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THE EXTENT, COST AND CONTROL OF LIVESTOCK PREDATION BY EAGLES WITH A CASE STUDY ON BLACK EAGLES (*AQUILA VERREAUXII*) IN THE KAROO

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Intense persecution of predators in the sheep-farming Karoo region of South Africa has been suggested as the reason for irruptions of rock hyrax (*Procavia capensis*) which have caused significant damage to vegetation resources in the past (Thomas 1946, Kolbe 1967, Rubidge in Kolbe 1983). I carried out a 5-yr field study in and around the Karoo National Park (KRNP) near Beaufort West to assess the costs and benefits of Black Eagles (*Aquila verreauxii*) to Karoo farmers (Davies 1994). This paper summarizes the harm that Black Eagles may cause on farmland, and this is discussed in relation to livestock predation by eagles worldwide, and it appraises possible management solutions for problem situations.

Predators can cause major losses to livestock ranching operations (O'Gara et al. 1983). Predators may only remove a small percentage of sheep flocks, but these fractions may amount to great financial loss when applied to nationwide livestock numbers (U.S. Fish and Wildlife Service 1978, Texas Crop and Livestock Reporting Service 1979, Lawson 1989). Bounty systems, that resulted in the destruction of millions of predators, have been invoked to avert such losses, but they have been largely ineffectual, and most have now been discontinued (Hey 1959). Large eagles have not been exempt from bounty systems and they have been persecuted in all the major sheep-farming regions where they occur (Brown 1976). Kill rates of Wedge-tailed Eagles (*Aquila audax*) in Australia (Leopold and Wolfe 1970) were held to be the highest for any large raptor worldwide (Brown 1975), but they were much lower than kill rates of Black and Martial (*Polemaetus bellicosus*) Eagles claimed by farmers in parts of the Karoo in the 1960s (Siegfried 1963).

Has such persecution been based on any factual evidence of eagles killing livestock? Golden (*Aquila chrysaetos*) and Crowned (*Stephanoaetus coronatus*) Eagles have killed prey (including domestic sheep) weighing 20–50 kg (Lehti 1947, Cooper 1969, Bruns 1970, Skogland 1974, Svendsen 1980, Steyn 1982, O'Gara et al. 1983, Bergo 1987). Large eagles are, therefore, capable of killing domestic sheep up to about half adult size, so the issue appears to be not whether they kill domestic lambs, but to what extent does this occur and under what circumstances.

Most ranchers maintain that only small lambs (<10-d old) are vulnerable to eagle attack (Arnold 1954, Wiley and Bolen 1971, Palmer 1983). It is immature eagles that most often become involved in livestock depredations (Foster and Crisler 1979, O'Gara 1978). The Golden Eagle is the chief offender in the northern hemisphere. Only three species of *Haliaeetus* have been recorded killing lambs in North America, Europe and Australia, but there is little evidence to support these accusations. In Australia, lamb-killing by Wedge-tailed Eagles has been confirmed (Brooker and Ridpath 1980) and, in Africa Martial Eagles (plains), Black Eagles (mountains) and Crowned Eagles (forests) are regularly accused of killing lambs, with some confirmation that they do. There is little overlap between the ranges of large, forest-dwelling eagles and the major sheep farming regions of the world.

Domestic lamb remains comprised 1.1% of the 3586 prey items collected beneath Black Eagle nests in and around the KRNP, and, 1.6% of those collected solely beneath farm nests. Domestic lambs comprised a similar proportion of 389 prey items delivered to nests as monitored by time-lapse photography, and of sightings of fresh prey on the nest. With an estimate of prey capture rate (173 prey/pair/yr), this indicated that a resident pair of Black Eagles normally consumed three lambs per year on Karoo farmland. In other regions of the Cape, Black Eagles may consume more domestic lambs since they comprised 8% of prey remains collected in the heavily-vegetated Eastern Cape (Boshoff et al. 1991). Bolen (1975) observed that livestock comprised a greater portion of Golden Eagle diet in areas of thick brush in Texas, where

natural prey was highly abundant but presumably less vulnerable. While these collections of eagle prey indicate that domestic livestock represent a very small portion of large eagle diets, they should, however, be interpreted cautiously. They only reflect diet of breeding birds during the nesting season and we know that nonbreeding eagles cause more harm. The collections may also be biased because remains of large animals like lambs tend to decompose more slowly nor do they indicate whether lambs delivered to nests were killed or scavenged (Matchett and O'Gara 1987). Lockie (1964) showed that only three of 10 assayable lamb carcasses brought to Golden Eagle nests were killed by eagles.

I observed resident Black Eagles for 55 d. During this time, I did not see any attacks on livestock, but I observed the eagles scavenging on domestic sheep twice. During 80 d of observation on Merino sheep as part of another study, I witnessed regular attacks by an immature Martial Eagle on various natural prey, but the eagle ignored 40 vulnerable Merino lambs which occasionally bedded directly beneath one of the eagle's roost trees. Birds, including raptors, are known to become 'imprinted' or 'wedded' to particular food types if these are fed to the exclusion of all else during sensitive developmental phases in the nestling period (Woodford 1966, Rabinowitch 1969, Hess 1973, Immelmann 1975). Infrequent predation on domestic lambs by eagles in the Karoo, despite high availability and vulnerability of this prey, may be explained if most young eagles are raised on a diet of natural prey items. Greater incidence of eagle predation on goat kids rather than sheep lambs has been attributed to poor attendance by nannies (Glover and Heugly 1970) and isolation in rough terrain (Nass et al. 1984), but goat kids bear a closer resemblance to juvenile antelope which are regularly killed by large eagles.

I interviewed farmers during 30 visits to farms in the central Karoo region, and some claimed extremely high kill rates of eagles in certain low-income districts. Despite this, there was no evidence for a decline in Black Eagle numbers in the Karoo so there is probably a large 'floating population' of nonbreeders. The majority of farmers were prepared to tolerate resident eagles until lamb killing was suspected. A minority of farmers took active steps to encourage eagles on their farms through the provision of artificial nest sites and rehabilitation of injured birds. Approximately half of the 37 farmers spoken to reported no lamb losses to eagles; 27% reported occasional losses and 24% reported significant losses including a few eyewitness accounts of kills.

Twelve questionnaire surveys of ranchers (worldwide) indicated that most ranchers believed that predators removed nearly 7% of lambs born (9% of lambs born were thought to die of other causes) (Fig. 1). However, estimates of predation are often exaggerated in these surveys (Nesse et al. 1976, Armentrout 1980, Boshoff 1980, Hewson 1981).

Field necropsies conducted on lamb carcasses found in lambing camps gave reliable data on causes of death and whether lambs killed by predators were dying from other causes (Rowley 1970, Wiley and Bolen 1971, Bowns et al. 1973, Brown 1976, Nesse et al. 1976, Tigner and Larson 1977, 1981, O'Gara 1978, Wade and Bowns 1980). Massive subcutaneous hemorrhaging surrounding irregularly-spaced talon punctures on the neck and upper back are prime indicators for eagle-killed lambs. Carcass inspections are considered to be the only realistic method for quantifying livestock predation by eagles and also provide good opportunities for constructive interaction with ranchers. I only examined 23 carcasses on visits to farms where eagles were allegedly killing lambs. None of these lambs were found to have been killed eagles. I also obtained data from 44 studies involving about 30 000 necropsies worldwide (Fig. 1). These results indicated that most ranching operations experience very low losses to predation but at a few 'problem situation' ranches very high losses probably occur. Necropsies show that predators remove only an average of 4.9% of lambs born as compared to the average of 13.7% lambs that die from nonviolent mortality factors.

Evidently ranching operations in Australia and especially South Africa and Scotland experience relatively low losses of lambs to predators; whereas North American operations experience relatively high losses (Fig. 2). This can be attributed to severe problems with coyotes (*Canis latrans*) in some parts of the U.S., and to the fact that inviable lambs (already dying to other causes) were not distinguished in most North American estimates of predation. Certain investigations provided data on the relative involvement of different predators. It is clear that wild and domestic canids cause the most damage to ranching operations. In South Africa, caracals (*Felis caracal*) cause significant losses, and in Australia feral pigs (*Sus scrofa*) are significantly

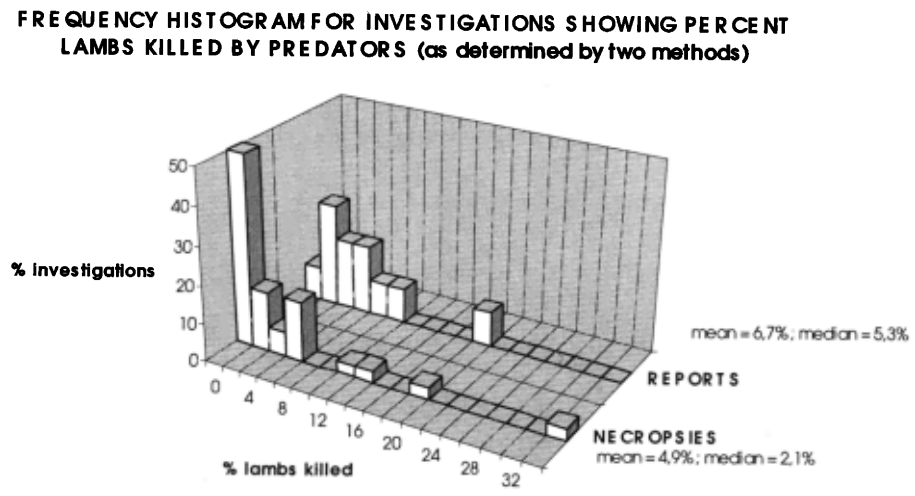


Figure 1. Percentage of lambs born that are killed by predators based on 12 questionnaires completed by ranchers and 44 investigations with field necropsies of dead lambs.

involved. Avian predation was less frequent than mammalian predation in all regions and losses to corvids exceeded those to eagles. Only in Scotland were eagles significantly involved in livestock predation, but this is based on only three studies and overall losses to predators were exceptionally low. Eagles were least involved in livestock predation in South Africa. Black, Martial and Crowned Eagles are all highly territorial and are not inclined to scavenge. There are no records of these eagles being attracted in large numbers to an abundance of dead or dying lambs, unlike Golden and Wedge-tailed Eagles.

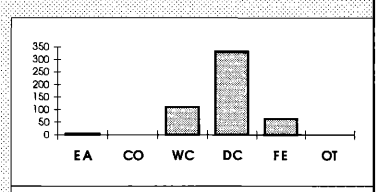
The average Karoo farm accommodates 1534 small livestock which annually produce roughly 820 juveniles. Using the extensive Australian data on neonatal mortality where Merino sheep are ranched under very similar conditions, 145 of these juveniles are likely to die before weaning, and predators are likely to be the prime cause for 14 of these deaths (estimated cost R999 = US$289). Using worldwide data, it is likely that eagles would be responsible for the death of only 0.32 lambs on the average Karoo farm annually (estimated cost R24 = US$7). Current South African data would indicate lower rates of loss but are not yet considered sufficiently complete for such calculations. This estimated cost of having Black Eagles on the farm is negligible and should be borne by farmers in order to conserve a potentially vulnerable species, especially in light of their ecological benefits. Population modeling of rock hyrax suggests that the cost in grazing of increased hyrax numbers in the absence of Black Eagles may be 150 times greater than the cost of lambs lost to eagles (Davies and Ferguson, in press). Eagles may also serve a valuable role on farmland by removing animals infected with rabies and other disease.

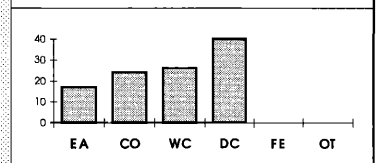
It is certain that eagles have caused problems on some African farms in the past and will do so again. So far translocation of problem eagles has proved unsuccessful (Matchett and O'Gara 1987). Five of eight translocated eagles in the Cape returned to their former ranges (Boshoff and Vernon 1988), and 12 of 14 translocated eagles in North America returned to former ranges (Phillips et al. 1991). Harassment of problem eagles by airplane, explosive charges and distress call tapes did not alleviate livestock losses in southwestern Montana, but human activity in the lambing paddocks did help (Matchett and O'Gara 1987). Field trials of food aversion using lithium chloride in lamb carcasses are not yet conclusive (Brand 1992), but trials on captive eagles in South Africa are planned and this method may still prove useful in the future.

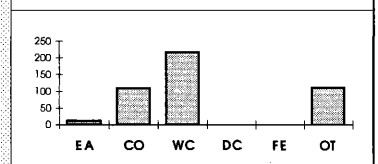
A recent trend in ranch management has been that small improvements in flock management may be far more beneficial to productivity than large-scale and often unsuccessful attempts to control predators. Most farmers are well aware that the provision of sufficient food and shelter is most im-

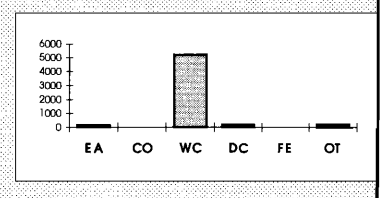
WORLDWIDE NECROPSY SURVEYS

	no. carcasses	% lambs lost to predators		% lambs lost to other causes	total lambs lost	% kills made by eagles
RSA	191	0.9	(healthy)	16.15	17.05	0.98
UK	1423	0.32	(healthy)	35.5	35.82	15.9
AUS	15704	1.66	(healthy)	16.81	18.47	2.46
NZ	?	?		16	?	0
USA	12660	6.42	(total)	6.42	12.92	2.25
WORLD	29978	3.91	(mixed)	11.23	15.14	2.38









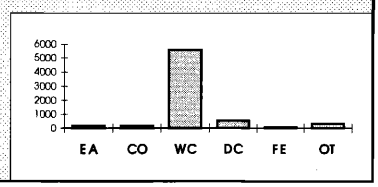


Figure 2. A geographical summary of results on neonatal lamb mortality derived from field necropsy surveys. RSA = South Africa; UK = United Kingdom; AUS = Australia; NZ = New Zealand; USA = United States. Losses are expressed as % of lambs born. American studies clump predation of both viable (healthy) and inviable lambs, whereas only healthy lambs are considered in other regions. Histograms to the right show the relative involvement of different predators in total small stock losses. EA = eagles; CO = corvids; WC = wild canids; DC = domestic canids; FE = felids; OT = other. Exact percentage predation attributable to eagles is given in the last column.

portant for successful lambing. Livestock are no longer gathered into 'kraals' for overnight protection in the Karoo, but there has been a successful return to this tradition in parts of Namibia. By far the simplest and most effective management technique employed in the Karoo to reduce lamb losses is to place a shepherd with the flock during the crucial lambing period. Farmers who employed shepherds reported no losses to eagles. Where flocks are not habituated to humans, scarecrows may be used successfully (Matchett and O'Gara 1987). Another simple management option currently employed by many Karoo farmers is to move their lambing flocks away from areas of eagle activity such as nests. This is especially important during July and August in the Karoo (spring lambing) when eagle nestlings are going through sensitive developmental phases and when dietary imprinting may occur. Removal of lamb carcasses from the lambing area prevents attraction of unwanted predators which may turn their attentions to live lambs when carrion becomes unavailable. If such management options fail to prevent livestock predation by problem eagles, these birds should be removed from the wild to prevent spread of a lamb-killing trait in the population. Captive-breeding programs, falconers and zoos can be considered as destinations for such birds.

Simply on the basis that lamb killing by eagles is very rare and can be dealt with, I would argue that large eagles are compatible with the open-range farming of small stock. Farmers must learn to tolerate compatible predators, especially in the case of vulnerable eagle populations. Conservationists must remain prepared to help farmers manage any problem situations that arise. Ecological benefits to farmers (which are obvious for black eagles in the Karoo) can be stressed to win the case for large eagles in sheep-farming areas, but future survival of wildlife should not have to depend on a significant financial gain to society, and education programs should also aim to instill an aesthetic appreciation of these predators.

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