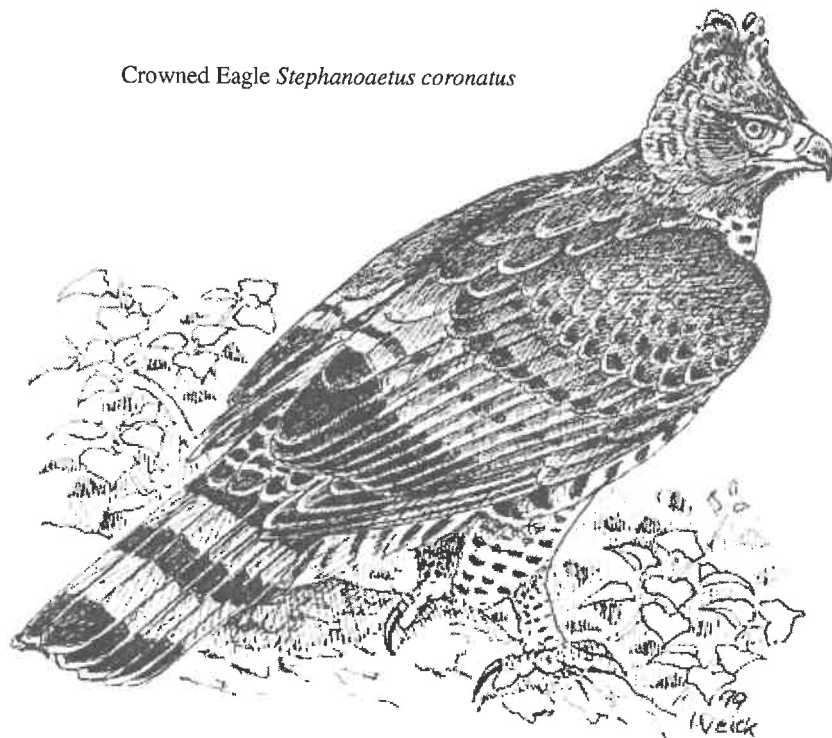


Part 10

Impact of Electricity Utility Structures on Raptors

Crowned Eagle *Stephanoaetus coronatus*



Conveners:

Chris van Rooyen & Peter Nelson

Raptor Mortality on Powerlines in South Africa

Chris S. van Rooyen

INTRODUCTION

Eskom is the largest electrical utility in Africa. To accomplish its mission "to supply the world's lowest cost electricity to encourage growth and prosperity", without negative environmental effects presents a significant challenge to the company. In 1996, Eskom's network of powerlines amounted to 255,745 km (158,847 miles) (Eskom 1996). After numerous vultures were electrocuted on an 88 kV powerline, a subsequent study revealed that bird mortalities on the electricity network were much higher than originally envisaged.

The southern African experience with regard to wildlife interactions and electricity structures is (with some notable exceptions) generally characterised by an *ad hoc* approach, fragmented documentation, inconsistency of data and few "before and after" studies. The vast distances, poor coordination and integration of mitigation efforts as well as discontinuity and duplication further exacerbated the problem.

Eskom has had an informal alliance with the Endangered Wildlife Trust (EWT), an environmental non-government organisation focusing on promoting the region's biodiversity, since 1978. In view of the complexity, scope and persistence of the problem of interactions between wildlife and utility networks, Eskom and EWT formalised their long-standing relationship by entering into a partnership at the end of 1995 to address the problem in a systematic manner on a national basis.

HISTORICAL OVERVIEW

There are no records of interactions between raptors and electricity structures in southern Africa documented in biological literature prior to 1972 (Ledger 1996). In that year a note on mortality of Cape Griffons on 88 kV distribution lines in the former Transvaal province of South Africa was published in the journal *Nature* (Markus 1972). Later Ledger and Annegarn (1981) revealed a serious problem for vultures on 88 kV lines where the so-called kite structure was used. In response to this problem, the South African national supplier of electricity, Eskom (then known as the South African Electricity Supply Commission), established the Bird Research Committee in 1978, which later developed into the voluntary Eskom Wildlife Impacts Advisory Committee (EWIAC). Dr. John Ledger, the current director of the Endangered Wildlife Trust (EWT), acted as consultant on wildlife matters to EWIAC from 1978 to 1996.

Considerable progress was made in terms of finding solutions for the problem of raptor electrocutions. The knowledge and experience gained were summarised in 1988 in the Eskom Bird

Identification Guide, which offered practical advice on how to deal with bird related problems (Ledger 1988).

Despite efforts by members of EWIAC to communicate recommendations throughout the organisation, implementation of solutions did not always take place in a satisfactory manner. In 1995 a serious incident involving the electrocution of vultures on 88 kV structures in the North-West Province of South Africa prompted Eskom to look afresh at the problem of wildlife interactions with its electricity structures (Verdoorn 1996).¹ A subsequent investigation into the matter revealed that the following factors had, (and to some extent still have) a major impact on the effective management of this issue (Van Rooyen 1996):

- Discontinuity due to staff turnover.
- *Ad hoc* approach to problems.
- Lack of ornithological expertise among Eskom technical staff.
- Little integration and coordination of efforts to reduce wildlife mortalities on electricity structures.
- Ineffective communication resulting in duplication of efforts and/or application of ineffective solutions to problems.
- Very little monitoring of the effectiveness of implemented mitigation measures.
- Lack of systematic data collection

The problem of negative interactions between wildlife and electricity structures is an international one, and has given rise to a vast amount of literature. Studies in southern Africa deal largely with biological and engineering perspectives i.e. the impact on species that may be biologically significantly affected, and engineering solutions to the problem (Ledger & Annegarn 1981; Ledger 1983; Ledger 1984; Hobbs & Ledger 1986a; Hobbs & Ledger 1986b; Hobbs *et al.* 1990; Mundy *et al.* 1992; Ledger 1992; Ledger *et al.* 1992;). This has also been the case elsewhere (Hess 1996; Galushin 1996; Harness 1996; Janss & Ferrer 1996;). Studies often take the form of a pre- or post-construction study with regard to specific structures (McCann & Wilkens 1995).

Co-operative management has only lately been recognised as a vitally important aspect in the field of electricity/wildlife interactions (Olendorff *et al.* 1996). Without a proper, integrated management system, incorporating biological, engineering and economic perspectives, any large-scale effort to reduce or eliminate negative interactions between wildlife and electricity structures is bound to run into difficulties sooner or later (Van Rooyen 1996; Van Rooyen *et al.* 1998).

Persistent problems previously thought to have been solved, led to the formation of an Eskom-Endangered Wildlife Trust Strategic Partnership (the Partnership) in 1996. The goal of the Partnership is the establishment of an integrated management system to reduce negative interactions between wildlife and electricity infrastructures to within acceptable levels, by systematically managing it in an integrated manner².

METHODS

Systematic data capturing on raptor electrocutions started on 1 August 1996, and is still continuing. Raptor electrocutions are reported to the Partnership co-ordinator by Eskom staff and members of the public through a toll-free line at the headquarters of the Endangered Wildlife Trust. Whenever possible, volunteer field investigators follow up with field investigations at the site of the incident to

¹ The remains of many electrocuted Cape Griffons and African Whitebacked Vultures were found under an 88 kV line after farm labourers alerted the landowner, who then contacted Eskom.

² It goes without saying that any attempt to completely eliminate negative interactions between birds and electricity structures would inevitably fail due to the sheer number of interactions, as well as the enormous size of the electricity grid. For the same reasons detailed bird impact assessment studies *for each incident* fall outside the scope of the Partnership. The focus is on the provision of hands-on, practical advice to Eskom staff to deal with problems encountered in the course of their everyday duties. However, the identification of opportunities for dedicated research and the facilitation of such research fall well within the scope of the Partnership.

capture as much data as possible, *inter alia*:

- Species impacted upon
- Type of structure involved

The following wildlife mortalities have been reported to the Partnership:

Table 1. Birds killed through collisions with electricity structures during the period 1 August 1996 to 1 August 1998

<i>All species</i>	<i>Raptors</i>
480	25

Table 2. Raptors killed through collisions with electricity structures during the period 1 August 1996 to 1 August 1998

<i>Species</i>	<i>Number</i>	<i>Conservation status</i>
Cape Griffon <i>Gyps coprotheres</i>	7	Vulnerable*
Secretarybird <i>Sagittarius serpentarius</i>	7	
African Whitebacked Vulture <i>Pseudogyps Africanus</i>	4	
Tawny Eagle <i>Aquila rapax</i>	2	Endangered**
African Hawk Eagle <i>Hieraaetus spilogaster</i>	1	
Barn Owl <i>Tyto alba</i>	1	
Blackbreasted Snake Eagle <i>Circaetus pectoralis</i>	1	
Martial Eagle <i>Polemaetus bellicosus</i>	1	Vulnerable*
TOTAL	25	

* South African Red Data book - Birds (Brooke, 1984)

** The Atlas of Southern African Birds (Harrison *et al.* (eds), 1997)

Table 3. Wildlife killed through electrocution on electricity structures during the period 1 August 1996 to 1 August 1998

<i>All species</i>	<i>Raptors</i>
232	158

DISCUSSION

1. Collision

Raptors comprised only 5% (n=25) of all reported collision mortalities (n=480). The relatively low collision rate corresponds with other studies (Ferrer *et.al.* 1991), and indicates that generally speaking collisions with powerlines are not a major cause of unnatural raptor mortality. The only southern African raptor that seems to be relatively susceptible to collisions with powerlines, is the solitary, semi-terrestrial Secretarybird. No detailed study has been made to date to clarify this phenomenon, but from anecdotal accounts from farmers and Eskom field staff, it would seem that human disturbance that causes birds to flush and fly blindly into overhead lines may play a major role.

2. Electrocution

Raptors (n=158) make up 68% of all reported wildlife electrocutions (n=232). This may be a function not only of raptor behaviour i.e. using electricity structures for perching roosting and nesting purposes, but also of the high profile that raptors currently enjoy among the general public and Eskom staff in particular (pers.obv.).

Table 4. Raptors killed through electrocution on electricity structures during the period 1 August 1996 to 1 August 1998

<i>Species</i>	<i>Number</i>	<i>Conservation status</i>
African Fish Eagle <i>Haliaeetus vocifer</i>	1	
African Hawk Eagle <i>Hieraaetus spilogaster</i>	1	
African Whitebacked Vulture <i>Pseudogyps africanus</i>	31	
Barn Owl <i>Tyto alba</i>	12	
Black Eagle <i>Aquila verreauxii</i>	7	
Blackbreasted Snake Eagle <i>Circaetus spilogaster</i>	2	
Blackshouldered Kite <i>Elanus caeruleus</i>	2	
Brown Snake Eagle <i>Circaetus cinereus</i>	1	
Cape Griffon <i>Gyps coprotheres</i>	40	Vulnerable*
Eastern Redfooted Kestrel <i>Falco amurensis</i>	1	
Giant Eagle Owl <i>Bubo lacteus</i>	3	
Greater Kestrel <i>Falco rupicoloides</i>	2	
Gymnogene <i>Polyboroides typus</i>	1	
Jackal Buzzard <i>Buteo rufofuscus</i>	5	
Lanner Falcon <i>Falco biarmicus</i>	1	
Longcrested Eagle <i>Lophaelus occipitalis</i>	3	
Marsh Owl <i>Asio capensis</i>	1	
Martial Eagle <i>Polemaetus bellicosus</i>	10	Vulnerable*
Pale Chanting Goshawk <i>Melierax canorus</i>	2	
Peregrine Falcon <i>Falco peregrinus</i>	1	Rare*
Spotted Eagle Owl <i>Bubo africanus</i>	8	
Steppe Buzzard <i>Buteo buteo</i>	3	
Tawny Eagle <i>Aquila rapax</i>	1	Endangered**
"Eagle"	2	
"Owl"	7	
"Raptor"	1	
"Vulture"	10	
TOTAL	158	

* South African Red Data book - Birds (Brooke, 1984)

** The Atlas of Southern African Birds (Harrison *et al.* (eds), 1997)

Table 5. Type and number of structures implicated in the electrocution of raptors for the period 1 August 1996 to 1 August 1998

<i>Type of structure</i>	<i>Number</i>	<i>Percentage of total</i>
Predominantly steel *	59	42.1%
Non-earthed T-structure	8	5.7%
Earthed T-structure	22	15.7%
Terminal structure**	31	22.1%
Other	20	14.2%

* Includes both an all-steel structure and a wooden structure with energised components attached to a steel cross-arm.

** A typical terminal structure incorporates surge arrestors, a transformer, jumper cables and a bonded and earthed cross-arm.

African Whitebacked Vultures (n=31) and the closely related Cape Griffons (n=40) together make up 44% of all reported raptor electrocutions. If it is assumed that the unidentified electrocuted vultures (n=10) are Cape Griffons and African Whitebacked Vultures, the percentage is 51%.³ It is submitted that the comparatively high number of electrocutions reported for these species can be attributed to a combination of the following factors:

- Both species are large with wingspans of more than 2 metres, that makes them vulnerable to electrocution, as they easily bridge the air gap between two energised components or an energised and an earthed component.
- Both species congregate in large numbers when feeding. This leads to multiple electrocutions on electricity structures in close proximity to carcasses utilised for feeding.
- Feeding vultures of these species are often the first indication to a farmer of possible stock losses, who finds and reports electrocuted birds on closer inspection.

It is difficult to assess the impact of electrocution on Martial Eagles. Electrocution of this species on Eskom structures is not a new phenomenon (Smith 1992).⁴ The relatively low number of Martial Eagles (n=10) reported to the Partnership may be due to a combination of low numbers and low reporting rate, but does not necessarily mean that the impact is not biologically significant:

- Although widespread, Martial Eagles are thinly distributed on the ground, with extensive territories, anything from a 100 to a 150 km² (Tarboton *et.al.* 1989). The electrocution of a single eagle or a pair of eagles in such a vast area could easily escape attention, unless it causes a permanent electrical fault (which rarely happens).
- Apart from electrocution, Martial Eagles face a host of other man-induced threats i.e. direct persecution by small-stock farmers, indirect persecution through poisoning, drowning in sheer-walled reservoirs and reduction of natural prey through habitat alteration and degradation (Boshoff 1997). It is therefore not surprising that a decrease in numbers has been reported from many parts of southern Africa (Boshoff 1997).⁵

Tawny Eagle numbers have crashed dramatically over the past two decades and the species is now considered to be one of the most threatened eagles in southern Africa, with centres of distribution now confined to major protected areas and sparsely inhabited regions (Simmons 1997). Electrocution no doubt poses a real threat to existing populations, and despite the fact that only a single electrocution was reported, it remains a cause for concern. This figure no doubt does not reflect the true electrocution induced mortality, and/or could be a function of the already low numbers of this species. Further investigation of this issue is urgently required.

3. Structure types

Steel structures comprised 42.1% of all structures that were implicated in raptor electrocutions. This emphasises the lethal nature of steel structures to raptors, as the number of steel structures used in the reticulation network is far outnumbered by wood poles (pers. obs.), yet they seem to cause the majority of electrocutions. The steel structures most commonly implicated are the so-called 88 kV Kite-structure and the 88/132 kV Delta suspension structure.

The problem of electrocutions on Kite-structures was thought to have been solved after they were fitted with perches and PVC spirals wrapped around the centre conductor clamp to form a "basket" to prevent birds from touching them.

However, investigations into continued electrocutions on Kite-structures thought to have been rendered safe in the manner described above, revealed that the problem had not been solved (Van Rooyen 1998).

³ The area from where these electrocutions were reported has a history of electrocutions of Cape Griffons and African Whitebacked Vultures, and these two species are the only vultures known to occur there in large numbers.

⁴ During an Eskom survey in 1992 among farmers in what was then the north-eastern Cape Province of South Africa in an area of 7 square kilometres, farmers reported 22 Martial Eagles and 16 unidentified eagles presumably killed through electrocution on electricity structures, over an unknown period of time.

⁵ At least two farmers from the Burgersdorp region in the north Eastern Cape have categorically stated to the author that they each lost Martial Eagle pairs breeding on their farms through electrocution about a decade ago, which have not been replaced since.

Figure 1. Delta suspension structure

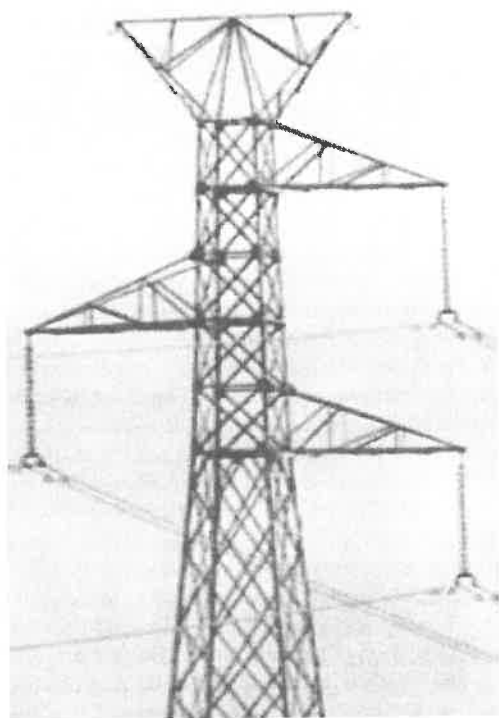


Figure 2. Kite structure

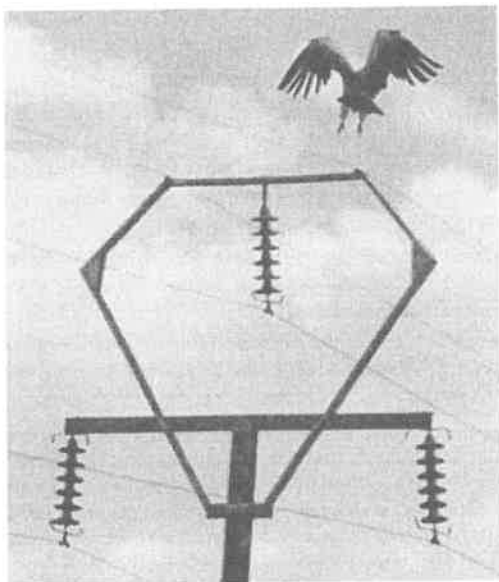
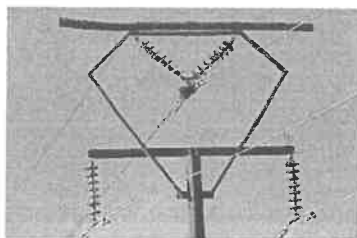


Figure 3: Kite structure modified with perch and PVC “basket” wrapped around the centre conductor clamp.



A new approach was tried i.e. to stretch two inter-linked PVC spirals directly above the bottom cross-arm to form an obstacle, thereby effectively preventing the vultures from landing on the bottom cross-arm. This seems to have reduced the rate of electrocutions, but the problem has not been entirely solved⁶.

On the Delta suspension structure, birds are electrocuted presumably when they take off from or land on the lowest cross-arm. The vultures prefer to perch on the extreme end of the cross-arm, right above the string insulator (pers.obs.). Another possibility (believed widely by Eskom field staff) is that the birds often excrete before taking off, thus bridging the critical gap between conductor and cross-arm, and causing a phase to earth fault.

Various bird guards have been proposed to prevent the birds from perching above the insulator, but by preventing the bird from perching on the structure, the problem is simply transferred to the next structure. An attempt was made to accommodate the birds by fixing PVC spirals to the conductor around the insulator clamp to create a barrier to the wing-tips touching the conductor at the moment of landing (as was done with the 88 kV Kite constructions). Although this method initially rendered positive results, electrocutions were again reported from poles modified in this manner. A possible explanation might be that the spirals themselves become energised after a couple of years, and/or the fact the Cape Sparrows *Passer melanurus* have taken to nesting inside the spirals (pers.obs.), thereby seriously reducing their insulating effect. Steps are currently being taken to physically modify the design of these poles in order to eliminate the electrocution problem.

A design that is becoming increasingly popular with Eskom for 88 kV and 132 kV feeders due to its relatively cheap construction, little impact on the physical environment, ease of construction and limited visual impact, is the new 259 series. These are single, earthed steel poles with three staggered insulators, each 1.5 metres in length. The areas through which many of these powerlines will run harbour populations of large scavenging birds such as Cape Griffons and African Whitebacked Vultures, and large eagles such as Martial and Black Eagles. These birds will almost certainly attempt to perch on the new poles, and specifically the insulators. In the process, the bird will most probably not be able to secure a firm foothold on the slippery insulator. Given the length of the insulator relative to the wingspan of these species, the chances of a phase to earth fault in the process are considerable, not only resulting in the electrocution of the bird, but also causing problems in the power supply.

The EWT through the Partnership expressed concern over the electrocution potential of this design. Eskom design engineers have undertaken that poles of this design will be fitted with a wooden perch fastened to the top of the pole as a standard feature in specific areas, to create perching space for birds, if so advised by the EWT.

The next most common structures implicated in electrocutions (22.1%), are terminal structures. The lethal nature of terminal structures has been recognised elsewhere (Harness 1997), as well as in southern Africa (Smith 1992, Ledger *et al.* 1992).

⁶ On a 10km stretch of line modified in this manner, electrocutions have dropped to two to three a year.

Figure 4. Steel suspension structure Type 259

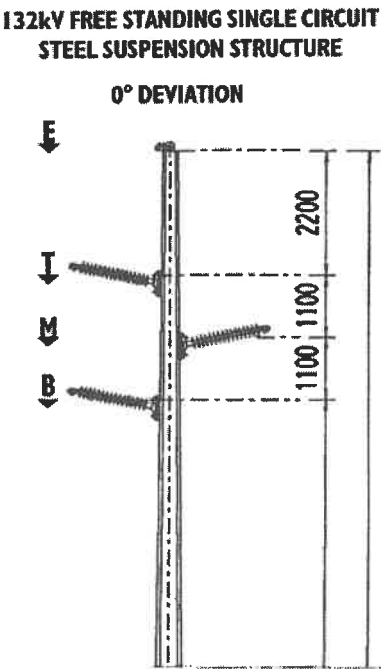
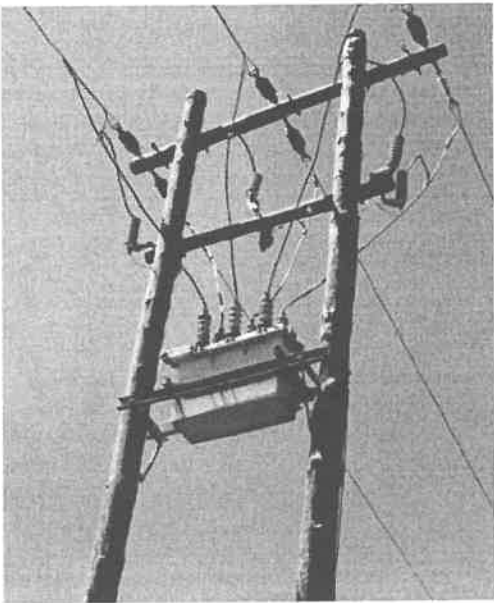


Figure 5. Terminal structure with pole mounted transformer



These structures are particularly lethal because of the following reasons:

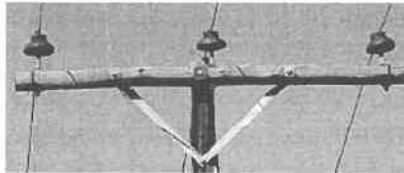
- Minimal phase to phase and phase to ground spacing between the energised components, particularly the bare jumper cables connecting transformers, protective switches and surge arrestors.
- Terminal structures often serve water pumps in remote, arid areas to provide surface water for livestock. Raptors are drawn to the water for drinking and bathing purposes, and get electrocuted on the terminal structure. This problem is likely to be aggravated by wet feathers.
- Virtually every farmyard in South Africa has one or two terminal structures. Barn Owls and Spotted Eagle Owls often frequent farm yards, presumably for the nesting opportunities in barns, and the large rodent populations often associated with farm yards. They use the terminal structures as convenient hunting perches with fatal consequences. Neither the Barn Owl nor the Spotted Eagle Owl is presently regarded as threatened in southern Africa, but the situation needs careful monitoring.

A factor that may also explain the high incidence of reports of birds electrocutions on terminal structures, is that birds killed on these structures are more likely to be noticed and reported than those on other structures, since terminal structures are frequently visited by landowners, or Eskom staff (for maintenance purposes).

To render the terminal structures safe for raptors and other birds, suitable insulation is fitted to all the jumper leads above the cross-arm, and to the jumpers running to the transformer. Lightning arrestors are now fitted on the transformer rather than the cross-arm, eliminating the need for jumper leads on the top cross-arm. In several areas, the systematic modification of terminal structures to render them harmless for birds, have started. The process is however far from being completed and many thousands of these lethal structures still dot the landscape of South Africa.

T-structures accounted for 21.4% of reported raptor electrocutions. The T-structure is a very common design, and probably comprises the majority of 11 and 22kV rural structures in southern Africa. In many cases, an earthwire for lightning protection runs up the pole and terminates in a spike between the middle and an outer insulator on the 2.5 metre cross-arm. The potential for phase to phase, or phase to earth electrocutions on such structures is clearly high.

Figure 6. T-structure with earthwire

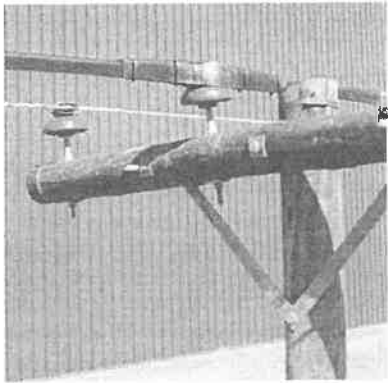


T-structures can be rendered safe by cutting a 500 mm gap in the earth wire (or removing the earth spike completely and terminating the earthwire just below the cross-arm braces), in conjunction with insulation of the middle phase conductor. This is done by fitting the locally developed RP 3 Raptor Protector (Ledger 1992).

An important milestone for the Partnership was Eskom agreeing to fit approximately 683 km (6830 poles) of reticulation lines in the raptor rich Molopo area in the North-West Province of South Africa with RP3 Raptor Protectors. The programme started in March 1998 and will run over the next six years, at a cost of approximately R 600,000 (US\$ 120,000) to Eskom⁷. This action was decided upon after a risk assessment was conducted by the Partnership to establish the risk that the reticulation network posed to raptors in the area. The possibility to fit RP3 Raptor Protectors with a link-stick under live-line conditions to save costs and speed up the programme is currently being investigated, and field tests with an experimental link-stick will soon commence.

⁷ To date, approximately 1800 out of a total of 6830 structures have been retrofitted.

Figure 7: T-structure fitted with RP3 Raptor Protector



4. Implementation of mitigation measures to minimise raptor electrocutions

The following table illustrates the progress made with the retrofitting of lines in South Africa at locations where raptor electrocutions occurred as identified by the Partnership in the period 1 August 1996 to 1 August 1998 (Eskom structures only)⁸.

<i>Number of locations identified</i>	<i>Number of locations recommended to be retrofitted</i>	<i>Number of locations retrofitted by Eskom</i>	<i>Percentage retrofitted</i>
78	48	15	31%

These statistics should be interpreted in the light of the following:

- The 48 locations for which retrofitting was recommended accounted for 77.8% of reported raptor mortalities.
- Supplies of mitigation measures seem to be generally low. The long waiting period (6 weeks) from date of order to delivery are causing bottlenecks.
- The complexity of the problem prevents the immediate application of mitigation measures in some instances. No suitably tested device exists at this stage that can be fitted to alleviate the problem of electrocution of vultures on 132 kV structures.
- Mitigation measures thought to have solved problems in the past are not entirely effective. This seems to be the case with vulture electrocutions on 88 kV and 132 kV structures.
- Field services staff, as reasons for delays, often cite budget, time and manpower constraints. The various Eskom procedures to be followed to obtain authorisation for capital expenditure can seriously hamper mitigation efforts, since obtaining the necessary funding for mitigation measures is often a protracted process.
- Confusion among field services staff as to what mitigation measures to apply and the procedures involved in acquiring them. This is in the process of being addressed by Eskom's line design departments after it was brought to their attention by the Partnership in order to standardise procedures and standards where possible.
- Difficult terrain and adverse weather conditions (wet conditions) prevent the speedy fitting of mitigation measures in some instances.

⁸ This does not take into account the Molopo retrofitting scheme.

- The remoteness of certain areas where negative interactions occur. This leads to delays in the investigation of incidents, as field investigators sometime have to travel hundreds of miles to conduct investigations.
- Work pressure and other priorities often prevent action from being taken. Unfortunately, not all Eskom employees regard attempts to address wildlife interactions as an important part of their work, as awareness and attitude vary greatly within Eskom from region to region.
- Organisational restructuring within Eskom leads to huge delays in the completion of projects, or even *de facto* termination of projects in certain cases.

In conclusion it must be mentioned that the fitting of mitigation devices to powerlines has also produced other positive spin-offs for Eskom, particularly in terms of their image with their customers. Many landowners have contacted the EWT to express their appreciation at Eskom's response to their concerns about birds being killed on their property.

CONCLUSION

The EWT/Eskom Strategic Partnership has been in existence for two years. In that time it has made some progress towards achieving its goal of an integrated management system to reduce negative interactions between wildlife and electricity infrastructures. It is equally clear, however, that a lot remains to be done. The problem of raptor electrocutions in South Africa (and the rest of the world) is far from solved and remains a difficult and unavoidable challenge to engineers, conservationists and managers.

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