ARTICLES

Ten years of monitoring breeding Lappet-faced 
Vultures *Torgos tracheliotos* in 
the Namib-Naukluft Park, Namibia

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Summary
The 10 years of monitoring the Lappet-faced Vultures in the Namib-Naukluft Park (N-NP), Namibia, is one of the longest studies for this species. Breeding birds were found by driving from tree to tree, looking for occupied nests. The majority of the trees were in watercourses or dry riverbeds. Chicks were ringed with a metal and five colour-rings. Information on nest size, tree species, chick wing and tail measurements and mass were recorded on the nest record sheet.

Two hundred and seventy-five nestlings were ringed and 325 breeding records obtained. The Namib Desert population is influenced by rainfall (fewer pairs breed when rains are good), poisoning (fewer birds breed the year following the poisoning incidents outside the N-NP) and probably from disturbance (increased tourist traffic and construction work on the road) near one of the areas in which they breed.

Introduction
Despite the isolation of the area, especially 40 years ago, several vulture research projects have taken place in Namibia's Namib-Naukluft Park (N-NP). In the 1960s, Professor Sauer did some research on Lappet-faced Vultures *Torgos tracheliotos* and Cape Griffons *Gyps coprotheres* (Sauer 1973). This was followed in 1968 by Rolf Jensen's unpublished study of the breeding biology of Lappet-faced Vultures, and in 1975, Charles Clinning began his ringing of these vultures (Climming 1980). All these studies were conducted in the Ganab area of the Namib Desert Park, now part of the N-NP. Chris Brown (1986) ringed Lappet-faced Vulture nestlings in the same locality, and used road raptor-count figures to determine the density of these and other vultures in various habitat types.

In 1991 with the encouragement and assistance of Chris Brown, we started ringing Lappet-faced Vulture nestlings in the Sossusvlei and Tsondabvlei areas of the N-NP. This was an attempt to determine the number of breeding birds and dispersal of fledglings. Rangers were involved in the search for nests and the ringing process. Later friends, neighbouring farmers and journalists were also taking ringing, especially if they were strong and could help handle the eight-metre extension ladder. This involvement generated a lot of enthusiasm and awareness of vultures and the threat of poisons to vulture populations. Here we describe the nesting areas and determine the fluctuation in breeding attempts in relation to poisoning and rainfall over a 10-year period. Breeding success to fledging could not be measured because this would have involved multiple visits and due to the vast size of the area, this could not be done.

Study Area
Namib-Naukluft Park
The N-NP, the largest formal conservation area in Namibia, is essentially a desert park. It stretches from the Swakop River in the north to the Aus/Lüderitz road in the south, a distance of 450 km. Bordered by the Atlantic Ocean in the west and commercial farms in the east, it is 150 km at its widest (Figure 1). The Naukluft Mountains are joined to the desert by a narrow corridor, which allows animals to move from one habitat to the other. The Park covers an area of 49,768 km².

Summer rainfall in the Namib is generally early in the year, with records for Ganab and Zais showing most showers from January to March. The conservation station at Ganab is in the middle of the Lappet-faced Vulture breeding area. Although Zais is further east in the Naukluft Mountains, this was the only reliable source of rainfall data available close to the Tsondab breeding area. The summers can be extremely hot with temperatures (35-40°C) from October to April, but the nights are
Figure 1. Sketch map of Namib-Naukluft Park with breeding areas hatched.

generally cool. Winter temperatures are mild, but can drop to below freezing during June and July. The main egg-laying season starts in June, but can extend into October (Simmons & Bridgeford 1997).

Main Breeding Sites
The N-NP was divided into six main breeding areas, as shown in Figure 1. The number of active nests for each area is summarized in Table 1. Active nests are separated by large areas
where there are no suitable trees for nesting.

Ganab
This vast stretch of 1200 km² is the largest breeding area in the southern Namib. It consists of huge plains with inselbergs and myriad dry watercourses with hundreds of trees and is bordered in the north and south by the Swakop and Kuiseb Rivers respectively. The western boundary is more or less on the 15°20' east line of longitude. Further west, there are few trees. Farms to the east of the Park, many of them hunting farms, have vulture nests, but attempts to determine the number of vultures breeding here have been unsuccessful. The plains and mountains support a good population of gemsbok Oryx gazella, springbok Antidorcas marsupialis, Hartmann’s mountain zebra Equus zebra hartmannae and Ostrich Struthio camelus, all potential sources of food for vultures.

The Ganab area has a network of public and tourist roads, with several campsites. Although vultures no longer use the nests close to campsites and main roads, there are many suitable trees for nesting away from human and vehicular disturbance. Initially, because of logistical problems, this section did not receive the same attention as the TsauChab and Tsondab. This area was only surveyed from 1993 and coverage improved annually.

Saagberg/Kamberg
This area, of about 350 km², is situated about a third of the way down the eastern boundary of the N-NP, and consists mainly of plains with a small section of dunes in the centre and bordered on the west and southwest by the Kuiseb River and the dune sea respectively. The Saagberg and Kamberg, two prominent mountains on the eastern boundary, border on commercial farms.

Vulture nests occur in scattered trees, in dry watercourses and small pans on the plains. Some camel thorn trees Acacia erioloba are found in the dunes, but usually near the edge of the dune field. This area is undisturbed and only occasionally visited by patrolling conservation staff.

Varying numbers of game, such as gemsbok, springbok and Ostrich are found on the plains and dunes. The broken, mountainous ter-

rain along the Kuiseb River has herds of Hartmann’s mountain zebra

Tsondab River, Plains and Tsondabvlei
The Tsondab River, a linear oasis with many large camel thorn and umbrella thorn Acacia tortilis trees, rises in the Naukluft Mountains and ends at Tsondabvlei. Dunes have blocked the flow of floodwaters forming a long, wide, shallow pan with scattered trees. The portion of the river in the N-NP is 26 km long, while the pan is 16 km by 2 km. The river flows only periodically, and pools in the shallow riverbed seldom last more than a few days.

To the north of the river lie the Tsondab plains, a flat, almost featureless area of 10 km by 20 km. In several small, shallow pans, there are acacias and the occasional ebony tree Euclea pseudoebenus although the vultures do not use the latter for nesting. The dune sea borders the north, and Tsondabvlei lies to the west. To the south of the Tsondab River is a small plain with scattered trees and the Diep River, a tributary of the Tsondab. Commercial farms lie to the east. The total area of about 300 km² supports Ostrich, springbok and gemsbok, while spotted hyaena Crocuta crocuta move in and out of the area and cause some stock losses on the farms. Until 1999 in this part of the N-NP, even conservation staff access was kept to a minimum, as it is the most important breeding area for Lappet-faced Vultures, with the highest number of breeding birds. The first record of two Lappet-faced Vulture chicks reared in the same nest was documented here in October 1991 (Bridgeford et al. 1995).

Sukses Area
Lying to the west of the Naukluft Mountain massif, the Sukses area of 225 km² is bordered on the other three sides by dunes. Predominantly plains, with isolated mountains, this area has several large watercourses with numerous trees that provide suitable nesting sites. There are two artificial water points with saucer-shaped drinking troughs, which are favourite bathing spots for the vultures. Many gemsbok, springbok, Ostrich, and at times mountain zebra frequent the plains. This is a relatively undisturbed area where nesting sites do not appear to be a limiting factor.
Tsuaebab River and Plains
The Tsuaebab River enters the Park at the Sesriem Canyon and ends at Sossusvlei, the second most important tourist attraction in Namibia. This linear oasis is the most vulnerable breeding area due to the constant stream of vehicles along the very busy road running the length of the Tsuaebab Valley, parallel to the Tsuaebab River. Besides the large number of tourist vehicles, construction for the tarring of this road started in 1997, with the influx of a large number of people and road-building machinery. This construction work ended in August 2000. Since the flooding of Sossusvlei in early 1997, sightseeing aircraft have been based at Sesriem and frequently fly to Sossusvlei, over the river and other breeding areas.

The first 30 km of the river, heavily wooded, has several old vulture nests, but this stretch of river, closest to the bustling Sesriem tourist camp, has no known active nests. West of where the tourist road crosses the Tsuaebab River are many Lappet-faced Vulture nests. A smaller river, the Aub, parallel to and south of the Tsuaebab River, also has several nests, though they were seldom used during the past ten years. Other watercourses have vulture nests, but only one or two are active. This is an area of 180 km² with gemsbok, springbok and Ostrich. Since 1991, this area has been checked regularly.

Koigab River
On previous visits to the southern end of the Park, we had seen Lappet-faced Vulture nests. However, as it was about 300 km from our base station, we were unable to visit the area during the breeding season. In 1998, we ringed one chick. The potential breeding area covers about 70 km². Gemsbok, springbok and Ostrich are found in the Koigab River and surrounding plains and dunes, while the only herd of feral horses in Namibia is about 20 km further south.

Methods
To find nests, we literally drove from tree to tree, a time-consuming but necessary practice. This process generally began in October, when the majority of eggs had hatched and not earlier because of possible nest desertion in the egg stage. Some trees could be scanned with binoculars, but any tree with thick foliage had to be inspected closely from all sides. "White-wash", feathers and pellets on the ground were good indicators of an occupied nest, but these were also signs of favourite roosting spots. At the majority of trees used for nesting were thorny, a mirror on extendable aluminium pipes was used to check nests. An extension ladder was used to get to the nest if it contained an egg or chick and ringing was mainly done without removing the nestling from the nest. Eggs were checked to see if they were addled or not. Many older, larger nests comfortably held the weight of a person. In smaller trees, the ringer stood on the ladder, propped against the side of the nest. At times, the ladder was tied to the vehicle if the tree could not support its weight.

The nestlings were ringed with one metal and five colour rings, the unique combinations originally supplied by the Vulture Study Group (of the Endangered Wildlife Trust, which is based in South Africa). In 1991, nest positions were plotted on a map, but since 1992, we used a GPS (Sony and Garmin). Ringing recoveries will be dealt with separately.

In 1991/92 the main aim was to ring as many nestlings as possible and very little other information was collected, except tree species and nest heights. From 1993 a nest record sheet was used and the following information was collected: date, time and ringing site, ring details, tree species and nest height, nest size, nest number, nestling measurements, nearest other vulture/raptor nest and whether these nests were occupied/unoccupied. In 1993, we introduced a unique nest number for each nest with either an egg or chick. A small aluminium plate 30x30 mm with a number stamped on it was nailed to the tree trunk. This made it easier to keep track of nest utilization on an annual basis.

Results and Discussion
To date, we have 325 breeding records (chicks or eggs found in a nest) of which 275 nestlings were ringed over the 10-year monitoring period (Table 1). The nesting density was highest in the Tsobab area, namely one pair per 14.3 km². By contrast nesting density in the Gonarezhou National Park varied from one pair per 7 km² to one pair per 23 km² (Nundy et al.)
Table 1. Number of active pairs of Lappet-faced Vultures in the Namib-Naukluft Park, 1991 to 2000.

<table>
<thead>
<tr>
<th>Year</th>
<th>Ganab</th>
<th>Saagberg/Kamberg</th>
<th>Tsondab</th>
<th>Sukses</th>
<th>Tschauchab</th>
<th>Kolgab</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
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<td>No data</td>
<td>34</td>
</tr>
<tr>
<td>1993</td>
<td>2</td>
<td>3</td>
<td>15</td>
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<td>6</td>
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<td>19</td>
<td>9</td>
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<tr>
<td>1995</td>
<td>9</td>
<td>2</td>
<td>7</td>
<td>8</td>
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<td>34</td>
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<td>13</td>
<td>13</td>
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<tr>
<td>1997</td>
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<td>5</td>
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<td>13</td>
</tr>
<tr>
<td>1998</td>
<td>21</td>
<td>3</td>
<td>10</td>
<td>6</td>
<td>11</td>
<td>1</td>
<td>52</td>
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<tr>
<td>1999</td>
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<td>5</td>
<td>10</td>
<td>6</td>
<td>5</td>
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<td>44</td>
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<td>2000</td>
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<td>No data</td>
<td>3</td>
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<tr>
<td>Total</td>
<td>73</td>
<td>18</td>
<td>113</td>
<td>59</td>
<td>61</td>
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<td>325</td>
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<tr>
<td>%</td>
<td>22.5</td>
<td>5.5</td>
<td>34.8</td>
<td>18.2</td>
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<td>0.3</td>
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<table>
<thead>
<tr>
<th>Area</th>
<th>Size (km²)</th>
<th>Highest number of nesting pairs recorded</th>
<th>Nesting density: km²/pair</th>
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</thead>
<tbody>
<tr>
<td>Ganab</td>
<td>1,200</td>
<td>16</td>
<td>75.0</td>
</tr>
<tr>
<td>Saagberg/Kamberg</td>
<td>350</td>
<td>5</td>
<td>70.0</td>
</tr>
<tr>
<td>Tsondab</td>
<td>300</td>
<td>21</td>
<td>14.3</td>
</tr>
<tr>
<td>Sukses</td>
<td>225</td>
<td>13</td>
<td>17.3</td>
</tr>
<tr>
<td>Tschauchab</td>
<td>180</td>
<td>11</td>
<td>16.4</td>
</tr>
<tr>
<td>*Gonarezhou N.P.</td>
<td></td>
<td></td>
<td>7 to 23</td>
</tr>
<tr>
<td>*Serengeti</td>
<td></td>
<td></td>
<td>43.0</td>
</tr>
<tr>
<td>*Hluhluwe/Umfolozi</td>
<td>960</td>
<td>15</td>
<td>64.0</td>
</tr>
</tbody>
</table>

*Mundy et al. (1992)

1992). These are very high nesting density estimates relative to other areas in Africa (Table 2).

There was a crash in breeding during 1997 in the southern half of the N-NP, which could possibly have been due to the exceptionally high rainfall in the Tschauchab, Sukses, Tsondab, Saagberg/Kamberg areas and the surrounding farms where the vultures normally feed. In fact, this was the highest rainfall in 20 years (see Figure 2), which resulted in fewer game and stock mortalities, due to exceptionally good grazing. We know of no other factors which could have influenced the breeding so dramatically. Ganab also experienced higher than normal rainfall in 1997 (44.2 mm) but unfortunately, the area was not surveyed for breeding birds (Figure 3).

In 2000, Ganab had the highest rainfall for many years (65 mm). Similarly, the rest of the N-NP and surrounding farms experienced good rains. This also had a marked effect on the breeding of the Lappet-faced Vultures. At Ganab, only two chicks were reared and two rotten eggs were found. At Tsondab, no chicks and one addled egg were found. Because of the shortage of qualified and interested staff in the N-NP during 2000, only the Ganab and Tsondab areas were checked for birds.

Optimum ringing period

When Brown (1986) located nests in the Ganab area, he went in June and July and returned in November to ring nestlings. Because of the fear of causing the birds to desert the egg (Steyn 1982), we have opted for a single visit to the nest once most of the eggs have hatched. In most years, we started ringing in late Septem-
ber or early October, finding that the majority of chicks were big enough to ring. We carried on into November and even December, with the latter period usually being a second visit to a specific nest as, on initial inspection, the nesting had been too small to ring or the nest had contained an egg.

Although we have no definite proof of desertion of an egg, two incidents near the beginning of August 1996 caused us to reassess early visits to nests. On 10/8/96, two nests were found in the Sukses area, fairly close to one another, each with an egg. On our

Figure 2. Rainfall and breeding of Lappet-faced Vultures in the Tsondab area.

approaching the nest, an adult bird flew off each one. On returning on 20/10/96 to ring the nestlings, both nests were empty. In one nest no trace of an egg could be found, while in the other, pieces of eggshell were seen. Was this due to coincidence, or to disturbance by the ringer? Crows (Corvus species), common in the area, could have been responsible for predation, as has been reported by Mundy et al. (1992).

Ganab

It can be seen from Table 1 that Ganab supports the second highest number of breeding pairs found over 10 years, namely 73 breeding pairs or 22.5% of the total number of pairs in
the N-NP. No ringing was undertaken in 1991, 1992 and 1997. Even if the Ganab area had been surveyed annually since 1991, it would probably not outrank the Tsandab. In 1998, 21 active nests were found, the highest single number of active nests in any one year. This is only half of the 40 pairs estimated to occur in the Ganab area by Brown (1986). However, Brown did his surveys in the early 1980s, 10 years before our project. We do not think the apparent decline was due to increased tourist numbers. We found many unused nests away from roads or campsites, where there was no sign of human disturbance.

Saagberg/Kamberg
No large numbers of breeding birds were recorded here and unfortunately the area was not sampled in the good rain year of 1997. In 1999, there were five breeding records.
Tsandab River, Plains and Tsandabville
Although this area has the highest number of breeding records (113), there has been a steady decline in the Tsandab area, from 21 active nests in 1992 to 10 in 1999. In August 1995, 12 Lappet-faced Vultures were poisoned, including three ringed birds, on the farm Constantia, bordering the Tsandab area (Bridgeford 2001). This could have been one of the reasons for a drop from 19 records in 1994 to seven in 1995. However, why did the numbers rise again to 13 records in 1996? The decline in five records in 1997 was probably due to the high rainfall in the southern half of the N-NP (Figure 2). In 2000, only conservation staff that did not know the area carried out a partial survey. It is thus likely that there were more breeding birds than the single one found.

Sukses
The Sukses area has been reasonably stable, the most interesting year being 1996. Six chicks were ringed, as well as seven additional breeding records of four dead chicks and two eggs that disappeared. The seventh record was of pieces of eggshell in a freshly prepared nest.

Tschaubach River and Plains
The Tschaubach area, which has nesting sites and many nests, should support a larger breeding population. However, with the very busy road down the length of the Tschaubach valley, this is a very disturbed area. The large number of tourist vehicles and the three years of road construction work appear to have affected the breeding vultures in a negative way. Sightseeing aircraft based at Sesriem and regularly flying over the valley could be a further disturbance. Although the Table shows that there had been an initial increase in the number of active nests found in the area, there was a dramatic decrease from ten records in 1996 to four in 1997, which could also have resulted from the good rains in the area. In 1998, there were 11 breeding records. The decrease to five records in 1999 could have been due to road construction teams moving into the main breeding area (pers. obs.). Bulldozers were working in the river, where most of the nesting sites occur, during the nesting period. Whether breeding will increase now that construction work has been completed, needs to be determined during future monitoring.

The influence of poisons and rainfall
The decline of breeding birds was probably due to continual poisoning over the years (Brown 1986; Simmons 1995; Simmons & Bridgeford 1997; Bridgeford 2001). We found 35 trees marked by Brown more than 15 years previously and only two of these nests were used during the present study. Many of the trees contained more than one nest. Whether the poisoning of 86 Lappet-faced Vultures just north of this area in May 1995 (Simmons 1995) has affected this population, remains to be seen. There are now some doubts about the veracity of the statement made by the farmer regarding the total number actually killed by him. Because of the decomposing state of the carcasses, only some were exhumed and while these were Lappet-faced Vultures, the total was not counted. As can be seen from Table 1, there was no sudden decrease in pairs breeding in the Ganab area. Whether the overall decrease from 47 breeding pairs in 1994 to 34 breeding pairs in 1995 throughout the N-NP, was due to the poisoning (Simmons & Bridgeford 1997) or to environmental factors, is difficult to say. There is no doubt that some Lappet-faced Vultures were killed. The actual increase to 13 nesting records in 1996 may be due to extra effort to locate nests that year, and similarly, in 1998 and 1999, more time was spent looking
for breeding birds over a wider area.

We tested the association between high rainfall and low breeding activity by regression analysis using 10 years’ data (1991 - 2000) from the Tsondab area. The first year (1991) was omitted, as nest finding coverage was incomplete and the year poisoning took place (1995) was not included because breeding activity was presumed to be depressed. There was a significant ($t=2.52$, d.f.=6, $P=0.05$) inverse correlation between annual rainfall and the number of birds breeding at the end of the same year ($r=-0.72$). The equation linking the two variables can be expressed as:

$$\text{Active Nests} = 18.68 - 0.051 \times \text{(rainfall)}$$

While rainfall has been suggested to influence vulture breeding in a positive way in the Serengeti (Mundy et al. 1992), these data are the first to quantify any relationship. It is an inverse relationship (less rain, more breeding) probably because in arid areas more prey animals die in low rainfall years, thereby supplying vultures with food at a critical (pre-breeding) time.

This equation also allows us to predict how many nests were expected in the year poisoning took place (1995), based on the rainfall (71 mm). While only seven were found active in the season following the poisonings in May 1995 (the start of breeding), the low rainfall predicted that 15 nests should have been active. Thus, less than half the nests expected were actually active. This strongly suggests that the poisonings did influence the breeding for that year, since in no other comparison of the predicted number and observed number of nests, was the difference between observed and expected as high as eight nests.

A longer-term trend is also apparent from the rainfall association. In 1992, 21 active nests were found in the season following 61 mm of rain. However, six years later in 1998, when even less rain fell (29 mm), only ten active nests were located. This suggests either that other factors were influencing vulture breeding (e.g., general ungulate numbers) or that poisoning is having a long-term influence over and above the annual influence detected above.

We conclude that rain plays a major role in regulating Lappet-faced Vulture breeding activity and poisoning can significantly reduce that activity in the short-term. Long-term effects need to be monitored closely with further research.

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References

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