Ostrich 2006, 77(3&4): 127–135
Printed in South Africa — All rights reserved

OSTRICH
EISSN 1727–947X

Observations on the population and breeding status of the African White-backed Vulture, the Black-chested Snake Eagle, and the Secretarybird in the Kgalagadi Transfrontier Park

JJ Herholdt[1] and MD Anderson[2]*

[1] Mkhunyane Reserve, PO Box 1274, Piet Retief 2380, South Africa
[2] Deptartment of Tourism, Environment and Conservation, Private Bag X6102, Kimberley 8300, Northern Cape, South Africa
* Corresponding author, e-mail: manderson@half.ncape.gov.za

The breeding success of the nests of 60 African White-backed Vultures *Gyps africanus*, nine Black-chested Snake Eagles *Circaetus pectoralis* and 12 Secretarybirds *Sagittarius serpentarius* was monitored for three years, during a seven-year population dynamics study on raptors in the Kgalagadi Transfrontier Park (KTP). We also report on nest site selection, timing of breeding, population fluctuations and anthropogenic factors that affect mortality. On average, African White-backed Vultures produced 0.47 young per breeding attempt per year (ypby), Black-chested Snake Eagles 0.67 ypby, and Secretarybirds 2.2 ypby. Most African White-backed Vultures laid eggs in June, and both Black-chested Snake Eagles and Secretarybirds laid mostly in June and July. Mean nest heights were as follows: African White-backed Vultures 11m, Black-chested Snake Eagles 5m, and Secretarybirds 6m. Populations of Black-chested Snake Eagles and Secretarybirds fluctuated between years and in some years most of the populations moved away, especially during very dry periods. Anthropogenic threats include poisoning, drowning and roadkills.

Introduction

The Kgalagadi Transfrontier Park (KTP) is an important area for the conservation of raptors, with at least 52 species being recorded (Funston *et al.* nd). The KTP is recognised as an Important Bird Area (Barnes and Anderson 1998), mainly because of the Park's population of globally, and nationally, threatened and near-threatened raptors and bustards (Barnes 2000), as well as of several range-restricted passerines. In terms of the number and diversity of raptors, the KTP contributes significantly to the conservation of these birds (Liversidge 1984, 1994, Anderson 2000a). In order to conserve raptors, however, knowledge of their abundance, distribution, and factors affecting their population dynamics is necessary (Watson 1984). During a seven-year study (1988–1994) on raptors in the KTP (Herholdt 1995), some observations were made on the breeding and population status of the African White-backed Vulture *Gyps africanus*, the Black-chested Snake Eagle *Circaetus pectoralis*, and the Secretarybird *Sagittarius serpentarius*.

The KTP is bordered on the west, south and east (Namibia, South Africa and Botswana) by small-stock farming areas (Figure 1), where the use of poisons to control Black-backed Jackals *Canis mesomelas* and caracals *Felis caracal* was widespread during the 1980s and 1990s (cf Brown 1988, 1991, Allan 1989). There is no buffer zone between the KTP and these adjacent small-stock farms. As many raptor species have large home ranges (see, for example, van Zyl 1992), the KTP's birds may forage on adjacent livestock farmland, thus potentially coming into contact with poisons (Herholdt 1995). This poses problems, in particular for the scavenging African White-backed Vulture.

The KTP is one of the most important conservation areas in southern Africa for raptors (Liversidge 1984, 1994, Anderson *et al.* 1997, Anderson 2000a, Kemp *et al*. 2001). Despite this importance, very little is known about the Park's raptors. Apart from data obtained from road censuses (Liversidge 1994), no previous information on the breeding and population status of raptors has been collected from this area. We report on aspects of the population fluctuations, conservation threats, and breeding, of the African White-backed Vulture, the Black-chested Snake Eagle, and the Secretarybird.

Study area and methods

The KTP is situated in north-western South Africa and in the south-western corner of Botswana, covering an area of 36 191km². Together with the adjacent Mabuasehube Game Reserve and various Wildlife Management Areas in Botswana, it is one of the largest conservation areas in the world, totalling 80 000km².

The area receives irregular and low rainfall, which falls mostly during summer and autumn, with more than 50% between January and April (Nel 1990). The rainfall averages 250mm per annum. Temperatures fluctuate widely on a daily and seasonal basis. Temperatures measured at three different stations in the study area over a 24 month period (April 1990–March 1992), revealed that the mean annual temperature fluctuated between 10.9°C and 32°C, with absolute values at 43°C and –9.0°C (Herholdt 1995).

Most of the KTP consists of undulating dunes (Lewis 1936) with scrub savannah, traversed by two fossil riverbeds (the

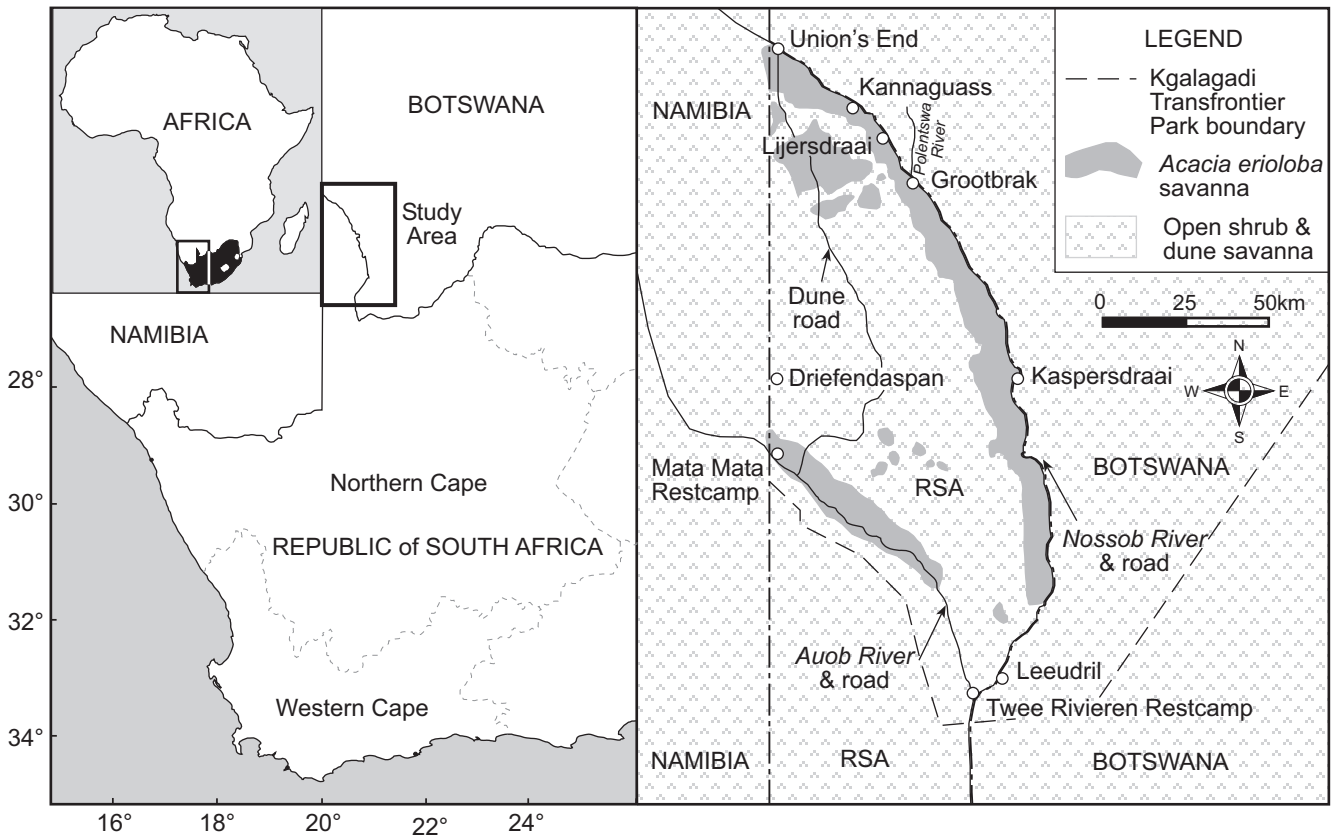

Figure 1: Map of the study area in the KTP, showing habitat types and locations mentioned in the text

Auob and Nossob) which are lined with tall acacias (mostly *Acacia erioloba*) and scattered pans (van Rooyen 1984). The vegetation has been described as Thorny Kalahari Dune Bushveld and the Shrubby Kalahari Dune Bushveld of the savanna biome (Low and Rebelo 1996).

The study was conducted mostly on the South African side of the KTP (Figure 1), from 1988–1994. Breeding data were collected between 1988 and 1990, with additional road census data being collected from 1991–1993.

Nests of the three species of raptors were located, and their positions were determined with a Global Positioning System. Their localities were then plotted on a map of the KTP (Bothma *et al.* 1993 — Figure 2). Due to the vastness of the study area, it is very likely that some nests of these raptor species were not located in the interior dune areas. The rivers were, however, very thoroughly covered, and it is considered that most, if not all, nests were located in the different breeding seasons.

The nests of the raptors were inspected, 3–5 times on average, during each breeding season, using a mirror pole or by physically climbing the nesting trees. Nestlings were aged as far as possible to establish laying dates, according to criteria given by Steyn (1982). The laying dates are considered to be accurate to within c. 10 days. The breeding success was calculated as the number of nestlings that fledged successfully per breeding attempt per year (ypby).

Road censuses were conducted once every three months, from June 1991–December 1993, by two observers on the backs of two different vehicles, each travelling a different route on the same day. Three routes were counted on one or two consecutive days: Union's End to Twee Rivieren (300km); Mata Mata to Twee Rivieren (118km); and Union's End through the interior dune veld to Mata Mata (160km) (Figure 1). The surveys were conducted at a speed of c. 40km/h. When a raptor was seen, the vehicle was stopped, to facilitate accurate identification.

Data on raptor mortalities were collected on an *ad hoc* basis, e.g. while examining nesting sites and water reservoirs during routine inspections, or during discussions with landowners on adjacent farms.

Results

African White-backed Vulture

Breeding success

From 1988–1990, there were 60 breeding attempts by African White-backed Vultures in the KTP. The Kaspersdraai breeding colony was the largest (23 pairs in 1989), while the rest of the pairs bred in small aggregations (1–4 nests) in the *Acacia erioloba* savanna areas of the Park (Figure 2). In total, 75% of all eggs laid (n = 60) hatched, and 46.7% (or 0.47 ypby) of chicks were reared (Table 1). Of the eggs that hatched, 37.8% failed to fledge (Table 1). All clutches consisted of single eggs.

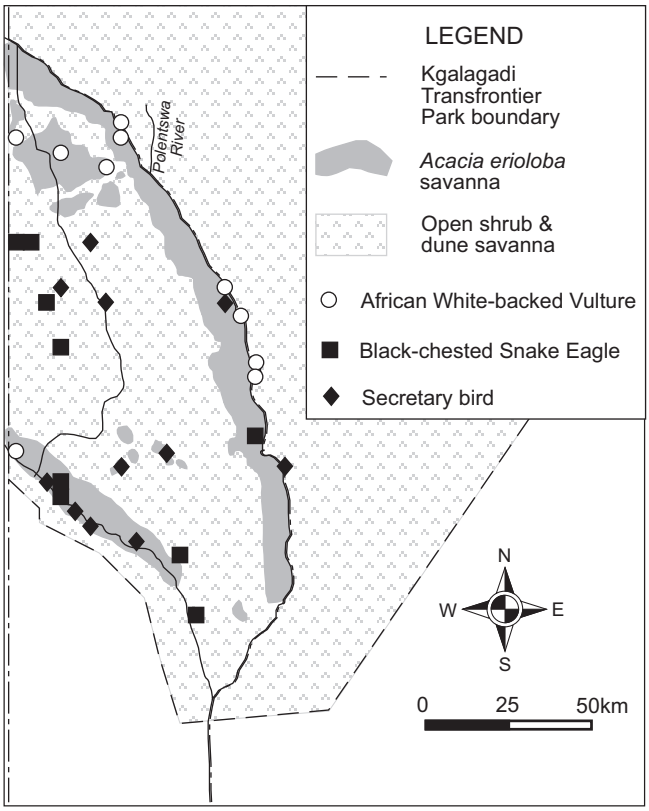

Figure 2: Location of raptor nests in the KTP

Table 1: Breeding statistics for African White-backed Vultures in the KTP (n = 60 breeding attempts)

Year	1988	1989	1990	Total
Pairs attempting to breed	23	25	12	60
Laid, failed to hatch	5	2	8	15
Laid, hatched, failed	4	10	3	17
Laid, hatched, fledged	14	13	1	28
Chick reared/br. attempt (n = 60) %	60.9	52	8.3	46.7
% failed with eggs	21.7	8	66.7	25
% failed with chicks	22.2	43.5	75	37.8

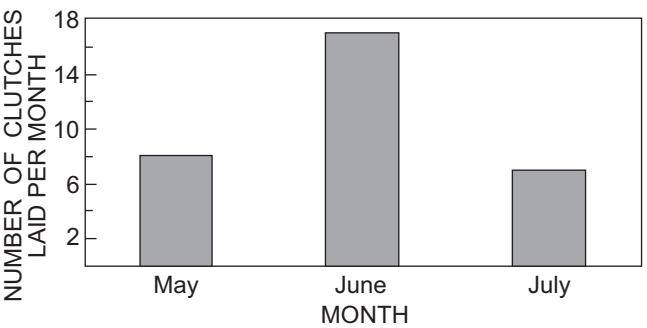

Figure 3: Laying dates (n = 32) for African White-backed Vultures in the KTP

Some of these small 'colonies' would be active for a year or two and then they would suddenly be vacated. If the 1990 Kaspersdraai breeding results are excluded, an overall productivity of 0.56 ypby was achieved.

Timing of breeding

The approximate laying dates (c. 10 days) for 32 nests could be established. Most eggs (53%) were laid in June, while the rest were laid in May (25%) and July (22%) (Figure 3).

Nest site selection

All nests were found in the *Acacia* savanna areas of the Park (Figure 2), in the tops of large trees. Of 37 measured nests, nine (24.3%) were located in trees that were on average 11m in height (mean 10.76m, range 6–15m). Fifty-six nests were in *A. erioloba* trees and four were in *Albizia anthelmintica* trees. The latter four nests were all located in the dry Polentswa River (Figure 1), to the north-east of Grootbrak in Botswana, where *Albizia* was the largest tree species available to the vultures.

Anthropogenic threats

No chicks fledged at the Kaspersdraai colony in 1990 (Herholdt 1995). In total, 10 active nests were found at this colony during this season, but only three chicks hatched and not a single young fledged successfully. Only broken eggshells and remains of chicks were found when the nests were inspected in September of that year and only a few adults were seen in the vicinity of the breeding area. This suggests that the adult vultures succumbed to poisoning, perhaps after they fed on poisoned carcasses. Only one adult African White-backed Vulture carcass was found in the area, and it was partly eaten by scavengers. No analyses for poison residues were conducted. The vultures never used this area again for the duration of the study period until 1994, confirming that they had either moved away or were poisoned.

The drowning of vultures and other raptors in water reservoirs in and around the KTP was frequently observed (Herholdt 1995). One African White-backed Vulture was found dead in the reservoir at Haaspan (where the windmill was no longer used) and a Lappet-faced Vulture *Torgos tracheliotos* drowned in the reservoir at Lijersdraai (Herholdt 1995 — Figure 1).

At the Kannaguass waterhole, some Black-backed Jackals *Canis mesomelas* learnt to catch vultures when they emerged from the waterhole after bathing. During one visit, eight African White-backed Vulture carcasses (or bundles of feathers of these vultures) were found around the waterhole. JJH observed a Black-backed Jackal catching and killing a vulture — which did not appear to be injured or ill, but only wet after it had bathed at the waterhole. A tourist reported another similar incident to JJH.

Black-chested Snake Eagle

Breeding success

A total of nine nests were found in the KTP, from 1988–1991 (Table 2). Only one egg failed to hatch (11.1%), and two chicks that hatched failed to fledge (25%), and six fledged successfully (66.7%, 0.67 ypby) (Table 2).

Table 2: Breeding statistics for Black-chested Snake Eagles in the KTP (n = 9 breeding attempts)

Year	1988	1989	1991	Total
Pairs attempting to breed	3	5	1	9
Laid, failed to hatch	0	1	0	1
Laid, hatched, failed	0	2	0	2
Laid, hatched, fledged	3	2	1	6
Chick reared/br. attempt (n = 9) %	100	40	100	66.7
% failed with eggs	0	20	0	11.1
% failed with chicks	0	50	0	25

Timing of breeding
In four instances, the estimated time of egg laying (c. 10 days) was June (n = 2) and July (n = 2).

Nest site selection
Of seven nests, three were in trees that were on average 5m in height (mean 5.36m, range 4–7m). All nests were in *A. erioloba* trees. Four of nine nests were in the *A. erioloba* savanna areas of the South African side of the KTP, with the rest being located in the open dune areas, with scattered low *Acacia* trees, in the interior of the Park (Figure 2).

Population fluctuations
Black-chested Snake Eagles are abundant in the KTP in certain years (JJH pers. obs.). However, in other years they are very scarce and may be almost totally absent from the area (cf Liversidge 1994), e.g. in 1992 (see Figure 4). This is also apparent from the number of active nests found in the KTP from 1988–1989: in 1991, only a single nest was located, with none located in 1992 (Table 2).

Anthropogenic threats
From 1988–1994, 30 raptors were found drowned in water reservoirs in the KTP, of which one was a Black-chested Snake Eagle, which drowned in the Leeudril reservoir (Figure 1).

Secretarybird
Breeding success
In the study, 2.4 eggs per breeding attempt were recorded (range 1–3 eggs, SD = 0.79), only one egg failed to hatch (3.4%), and two that hatched failed to fledge (7.1% of the eggs that hatched — Table 3). Of these clutches, 58.3% (n = 7) consisted of three eggs and, of these, three young hatched in six nests. In two of the nests, all three nestlings were seen fully fledged and on the brink of fledging, and in one breeding territory, the three nestlings were seen together after fledging. In three nests, it is possible that some of the nestlings may have died, although this is unlikely as all three nestlings were still in the nest and fully feathered at 4–5 weeks old (n = 1 nest) and eight weeks old (n = 2 nests). No dead chicks or parts thereof were found in the latter three nests after the young were considered to have fledged and the amount of whitewash on and around the nests suggested that the chicks stayed in the nests for a considerable period before fledging.

Of the chicks that hatched (n = 26), 92.9% are considered to have fledged successfully (Table 3); 2.2 young fledged per breeding attempt per year (Table 3).

Timing of breeding
Approximate laying dates (c. 10 days) could only be accurately established for six attempts. Of these, 33% were laid in June and July, respectively, while the rest were laid in April and May (Figure 5).

Nest site selection
Of all nests found (n = 12), eight were located in the *A. erioloba* savanna of the KTP, while four were in the open dune areas with scattered short *Acacia* trees. All nests were in *A. erioloba* trees, with four being situated at an average height of 6m above ground level (mean 5.8m, range 3.5–8m).

Population fluctuations
Secretarybirds were abundant in the study area from 1988–1991, but in 1992 (a period of very low rainfall) the population numbers were very low (see Figure 6) with very few individuals being seen at waterholes, where they normally congregated during midday in groups of up to 30 individuals (Herholdt 1995).

Anthropogenic threats
One Secretarybird was killed by a speeding motorist near Leeudril (Figure 1) in the southern section of the KTP (Herholdt 1995). A chick ringed in the nest on 28 July 1989 was recovered drowned in a nearby reservoir at Driefendaspan (Figure 1) on 9 October 1989.

Discussion

African White-backed Vulture
Breeding success
The overall breeding success of African White-backed Vultures in the KTP of 0.47 ypby is lower than that recorded in the Kruger National Park (0.58 and 0.64 ypby — Kemp and Kemp 1975) and Swaziland (0.58 ypby — Monadjem 2001), but similar to the 0.46 ypby recorded in 2003 in the Kimberley area, South Africa (MDA unpubl. data). Although the overall breeding success of African White-backed Vultures in Africa is between 0.55 and 0.57 ypby (Mundy *et al.* 1992), this can be as high as 0.8–0.9 ypby in optimal habitats such as the Serengeti (Brown *et al.* 1982). The lower success rate in the present study could be attributed to the drier and harsher climate of the KTP and, importantly, during 1990, to the suspected poisoning incident and total breeding failure of the colony at Kaspersdraai. If the breeding success of the 1990 season is thus excluded, the higher success rate of 0.56 ypby compares favourably with the overall breeding success of the African White-backed Vulture in Africa, as reported by Mundy *et al.* (1992).

Timing of breeding
Egg laying in the African White-backed Vulture in southern Africa takes place from late April to the end of June, with a peak in May (e.g. Kemp and Kemp 1975, Mundy *et al.*

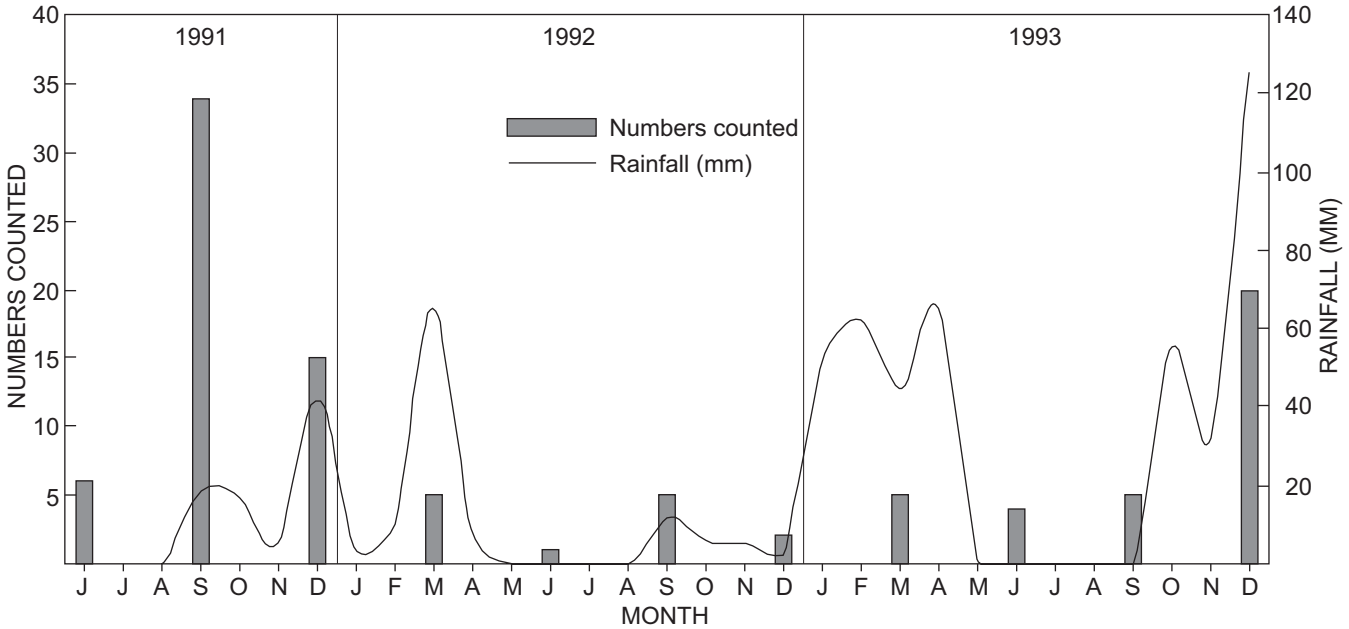

Figure 4: Comparison between rainfall and numbers of Black-chested Snake Eagles counted along roads in the KTP from June 1991–December 1993

Table 3: Breeding statistics for Secretarybirds in the KTP (n = 12 breeding attempts)

Year	1988	1989	1990	Total
Pairs attempting to breed	6	5	1	12
Eggs laid, failed to hatch	1	0	0	1
Eggs laid, hatched, failed	0	2	0	2
Eggs laid, hatched, fledged	16	8	2	26
Chick reared/br. attempt %	266.7	160	200	216.6
% failed with eggs	5.9	0	0	3.4
% failed with chicks	0	20	0	7.1

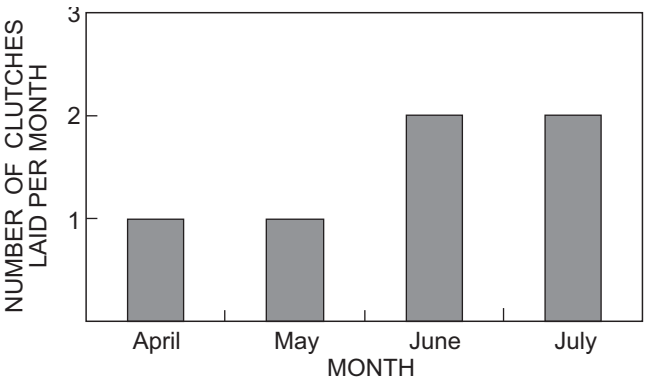

Figure 5: Laying dates (n = 6) for Secretarybirds in the KTP

1992). In the present study, the egg laying peaked in June, which is one month later than the African average. It, however, correlates with the laying dates at other Northern Cape colonies, namely Askham and Van Zylsrus in the Kalahari (AWA Maritz pers. comm.) and Kimberley (MDA unpubl. data).

Nest site selection

African White-backed Vultures typically nest in *Acacia* trees (Craib 1979, Tarboton and Allan 1984), although in some areas, such as Swaziland, a wider variety of trees is selected (Monadjem 2003). As in the KTP, elsewhere in the Northern Cape the African White-backed Vulture predominantly nests in *A. erioloba* trees (Anderson and Maritz 1997, Murn 2001). There are a few records of African White-backed Vultures nesting on electricity pylons in the Northern Cape (Anderson 2001).

The mean nest height of 11m in the KTP is slightly lower than that reported for the former Transvaal Province (13.6m — Tarboton and Allan 1984) and Swaziland (13.3m — Monadjem 2003). Nest heights can range from 8–50m above the ground (Brown *et al.* 1982), but this is related to the height of trees in the area.

The recorded phenomenon in the KTP of breeding colonies suddenly appearing and then later disappearing was an interesting but not unique finding, and this has also been reported in other areas, such as Lake Ngami in Botswana and Hwange National Park in Zimbabwe (Mundy *et al.* 1992). This may be related to temporarily available food resources or, more likely, to the disturbance at nesting sites. In the KTP, a high level of nesting predation was recorded for raptors by ground-dwelling predators (Herholdt 1995). These high predation levels are no doubt exacerbated by the fact that nests in *Acacia erioloba* trees are very easy to reach (JJH pers. obs.). It is possible that raptors in arid environments may shift their nest sites to avoid predation.

Anthropogenic threats

The fact that the Kaspersdraai colony failed to fledge a single nestling in 1990 (Herholdt 1995), despite attempting

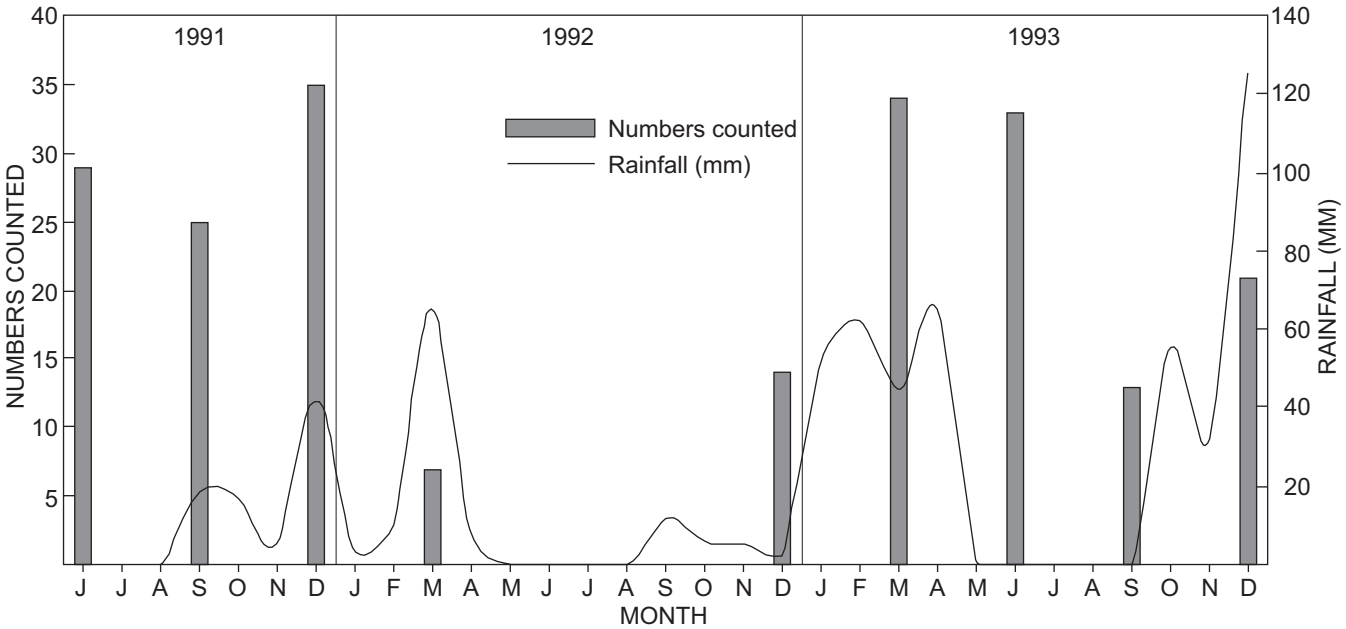

Figure 6: Comparison of rainfall and numbers of Secretarybirds counted along roads in the KTP from June 1991–December 1993

to breed that year, suggested that the adults must have fed on a poisoned carcass. Poisoning of vultures has been recorded in the past in adjacent Namibia where, in June 1979, 113 African White-backed Vultures were poisoned in a single incident (Herholdt 1995, 1998), and elsewhere in the Northern Cape and North West Province (Anderson 1994, 1995). Of 43 recorded raptor mortalities in the KTP, six were suspected poisoning incidents. Four were bateleurs *Terathopius ecaudatus* (one bateleur died after consuming organophosphate poisons), while two were African White-backed Vultures (Herholdt 1995).

There are records of at least 67 African White-backed Vultures drowning, in seven incidents in southern Africa (Anderson *et al.* 1997, 1999), the majority of which took place in the Northern Cape (Anderson and Maritz 1997). Most recorded drownings in the KTP (not only vultures) took place in the reservoirs with more palatable (less brackish) water, such as Grootkolk, Lijersdraai and Kannaguass. The creation of these permanent water reservoirs in a landscape that would otherwise have only seasonal water pools after rains is problematic. Algae invariably covers the water in the reservoirs, which creates the sense of a solid surface for the birds to land on. In the event that they fall in, there is no way for them to get out. The supplying of ladders in these reservoirs would alleviate the problem to a great extent.

Increased jackal predation, at waterholes, of African White-backed vultures and other large birds of prey is possibly also an indirect result of human interference. During historic times there were no permanent waterholes in the area. The creation of waterholes — particularly less brackish ones such as at Kannaguass — has allowed Black-backed Jackal greater access to birds of prey when the latter visit to drink and bathe. In former times, such an occurrence would probably have been unlikely, as birds would drink randomly where water was available after rains.

Another important mortality factor in the Northern Cape is electrocution on electricity pylons (Anderson and Kruger 1995, Kruger 1999, van Rooyen 2000).

As a result of these various mortality factors and the fact that the population has probably declined by 10% in the last three generations, the African White-backed Vulture is listed as 'vulnerable' in The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland (Anderson 2000b).

Black-chested Snake Eagle

Breeding success

Observations on the breeding success of the Black-chested Snake Eagle are scanty; a single pair reared four young in five years, giving a productivity of 0.8 ypby (Steyn 1982). Tarboton and Allan (1984) reported that few nests of these eagles were found in the former Transvaal from 1976–1981 and no productivity data were given. The fact that the Black-chested Snake Eagle is considered to be an intra-African nomad (Steyn 1982) and that the eagles may appear and disappear from an area makes it difficult to get accurate data on breeding success for individual pairs. In Kenya, the breeding success was estimated to be 0.2–0.3 ypby (Brown *et al.* 1982). In the present study, the total mean breeding success for nine nesting attempts of single eggs each was 0.67 ypby.

Timing of breeding

Black-chested Snake Eagles laid eggs from July–August in the former Transvaal (Tarboton and Allan 1984), from March–October in Namibia (Jarvis *et al.* 2001), and from March–October in Zimbabwe (Steyn 1992, Maclean 1993). The data from the present study are consistent with these findings, although KTP birds seem to lay on average earlier than the Transvaal birds. With egg laying in the KTP during June and July, and a 51–52-day incubation period and 90–113 day nestling period (Simmons 2005), the young will fledge during

early to mid-summer, when there is a greater availability of food. Black-chested Snake Eagles readily took rodents in the KTP (JJH pers. obs.), which are usually abundant in the rainy season (summer). Snakes, which form the bulk of the eagles' diet, are also more active during the summer months.

Nest site selection

Nest heights have been recorded at 3.5–20m (average 7m) (Brown *et al.* 1982, Tarboton and Allan 1984, Steyn 1982, Maclean 1993, Simmons 2005), in the tops of *Acacia* and *Euphorbia* trees (Tarboton and Allan 1984, Tarboton 2001, Simmons 2005). In the KTP, all nests were in *A. erioloba* trees with a mean height of 5m above ground, thus in agreement with other studies.

Population fluctuations

The recorded population fluctuations of this eagle species in the KTP agree with observations elsewhere in Africa (e.g. Tarboton and Allan 1984, Anderson 2000c). In 1988, many Black-chested Snake Eagles, especially immature birds, were observed in the KTP, which could have represented an influx from elsewhere in Botswana or Africa (Herholdt and de Villiers 1989). It has been suggested that there are two populations in southern Africa: a nomadic breeding population and non-breeding visitors from beyond the region (Brown *et al.* 1982, Steyn 1982, Boshoff 1997). In the KTP, there was a marked decline in numbers of eagles during the winter months, although a few were also counted in the summer of 1992 (Figure 4). Rainfall in the KTP alone cannot explain the population fluctuations, and environmental conditions elsewhere in Africa may be responsible; in addition, rodent populations take longer to react to rainfall than insects (on which Secretarybirds also feed). The movements of this species are, however, poorly understood and need further research (Boshoff 1997).

Anthropogenic threats

Only one Black-chested Snake Eagle was found drowned in the study area. Anderson *et al.* (1999) reported on six additional drowned birds, but the incidence of drowning of this species may be a more common phenomenon in arid areas. Ring recoveries confirm the importance of this mortality factor, with two of five recoveries being of drowned birds (Oatley *et al.* 1998). The safeguarding of water reservoirs by providing ladders — for the birds to climb after falling into the water — is essential (see Anderson and Taljaard 1994, Herholdt 1995, Anderson *et al.* 1999). Fortunately, the Black-chested Snake Eagle is not susceptible to poisoning, since it does not feed on carrion (Simmons 2005).

Secretarybird

Breeding success

Brown *et al.* (1982) recorded that, despite the absence of sibling aggression, two young are seldom raised, and there are no records of three chicks fledging. These authors also reported breeding productivity of 1.2–1.3 ypby. Tarboton and Allan (1984) observed broods of young in 23 nests in the former Transvaal, of which 43.5% consisted of one nestling, 39.1% of two nestlings and 17.4% of three nestlings. Whether these birds fledged successfully was not mentioned. Steyn (1982) observed that in nests with three young the youngest usually dies of starvation, and mentioned that there is only one record of three young fledging successfully.

In the present study, 58.3% (n = 7) of clutches consisted of three eggs, of which all hatched and all are considered to have fledged. Although some of the chicks were observed after fledging, the youngest nestlings observed when the nest was last inspected were 4–5 weeks old, and no sign of predation or mortality was observed when the nests were inspected again at a later date.

We consider it likely that all the young in these nests fledged successfully. Furthermore, Brown *et al.* (1982) reported that Secretarybirds could survive if they departed from the nest at 47–50 days. Normal fledging periods may vary from 75–85 days (Maclean 1993). These breeding results may have been due to very favourable environmental factors being prevalent at that time.

Tarboton and Allan (1984) reported that Secretarybird productivity could not be measured conventionally (ypby) because of the erratic breeding pattern of the birds and because of the difficulty of quantifying non-breeding years. These authors recorded a breeding success of 1.16 ypby (n = 29 breeding attempts). In East Africa, a mean of 1.96 eggs per nest was recorded (Brown *et al.* 1982), while clutch sizes of between 1–3 eggs (usually 2) were recorded by Maclean (1993).

The overall breeding success of 2.2 ypby is higher than recorded elsewhere in Africa, and may have been due to very favourable environmental conditions that prevailed in the KTP during the study period; 1988 and 1989 (when most nests were located) were years with above average rainfall (Herholdt 1995).

Timing of breeding

The Secretarybird lays eggs in all months in southern Africa (Dean and Simmons 2005), but with a possible August–December peak (Maclean 1993). In the former Cape Province, egg laying peaked in September (Brown *et al.* 1982), which is later than the June and July peak recorded in the KTP during this study.

Nest site selection

Nest height in the Secretarybird is very variable, with heights of 2–16.5m being reported (Brown *et al.* 1982, Steyn 1982, Tarboton 2001, Dean and Simmons 2005). The Secretarybird mainly breeds in thorny trees, frequently *Acacia* trees (Dean and Simmons 2005). All nests located during this study were in *A. erioloba* trees, with the mean height being 6m. As nests are often built in low trees (see Brown *et al.* 1982), protection from terrestrial predators may be a more important factor than tree height in nest site selection.

Population fluctuations

Although there is no evidence for regular seasonal movements, the Secretarybird may be nomadic in low-rainfall areas (Boshoff and Allan 1997), especially in the Namib Desert and the Kalahari (Brown *et al.* 1982). These nomadic patterns were clearly evident during this study when, during a period of exceptionally low rainfall, no Secretarybirds were observed in the KTP. R Liversidge (pers. comm.) reported that it was the first time since 1973 (when he commenced regular bird surveys in the South African side

of the KTP) that he had observed the absence of these birds in the Park. Recoveries of ringed juveniles have provided evidence of postnatal dispersal, including distances of up to 1 537km from the nest site (Oatley *et al.* 1998). The fact that Secretarybird numbers increased substantially during 1993 (which was also a very dry year) but Black-chested Snake Eagle numbers stayed low during this period (Figures 4, 6), could not be explained, but it seems that rainfall alone may not be useful when looked at in isolation in relation to the population fluctuations. Environmental factors prevailing elsewhere in Africa at that time may have been responsible for these results. Also, Secretarybirds feed on insects such as locusts, which emerge after rains, while Black-chested Snake Eagles do not utilise such a resource. It may take longer for the rodent populations, on which the eagles also feed, to respond to rainfall. Successive years of constant rainfall may be necessary to build up rodent numbers.

Anthropogenic threats

Vehicle collisions may be a minor cause of mortality in the KTP, with only one incident having been recorded during the study period. Another such record was reported by Tarboton and Allan (1984). A Secretarybird that was ringed as a nestling later drowned in a reservoir and this and another record were cited by Anderson *et al.* (1999). The Secretarybird may be vulnerable to poisoning, either by eating poisoned baits, or by eating poisoned rodents (see Tarboton and Allan 1984). A more significant mortality factor is collision with telephone and electricity lines (Dean and Simmons 2005). The Secretarybird is 'near-threatened' in South Africa (Barnes 2000), possibly due to habitat-related factors, such as overgrazing, bush encroachment and afforestation.

Acknowledgements — We are grateful to the South African National Parks and the former warden of the KTP, EAN le Riche, for allowing us to conduct this study. Rangers Dawie de Villiers, Willem Swartz and Isak van Wyk are thanked for assisting with the locating and monitoring of nests. We acknowledge the contribution by the late Richard Liversidge who provided literature, many fruitful discussions on raptors and comments on various manuscripts, while JJH was based at Nossob Camp in the KTP. Richard Dean and Peter Steyn commented on drafts of the manuscript.

References

Allan DG 1989. Strychnine poison and the conservation of avian scavengers in the Karoo, South Africa. *South African Journal of Wildlife Research* 19: 102–106

Anderson M 2001. Vultures nesting on electricity pylons. *African Wildlife* 55: 10

Anderson MD 1994. Mass African White-backed Vulture poisoning in the Northern Cape. *Vulture News* 29: 31–32

Anderson MD 1995. Mortality of African White-backed Vultures in the North-west Province, South Africa. *Vulture News* 33: 10–13

Anderson MD 2000a. Raptor conservation in the Northern Cape Province, South Africa. *Ostrich* 71: 25–32

Anderson MD 2000b. *The African White-backed Vulture Gyps africanus*. In: Barnes KN (ed) The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland. pp 75–77. BirdLife South Africa, Johannesburg

Anderson MD 2000c. Influx of Black-chested Snake Eagles. *Bee-eater* 51: 21

Anderson MD and Kruger R 1995. Power line electrocution of eighteen African White-backed Vultures. *Vulture News* 32: 16–18

Anderson MD and Maritz AWA 1997. *The status and distribution of vultures in the Northern Cape Province, South Africa*. In: Boshoff AF, Anderson MD and Borello WD (eds) Vultures in the 21st Century: Proceedings of a Workshop on Vulture Research and Conservation in Southern Africa. pp 37–45. Vulture Study Group, Johannesburg

Anderson MD and Taljaard FD 1994. *Farm reservoirs can be deadly for raptors*. *Farmer's Weekly*, 2 December 1994, pp 38–40

Anderson MD, Maritz AWA and Oosthuysen E 1997. *Vultures drowning in farm reservoirs*. In: Boshoff AF, Anderson MD and Borello WD (eds) Vultures in the 21st Century: Proceedings of a Workshop on Vulture Research and Conservation in Southern Africa. pp 98–101. Vulture Study Group, Johannesburg

Anderson MD, Maritz AWA and Oosthuysen E 1999. Raptors drowning in farm reservoirs: impacts on southern African populations. *Ostrich* 70: 139–144

Barnes KN 2000. *The secretary bird Sagittarius serpentarius*. In: Barnes KN (ed) The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland. p 139. BirdLife South Africa, Johannesburg

Barnes KN and Anderson MD 1998. *Important Bird Areas of the Northern Cape*. In: Barnes KN (ed) The Important Bird Areas of Southern Africa. pp 103–122. BirdLife South Africa, Johannesburg

Boshoff AF 1997. *The Black-chested Snake Eagle Circaetus pectoralis*. In: Harrison JA, Allan DG, Underhill LG, Herremans M, Tree AJ, Parker V and Brown CJ (eds) The Atlas of Southern African Birds. Vol. 1: Non-passerines. pp 198–199. BirdLife South Africa, Johannesburg

Boshoff AF and Allan DG 1997. *The Secretarybird Sagittarius serpentarius*. In: Harrison JA, Allan DG, Underhill LG, Herremans M, Tree AJ, Parker V and Brown CJ (eds) The Atlas of Southern African Birds. Vol. 1: Non-passerines. pp 152–153. BirdLife South Africa, Johannesburg

Bothma J du P, van Hoven S and le Riche EAN 1993. GPS-corrected and GIS-based remapping of the Kalahari Gemsbok National Park and the adjacent areas in Botswana. *Koedoe* 36: 105–108

Brown CJ 1988. Scavenging raptors on farmlands: what is their future? *African Wildlife* 42: 103–105

Brown CJ 1991. Declining Martial Eagle *Polemaetus bellicosus* and Tawny Eagle *Aquila rapax* populations and cause of mortality on farmlands in central Namibia. *Biological Conservation* 56: 49–62

Brown LH, Urban EK and Newman KB 1982. *The Birds of Africa*. Vol. 1. Academic Press, New York

Craib CL 1979. The African White-backed Vulture colony. *Witwatersrand Bird Club News* 107: 9–10

Dean WRJ and Simmons RE 2005. *The secretarybird Sagittarius serpentarius*. In: Hockey PAR, Dean WRJ and Ryan PG (eds) Roberts' Birds of Southern Africa (7th edn). Black Eagle Publishing, Cape Town

Funston P, Herrmann E and Forsyth E nd. *Kgalagadi Transfrontier Park Annotated Bird Checklist*. SANParks, Pretoria

Herholdt JJ 1995. *The Breeding Status (1988–1994) and Management of Raptors in the Kalahari Gemsbok National Park*. MTech thesis, Technikon Pretoria, South Africa

Herholdt JJ 1998. Survival threats and conservation management of raptors in the Kgalagadi Transfrontier Park. *Transactions of the Royal Society of South Africa* 53: 201–218

Herholdt JJ and de Villiers DJ 1989. Interesting bird observations in the Kalahari Gemsbok National Park (1988). *Mirafra* 6: 13–18

Jarvis AM, Robertson A, Brown CJ and Simmons RE 2001. *Namibian avifaunal database*. National Biodiversity Programme, Windhoek, Namibia

Kemp AC and Kemp MI 1975. Observations on the African White-

backed Vulture *Gyps africanus* in the Kruger National Park, with notes on other avian scavengers. *Koedoe* 18: 51–68

Kemp AC, Herholdt JJ, Whyte I and Harrison J 2001. Birds of the two largest national parks in South Africa: a method to generate estimates of population size for all species and assess their conservation ecology. *South African Journal of Science* 97: 393–403

Kruger R 1999. *Towards Solving Raptor Electrocutions on Eskom Distribution Structures in South Africa*. Unpublished MSc thesis, University of the Orange Free State, Bloemfontein, South Africa

Lewis AD 1936. Sand dunes of the Kalahari. *South African Geographic Journal* 19: 22–32

Liversidge R 1984. *The importance of national parks for raptor survival*. In: Ledger J (ed) Proceedings of the 5th Pan-African Ornithological Congress. pp 589–600. South African Ornithological Society, Johannesburg

Liversidge R 1994. *Long-term population fluctuations of large raptors in the southern Kalahari*. In: Meyburg B-U and Chancellor RD (eds) Raptor Conservation Today. pp 55–59. WWGBP/Pica Press, Berlin

Low AB and Rebelo AG 1996. *Vegetation of South Africa, Lesotho and Swaziland*. Department of Environmental Affairs and Tourism, Pretoria

Maclean GL 1993. *Roberts' Birds of Southern Africa.* John Voelcker Bird Book Fund, Cape Town

Monadjem A 2001. Observations on the African White-backed Vulture nesting at Mlawula Nature Reserve, Swaziland. *Vulture News* 45: 3–10

Monadjem A 2003. Nest site selection by African White-backed Vultures *Gyps africanus* in Swaziland. *Vulture News* 48: 24–30

Mundy P, Butchart D, Ledger J and Piper S 1992. *The Vultures of Africa*. Acorn Books CC and Russel Friedman Books, Randburg

Murn C 2001. *The Breeding and Foraging Distribution of African White-backed Vultures Gyps africanus in the Kimberley Area, South Africa, in Relation to Different Land Use Practices*. MSc thesis, University of Reading, Berkshire, UK

Nel JAJ 1990. Foraging and feeding of Bat-eared Foxes *Otocyon megalotis* in the south-western Kalahari. *Koedoe* 33: 9–16

Oatley TB, Oschadleus HD, Navarro RA and Underhill LG 1998. *Review of ring recoveries of birds of prey in southern Africa: 1948–1998*. Endangered Wildlife Trust, Johannesburg

Simmons RE 2005. *Black-chested Snake Eagle Circaetus pectoralis*. In: Hockey PAR, Dean WRJ and Ryan PG (eds) Roberts' Birds of Southern Africa(7th edn). Black Eagle Publishing, Cape Town

Steyn P 1982. *Birds of Prey of Southern Africa*. David Philip, Cape Town

Tarboton W 2001. *A Guide to the Nests and Eggs of Southern African Birds*. Struik, Cape Town

Tarboton WR and Allan DG 1984. *The Status and Conservation of Birds of Prey in the Transvaal*. Transvaal Museum Monograph No. 3. Transvaal Museum, CTP Book Printers, Cape Town

van Rooyen CS 2000. An overview of vulture electrocutions in South Africa. *Vulture News* 43: 5–22

van Rooyen TH 1984. The soils of the Kalahari Gemsbok National Park. *Koedoe* 27: 45–61

van Zyl AJ 1992. Do breeding pairs of Martial Eagles hold 'supernormal' territories? *Gabar* 7: 9–10

Watson RT 1984. *Home range and habitat utilisation of the bateleur: a preliminary study.* In: Mendelsohn JM and Sapsford CW (eds) Proceedings of the 2nd Symposium on African Predatory Birds. pp 43. Natal Bird Club, Durban

Received February 2005, accepted November 2005
Editor: WRJ Dean