at the Kransberg, in the form of a heavy mist covering the nesting cliff for an extended period of 2-3 days, as the ultimate cause of some nestling loss in 1981. Subsequent observations suggest this weather pattern is not a typical occurrence. Though mist regularly engulfs the Kransberg, this generally dissipates by mid-day, and poses little danger to nestlings. This same weather pattern occurs at colonies in the Magaliesberg, Soutpansberg, Drakensberg and at the Blouberg (pers. obs.).

Starvation

Of these 142 nestling carcasses, none was thought to have actually starved, even though the ultimate cause of death of most is probably food shortage. These include birds for which there was a negative result when testing for poisoning, or where no testing was done. Of 67 carcasses, collected between 2 September 1981 and 7 December 1983, and for which an approximate date of death could be determined, 50 (74.6%) died in the period 60-100 days after the average hatching date, at the same time that the highest period of nestling mortality occurs on the nests. Five additional birds died during an inclement weather period, when adults could not forage (see above and Benson & Dobbs, 1984).

Some of these 142 birds may have died of other causes, such as poisoning (see below), but could not be definitely linked to other specific mortality factors. Forty-four carcasses were scavenged and 21 had some sort of skeletal abnormality. An additional 32 nestling carcasses were observed on nests, but were not retrieved as it would have created undue disturbance to other nesting birds.

Mis-fledging

Forty-nine fledgling carcasses were found along the cliff base or the scree slope. Skeletal abnormalities occurred in 19 of these. Fifteen birds showed signs of being scavenged. Seven birds were discovered alive and some were so weak they made no effort to fly when approached. One bird was observed at the base of the cliff on 7 December 1983, and nine days later the bird was in the same place, too weak to flee. Three birds had severe recent unhealed breaks. One of those birds was flushed, and flew out from the cliff with a broken leg dangling. Upon circling several times, gaining altitude, one of its wings collapsed and the bird fell to the scree slope below.

Drowning

One fledgling was discovered drowned in a farm dam. This bird had slight unilateral bone abnormalities in the wing, on the keel and in the leg.

Collisions

There are four communication towers on the top of the Kransberg nesting cliff. The largest and most significant to the vultures is the South African Broadcasting Corporation's (SABC) radio and television transmitter (Benson & Dobbs 1984). This tower, 235 m high, is supported by 16 guy wires, attached diagonally to ground anchors from four levels. Since 1981, I have recovered 98 carcasses under this tower. Of 43 birds for which age at death could be determined, all but one were recent fledglings. The remaining bird was a subadult. Collisions occurred mainly between October and February, when all fledging occurs at the Kransberg. These values may be low as there is evidence that scavenging of carcasses does occur and that some may have been carried off by mammalian carnivores (e.g. brown hyaena *Bruneia brunea*) which have increased in the area since the proclamation of Marakele National Park (pers. obs.). Despite placement of objects on the guy wires, first orange metal balls and then coiled bird diverters (Koop 1979; Koop & de Jong 1982), birds continue to be killed.

Poisoning

Chemical testing for strychnine was conducted on 90 birds from Kransberg. Poisoning was confirmed in 30 of 36 adults, one subadult, one juvenile and 24 of 52 nestlings. Testing was done between 1981-1984 while I lived full-time at the Kransberg. Though 34 of the birds tested were negative for strychnine it is likely the adult birds were also poisoned. Some breeding adults fed their young poisoned meat on returning to the nest, resulting in the nestling's death. Four additional adult carcasses were found after they had decomposed too much for sample collection.

Poisoning was suspected in an additional 88 free-flying birds, discovered from 1985-1997. After 1984, the cliff base was searched less regularly and the state of decomposition of the carcasses found precluded sample collection for testing. However, the pattern of the 1981-1984 poisoning incidents suggests probable poisoning of these 88 birds.

Poisoned adults were generally discovered along the cliff under nesting areas. For birds discovered soon after death, it was sometimes possible to correlate their location with nest failures in the areas above where the carcasses were found. Some carcasses were concentrated under areas where little or no nesting occurred. In one case 14 birds (12 adults, one fledgling and one nestling) were discovered in one area. Nine of these birds were in a "pile". Little nesting occurs above that site, though birds often roost there. Some areas on the nesting cliff are used almost exclusively by adults as roosts once fledging begins (pers. obs.). This discovery was made on 13 November 1983, well into the fledging period, when adults often roost away from their nest site.

I believe that sub-lethal doses of strychnine can ultimately cause the death of adult vultures returning to the colony, as seizures occurring from the poison induce the birds to fall from the cliff, resulting in death from traumatic injury. I have observed birds falling from the nesting cliff and sustaining such injuries at the Kransberg and at the Blouberg colony. These birds tested positive for strychnine. One such bird fell from the cliff while I was walking at the base, landing a few metres from me. When approached, it got up and ran off another ledge to fall approximately 30 m. Although still alive, it was weak, had many broken bones and subsequently died.

Several adult vultures tested negative for strychnine when poisoning was likely. Generally, groups of birds were discovered in poisoning incidents. Some of these birds tested negative while others were positive. Crop and stomach contents, and liver were collected for strychnine tests. Crop and stomach samples were not always available from carcasses, and when present, test results were not always consistent with those from the liver. Positive results from stomach and crop samples sometimes occurred when liver tests were negative, while other birds tested positive for all three.

At least 23 incidents of poisoning occurred at the Kransberg between 1982 and 1997, affecting a minimum of 124 free-flying birds. The number of carcasses discovered per chemically-confirmed incident varied greatly from 1-19 birds. It is unlikely that carcasses of all of the poisoned birds returning to the colony were found and others probably died at the poison site or elsewhere. Nestlings discovered during the period 1985-1997 were not tested and none have been considered as dying of poisoning, though some probably did. Those birds are classified above as having died of starvation.

DISCUSSION

Nesting mortalities

Eggs and nestlings were the age groups with the highest mortality at the Kransberg colony. Eggs not hatching was the greatest cause of nesting failures. The group with the second highest mortality was nestlings 60-100 days of age (Fig. 3). Nestling growth rate is fastest and food consumption greatest during this period (Komen 1991). This high mortality rate, when the nestlings' energy demand is greatest, suggests that food availability limits reproductive success.

Predation

The impact of predation on Cape Vultures is difficult to quantify as observations of interactions with predators are irregular. Although Black Eagles do interact with adult vultures, it is usually when attempting to capture the latter's nestling. Little interaction occurs at the egg stage. The large number of carcasses discovered which had been fed upon and the attempts to take live nestlings indicates that eagles recognise vulture nestlings as a food source. The adult vultures' roaring indicates recognition of the eagles' threat and serves as an alarm to other nesting birds. This interaction has certainly occurred for as long as both birds have been present on the cliffs and eagles must represent little threat to the vultures' long-term viability as a species.

Traumatic injury

The nature of the bone abnormalities observed in Cape Vulture nestlings suggests that traumatic injury is the origin. The high incidence of unilateral abnormalities of the wing is consistent with other studies where traumatic injury of birds has been studied (Howard & Redig 1993; Goodman & Glynn 1988). Though some authors suggest that Cape Vulture bone anomalies are due to a calcium

deficiency (Mundy & Ledger 1976; Richardson *et al.* 1986), no evidence has been presented indicating this is the case. Abnormalities in those studies are also primarily in the wings (Ledger & Mundy 1976; Mundy & Ledger 1977; see also Fig. 3.2 of Mundy 1983, p. 61). In most nutritional or metabolic disorders, the entire skeleton will be impacted and weight-bearing bones (i.e. legs, pelvis) are usually those most affected (Fowler 1981). This is not the type of abnormality observed in the great majority of nestlings with bone anomalies. Observations of adult and subadult skeletal material collected from poisoning and other events also indicate that additional abnormalities occur which are not externally observable but which do not interfere with the bird's normal functioning and breeding (Benson in press a).

There is evidence that some of the abnormalities observed may be of a genetic or developmental disposition, and a few may have a metabolic or nutritional origin (Benson in press a). It is however impossible to determine the aetiology of these last two categories, without knowing the history of the individual involved. Developmental, genetic, metabolic and nutritional disorders appear to represent less than 5% of the total abnormalities observed (pers. obs.). Though these anomalies are interesting, they are a normal part of the Cape Vultures' biology, as they are of many other birds and vertebrates (e.g. Brandwood *et al.* 1986; Goodman & Glynn 1988), and have little significance on the long-term viability of the species.

Weather

Although prolonged periods of inundation by heavy mist may cause increased Cape Vulture nestling mortality within a single season, the extended period of cloud observed in 1981 (Benson & Dobbs 1984) cannot be considered the norm and does not represent a major long-term mortality factor for the species.

Starvation

Although data suggesting a food shortage are largely circumstantial, with the highest nestling mortality occurring at the period of greatest energy demand, it is likely that food is the main factor limiting reproduction. For Kransberg and other large colonies (e.g. Blouberg, Manutsa), the food demands of thousands of birds must increase intra- and interspecific competition, and it is likely these colonies can only exist in areas of high livestock mortality such as occurs near the communal grazing areas of the former homelands of South Africa (Huntley *et al.* 1989; Benson in press b). The existence of the largest Cape Vulture colonies in, adjacent to or very near the former homelands supports this view. It is likely that with development of these areas and improved farming practices, the food available to vultures will decline. Though it has been suggested that feeding stations can alleviate this food shortage (Butchart 1988), the high demands of large colonies makes this food source appear meagre. These feeding stations do however, have other benefits (e.g. public relations, education) which justify their continuance. It is likely that Cape Vulture populations will decline to levels which can be supported by local food availability. Breeding numbers of Cape Vultures in the Northern Province have declined from the drought years of the early 1980's (Benson *et al.* 1990; Benson in press b), suggesting that this may already have started. If lower breeding numbers persist, then greater vigilance will be required to prevent catastrophic poisoning incidents from decimating already reduced populations.

Mis-fledging

Fledging must be one of the periods of highest mortality for all birds. It is difficult to document for vultures, as individuals may travel long distances from the colony before dying. If a Cape Vulture fledgling does not return to its nest it will not be fed and more than likely will die. From October to February, fledgling vultures can be seen on many of the roads surrounding the Kransberg. Birds often land in the wooded area on the scree slope below the nesting cliff, unable to become airborne and so cannot return to their nest site.

Collection of these fledglings and attempts to return them to the wild have become the focus of several conservation efforts directed toward vultures (H. A. Scott pers. comm). Although this may have some public relations value, its biological significance to the species should be considered

carefully. There are indications that some of these birds continually end up grounded, even after repeated expensive efforts to rehabilitate them. Several questions arise. Is there a genetic component to these birds' inability to survive on their own? Are we working against natural selection when attempting to put their genes back into the population? Could the time and financial effort expended on these individuals be better spent in other areas necessary for the species' conservation?

Fledglings reflect the experiential history and genetic and behavioural adequacy of their parents. The fledging process is a major hurdle, and the bird's ability to return to the nest a measure of its physical and behavioural competence. Though "accidents" may occur, it could be argued that even these gauge an individual's survival capacity. Though the inability of birds to successfully raise young might have a component based in human-caused environmental degradation (e.g. lack of food due to changes in land use) the answer to the birds' problem is not to "rescue" the weakest individuals (i.e. unsuccessful fledglings) but rather to enhance the survival potential of successful fledglings by addressing and modifying the ultimate problem.

Collisions

The impact of collisions on the Kransberg Cape Vulture population is relatively small compared to some mortality causes. Few birds are killed each year and they are a cohort which probably has a relatively high mortality rate from other factors. However, they have passed through the nestling period and have apparently fledged successfully, thus they are relatively robust individuals and perhaps fit to breed, making these deaths cause for concern.

The SABC has placed metal balls and bird diverters on the guy wires of the tower, yet collisions continue to occur. Though these diverters have proven successful in deterring collisions on horizontal power and telephone lines (Koop 1979; Koop & de Jong 1982), the diagonally placed guys blend against the background of the earth below (pers. obs.), probably making them difficult to see for birds flying above them. These devices, meant to make the guys more visible, are relatively useless, particularly for young inexperienced birds. Adults, by contrast, do fly in the area of the towers and even roost on some of them, yet seem to have no problem avoiding the offending guy wires, suggesting that birds learn to avoid the wires with experience.

Drowning

The relative lack of farm dams in the immediate surroundings of the Kransberg colony may partially account for the low numbers of birds drowned. This mortality factor is important in other areas (M. D. Anderson pers. comm., this proceedings) and should be mitigated for as it affects free-flying birds which are breeding or potential breeding individuals.

Poisoning

Poisoning is the most significant cause of adult and subadult Cape Vulture mortality at the Kransberg colony. Poisoning incidents vary in size, yet the numbers of birds discovered undoubtedly under-represents the total killed. Poisoning has been implicated in the decline of Cape and other griffon vultures elsewhere (Brown 1977; Schenk 1977; Brown & Piper 1988; Allan 1989).

Some breeding adults return to the nesting cliff and feed their young poisoned meat, resulting in the adult's and nestling's deaths. This suggests strychnine can be stored in the crop without harm to the adult, only affecting a bird once digestion occurs. I believe sub-lethal doses of strychnine can also ultimately lead to death in adult birds returning to the nesting cliff, when seizures, occurring with strychnine poisoning, cause them to fall from the cliff and ultimately die from traumatic injury.

Although extensive information is distributed to farmers, by organisations including the provincial nature conservation authorities and Vulture Study Group, poisoning continues. Poisoning is generally the unintentional result of commercial farmers placing poison over whole carcasses for Black-backed Jackal *Canis mesomelos* control. Although this method is illegal, it is impossible to control. This contrasts with poisoning incidents in the South African Lowveld, adjacent to the large Kruger National Park and private game reserves, where vultures are intentionally poisoned for parts to be sold in the traditional medicine market (van Jaarsveld 1988; pers. obs.). Other poisons have been employed in these incidents, including almost any agricultural pesticide or dip.

One must be cautious not to attribute other causes of mortality to poisoning. In spring and early summer, many newly fledged birds are found on the ground in the Thabazimbi area. These birds are often dehydrated or emaciated and unable to fly, and may have seizures similar to those caused by strychnine poisoning which leads to mis-diagnosis of their condition. The discovery of adults or sub-adults in such a condition, particularly in large numbers, may be a relatively good indicator of poisoning. However, it is impossible to attribute a recent fledgling's similar condition to poisoning without chemical analysis.

When collecting specimens for chemical analysis it is important to take as much material as possible. Crop and stomach samples are probably the best specimen source, as negative results have occurred from liver samples when crop samples were positive. This suggests the poison may act before reaching the liver, or at least in levels sufficient for positive test results.

It is likely that there is a time lag for the poison to reach the liver even though it is having an effect on the bird's nervous system. Because vultures often regurgitate crop and/or stomach contents when stressed, it is possible some of the birds discovered eliminated these contents before death, resulting in negative test results. When only liver samples are available, negative results may be misleading. These birds could also have died from other poisons untested for, although this seems unlikely considering the presence of the other carcasses with which they were discovered. From the pattern observed from 1981-1984 it is likely that some of those birds were also poisoned, suggesting that mortality due to poisoning is much higher than positive test results suggest.

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Patrick C. Benson, Ph.D.
 Department of Zoology
 University of the Witwatersrand
 Private Bag 3
 P.O. Wits
 2050
 Johannesburg
 South Africa