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DECLINE OF RAPTORS OVER A THREE-YEAR PERIOD IN LAIKIPIA, CENTRAL KENYA

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ABSTRACT.—Raptors were monitored monthly over a three-year period in a protected area in central Kenya. The number of raptors declined more than 40% per year. Scavenging birds accounted for most of the decline; sightings decreased by 70% during our surveys, although these declines were not statistically significant. During the time of the study, the overall populations of large wild herbivores showed little change, whereas domestic herbivores, particularly sheep and goats, increased markedly, suggesting that food limitation was not the cause of the vulture declines at the study site. Possible causes of raptor decline include the consumption of poisoned baits, which are placed by pastoralists to kill large predators that attack livestock. Scavenging birds provide one of the most important yet underappreciated ecosystem services of any avian group. The rapid decline of scavenging birds, especially vultures, in central Kenya warrants additional population monitoring to understand whether declines are local or regional, and to elucidate causes of population decreases.

KEY WORDS: *Africa*; *decline*; *Furadan*; *livestock*; *poisoning*; *raptors*; *vulture*.

DISMINUCIÓN DE AVES RAPACES DURANTE UN PERIODO DE TRES AÑOS EN LAIKIPIA, KENIA CENTRAL

RESUMEN.—Las aves rapaces fueron monitoreadas mensualmente por un periodo de tres años en un área protegida en el centro de Kenia. El número de aves rapaces disminuyó en más de un 40% por año. Las aves carroñeras fueron el grupo que dio cuenta de la mayor parte de esta disminución ya que sus avistamientos disminuyeron en un 70% durante nuestros muestreos, pero estas disminuciones no fueron estadísticamente significativas. Durante el periodo de nuestro estudio, la población de grandes herbívoros silvestres no varió mucho, mientras que la población de herbívoros domésticos, principalmente ovejas y cabras, aumentó considerablemente, lo que sugiere que la limitación de alimento no fue la causa de la disminución de los buitres en el sitio de estudio. Las posibles causas de la disminución de aves rapaces incluyen el consumo de cebos envenenados que son colocados por los pastores locales para matar depredadores de gran tamaño que atacan a su ganado. Entre todos los grupos de aves, las carroñeras proveen uno de los servicios ecosistémicos más importantes y más subestimados. La rápida disminución de aves carroñeras en Kenia, especialmente de los buitres, justifica monitoreos poblacionales adicionales para entender si estas disminuciones son locales o regionales y para elucidar sus posibles causas.

[Traducción del equipo editorial]

National parks and other protected areas are playing an increasingly important role in the conservation of raptors (Liversidge 1984, Thiollay 2006). Not surprisingly, protected areas are critical refuges for most raptor species and they harbor the bulk of large raptor populations in Africa (Sorley and Andersen 1994, Herremans and Herremans-Tonnoeyr 2000, Thiollay 2006). Outside protected areas, raptors face increased threats associated with human activities including deforestation, overgrazing, increase in pesticide use, poisoning of predators, overhunting, and direct persecution (Thiollay 2006).

Raptors living within protected areas are assumed to be relatively free from these disturbances. However, substantial increases in human population have occurred in recent decades and protected areas are

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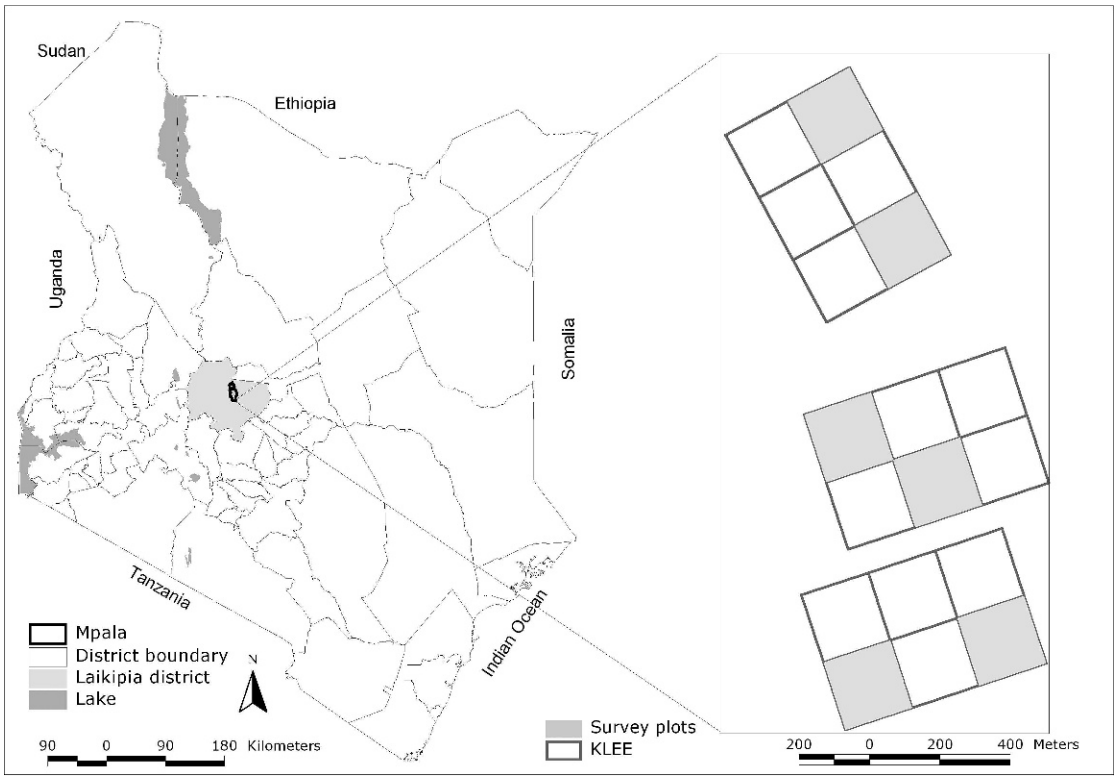

Figure 1. Location of the Mpala Research Centre within Laikipia District in central Kenya.

not immune to the pressures this has created on limited natural resources. A recent study showed that raptor numbers within 30 km of protected area boundaries were more than 40% lower than in the core, indicating a large edge effect on populations inside protected areas (Herremans and Herremans-Tonnoeyr 2000). In addition, some raptors, most notably vultures and large eagles, travel large distances in search of food and require extensive territories for breeding, making them more likely to range outside of protected areas to locations where they may become vulnerable to harmful human activities (Houston 1974, Pennycuick 1976, Herholdt et al. 1996).

The core of central Kenya's Laikipia District functions largely as a protected area despite being divided and privately owned. Almost half of the district's 966 600 ha consists of large-scale ranches and conservancies that are hospitable to wildlife and enable large-ranging birds like vultures and eagles to exist relatively free from habitat destruction and human interference. However, areas mostly outside of the core have seen considerable recent settlement by small-scale crop farmers and traditionally nomadic pastoralists. Approximately 35% of the district consists of settlements or small-scale urbanization (Frank et al. 2005).

To determine whether the abundance of raptors in central Kenya was changing, we monitored raptors every month for three years (2001–2003) in central Laikipia District.

METHODS

Study Site. The study was conducted from January 2001–December 2003 at Mpala Research Centre (MRC), located in central Laikipia District in the highlands of central Kenya (Fig. 1). The habitat consists of wooded savanna, and the dominant tree species is *Acacia drepanolobium*. Large wildlife species include elephants (*Loxodonta africana*), reticulated giraffes (*Giraffa camelopardalis*), Grevy's zebras (*Equus grevyi*), elands (*Taurotragus oryx*), cape buffalos (*Syncerus caffer*), lions (*Panthera leo*), leopards (*P. pardus*), cheetahs (*Acinonyx jubatus*) and spotted hyenas (*Crocuta crocuta*).

The more common avian fauna in the study area comprises approximately 75 species (Ogada et al.

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2008), of which nine are seasonal migrants. Common raptors include Rueppell's Vulture (*Gyps rueppellii*) and African White-backed Vulture (*G. africanus*), Black-winged Kites (*Elanus caeruleus*) and Eurasian Kestrels (*Falco tinnunculus*), which are seasonal migrants.

Study Design. This research was conducted within a long-term herbivore exclusion experiment (Kenya Long-term Exclusion Experiment, or KLEE; Young et al. 1998) that was established at MRC in 1995. KLEE consists of a randomized block design, with three replicates of six treatments. The six treatments selectively exclude different combinations of wild and domestic herbivore species and each treatment is 200 m × 200 m, or 4 ha. The total area surveyed was 1.12 km^2.

Raptor Surveys. We sampled raptors as part of a larger experiment that examined the effects of herbivores on small mammals (Keesing 2000). We conducted surveys from within six of the eighteen plots every month—three that excluded all large herbivores and three that allowed access to all large herbivores (Fig. 1). We sampled the same plots every month. We did not survey during November 2001, February 2002, and November 2003 due to excessive rainfall or other logistical complications, so we excluded the months of November and February from our analyses for all three years. Each survey was conducted between 10:00–12:30 H and was completed within three days. Surveys were conducted in late morning in order to include large vultures, which typically do not begin soaring until thermals are produced by solar heat (Brown 1971).

During surveys, observers walked the perimeter of each 200 m × 200 m plot, then walked diagonals through the center of each plot, scanning the horizon, trees, and ground for any perched, ground-roosting, walking, or flying raptors. Total walking time was approximately 30 min per plot. Plots were walked to ensure that all ground-roosting raptors (e.g., owls and harriers) were counted, because the grass height could reach 0.5 m in plots that excluded all large herbivores. We recorded all raptors observed using binoculars, regardless of whether the birds were inside or outside the plots. Raptors were identified to species level, when possible. Given the difficulty of identifying raptors, especially those flying at a distance, many were recorded only by group (i.e., vulture, falcon).

Large Herbivore Surveys. Estimates of large herbivore abundances were from two aerial censuses conducted January–March 2001 and February 2003 by the Laikipia Wildlife Forum and provide a sample count of large herbivores species in Laikipia District including the study area (Georgiadis and Ojwang 2001, Georgiadis et al. 2003).

Species were grouped for analyses. ''Scavenging birds'' included Rueppell's Vultures, African White-backed Vultures, Lappet-faced Vultures (*Torgos tracheliotus*), Bateleurs (*Terathopius ecaudatus*), and Tawny Eagles (*Aquila rapax*). ''Non-scavenging eagles'' were Wahlberg's Eagles (*A. wahlbergi*), Black-chested Snake-Eagles (*Circaetus pectoralis*), African Hawk-Eagles (*Hieraaetus spilogaster*), and Martial Eagles (*Polemaetus bellicosus*). ''Hawks'' included Augur Buzzards (*Buteo augur*), Eurasian Buzzards (*Buteo buteo*), and Eastern Chanting-Goshawk (*Melierax poliopterus*). We omitted harrier sightings, which included three unknown harriers (*Circus* sp.) and two Pallid Harriers (*C. macrourus*) because their numbers were so few. ''Falcons'' were Eurasian Kestrels and Pygmy Falcons (*Polihierax semitorquatus*). The only kite was the Black-winged Kite. We included ''unknown'' and harrier sightings for estimates of raptor abundance by year, but not for group-level analyses.

Because of their large ranges, raptors observed during the surveys of each KLEE treatment were not necessarily independent sightings. Therefore, we pooled data from all blocks and treatments. We conducted a correlation analysis between year (2001–2003) and the mean number of monthly sightings of all raptors for the first analysis, and of just scavenging birds for the second. We also performed a linear regression using the number of scavenging birds as the dependent variable and rainfall as the independent variable (rainfall was measured daily using a standard rainfall gauge as part of a weather station based at Mpala Research Centre).

RESULTS

Raptor Surveys. From January 2001–December 2003 we had 535 raptor sightings comprising 16 species, three of which were palearctic migrants. Of the species that were identified, the most common were *Gyps* vultures (69%) followed by Black-winged Kites (5%) and Tawny Eagles (4%).

The mean number of raptors observed each month declined significantly over time ($P = 0.05$). Raptors declined 40% in the first year and 48% in the second, for an overall decline of 68% between 2001 and 2003. Scavenging birds accounted for most of the decline, although the correlation be-

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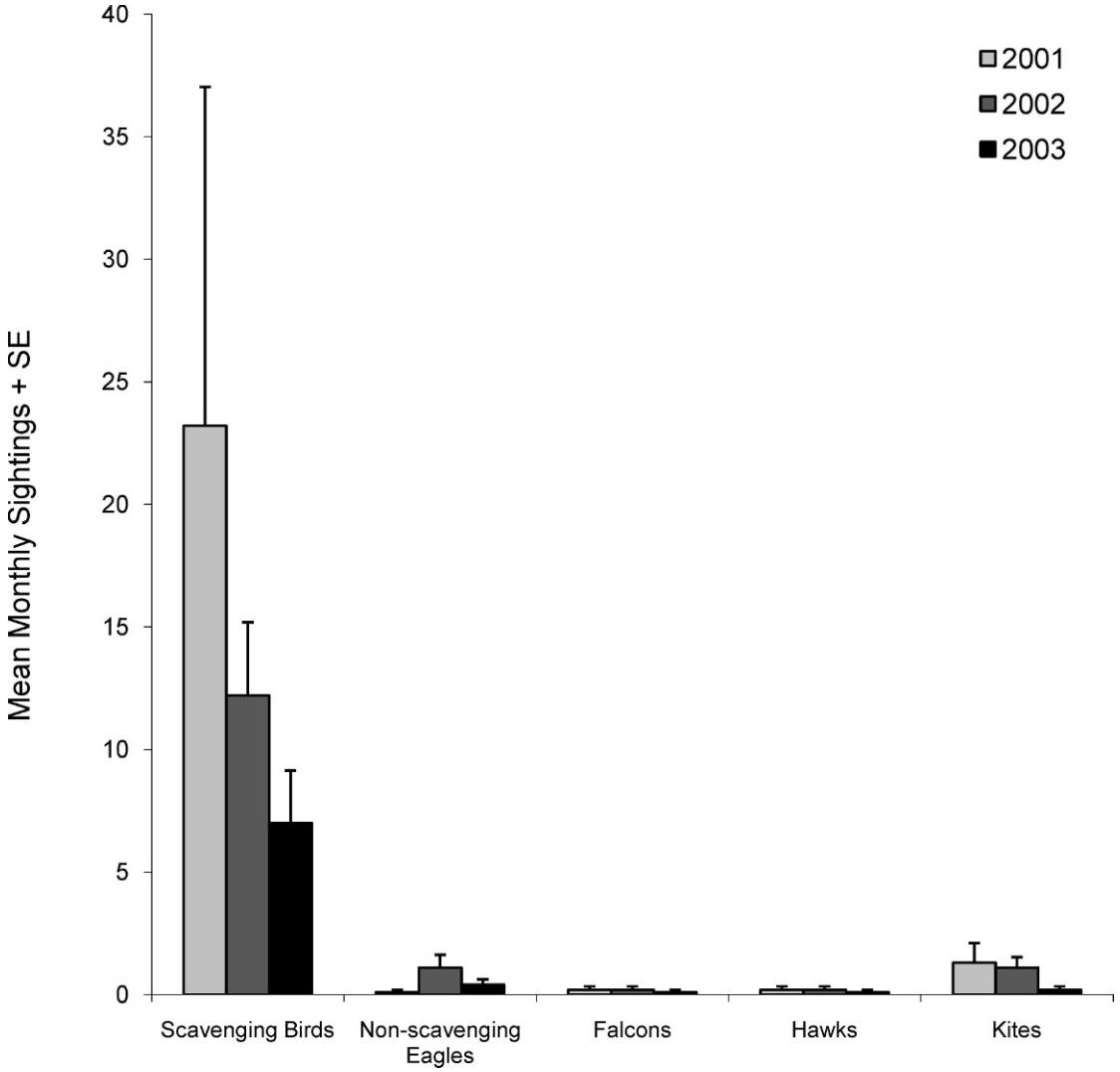

Figure 2. Annual monthly mean (+SE) number of raptor sightings during 2001–03, by raptor group. Species in each group are described in the text.

tween year and mean monthly sightings of scavenging birds was not significant ($P = 0.40$; Fig. 2). Scavenging birds declined approximately 50% per year and a total of 70% over the study period. Sightings for other raptor groups were too infrequent to permit analysis. The number of scavenging birds was not related to rainfall ($P = 0.28$).

DISCUSSION

In our surveys, raptors declined by 68% over three years. Scavenging birds were primarily responsible for this decline (Fig. 2). Scavenging birds, especially vultures, are declining worldwide due to poisoning, persecution, food shortages, and land-use changes (Pain et al. 2003, Thiollay 2006). Precipitous declines have occurred in West Africa (Thiollay 2006) and recent catastrophic population crashes have garnered attention in South Asia (Oaks et al. 2004, Prakash et al. 2003, Green et al. 2004). Our results suggest that this pattern is occurring in East Africa as well.

Because we sampled only a small area, the declines we observed may have resulted from a change in space use by scavenging birds rather than a re-

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gion-wide population decline. Dispersion in subtropical African raptors is usually related to rainfall (Brown 1971, Herremans and Herremans-Tonnoeyr 2000). Rainfall at the study site during the period of our observations was not unusual in magnitude or distribution, and we detected no significant effect of rainfall on scavenging bird abundance. However, we cannot rule out the possibility that scavenging birds in our study area relocated to other sites. Nevertheless, abundance at our site declined significantly, whether these declines represent local or region-wide declines.

One hypothesis to explain the rapid decline we observed at the study site is a lack of available food. Large vultures in particular feed mainly on carrion of large- and medium-sized mammals and are obligate scavengers (Ruxton and Houston 2004). However, during the study period, wild herbivores in Laikipia District increased by 9% and domestic herbivores, especially sheep and goats, increased by 37% (Georgiadis and Ojwang 2001, Georgiadis et al. 2003). These data suggest that low food availability was not the primary cause of the declines in scavenging birds.

Another potential explanation for raptor decline is mortality from infectious disease. Although this hypothesis could not be ruled out, it seemed unlikely in our study region, as there were no reports of scavenging birds, e.g., vultures, dying of natural causes at a number of colonies where monitoring is ongoing (M. Virani pers. comm.). Infectious disease does not appear to be a major cause of mortality in *Gyps* vulture populations in southern Africa (Benson 2000).

A third hypothesis is that scavenging birds were poisoned at carcasses. Vultures are particularly vulnerable to poisoning, because they can rapidly congregate in large numbers at a carcass. Thus, one poisoned carcass can affect a large number of birds (Newton 1979). Indeed, reports of mass vulture poisonings within Africa are numerous (Borello 1985, Allen 1989, Anderson 1994, Simmons 1995). Two groups of neurotoxic pesticides, the organophosphorous and carbamate compounds, tend to be very acutely toxic to birds and cases of mortality are frequently reported (e.g., Mineau et al. 1999, Mineau 2005). Because of their acute toxicity, carbofurans are frequently implicated in abuse cases where raptors or other vertebrates are targeted directly (Mineau et al. 1999). Carbofuran, sold under the trade name Furadan, is an agricultural pesticide that is legally sold throughout Kenya, and its use as a cheap, effective poison is well known among farming communities in Kenya (Ogada and Kibuthu 2008). In Laikipia District soil, water and plant samples have shown high environmental contamination with concentrations of carbofuran and its two toxic metabolites (Otieno et al. 2010). Recent studies have implicated carbofuran in the mortality of African White-backed Vultures near our study site (Otieno et al. in press a, Otieno et al. in press b). These reports also confirmed widespread involvement of carbofuran in vulture poisoning incidents throughout Kenya (Mijele 2009, Otieno et al. in press a, Otieno et al. in press b). Vultures, and perhaps other scavenging birds, may have become unintended victims of poisoning of predators that occurs following livestock depredation events (Otieno 2009). Whether poisoning explains the rapid decline in abundance of scavenging birds at our site is currently under investigation.

Scavenging birds provide some of the most important yet underappreciated ecosystem services of any avian group (Houston and Cooper 1975, DeVault et al. 2003, Sekercioglu 2006). Yet among birds, nearly 40% of vultures are extinction-prone, more than any other functional group (Sekercioglu et al. 2004). All the vulture species observed during our study are on the IUCN Red List of Threatened Species (IUCN 2009). The apparent decline of scavenging birds that we observed in central Kenya warrants population monitoring to understand whether declines are local or regional and to elucidate causes of population decreases.

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