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The power of poison: pesticide poisoning of Africa's wildlife

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Poisons have long been used to kill wildlife throughout the world. An evolution has occurred from the use of plant- and animal-based toxins to synthetic pesticides to kill wildlife, a method that is silent, cheap, easy, and effective. The use of pesticides to poison wildlife began in southern Africa, and predator populations were widely targeted and eliminated. A steep increase has recently been observed in the intensity of wildlife poisonings, with corresponding population declines. However, the majority of poisonings go unreported. Under national laws, it is illegal to hunt wildlife using poisons in 83% of African countries. Pesticide regulations are inadequate, and enforcement of existing legislation is poor. Few countries have forensic field protocols, and most lack storage and testing facilities. Methods used to poison wildlife include baiting carcasses, soaking grains in pesticide solution, mixing pesticides to form salt licks, and tainting waterholes. Carbofuran is the most widely abused pesticide in Africa. Common reasons for poisoning are control of damage-causing animals, harvesting fish and bushmeat, harvesting animals for traditional medicine, poaching for wildlife products, and killing wildlife sentinels (e.g., vultures because their aerial circling alerts authorities to poachers' activities). Populations of scavengers, particularly vultures, have been decimated by poisoning. Recommendations include banning pesticides, improving pesticide regulations and controlling distribution, better enforcement and stiffer penalties for offenders, increasing international support and awareness, and developing regional pesticide centers.

Keywords: wildlife poisoning; Africa; pesticides; predator poisoning; scavengers

Introduction

The use of poisons to kill wildlife has a long history worldwide. More recently, synthetic pesticides have replaced traditional plant- and animal-based poisons used to deliberately kill wildlife—a particular problem in developing regions that harbor significant wildlife populations. Such is the case in Africa, where the poisons used to kill wildlife can be best described as silent, cheap, easy (to obtain and use), and effective. Here, such agents are increasingly the method of choice for killing damage-causing animals,[1–4] harvesting wild animals for food,[5–7] and for traditional medicine,[8,9] and they are increasingly used to poach elephants for ivory, rhinos for horn, and carnivores for fur.[10–13] Apart from intentional poisoning, populations of nontargeted wildlife—particularly vultures—have declined dramatically owing primarily to feeding on poisoned carcasses.[14,15] The blatant and widespread abuse of agricultural pesticides to kill wildlife is illegal, yet as a result of lax attitudes toward enforcement combined with inherent difficulties in preventing pesticide abuse, they have become one of the most widely used means of killing wildlife in Africa.[4,6,16–19]

This review focuses on the deliberate abuse of poisons used to kill or harvest wildlife (often for human consumption) in Africa. It also examines historical wildlife poisoning methods and agents, including their historical and political context in southern Africa, which is particularly relevant to understanding the current poisoning situation in that region. The majority of the review is dedicated to the increasing intensity of wildlife poisoning incidents seen across Africa since the 1990s and evidence for subsequent wildlife population declines, including

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the unintentional effects on nontargeted populations. It describes the prevalent methods of poisoning wildlife, the most abused pesticides, the inherent challenges of reporting and monitoring abuses, and the lack of pesticide regulation in Africa. The national laws intended to protect wildlife from poisoning within each African country are discussed alongside relevant international conventions. The main drivers behind wildlife poisoning are discussed in detail, emphasizing the effects on species and populations at local and regional levels. Finally, the review provides recommendations and considerations for tackling the menace of wildlife poisoning in Africa.

Historical use of poisons in Africa against wildlife

Our knowledge of poisonous substances, and their effects, has been described throughout much of recorded history.[20] Since prehistoric times, poison arrows have served as both a weapon of war and a tool to kill game animals.[21] The Ainos of Japan used poisoned arrows to kill game and were able to consume the meat without harm, providing that a small portion of the flesh surrounding the wound was removed.[21] In Central and South America, poisons have been extensively applied to the tips of darts inserted into a blowgun.[21] Poison arrows were ubiquitous in Africa, with the most conspicuous use recorded along the west coast in Gabon, by the pygmies of central Africa, and among the Somali.[21,22] Their use has also historically been favored by the Bushmen of southern Africa, representing the oldest known evidence of hunting using poison.[23]

A variety of poisons were used, differing by geographic region. The pygmies used one of many plant-based toxic alkaloids from the genus *Strychnos* that is widely distributed across the tropics.[24] The Bushmen favor poisons from a variety of sources, including the pupae of the small beetle *Diamphidia simplex*, snake venom, and plant extracts.[23,25] The Muntschi (or Munchi) tribe in northern Nigeria tipped their arrows with a "dreaded poison" that was said to kill a man in 10 min by stopping his heart.[26] Its major toxic ingredient was the glucoside strophanthin that likely originated from the seeds of *Strophanthus hispidus*, which were widely used for arrow poison in West Africa.[26] In addition to the toxic substances acquired from plants and animals, it is believed that some arrows were also dipped in the flesh of putrefying corpses to become carriers of bacterial infection,[26] though it is unclear if these were applied to kill game or reserved solely as weapons of war.

Apart from arrow poisons, the use of poisons to kill or debilitate fish has a long history in Africa, as well as in many other tropical regions throughout the world.[27] Poisons were procured from a number of plants, including *Tephrosia* spp. in east and south Africa, and *Mundulea sericea* was used throughout tropical Africa.[27] Although the applications of these plants varied, only a certain part of the plant was used in most cases, such as the bark or root, which was mashed between stones and thrown into a pool or netted-off section of a river.[27] The poison acted on the respiratory organs, first stupefying the fish and eventually killing it.[27] According to Howes,[27] "the fish obtained by the use of these poisons seem to be in no wise rendered unwholesome for food." However, according to Greenway,[28] "most locals agreed that fish caught by the use of Mundulea bark were eaten with considerable risk of poisoning and that a number of such cases were known to them." *Mundulea* is claimed to be more poisonous than *Tephrosia* and capable of driving crocodiles from the river, if not killing them.[28] Indeed, in an historic record of the use of poisons against predators by Africans, Greenway[28] states that a game warden informed him that all the crocodiles had been cleared from the Umba River, Kenya by the Wakamba, who used a (very effective) poison presumed to be *Mundulea.*

Southern Africa: the turning point in poisoning practices and outlooks toward wildlife

Hostile attitudes toward dangerous predators have likely existed since the dawn of humankind; however, European settlers have been widely perceived to have introduced an extermination mentality toward predators and scavengers in Africa.[29–31] As early as 1652, European settlers in the Cape Colony (South Africa) targeted carnivores (e.g., lions and hyenas) and crop-raiding animals (e.g., antelope, porcupines, and moles) because of real and perceived threats to human lives and food production, respectively.[32] The first control program to destroy "vermin" was introduced in 1656.[32] By 1814, the British authorities in Cape Colony incentivized the destruction of carnivores[33] through a combination of methods that included poisoning and trapping. The first Wild Animal Poisoning Club was formed

in 1884, and the clubs began meeting in an annual congress after 1887.[33] Declaring that forest reserves that had been recently protected from hunting were refuges for vermin, the clubs took it upon themselves to lay poisoned meat in the reserves and to award public bounties for animal destruction, among other initiatives.[33,34] By the late 19th century, poison (particularly strychnine) was favored to eradicate wild carnivores, especially jackals.[35] As under other colonial regimes, notably Australia,[32] synthetic poisons were introduced to Africa, and their use to eradicate predators was encouraged and disseminated via the Department of Agriculture and its agricultural journal.[35]

In addition to poisoning wild carnivores, the colonial government in the Transkei and Eastern Cape routinely targeted African-owned game hunting dogs with poisoned baits of meat and bread laced with strychnine, a situation that was mirrored in colonial Namibia at the same time.[34] In fact, there is a long history of the use of poisons as a political tool and as weapons of bio-warfare in southern Africa.[36] The significance of these should not be overlooked when examining the countries where poisons are frequently used against wildlife today. Poisons were used to fight guerilla wars in Angola, Zimbabwe, and Mozambique,[36] by the colonial government in German Southwest Africa (Namibia) to eliminate the native Herero people,[37] and to fight political dissidents in apartheid South Africa.[36] A frequent tactic was to poison waterholes.[36,37]

Lethal predator control was widespread in southern Africa (South Africa, Namibia, Botswana, and Zimbabwe), and wild dogs were the first to be eliminated from the region, followed by lions (*Panthera leo*), spotted hyenas (*Crocuta crocuta*), and cheetahs (*Acinonyx jubatus*).[29,38,39] Black-backed jackals (*Canis mesomelas*) were the main targets of poisoning campaigns by small-stock (e.g., sheep and goats) farmers.[29,38,39] Birds of prey including vultures were also deliberately targeted because of their potential to kill lambs and irrational fears that they could carry off children.[29] More recent evidence suggests that the history of intensive wildlife poisoning in southern Africa has carried on with little respite since the intensive poisoning campaigns of the late 1880s. Historical declines in the range and numbers of Cape vultures (*Gyps coprotheres*) in Cape Province from before 1905 until 1978 suggest that poisoning remained a problem throughout this period, particularly for carnivores, but there were also campaigns specifically targeting the "vulture problem."[40] Other raptor species in Cape Province, particularly eagles—tawny *Aquila rapax* and long-crested *Lophaetus occipitalis*—showed range retractions between the periods 1700–1969 and 1970–1979 owing to persecution by small-stock farmers.[41] From the mid-1970s through the mid-1980s, poisoning campaigns against black-backed jackals were ongoing in areas of South Africa.[42] By 1980, there were already reports of large numbers of vultures (more than 100) poisoned in the Caprivi region of Namibia.[29,43,44]

History of wildlife poisoning in other areas of Africa

Compared to southern Africa and to a lesser extent North Africa, the arrival of European settlers in the rest of Africa was more recent and their numbers were significantly less.[45] Nevertheless, where European-style ranching was the norm, there are numerous reports of the use of poisons, and strychnine in particular, to control problem animals and their subsequent effects on scavengers. Jackson[46] wrote of the demise of Rüppell's vultures (*G. rueppellii*) in the Kenyan highlands due to strychnine poisoning during the early 1900s. In 1928, the Game Department in Kenya recruited two officers to control problem animals either by trapping, shooting, or poisoning.[47]

Of particular note was the entrenchment of the use of poisons to control problem animals by government wildlife authorities, a situation that has continued into recent decades.[31,48–51] In west and central Africa, strychnine poisoning campaigns were organized annually by the administration charged with livestock development.[52] In Senegal, wildlife was systematically poisoned with strychnine between 1950 and 1965, a situation that began under French colonial rule.[53] Between 1970 and 1972, 55 lions were poisoned with strychnine in what was then known as Upper Volta (Burkina Faso).[54] In Morocco, carnivores such as jackals and foxes were poisoned with strychnine in a campaign that likely began around the mid-20th century.[55–57]

By the time of independence, the use of poisons to eliminate predators and scavengers was widespread in Africa, and synthetic chemicals had spread among the native African population. As of the 1960s and early 1970s, the majority of ranches in

Laikipia, Kenya were using strychnine and the cattle dip toxaphene to poison predators.[58] Verschuren[59] noted during a survey of wildlife in Zaire (Democratic Republic of Congo) that lions were poisoned at baited carcasses, which also caused significant declines of vultures in several parts of the country. During the 1980s in Uganda's Murchinson Falls National Park, the local community poisoned waterholes and used poisoned baits to slaughter wildlife within the park.[60]

Wildlife poisoning 1990s to present

The dramatic increase in Africa's human population from the 1980s onward[61] brought about increased conflicts with wildlife over land and food resources (especially with carnivores),[52] and ushered in the general commodification of the continent's resources, including wildlife.[62] These changes have been reflected in the overall intensification and spread of wildlife poisoning over the past three decades, and there is substantial evidence of corresponding population declines in lions,[1,63] raptors,[64,65] Cape vultures,[66] bearded vultures (*G. barbatus*),[67] tawny eagles (*A. rapax*),[68] large mammals,[69] vultures,[14] and hyenas.[70]

Classification of exposure, difficulties in detecting and monitoring, and sublethal exposure

The circumstances involving lethal exposure to pesticides can be classified as (1) accidental—from approved/labeled use, (2) misuse, and (3) deliberate abuse.[71] Accidental mortality ensues when pesticides are applied to the approved target, at the proper dose.[71] In Africa, this is frequently the case following the spraying of pest species such as locusts, tsetse flies, and quelea birds,[72–76] with birds of prey often the unintentional casualties.[75,77] A pesticide is considered to have been misused when the specified instructions are not followed.[71] In the last case, which is the focus of this review, pesticides are used in a deliberate or illegal attempt to poison animals, and secondary poisonings of scavengers can result because of the high concentrations typically applied.[71]

Exact figures are hard to come by because most wildlife mortality is not reported, and even less is confirmed.[78,79] A mortality pyramid (Fig. 1) gives a generic representation of the underreporting of poison-related mortality and emphasizes that the data presented herein represent a tiny fraction of

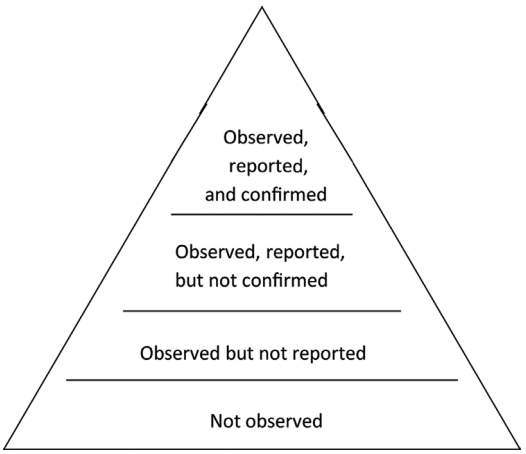

Figure 1. **Generic relationship of actual wildlife mortality and the information received. Most wildlife mortality is unaccounted for. Adapted from Ref. 78.**

the actual scale of poisoning in Africa.[78] Throughout most of Africa, there are no organized monitoring systems to record poisonings, and rural Africans frequently do not report incidents involving wildlife to the authorities or village leaders.[80,81] Even when poisoning incidents are reported, local authorities may be reluctant to share information with conservationists and wildlife organizations.[81] Further, remote field conditions limit the collection of samples, and few countries have protocols in place to preserve the forensic integrity of field samples.[81,82] Laboratory testing of suspected poisoned carcasses is expensive and difficult, and most countries in Africa lack proper (and modern) testing equipment and storage facilities.[81,82] South Africa is the only country in Africa that has an organized body dedicated to the problem of wildlife poisoning. The Endangered Wildlife Trust's Poison Working Group estimated that in excess of 500,000 wild birds and animals die from poisoning alone in South Africa every year.[2]

The evidence presented herein focuses solely on wildlife mortality events, but the use of pesticides can have delayed sublethal (chronic) effects.[83] Sublethal exposure can lead to reduced survival in exposed individuals,[84] as animals can be behaviorally or physiologically impaired from pesticide exposure, but die from other proximate causes.[85–87] There is substantial evidence among African wildlife, particularly in birds, of pesticide residues at levels sufficient to cause sublethal effects (e.g., eggshell thinning) to populations,[88–92] though the

majority of these studies were performed decades before the current levels of pesticide usage in Africa.

National laws and international conventions

The wildlife laws of 38 out of 46 African countries specifically mention that it is illegal to use poison, poison bait, or poisoned weapons for the purpose of hunting wildlife (Table 1). The most comprehensive legislation against the use of poison to kill wildlife can be found in South Africa, Ethiopia, Kenya (but see legal loopholes below), Namibia, and Botswana, where the use of poisons and/or pesticides for killing wildlife is outlawed under any circumstances. In the remaining 42 countries, the legislation against the use of poisons is typically found under the laws concerning hunting regulations. North African countries (Morocco, Algeria, Tunisia, and Egypt) have the weakest legislation against wildlife poisoning; none of their laws specifically state that the use of poisons to hunt or kill wildlife is illegal. Other countries whose legislation does not specifically mention that using poisons is illegal include Lesotho, Madagascar, Mali, and Zimbabwe.

A case study in Kenya has highlighted the need for African countries to harmonize national laws to close existing legal loopholes that still surround the matter of using poisons to kill wildlife.[93] Laws on poisons and pesticides typically fall under a number of different (and often conflicting) legislative acts, which assign varying motivations with regard to their use. In Kenya, laws on pesticides fall under the Pest Control Products Act, the Pharmacy and Poisons Act, the Wildlife Act, the Fisheries Act, the Agricultural Act, the Veterinary Surgeons Act, and the Environmental Management and Coordination Act.[93] Therefore, it may be possible under Kenyan law to legally use poisons against wildlife under the existing legislation because some laws, notably the Pharmacy and Poisons Act, justify the right to use poisons against wildlife.

The African Convention on the Conservation of Nature and Natural Resources prohibits the use of drugs, poisons, poisoned weapons, or poisoned baits for hunting, capturing, or fishing. The convention was signed by 40 African countries in 1968, and a revised edition was adopted in 2003.[94] Although it is the most comprehensive regional treaty on the environment and the conservation of natural resources, like most international conventions, there are few penalties for noncompliance, making specific implementation difficult and full implementation very unlikely. As of 2010, only eight countries had ratified the revised convention, which falls below the 15 countries necessary for its enforcement.[95]

Three international conventions address the issues of production, use, trade, and responsibilities involving hazardous chemicals. The Basel Convention controls the transboundary movement of hazardous wastes and their disposal.[96] The Stockholm Convention controls and eliminates production and use of persistent organic pollutants.[97] The Rotterdam Convention focuses on prior informed consent as a key tool for developing countries to make informed decisions on the import and use of highly toxic chemicals. It enables member governments to exchange information on banned or severely restricted chemicals and to prevent unwanted trade in the chemicals listed in Annex III of the Convention.[98] Annex III of the Rotterdam Convention lists pesticides that have been banned or severely restricted for health or environmental reasons, and, notably, many of these pesticides are still widely used in Africa.[99] All African countries except for Egypt, Algeria, Sierra Leone, South Sudan, the Central African Republic, Angola, and Tunisia have ratified the Rotterdam Convention. One of the world's biggest exporters of pesticides, the United States, has also failed to ratify it.[100]

Existing regulations and enforcement

Surveys undertaken in towns and surrounding regions throughout Kenya regarding the abuse of carbofuran to kill wildlife have shown that this pesticide is widely abused in pastoralist areas and in large farms supporting commercial agriculture, including rice schemes.[4,101] Nuisance animals including lions, hyenas, leopards (*P. pardus*), rodents, warthogs (*Phacochoerus africanus*), birds of prey, and bees were targeted.[4,101] In Kenyan rice schemes, carbofuran is frequently used to poison waterbirds and other birds that are sold as bushmeat to consumers who are aware that the highly toxic pesticide was used to procure the meat.[6,101] Bushmeat is perceived as more nutritious than conventional livestock.[6]

Even pesticides registered for restricted use or sold only on prescription are easily available over the counter in Africa.[4,7,19,64] Regulation of hazardous pesticides in Africa is clearly inadequate, and the onus has been put on individual researchers to prove

Table 1. List of 46 African countries, 38 of which have legislation specifically mentioning that poison is illegal to use for hunting wildlife

Country[a]	Name of legislation	Year enacted	Illegal to hunt wildlife	Illegal to use for fishing[b]	Comments
Algeria	Law no. 83–03	1983	No		Laws against use of chemicals in environment, but not against wildlife
Angola	Decree no. 40.040	1955	Yes		
Benin	Law no. 87–014	1987	Yes		
Botswana	Wildlife Conservation and National Parks Act	1992	Yes		Use of any poisoned weapon for killing any problem animal is illegal. Any person seen or found on any land in possession of poisoned bait or weapon without permission is prohibited
Burkina Faso	Decree no. 111/PRES	1997	Yes	Yes	May be authorized for problem animal control
Burundi	Decree Chasse et Peche	1937	Yes		
Cameroon	Law no. 94/01	1994	Yes	Yes	
Central African Republic	Ordonnance no. 84.045	1984	Yes		
Chad	Law no. 14/PR/2008	2008	Yes	Yes	
Congo	Law no. 37–2008	2008	Yes		
Djibouti	Decree no. 2004–0065	2004			Hunting, capture, and trade of all wildlife is prohibited
Democratic Republic of Congo	Law no. 82–002	1982	Yes		
Egypt	Law no. 4 Law no. 102 Act 124	1994 1983 1983	No	Yes	
Equatorial Guinea	Law no. 8/1.988	1988	Yes		
Eritrea	Proclamation 155/2006	2006			Hunting prohibited unless authorized by the Minister
Ethiopia	Regulation No. 163/2008	2008	Yes		Problem animals cannot be killed using poisons
Gabon	Law no. 0016101	2001	Yes	Yes	
Gambia	Wildlife Conservation Act	1977	Yes		
Ghana	Act 43	1961	Yes		
Guinea	Law no. L/97/038	1997	Yes		
Guinea-Bissau	Decree no. 40.040	1955	Yes		
Ivory Coast	Law no. 41	1965	Yes		

Continued

Table 1. *Continued*

Country[a]	Name of legislation	Year enacted	Illegal to hunt wildlife	Illegal to use for fishing[b]	Comments
Kenya	Wildlife Conservation and Management Act	2013	Yes	Yes	Hunting is prohibited; problem animals cannot be killed using poisons
	Fisheries Act	1991			
Lesotho	Environment Act	2001	No		
	Forestry Act	1998			
Liberia	Wildlife and Parks Act	1988	Yes		
Madagascar	Ordinance no. 60–I26	1960	No		Provisions against use of explosive weapons, but not poisons
Malawi	National Parks and Wildlife Act	1992	Yes		
Mali	Law no. 95–31	1995	No		
Mauritania	Law no. 97–006	1997	Yes		
Morocco	Law no. 29–05	2011	No		
Mozambique	Decree no. 40.040	1955	Yes		
Namibia	Nature Conservation Ordinance	1975	Yes	Yes	Minister can appoint qualified person to use poisons for problem animals
Niger	Law no. N98–007	1998	Yes		
Nigeria	Wild Animals Law	1963	Yes		
Rwanda	Decree-Law Office Rwandais du Tourisme et des Parcs Nationaux	1974	Yes		
Senegal	Law no. 86–04	1986	Yes		
Sierra Leone	Wildlife Conservation Act	1972	Yes		Legislation only covers hunting within protected areas
Somalia	Law no. 15	1969	Yes		
South Africa	Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act	1947	Yes	Yes	
South Sudan	Wildlife Conservation and National Parks Act	2003	Yes		
Sudan	Preservation of Wild Animals Ordinance	1935	Yes		

Continued

Table 1. *Continued*

Country[a]	Name of legislation	Year enacted	Illegal to hunt wildlife	Illegal to use for fishing[b]	Comments
Swaziland	Protection of Fresh Water Fish Act	1938	Yes	Yes	
	Game Act	1953			
Tanzania	Wildlife Conservation Act	2009	Yes		Possession of poison with intention is an offence
Togo	Ordinance no. 4	1968	Yes	Yes	
Tunisia	Forestry code, law no. 88–20	1988	No		
Uganda	Wildlife Act	1996	Yes		
Zambia	Wildlife Act	1998	Yes	Yes	
Zimbabwe	Parks and Wildlife Act	1975	No	Yes	Minister can issue permit to fish with poison

[a]Libya not included because of difficulty in translating legislation from Arabic; island nations apart from Madagascar were not included.
[b]All efforts were made to check wildlife legislation. For fish, legislation was included if it was included within wildlife legislation or was otherwise easily accessed. Therefore, the list of countries with legislation against using poisons for fishing may not be complete and are left blank for countries that may have separate fisheries legislation.

that pesticide abuse is occurring. In Kenya, the Pest Control Products Board (a regulatory agency) originally claimed no knowledge of the abuse of carbofuran to kill wildlife but offered their cooperation if it was proved that the abuse was actually happening.[4,81]

Methods used to poison wildlife

Various methods are employed to poison wildlife, all of them indiscriminate (i.e., unselective toward the target animal). Exposure to a poison either through ingestion or via dermal contact, as the case may be, can be fatal to any animal.[102] Worldwide, baited carcasses are the most common means of killing predators and scavengers.[103,104] Typically, an opened carcass or pieces of meat are sprinkled with an odorless pesticide.[81] Poisoned scavengers can be found in large numbers around the baited carcass, but, depending on how toxic and/or fast acting the pesticide, some animals succumb far from the site of exposure, confounding the true estimate of mortality.[105]

Numerous bait types are prepared to capture waterbirds and granivorous birds such as doves and pigeons. In western Kenya, bird poachers poison waterbirds using snails as bait.[6] The poachers collect *Bulinus* snails and use a thin stick to force the snail against its shell and then insert carbofuran granules into the shell cavity.[106] They also use termites and small fish that are laced with poison as bait.[6] Granivorous birds are poisoned using rice or maize grains that have been soaked in poison diluted with water.[6,17]

Bushmeat is poisoned by mixing pesticide with salt and placing it on the soil in areas that the animals are suspected to inhabit. The animals are attracted to the salt and are killed when they come to lick the mixture.[107]

The technique of poisoning waterholes is typically favored to harvest fish but has been increasingly used to kill elephants for ivory,[11] to harvest bushmeat,[11,108] and to kill problem animals.[11,80] Poisoning waterholes or rivers not only kills aquatic animals, but can also kill or harm terrestrial animals (including humans) that use the water for drinking.[7,109]

Poisons used

The use of traditional poisons is waning[107] owing to the easy availability of inexpensive, highly toxic agricultural pesticides.[4,100,110–112] Other substances used include brake fluid[8] and tobacco or snuff.[113] All classes of pesticides have been used to poison wildlife, including organochlorines, organophosphates, carbamates, and pyrethrins (Table 2). Carbofuran is the most widely abused pesticide in Africa

Table 2. List of most abused pesticides in Africa

Classification	Common name	Country	Reference
Acaricide	Amitraz[a]	Kenya	114
Alkaloid	Strychnine	Botswana, Namibia, Niger, South Africa, Tanzania	17, 114–122
Carbamate	Aldicarb[b]	Botswana, Malawi, Namibia, South Africa, Zambia	11, 17, 18, 115, 123, 188
Carbamate	Carbofuran	Botswana, Ghana, Kenya, Namibia, South Africa, Uganda	4–6, 17, 18, 43, 100, 110, 114, 115, 124–126
Carbamate	Carbosulfan	Kenya	114
Mitochondrial toxin	Cyanide	South Africa	115, 127
Organochlorine	Dieldrin[b]	South Africa	115
Organochlorine	Endosulfan[b]	South Africa	18
Organochlorine	Lindane[b] (Gamma BHC)	Cameroon, South Africa	7, 17, 18, 128
Organofluorine	Compound 1080	South Africa	17
Organophosphate	Chlorpirifos	South Africa	17, 18
Organophosphate	Diazinon	South Africa	17, 18, 115
Organophosphate	Dichlorvos	South Africa	18
Organophosphate	Dicrotophos	South Africa	18
Organophosphate	Dimethoate	South Africa	17
Organophosphate	Fenamiphos	South Africa	17
Organophosphate	Fenthion	South Africa	17, 18
Organophosphate	Isazophos	South Africa	18
Organophosphate	Malathion	South Africa	18
Organophosphate	Methamidophos	South Africa	17, 18
Organophosphate	Monocrotophos[b]	South Africa	17, 18, 115
Organophosphate	Parathion[b]	South Africa	17, 18, 115
Organophosphate	Profenofos	South Africa	18
Pyrethroid	Cyhalothrin	Kenya	114
Pyrethroid	Cypermethrin	South Africa	18

[a]Pesticides meeting the criteria for listing on Annex III but not yet listed.
[b]Pesticides listed on Annex III of the Rotterdam Convention.

(Table 2). Other commonly abused pesticides include strychnine, aldicarb, diazinon, and monocrotophos (Table 2). It is worth noting that each of the pesticides listed above are banned—or their use is severely restricted—in the United States, Canada, and E.U. countries.[99,129–137] In Uganda, abuses of carbofuran to kill wildlife and the associated dangers to humans are now so well known that two of the three major distributors there have ceased to import it.[110] In Kenya, proprietors of agro-vet shops near wildlife areas know carbofuran as "lion killer," as that is how their customers commonly refer to it.[138] In the rice fields of western Kenya, where carbofuran is used to poison birds for bushmeat, it is known locally as *dawa ya ndege*, meaning "a poison for birds."[6]

Reasons for using poisons to kill wildlife

The reasons wildlife are poisoned include control of damage-causing animals, harvesting for food, harvesting for traditional medicine, and poaching for wildlife products—all may entail different methods and agents, but all with the same approximate outcome.

Control of damage-causing animals.

Mammalian carnivores. Deliberate poisoning is one of the most serious threats to large carnivores in Africa, and an increase in the intensity

of predator poisonings has been widely noted in the past two decades.[1,31,81,128,139–143] A recent study in the northeast provinces of South Africa showed that 21% of farmers used poisons to kill carnivores during 2010, mostly illegally.[144] The most affected species are lions, hyenas (all species except aardwolf), wild dogs, leopards, and jackals and caracals,[1,31,70,122,126,140,142,145] which are often poisoned when returning to feed on their own kills on subsequent nights.[81] Cheetahs are also killed by poisons, but they are less susceptible to baits because they scavenge infrequently.[146] There are few, if any, African carnivore populations that have not been affected by poisoning.

Lions. Lions are relatively vulnerable to poison owing to their tendency to scavenge, and, because poisoning is indiscriminate, whole prides can be decimated at once.[31] Extinct in north Africa, lions in west and central Africa have all but been exterminated, outside of a few relic populations.[2,126] In Botswana, lions are more generally shot than poisoned; however, some believe that the ban on hunting lions in 2000 may have led to an increase in the latter.[147] In west and central Africa, poisoning and poaching are the two main direct causes of lion population declines throughout the region.[128,148] In East Africa, lion populations have been devastated by poisoning in recent years.[1,31,63,81,110,112,126,141,143,149–151] In the early 1990s, the entire population of lions in Amboseli National Park was lost, mainly through poisoning events,[63] and it has been estimated that lions will soon be extinct in southern Kenya because of spearing and poisoning.[1] Lions are widely poisoned in Tanzania and Uganda.[110,141,149]

Hyenas (spotted, brown, and striped). Perhaps more than any other animal in Africa, hyenas have been systematically targeted in poisoning campaigns across the continent, where they have also consistently been identified as the most despised predator.[48,128,143,152–154] Their indiscriminate food choices make them particularly vulnerable to poisoning.[48] That the three species, spotted, striped (*Hyaena hyaena*), and brown (*Hyaena brunnea*), have been exterminated in large parts of their former range owing predominantly to poisoning can be in little doubt.[70,144] There is ample evidence that local communities continue to use poisons against these species of hyenas throughout their remaining populations.[3,31,120,128,144,155]

Wild dogs. Wild dogs (*Lycaon pictus*) have been widely persecuted through poisoning.[145,156] Shooting and poisoning together account for 27% of mortality of adult wild dogs.[145] Packs of wild dogs have been poisoned mostly in retaliation for attacks on livestock in Tanzania, Zambia, Zimbabwe, and South Africa.[122,145,157]

Leopards. Leopards scavenge freely, and stock-killing leopards are frequently targeted with poison.[158] Because of their secretive nature, leopards that are poisoned are even less likely to be found than lions or hyenas; nonetheless, there is recent evidence linking poisoning to widespread population declines.[128,142,150] Indeed, Henschel[142] stated that poison-baited carcasses pose a rapidly increasing threat to leopards in Africa.

Jackals and caracals. As mentioned previously, jackals have been targeted for extermination for millennia, chiefly via poisoning. As a direct result of the extermination of large predators (e.g., lions and brown hyenas) in South Africa and Namibia, black-backed jackals and caracals have assumed a bigger threat to small stock, and poisoning of these species has therefore become the norm.[2,69,140] In Niger, golden jackals are routinely poisoned with strychnine.[120]

Other species.

Primates. Though their intelligence may offer them some protection, primates are illegally poisoned throughout Africa, mainly in retaliation for crop raiding.[111,159,160] Affected species include baboons (*Papio* spp.), Tantalus monkeys (*Chlorocebus tantalus*), red tail monkeys (*Cercopithecus ascanius*), vervet monkeys (*C. pygerythrus*), Campbell's monkeys (*C. campbelli*), Zanzibar red colobus (*Procolobus kirkii*), and chimpanzees (*Pan troglodytes*).[111,159–163]

Elephants, crocodiles, and hippopotamuses. Elephants are poisoned as a result of crop raiding.[164] Crocodiles and hippopotamuses are poisoned as a result of conflict with humans.[4,11,165,166]

Birds of prey. The most targeted species include martial (*Polemaetus bellicosus*), crowned (*Stephanoaetus coronatus*), tawny and verreaux's (*A. verreauxii*) eagles, as well as many species of accipiter.[4,65,67,68] Vultures are also deliberately poisoned, particularly in Namibia, where it is reported that some species kill newborn lambs.[118]

Other birds. Francolins are poisoned for damaging maize crops in farming areas in the Rift Valley, Kenya.[167] In southern Africa, francolins, helmeted guineafowl (*Numida meleagris*), pigeons, doves, cranes, weavers, bishops, quelea, ducks, and geese are deliberately poisoned for damaging grain crops.[17] Since the 1970s, the main factor behind drastic declines of blue cranes (*Anthropoides paradiseus*) has been widespread (deliberate and accidental) poisoning on agricultural land.[168,169] In Uganda, crowned cranes (*Balearica regulorum* and *B. pavonina*) are poisoned by farmers seeking to protect their crops.[170]

Harvesting for food.

Fish poisoning. The use of synthetic pesticides to procure food is a relatively recent phenomenon in Africa.[17,171,172] Likely stemming from the use of traditional poisons to harvest fish, pesticide fishing is now a pervasive practice on the continent, particularly in west and central Africa.[7,16,109,171–173] However, pesticide fishing is also known from marine fisheries off the Tanzanian coast,[174] in Lake Victoria,[175,176] and in Malawi.[11,177] In west Africa, pesticides—often organochlorine insecticides such as lindane (Gammalin 20) and thiosulfan (Thiosulfan-359)—are sprinkled or poured (depending on the formulation) into ponds, lakes, or rivers, usually during the dry season when water levels are low, after which dead fish are collected and sold to unwitting customers.[7,172] In Lake Victoria, carbofuran is poured into the water at night and fishermen use their boat engines to churn up the water until the fish rise to the surface.[175]

Pesticide fishing kills juvenile and noncommercial fishes[172] as well as nontarget animals, including crustaceans, invertebrates, otters, crocodiles, birds, water snakes, and even soil-dwelling worms.[7,173,177] Streams in which pesticides are applied are said to be devoid of fish for a very long time.[7] In comparison, traditional poisons are claimed to have a less toxic effect on the aquatic environment, as fish are "made temporarily drunk," after which they recover, rapidly repopulate the area, and other aquatic life is little affected.[7,178] In southern Cameroon, villagers claimed eating poisoned fish induced vomiting and stomach pains, and in some cases even death.[7] Human deaths due to eating fish contaminated with pesticides occurred around Lake Victoria and are ultimately what prompted authorities to take action against fish poisoning.[176]

Bushmeat poisoning. Synthetic pesticides are commonly used to poison terrestrial animals (bushmeat) for household consumption, or more typically, for sale.[171] The practice is widespread in west and central Africa, but also occurs in east and southern Africa.[5,6,11,17,107,171,179–183] As with fish poisoning, the menace likely originated from the traditional use of plant-based poisons to harvest bushmeat, but in recent years the use of chemicals has grown, presumably because they are easier and quicker to procure.[5,17,107,171] Ayeni and Mdaihli[171] noted that in Cameroon, the massive killing of cane rats (*Thryonomys* spp.) using pesticides was a recent phenomenon.

In Ghana, an average of 25–30% of bushmeat is harvested through the use of pesticides, and carbofuran is the mostly widely used.[5,107] Carbofuran was used exclusively to harvest birds for the bushmeat trade in the Bunyala rice-growing scheme in western Kenya.[6] Over 3000 birds were killed over a 10-month period using carbofuran-laced baits that included snails, termites, and small fish.[6] A 37% mortality rate was noted for all birds observed within the study area, of which 45% were palaearctic migrants. Species most commonly killed were storks, ibises, sandpipers, godwits, doves and pigeons, and weavers. Storks were hunted using live decoys of the African openbill (*Anastomus lamelligerus*), which were tethered in a field with their beaks tied with rubber bands and surrounded by carbofuran-laced snail baits. Of eight poachers interviewed about the practice, all had been poisoning birds for more than 5 years, and for most it was their sole source of income.[6] The poachers worked in teams, and most targeted specific families of birds (e.g., storks, pigeons and doves) to eliminate the need for multiple types of bait and to reduce conflict between adjacent poachers' territories.[6] All the poachers knew of the toxicity of carbofuran but claimed that any associated toxicity and chemical residues were eliminated by washing their hands and specially preparing the meat of the poisoned birds. Meat preparation typically involves removing the pesticide-poisoned bird's entrails, hanging it to drain fluids, and then slow heating and partial roasting—as was done traditionally when animals were killed with poisoned arrows. Then the "detoxified" birds are cooked and eaten. Unlike in

west and central Africa where people have a fear of eating poisoned bushmeat[107,171] and suppliers try to disguise animals killed with poisons by subsequently shooting them in the head,[5] in western Kenya consumers knowingly purchased bushmeat killed with pesticides.[6] Most consumers in western Kenya purchased poisoned birds opportunistically, and none said that they fed on poisoned bird meat because no other source of protein was available.[6] All maintained that the practice of draining the fluid from the carcass and slow roasting detoxified it, even though all acknowledged that carbofuran could be deadly and was known to be used by women to poison philandering husbands.[6]

For over 20 years, bird poisoning in Kenya's rice schemes originally targeted ducks.[4,6] However, many species of ducks have been significantly reduced and/or eliminated in Kenya's rice schemes, likely because of pesticide poisoning.[6] Bird poisoning in the Bunyala rice scheme also likely poses significant repercussions to both local and migratory bird populations.[6] There are also the potentially significant, but as yet undocumented, effects on human health resulting from eating poisoned bird meat.[6]

In South Africa, it is estimated that up to 470,000 gamebirds are poisoned annually,[181] with the most-targeted groups being waterfowl and guineafowl.[17,43] In KwaZulu-Natal, most gamebirds are poisoned for food,[184] but in other areas it also arises because they uproot germinating crops.[181]

Harvesting wildlife for commercial trade in traditional medicine. Pesticides are increasingly used to harvest wildlife for the commercial trade in traditional African medicine and magic.[62,148,185] A wide range of native species are harvested for this trade, but relatively little information exists on the methods used to do so. Among carnivores, lions are the most frequently used for medicinal and magical practices,[186] and the use of poisons to harvest lion parts for traditional medicine has been identified as a major threat to populations in west and central Africa.[148] In South Africa, crocodiles are also illegally harvested for traditional medicine using pesticides.[17]

Vultures are unsustainably harvested using pesticides for the traditional medicine trade.[9,185,187,188] The trade has always been present in some areas (e.g., southern Africa and west Africa), as it is heavily engrained in local cultures, but demand has increased with the upsurge in human population and the methods of harvesting have become more destructive (i.e., use of pesticides) and widespread.[62,185,188] In South Africa, 35% of vultures found in medicinal markets were harvested through poisoning,[8] and in northern Nigeria, 47% of traders said the use of poisons was the predominant means of obtaining vultures.[187] In addition, the practice is no longer limited to use in traditional medicines; vultures are harvested to improve success in gambling, betting, and in business ventures, and to increase intelligence in children.[8,9,187,188] In South Africa, the supposed clairvoyant powers of vultures are linked to important events, where having the ability to predict the outcome would be beneficial, such as national elections and the lottery.[9] Peaks in vulture poisoning have been linked to the first democratic election in South Africa.[9] Decapitated poisoned vulture carcasses are a by-product of the traditional medicine trade, as the heads are typically favored for this purpose.[8,11] Recent mass vulture poisoning incidents where headless carcasses have been found indicate both the demand and geographical scope of this illicit practice. In the past 4 years, approximately 1000 beheaded poisoned vultures have been found in Zambia, Zimbabwe, Cameroon, and Tanzania.[11,105,189–191] Other bird species including the southern ground hornbill (*Bucorvus leadbeateri*) are harvested for the traditional medicine trade using poisons.[192]

Poaching for wildlife products. There has been a recent wave of elephant and rhinoceros poisoning to harvest ivory and horn, respectively. Perhaps the most shocking of these incidents was the recent cyanide poisoning of over 100 elephants in Hwange National Park, Zimbabwe.[12,127] Poured into waterholes and on salt licks, the cyanide also killed other wildlife, including buffalo, lions, vultures, and wild dogs.[127] In October 2013, four elephants were poisoned with carbofuran for their tusks and tails in North Luangwa National Park, Zambia.[193] Other elephant poisoning incidents have been recorded in Malawi.[11]

Rhinoceroses are increasingly being poisoned in southern Africa, particularly in Mozambique, Zimbabwe, and South Africa because it is a quieter method that is less easily detected than shooting.[10] Recent reports document the use of poisoned

cabbage leaves to bait and kill rhinoceroses in Zimbabwe[108] and South Africa.[111]

Carnivores including leopards, genets, and servals are deliberately poisoned for the skin/fur trade occurring in South Africa.[13,111]

Poisoning wildlife sentinels. The recent increase in elephant poaching has also resulted in the mass poisoning of vultures.[194] Vultures are deliberately poisoned by poachers who lace elephant carcasses because circling vultures give away the location of poachers' illicit activities.[11,105,194] This method has been recorded at elephant carcasses in Tanzania, Mozambique, Zimbabwe, Botswana, Namibia, and Zambia in recent years.[194] The number of vultures poisoned in the past 2 years exceeds 1500 individuals.[191,194]

Effects on nontarget species. Apart from the deliberate persecution of wildlife using poisons, there has been an even greater secondary toll on scavenging species, and many populations have declined as a result.[67,68,195] Research conducted in Namibia indicates that for every targeted predator, in excess of 100 nontarget animals are killed.[69] The most common victims include vultures, tawny eagles, bateleurs, and owls,[67,68,151,196,197] as well as mammalian carnivores such as aardwolves (*Proteles cristata*) and bat-eared foxes (*Otocyon megalotis*).[2,69] Of these, vultures are the most susceptible to poisoning because most are obligate scavengers, foraging over huge areas because of the transient nature of carrion, and because their social feeding behaviors ensure hundreds can be killed at a single carcass.[14] Vulture researchers in Africa have recently raised the alarm over plummeting populations caused mainly by poisoning,[14,15,189,198] although this is not the first time such a concern has been raised.[199]

The potential for nontarget scavengers to be poisoned at carcasses is not limited to incidents of human–wildlife conflict. Urban centers throughout Africa host very large populations of stray dogs that are routinely poisoned to reduce their numbers and the possibility of a rabies epidemic.[200–202] Poisons used to kill stray dogs include strychnine and warfarin.[200,201] After authorities in Ethiopia poisoned almost 10,000 dogs in March 2013, residents complained that carcasses were left on the streets uncollected for days.[203] Though reports of incidental poisonings are difficult to acquire, the information that has been obtained indicates that poisoning of stray dogs clearly is a significant threat to urban scavenger populations.[200]

Conclusions and recommendations

An unsustainable number and diversity of African wildlife are being killed illegally using poisons. It is therefore imperative that both national and international efforts be stepped up immediately to contain and stop this menace. Although a pesticide is used against one or a few species, it is, in fact, always applied to—and affects—an entire ecosystem.[83] The use of poisons against wildlife is ultimately the use of poisons against people.

The following recommendations should be considering as a starting point to tackling the problem of wildlife poisoning in Africa.

Banning pesticides

Many of the pesticides that have been banned in developed countries remain legal for use in Africa and other developing regions. For example, carbofuran is banned in most of the developed world (the United States, Canada, the United Kingdom, and E.U. countries); however, it remains a legally registered pesticide throughout Africa.[16,110] Banning pesticides is a directive of governments, and in many African countries there is little support for deregistering pesticides solely on the basis of threats to wildlife.[14,16] Porous borders and corruption of a buy-back program (not a ban) to remove carbofuran from the shelves of East African agro-vet shops was only marginally effective over the short term.[16,204] The buy-back program also resulted in an influx of counterfeit pesticides being sold in some agro-vet shops in Kenya.[204] Given the limited success of the buy-back program, more concrete measures such as banning pesticides are recommended alongside greater accountability from pesticide producers and distributors.

Regulation and control of distribution

Throughout most of Africa, there is little control over the ease of access to highly toxic pesticides.[4,7,62,64,101,110] Even restricted-use pesticides are easily available in some countries.[4,7,101] Clearly, there is an urgent need to restrict and monitor access to all highly toxic chemicals, even if for the purpose of increasing human safety. All pesticides listed on Annex III of the Rotterdam Convention should not be easily available over the counter. Users must have a legitimate reason for obtaining the pesticide, and a

registry of user's needs to be established at a limited number of distribution points within each country.

Enforcement and penalties for poisoning

Enforcement of the existing laws has been ineffective and inadequate, and there are very few prosecutions of offenders.[16] The legal framework must be strengthened to ensure that any wildlife killed by poisons is stipulated to be illegal. Any loopholes should be identified and sealed.

Increasing international support and awareness

Aid to African countries needs to be tied to strict enforcement of pesticide regulations. As witnessed in Kenya, local government authorities failed to act against poisoning until there was pressure from outside of Africa.[204] The issue of wildlife poisoning needs to generate headlines outside of Africa, and citizens of developed nations should be made aware of the serious issue of wildlife poisoning, much as the issue of elephant and rhino poaching is currently making international headlines.

Development of regional pesticide centers across Africa

The continent should aim to develop centers in each region (north, west, east, central, and south) that would be the authority on pesticides and act as hubs for capacity building. The centers would have as their mandate chemical testing, public education and training, monitoring and reporting, and public policy and human health. Through support and training from developed-world institutions, these centers would have highly trained staff, modern equipment, and appropriate storage facilities. They would offer testing of samples at affordable rates and the results would be of sufficient forensic standards to support legal and criminal cases. The centers would also be the key institutions responsible for developing and implementing educational materials and guidelines to inform the public of the potential dangers of pesticide use, laws governing deliberate pesticide misuse, and actions to be taken in the event of a human or wildlife poisoning. An internal office would record, monitor, and report on wildlife and human poisoning incidents. The center would monitor and lobby policy activities with regard to pesticides. Staff would also conduct further studies on pesticide use across the continent. The most urgently needed studies would identify poisoning hotspots in all countries in Africa and examine the links between pesticide abuse and risks to human health, particularly with regard to eating pesticide-killed bushmeat. Additional work needs to be done on how to manage stray dog populations without resorting to poisons.

Relevant stakeholders, from industry, government, international aid organizations, and nongovernmental organizations, need to conduct regional meetings in an effort to agree on the methods and means of financial support to tackle this crisis. Suggestions for funding this initiative could be from a tax on manufacturers and distributors who sell pesticides registered for use in Africa. Additional financial support could be sought in the form of international aid, as well as nonmonetary support in the form of equipment donation and technical training through university partnerships.

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Conflicts of interest

The author declares no conflicts of interest.

References

1. Frank, L., S. Maclennan, L. Hazzah, *et al.* 2006. Lion killing in the Amboseli-Tsavo ecosystem, 2001-2006, and its implications for Kenya's lion population. Unpublished report. p. 9.
2. Daly, B., H. Davies-Mostert, W. Davies-Mostert, S. Evans, Y. Friedmann, N. King, T. Snow & H. Stadler, Eds. 2006. Prevention is the cure. In *Proceedings of a Workshop on Holistic Management of Human-Wildlife Conflict in the Agricultural Sector of South Africa.* Johannesburg: Endangered Wildlife Trust.
3. Kissui, B.M. 2008. Livestock predation by lions, leopards, spotted hyenas, and their vulnerability to retaliatory killing in the Maasai steppe, Tanzania. *Anim. Conserv.* **11:** 422–432.
4. Odino, M. & D.L. Ogada. 2008. Furadan use in Kenya and its impacts on birds and other wildlife: a survey of the regulatory agency, distributors, and end-users of this highly toxic pesticide. *Report to the Bird Committee of Nature Kenya*, p. 17.
5. Opare-Ankrah, Y. 2007. The bushmeat trade, livelihood securities and alternative wildlife resources: a case study of Mankessim and its environs in the Mfantseman District (Ghana). MP thesis. Norwegian University of Science and Technology. p. 126.

6. Odino, M. 2011. "Measuring the conservation threat to birds in Kenya from deliberate pesticide poisoning: a case study of suspected carbofuran poisoning using Furadan in Bunyala Rice Irrigation Scheme." In *Carbofuran and Wildlife Poisoning: Global Perspectives and Forensic Approaches.* N.L. Richards, Ed.: 53–70. UK: Wiley.
7. de Feu, T.A. 2001. Fish and fisheries in the southern zone of the Takamanda forest reserve, South-West Cameroon. Report to the Cameroonian-German (GTZ) Project for the Protection of Forests around Akwaya (PROFA). p. 86.
8. Mander, M., N. Diederichs, L. Ntuli, *et al.* 2007. Survey of the trade in vultures for the traditional health industry in South Africa. Unpublished report. p. **54**.
9. McKean, S. 2004. "Traditional use of vultures: some perspectives." In *The Vultures of Southern Africa – Quo Vadis? Proceedings of a Workshop on Vulture Research and Conservation in Southern Africa.* A. Monadjem, M.D. Anderson, S.E. Piper & A.F. Boshoff AF, Eds.: 214–219. Johannesburg: Birds of Prey Working Group.
10. Miliken, T., R.H. Emslie & B. Talukdar. 2009. African and Asian rhinoceroses—status, conservation and trade. Report to the CITES Secretariat pursuant to Resolution Conference 9.14 (Rev. CoP14) and Decision 14.89. p. 18.
11. Roxburgh, L. & R. McDougall. 2012. Vulture poisoning incidents and the status of vultures in Zambia and Malawi. *Vulture News* **62:** 33–39.
12. Lane, T. 2013. Hwange elephant poaching. Cited Dec 6, 2013. http://www.zimbabwesituation.com/news/hwange-elephant-poaching-trevor-lane./.
13. van der Westhuizen, H. Personal communication.
14. Ogada, D.L., F. Keesing & M.Z. Virani. 2012. Dropping dead: causes and consequences of vulture population declines worldwide. *Ann. N. Y. Acad. Sci.* **1249:** 57–71.
15. Virani, M.Z., C. Kendall, P. Njoroge & S. Thomsett. 2011. Major declines in the abundance of vultures and other scavenging raptors in and around the Masai Mara ecosystem, Kenya. *Biol. Conserv.* **144:** 746–752.
16. Lalah, J.O., P.O. Otieno & N. Richards. 2011. "A chronicling of long-standing carbofuran use and its menace to wildlife in Kenya." In *Carbofuran and Wildlife Poisoning: Global Perspectives and Forensic Approaches.* N.L. Richards, Ed.: 1–52. UK: Wiley.
17. Verdoorn G.H., N. van Zijl, T.V. Snow, *et al.* 2004. "Vulture poisoning in southern Africa." In *Vultures in the Vultures of Southern Africa – Quo Vadis? Proceedings of a Workshop on Vulture Research and Conservation in Southern Africa.* A. Monadjem, M.D. Anderson, S.E. Piper & A.F. Boshoff AF, Eds.: 214–219. Johannesburg: Birds of Prey Working Group.
18. Fourie, N., A.T. Basson, K.M. Basson, *et al.* 1996. Poisoning of wildlife in South Africa. *J. S. Afr. Vet. Assoc.* **67:** 74–76.
19. Kahumbu, P. 2010. Evidence for revoking carbofuran registration in Kenya. Report to the Ministry of Agriculture Taskforce. p. **39**.
20. Cole, L.A. 1998. The poison weapons taboo: biology, culture, and policy. *Polit. Life Sci.* **17:** 119–132.
21. Mason, Otis T., W.H. Holmes, *et al.* 1891. Arrows and Arrow-Makers. *American Anthropologist* **4:** 45–74.
22. Hall, I.C. & R.W. Whitehead. 1927. A pharmacobacteriologic study of African poisoned arrows. *J. Infect. Dis.* **41:** 51–69.
23. d'Errico, F., L. Backwell, P. Villa, *et al.* 2012. Early evidence of San material culture represented by organic artifacts from Border Cave, South Africa. *Proc. Natl. Acad. Sci. USA* **109:** 13214–13219.
24. The Global Biodiversity Information Facility: GBIF Backbone Taxonomy, 2013-07-01. Cited Nov 18, 2013. http://www.gbif.org/species/3169589 on 2013-11-25.
25. Campbell, A. & G. Lamont. 1968. Some notes on hunting with poisoned arrows. *Botswana Notes Records* **1:** 95–96.
26. Mines, G.R. 1908. On the Munchi arrow poison and strophanthin. *J. Physiol.* **37:** 37–49.
27. Howes, F.N. 1930. Fish-poison plants. *Bull. Misc. Inform. (Royal Gardens, Kew)* **4:** 129–153.
28. Greenway, P.J. 1936. Mundulea fish poison. *Bull. Misc. Inform. (Royal Gardens, Kew)* **4:** 245–250.
29. Mundy, P., D. Butchart, J. Ledger & S. Piper. 1992. *The Vultures of Africa.* London: Academic Press.
30. Brown, L. 1971. *African Birds of Prey.* Boston: Houghton Mifflin.
31. Frank, L. 2011. "Living with lions: lessons from Laikipia." In *Conserving Wildlife in African Landscapes: Kenya's Ewaso Ecosystem.* N.J. Georgiadis, Ed.: 73–84. Smithsonian Contributions to Zoology No. 632. Smithsonian Institution Scholarly Press. Washington DC.
32. Stadler, H. 2006. "Historical perspective on the development of problem animal management in the Cape Province." In *Prevention is the Cure. Proceedings of a Workshop on Holistic Management of Human-Wildlife Conflict in the Agricultural Sector of South Africa.* B. Daly, H. Davies-Mostert, W. Davies-Mostert, S. Evans, Y. Friedmann, N. King, T. Snow & H. Stadler, Eds.: 11–16. Johannesburg: Endangered Wildlife Trust.
33. van Stittert, L. 1998. "Keeping the Enemy at Bay": the extermination of wild carnivora in the cape colony, 1889–1910. *Environ. Hist.* **3:** 333–356.
34. Tropp, J. 2002. Dogs, poison and the meaning of colonial intervention in the Transkei, South Africa. *J. Afr. Hist.* **43:** 451–472.
35. Beinart, W. 1998. The night of the jackal: sheep, pastures and predators in the Cape. *Past Present* **158:** 172–206.
36. Purkitt, H.E. & S. Burgess. 2002. South Africa's chemical and biological warfare programme: a historical and international perspective. *J. South. Afr. Stud.* **28:** 229–253.
37. Steinmetz, G. 2005. From "Native Policy" to exterminationism: German Southwest Africa, 1904, in comparative perspective. Theory and Research in Comparative Social Analysis, Department of Sociology, UCLA, UCLA.
38. Holub, E. 1881. Seven Years in South Africa: Travels, Researches, and Hunting Adventures, Between the Diamond-fields and the Zambesi (1872-79) (Vol. 2). London: S. Low, Marston, Searle & Rivington.
39. Smithers, R.H.N. 1971. The mammals of Botswana. Salisbury: trustees of the National Museums of Rhodesia. pp. 110–111.
40. Boshoff, A.F. & C.J. Vernon. 1980. Past and present distribution and status of the Cape vulture in Cape Province. *Ostrich* **51:** 230–250.

41. Boshoff, A.F., C.J. Vernon & R.K. Brooke. 1983. Historical atlas of the diurnal raptors of the Cape Province (Aves: Falconiformes). *Ann. Cape Provinc. Mus. (Natural History)* **14:** 173–297.
42. de Wet, T. 2004. "Vermin>problem animal>damage control—a wake-up call." In *Prevention is the Cure. Proceedings of a Workshop on Holistic Management of Human-Wildlife Conflict in the Agricultural Sector of South Africa.* B. Daly, H. Davies-Mostert, W. Davies-Mostert, S. Evans, Y. Friedmann, N. King, T. Snow & H. Stadler, Eds.: 17–22. Johannesburg: Endangered Wildlife Trust.
43. Ledger, J. 1980. Vultures poisoned in Caprivi. *Vulture News* **3:** 15.
44. Ledger, J. 1985. The poison people. *Afr. Wildl.* **39:** 6–8.
45. Moore, R.I. 1981. *The Hamlyn Historical Atlas.* London, New York, Sydney, Toronto: The Hamlyn Publishing Group Limited.
46. Jackson, F.J. 1938. *The Birds of Kenya Colony and the Uganda Protectorate.* London: Gurney and Jackson.
47. Matheka, R. 2005. Antecedents to the community wildlife conservation programme in Kenya, 1946-1964. *Environ. Hist.* **11:** 239–267.
48. Gade, D.W. 2006. Hyenas and humans in the horn of Africa. *Geographic. Rev.* **96:** 609–632.
49. Ogada, M.O. & D.L. Ogada. 2004. Factors influencing levels of carnivore-livestock conflicts in Samburu Heartland and proposed mitigation measures. Report to African Wildlife Foundation.
50. Mwaniki, D. 1997. Hyenas as problem carnivores: the Mandera/Moyale experience. *Paper presented at KWS Workshop to Review Management of "Problem" Carnivores in Kenya.* 3 March 1997. Nairobi: Kenya Wildlife Service.
51. Jarvis, M.J.F. & M. La Grange. 1982. Problem vertebrate management in Zimbabwe. In *Proceedings of the Tenth Vertebrate Pest Conference.* Paper 25. R.E. Marsh, Ed. UC Davis, California.
52. Lamarque, F., J. Anderson, R. Fergusson, *et al.* 2009. Human-wildlife conflict in Africa: causes, consequences and management strategies. FAO Forestry Paper no. 157. Rome. p. 112.
53. Toure, O. 1988. The pastoral environment of northern Senegal. *Rev. Afr. Polit. Econ.* **15:** 32–39.
54. Chardonnet, P., U. Belemsobgo, W. Crosmary, *et al.* 2005. Influences directes et indirectes sur la conservation du lion en Afrique de l'Ouest et en Afrique Centrale. *Atelier sur la Conservation du Lion d'Afrique de l'Ouest et d'Afrique Centrale.* Douala, Cameroon, 5–7 October.
55. Thévenot, M., R. Vernon & P. Bergier. 2003. The birds of Morocco. British Ornithologist's Union. p. 594.
56. Thévenot, M., P. Bergier & P. Beaubrun. 1985. "Present distribution and status of raptors in Morocco." In *Conservation Studies on Raptors.* I. Newton & R.D. Chancellor, Eds.: 83–101. International Council for Bird Preservation: Cambridge, United Kingdom.
57. Cherkaoui, I. 2005. The bearded vulture *Gypaetus barbatus* in Morocco. *Vulture News* **52:** 37.
58. Denney, R. 1972. Relationships of wildlife to livestock on some developed ranches on the Laikipia Plateau, Kenya. *J. Range Manag.* **25:** 415–425.
59. Verschuren, J. 1975. Wildlife in Zaire. *Oryx* **13:** 149–163.
60. Kato, S.S. & J.O. Okumu. 2008. Making bush meat poachers willingly surrender using integrated poachers awareness programme: a case of Murchison Falls National Park, Uganda. In *Proceedings of the the 12th Biennial Conference of the International Association for the Study of Commons.* University of Gloucestershire.
61. Cincotta, R.P. & R. Engelman. 1997. Economics and rapid change: the influence of population growth. No. 3. Population Action International. p. 30.
62. Ledger, J. 1988. Tackling the problem of vulture poisoning. *Bokmakierie* **40:** 4–5.
63. Chardonnet, P.H., Ed. 2002. Conservation of the African lion: contribution to a status survey. International Foundation for the Conservation of Wildlife, France & Conservation Force, USA.
64. Allan, D.G. 1989. Strychnine poison and the conservation of avian scavengers in the Karoo, South Africa. *S. Afr. J. Wildl. Res.* **19:** 102–106.
65. Anderson, M.D. 2000. Raptor conservation in the Northern Cape Province, South Africa. *Ostrich* **75:** 25–32.
66. Brown, C.J. 1985. The status and conservation of the Cape vulture in SWA/Namibia. *Vulture News* **14:** 4–15.
67. Brown, C.J. 1991. An investigation into the decline of the bearded vulture in southern Africa. *Biol. Conserv.* **57:** 315–337.
68. Brown, C.J. 1991. Declining martial and tawny eagle populations and causes of mortality on commercial farmlands in central Namibia. *Biol. Conserv.* **56:** 49–66.
69. Brown, C.J. 2006. Historic distribution of large mammals in the Greater Fish River Canyon Complex, southern Namibia, and recommendations for re-introductions. Namibia Nature Foundation. p. 19.
70. Hofer, H. & M.G.L. Mills. 1998. Population size, threats and conservation status of hyaenas. In *Hyaenas: status survey and conservation action plan.* M.G.L. Mills & H. Hofer, Eds.: 64–79. IUCN/SSC Hyaena Specialist Group. Gland, Switzerland.
71. Martínez-Haro, M., R. Mateo, R.Guitart, *et al.* 2008. Relationship of the toxicity of pesticide formulations and their commercial restrictions with the frequency of animal poisonings. *Ecotoxicol. Environ. Safety* **69:** 396–402.
72. Bruggers, R.L., M.M. Jaeger, J.O. Keith, *et al.* 1989. Impact of fenthion on nontarget birds during quelea control in Kenya. *Wildl. Soc. Bull.* **17:** 149–160.
73. Mullie, W.C. & J.O. Keith. 1993. The effects of aerially applied fenitrothion and chlorpyrifos on birds in the savannah of northern Senegal. *J. Appl. Ecol.* **30:** 536–550.
74. Douthwaite, R.J. 1995. Occurrence and consequences of DDT residues in woodland birds following tsetse fly spraying operations in NW Zimbabwe. *J. Appl. Ecol.* **32:** 727–738.
75. McWilliam, A.N. & R.A. Cheke. 2004. A review of the impacts of control operations against the red-billed quelea (Quelea quelea) on non-target organisms. *Environ. Conserv.* **31:** 130–137.
76. Matthiessen, P. & B. Douthwaite. 1985. The impact of tsetse fly control campaigns on African wildlife. *Oryx* **19:** 202–209.

77. Thomsett, S. 1987. Raptor deaths as a result of poisoning quelea in Kenya. *Gabar* **2:** 33–38.
78. Vyas, N.B. 1999. Factors influencing estimation of pesticide-related wildlife mortality. *Toxicol. Ind. Health* **15:** 186–191.
79. Mineau, P. 2005. "Direct losses of birds to pesticides—beginnings of a quantification." In *Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference 2002.* Vol. 2. C.J. Ralph & T.D. Rich, Eds.: 1065–1070. Albany, CA: USDA Forest Service, GTR-PSW-191.
80. LeBel, S., A. Murwira, B. Mukamuri, *et al.* 2011. "Human wildlife conflicts in Southern Africa: riding the whirl wind in Mozambique and in Zimbabwe." In *The Importance of Biological Interactions in the Study of Biodiversity.* J. López-Pujol, Ed.: 283–322. Croatia: InTech.
81. Frank, L.G., A. Cotterill, S. Dolrenry & L. Hazzah. 2011. "The role of carbofuran in the decline of lions and other carnivores in Kenya." In *Carbofuran and Wildlife Poisoning: Global Perspectives and Forensic Approaches.* N.L. Richards, Ed.: 70–74. West Sussex, United Kingdom: Wiley.
82. Lancaster, S., N.L. Richards, A. Gachanja, *et al.* 2011. A snapshot of analytical, forensic and biological initiatives currently underway in Kenya to preserve environmental resources and species in jeopardy. *R. Soc. Chem. Environ. Chem. Group Bull.* September: 3–8.
83. Moore, N.W. 1967. Effects of pesticides on wildlife. *Proc. R. Soc. Lond. Ser. B, Biol. Sci.* **167:** 128–133.
84. Grue, C.E., A.D.M. Hart & P. Mineau. 1991. "Biological consequences of depressed brain cholinesterase activity in wildlife." In *Cholinesterase-Inhibiting Insecticides. Their Impact on Wildlife and the Environment.* P. Mineau, Ed.: 151–210. Amsterdam: Elsevier Science Publishers.
85. Mineau, P., M.R. Fletcher, L.C. Glaser, *et al.* 1999. Poisoning of raptors with organophosphorus and carbamate pesticides with emphasis on Canada, the United States and the United Kingdom. *J. Raptor Res.* **33:** 1–37.
86. Grue, C.E., P.L. Gibert & M.E. Seeley. 1997. Neurophysiological and behavioral changes in non-target wildlife exposed to organophosphate and carbamate pesticides: thermoregulation, food consumption, and reproduction. *Am. Zool.* **37:** 369–388.
87. Fry, D.M. 1995. Reproductive effects in birds exposed to pesticides and industrial chemicals. *Environ. Health Perspect.* **103**(Suppl 7): 165.
88. Crick, H. 1990. Poisoned prey in the heart of Africa. *New Scientist* **128:** 39–42.
89. Crick, H.Q.P. 1992. Organochlorine pesticides and birds of prey in Africa. In *Proceedings of VII Pan-African Ornithological Congress.* pp. 171–189.
90. Kairu, J.K. 1994. Pesticide residues in birds at Lake Nakuru, Kenya. *Int. J. Salt Lake Res.* **3:** 31–48.
91. Snelling, J.C., A.C. Kemp & J.L. Lincer. 1984. Organochlorine residues in Southern African raptor eggs. In *Proceedings of the 2nd Symposium on African Predatory Birds*, Durban, South Africa. pp. 161–168.
92. Bouwman, H., I.M. Viljoen, L.P. Quinn & A. Polder. 2013. Halogenated pollutants in terrestrial and aquatic bird eggs: converging patterns of pollutant profiles, and impacts and risks from high levels. *Environ. Res.* **126:** 240–253.
93. Odino, M. 2011. A review of Kenyan laws relating to wildlife poisoning. Report to BirdLife International. p. 9.
94. An introduction to the African convention on the conservation of nature and natural resources. 2006. IUCN, Gland, Switzerland. xvi + 96 pp.
95. List of countries which have signed, ratified/acceded to the African convention on the conservation of nature and natural resources (Revised version). 2010. African Union.
96. UNEP. 1998. Basel conservation on the control of transboundary movements of hazardous wastes and their disposal. p. 126.
97. UNEP. 2009. Stockholm convention on persistant organic pollutants (POPS). p. 64.
98. UNEP. 2011. Rotterdam convention on the prior informed consent procedure for certain hazardous chemicals and pesticides in international trade. p. 46.
99. Rotterdam Convention. 2010. Cited Dec 6, 2013. http://www.pic.int/Countries/Statusofratifications/tabid/1072/language/en-US/Default.aspx.
100. Rotterdam Convention. 2010. Cited Dec 6, 2013. http://www.pic.int/TheConvention/Chemicals/AnnexIIIChemicals/tabid/1132/language/en-US/Default.aspx.
101. Odino, M. & D.L. Ogada. 2008. Furadan use in Kenya: a survey of the distributors and end-users of toxic Carbofuran (Furadan) in pastoralist and rice growing areas. Report to Kenya Wildlife Trust. p. 19.
102. Crabtree, D.G. 1962. Review of current vertebrate pesticides. In Proceedings of the 1st Vertebrate Pest Conference. Paper 22.
103. Herranz, J. 2000. Efectos de la depredación y del control de predadores sobre la caza menor en Castilla-La Mancha. PhD thesis. Universidad Autónoma de Madrid.
104. Márquez, C., J.M. Vargas, R. Villafuerte & J.E. Fa. 2012. Understanding the propensity of wild predators to illegal poison baiting. *Anim. Conserv.* **16:** 118–129.
105. Groom, R.J., E. Gandiwa, P. Gandiwa & H.J. van der Westhuizen. 2013. A mass poisoning of White-backed and Lappet-faced vultures in Gonarezhou National Park. *Honeyguide* **59:** 5–9.
106. Odino, M., D. Ogada & S. Musila. 2008. Furadan killing birds on a large-scale in Bunyala Rice Fields-Western Kenya. *Kenya Birds* **12:** 7–10.
107. Owusu-Ansah, N. 2010. Evaluation of wildlife hunting restriction on bushmeat trade in five major markets around Digya National Park, Ghana. MA thesis submitted to University of Cape Coast, Ghana. p. 111.
108. Tavuyanago, B. & E.C. Makwara. 2011. Contested landscape: the struggle for the control of Gonarezhou since the inception of colonial rule in Zimbabwe. *J. Sustain. Dev. Afr.* **13:** 46–64.
109. Osemeobo, G.J. 2012. Can you manage wildlife in alienated lands? Tenure conflicts in protected forests in Nigeria. *J. Environ. Sci. Water Res.* **1:** 18–26.
110. Omoya, E.O. & A.J. Plumptre. 2011. An assessment of availability and use of carbofuran and other agro-vet chemicals used to poison lions, around Queen Elizabeth Conservation Area (QECA) and in Kampala, Uganda. Unpublished report. p. 20.
111. Snow, T. Unpublished data.

112. Maclennan, S.D., R.J. Groom, D.W. Macdonald & L.G. Frank. 2009. Evaluation of a compensation scheme to bring about pastoralist tolerance of lions. *Biol. Conserv.* **142:** 2419–2427.
113. Akagu, R. 2012. Notes of the vulture round table discussion. *Pan-African Ornithological Congress.* p. 6.
114. Clark, J. Unpublished data.
115. Basson, P.A. 1987. Poisoning of wildlife in southern Africa. *J. S. Afr. Vet. Assoc.* **58:** 219–228.
116. Smit, W. 1984. Cape vultures poisoned in the eastern Cape, South Africa. *Vulture News* **12:** 5–7.
117. Anderson, M.D. 1994. Mass African White-backed vulture poisoning in the northern Cape. *Vulture News* **29:** 31–32.
118. Bridgeford, P. 2001. More vulture deaths in Namibia. *Vulture News* **44:** 22–26.
119. Borello, W.D. 1985. Poisoned vultures in Botswana: known facts. *Babbler* **9:** 22–23.
120. Claro, F. 2003. Survey of fauna in Termit (Niger). Unpublished Report. p. 6.
121. Berliner, D. 1984. The use of strychnine poison by farmers in the NW Transvaal and their attitudes towards vultures. *Vulture News* **12:** 7–8.
122. Masenga, E.H., R.D. Lyamuya, A. Nyaki, *et al.* 2013. Strychnine poisoning in African wild dogs (*Lycaon pictus*) in the Loliondo game controlled area, Tanzania. *Int. J. Biodivers. Conserv.* **5:** 367–370.
123. Bridgeford, P. 2002. Recent vulture mortalities in Namibia. *Vulture News* **46:** 38.
124. Apps, P. & J.W. McNutt. 2009. Analytical report to BirdLife Botswana. p. 4.
125. Otieno, P.O., J.O. Lalah, M. Virani, I.O. Jondiko & K.W. Schramm. 2010. Carbofuran and its toxic metabolites provide forensic evidence for Furadan exposure in vultures (*Gyps africanus*) in Kenya. *Bulletin of Environmental Contamination and Toxicology* **84:** 536–544.
126. Frank, L., G. Hemson, H. Kushnir & C. Packer. 2006. Lions, conflict and conservation in eastern and southern Africa. Background paper for the Eastern and Southern African Lion Conservation Workshop, Johannesburg, South Africa.
127. Cox, P. 2013. Elephants killed by cyanide reveal alarming innovation in poaching tactics. *Voice of America.* Cited Dec 21, 2013. http://www.voanews.com/content/elephants-killed-by-cyanide-reveal-alarming-innovation-in-poaching-tactics/1760380.html.
128. Croes, B., R. Buij, J. van Dalen & H. de longh. 2008. "Livestock-carnivore conflicts: results of an inventory around Benoue National Park, Cameroon." In *Management and Conservation of Large Carnivores in West and Central Africa.* Proceedings of the International Seminar, November 15–16, 2006 in Maroua, Cameroon. Institute of Environmental Sciences, Leiden.
129. Pesticide Action Network Asia and the Pacific. 2011. Highly hazardous pesticides: Monocrotophos. Cited Nov 14, 2013. www.panap.net/en/p/post/pesticides-info-database/1211.
130. Pesticide Action Network UK. 2008. Which pesticides are banned in Europe? Cited Nov 14, 2013. www.pan-europe.info/Resources/Links/Banned_in_the_EU.pdf.
131. U.S. Environmental Protection Agency. 2011. Carbofuran cancellation process. Cited Nov 20, 2013. http://www.epa.gov/pesticides/reregistration/carbofuran/carbofuran_noic.htm.
132. U.S. Environmental Protection Agency. 2010. Agreement to terminate all uses of aldicarb. Cited Nov 20, 2013. http://www.epa.gov/oppsrrd1/REDs/factsheets/aldicarb_fs.html.
133. U.S. Environmental Protection Agency. 2004. Diazinon: phase out of all residential uses of the insecticide. Cited Nov 20, 2013. http://www.epa.gov/pesticides/factsheets/chemicals/diazinon-factsheet.htm.
134. Health Canada. 2009. Re-evaluation decision: Diazinon. Health Canada Pest Management Regulatory Agency, Ontario.
135. Health Canada. 2010. Re-evaluation decision: Carbofuran. Health Canada Pest Management Regulatory Agency, Ontario.
136. FAO. 1997. Decision guidance document: Monocrotophos. Cited Nov 20, 2013. http://www.fao.org/docrep/w5715e/w5715e04.htm.
137. Agriculture and Agri-food Canada. 1992. Strychnine reduction of allowable use pattern. Note to CAPCO. C92-09.
138. Kahumbu, P. Personal communication.
139. Frank, L.G., K.E. Holekamp & L. Smale. 1995. "Dominance, demographics and reproductive success in female spotted hyenas: a long term study." In *Serengeti II: Research, Management, and Conservation of an Ecosystem.* A.R.E. Sinclair & P. Arcese, Eds.: 364–384. Chicago: University of Chicago Press.
140. Avenant, N., H. de Waal & W. Combrinck. 2006. "The caniscaracal programme: a holistic approach." In *Prevention is the Cure. Proceedings of a Workshop on Holistic Management of Human-Wildlife Conflict in the Agricultural Sector of South Africa.* B. Daly, H. Davies-Mostert, W. Davies-Mostert, S. Evans, Y. Friedmann, N. King, T. Snow & H. Stadler, Eds.: 23–25. Johannesburg: Endangered Wildlife Trust.
141. Baldus, R.D. 2008. Man-eaters, witchcraft and poison: carnivore problems unsolved in Tanzania/East Africa. In *Proceedings of the International Symposium: "Coexistence of Large Carnivores and Humans: Threat or Benefit?"* R.G. Potts & K. Hecker, Eds.: 23–27. Belgrade.
142. Henschel, P., L. Hunter, U. Breitenmoser, *et al.* 2008. Panthera pardus. In IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. www.iucnredlist.org. Accessed 26 November 2013.
143. Frank, L.G., R.B. Woodroffe & M. Ogada. 2005. "People and Predators in Laikipia District, Kenya." In *The Conservation of Wildlife that Conflicts with Man.* R.B. Woodroffe, S. Thirgood & A. Rabinowitz, Eds.: 86–304. Cambridge: Cambridge University Press.
144. St John, F.A.V., A.M. Keane, G. Edwards-Jones, *et al.* 2012. Identifying indicators of illegal behaviour: carnivore killing in human-managed landscapes. *Proc. R. Soc. B.* **279:** 804–812.
145. Woodroffe, R. & J.R. Ginsberg. 1999. Conserving the African wild dog *Lycaon pictus.* I.Diagnosing and treating causes of decline. *Oryx* **33:** 132–142.

146. EWCA. 2012. National Action Plan for the Conservation of Cheetahs and African Wild Dogs in Ethiopia, Addis Ababa, Ethiopia.
147. Hemson, G. 2003. The ecology and conservation of lions: human-wildlife conflict in semi-arid Botswana. PhD thesis submitted to Oxford University. p. 213.
148. Bauer, H. 2003. Lion conservation in West and Central Africa: integrating social and natural science for wildlife conflict resolution around Waza National Park, Cameroon. PhD thesis submitted to Leiden University, the Netherlands. p. 168.
149. Packer, C., D. Ikanda, B. Kissui & H. Kushnir. 2006. The ecology of man-eating lions in Tanzania. *Nature Faune* **21:** 10–15.
150. Patrick, R., D. Patrick & K.D. Hunt. 2012. "Long term changes at Toro-Semliki wildlife reserve." In *Long-Term Changes in Africa's Rift Valley*. A. Plumptre, Ed.: 56–69. New York: Nova Science Publishers.
151. Mijele, D. 2009. Incidences of poisoning of vultures and lions in the Masai Mara National Reserve. Kenya Wildlife Service Masai Mara Veterinary Report. Nairobi, Kenya.
152. Romanach, S.S., P.A. Lindsey & R. Woodroffe. 2007. Determinants of attitudes towards predators in central Kenya and suggestions for increasing tolerance in livestock dominated landscapes. *Oxyx* **41:** 185–195.
153. Dickman, A.J. 2005. An assessment of pastoralist attitudes and wildlife conflict in the Rungwa-Ruaha region, Tanzania, with particular reference to large carnivores. MSc thesis submitted to University of Oxford. p. 95.
154. Kaltenborn, B.P., T. Bjerke, J.W. Nyahongo & D.R. Williams. 2006. Animal preferences and acceptability of wildlife management actions around Serengeti National Park, Tanzania. *Biodivers. Conserv.* **15:** 4633–4649.
155. Pangle, W.M. & K.E. Holekamp. Lethal and nonlethal anthropogenic effects on spotted hyenas in the Masai Mara National Reserve. *J. Mammal.* **91:** 154–164.
156. Estes, R.D. & J. Goddard. 1967. Prey selection and hunting behavior of the African wild dog. *J. Wildl. Manag.* **31:** 52–70.
157. Woodroffe, R., H. Davies-Mostert, J. Ginsberg, *et al.* 2007. Rates and causes of mortality in Endangered African wild dogs Lycaon pictus: lessons for management and monitoring. *Oryx* **41:** 215–223.
158. Santiapillai, C. & R. Jayewardene. 2004. Conservation of the leopard and other carnivores in Sri Lanka. *Curr. Sci.* **86:** 1063–1064.
159. Naughton-Treves, L. 2008. Predicting patterns of crop damage by wildlife around Kibale National Park, Uganda. *Conserv. Biol.* **12:** 156–168.
160. Eniang, E.A., H.M. Ijeomah, G. Okeyoyin & A.E. Uwatt. 2011. Assessment of human-wildlife conflicts in Filinga Range of Gashaka Gumti National Park, Nigeria. *Production, Agriculture and Technology (PAT) Journal* **7:** 15–35.
161. Edroma, E.L., N. Rosen & P.S. Miller, Eds. 1997. *Conserving the Chimpanzees of Uganda: Population and Habitat Viability Assessment for Pan troglodytes schweinfurthii*, p. 260. Apple Valley, MN: IUCN/SSC Conservation Breeding Specialist Group.
162. Nowak, K., A. Perkin & T. Jones. 2009. Update on habitat loss and conservation status of the endangered Zanzibar red colobus on Uzi and Vundwe Islands. Unpublished report for Department of Commercial Crops, Fruits and Forestry, Zanzibar. p. 22.
163. Saj, T.L., C. Mather & P. Sicotte. 2006. Traditional taboos in biological conservation: the case of *Colobus vellerosus* at the Boabeng-Fiema Monkey Sanctuary, Central Ghana. *Soc. Sci. Inform.* **45:** 285–310.
164. Thouless, C.R. 1994. Conflict between humans and elephants on private land in northern Kenya. *Oryx* **28:** 119–127.
165. Gandiwa, E., I. Heitkönig, A.M. Lokhorst, H.H. Prins & C. Leeuwis. 2013. Illegal hunting and law enforcement during a period of economic decline in Zimbabwe: a case study of northern Gonarezhou National Park and adjacent areas. *J. Nature Conserv.* **21:** 133–142.
166. Packer, C., H. Brink, B.M. Kissui, *et al.* 2011. Effects of trophy hunting on lion and leopard populations in Tanzania. *Conserv. Biol.* **25:** 142–153.
167. Turner, D. Personal communication.
168. Barnes, K.N. 2000. *The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland.* Johannesburg: BirdLife South Africa.
169. Gibbons, B. 2011. Recorded Blue Crane *Anthropoides paradiseus* mortalities from 2005 to 2009 in the Karoo. *INDWA* **7:** 41–43.
170. Olupot, W., H. Mugabe & A.J. Plumptre. 2009. Species conservation on human-dominated landscapes: the case of crowned crane breeding and distribution outside protected areas in Uganda. *Afr. J. Ecol.* **48:** 119–125.
171. Ayeni, J.S.O. & M. Mdaihli. 2002. Wildlife hunting and bush-meat utilization in the Takamanda Forest Reserve areas of South West Province, Cameroon. PROFA. Project for the Protection of Forests Around Akwaya PROFA (GTZ-MINEF). Mamfe, South West Province Cameroon, PROFA: 36.
172. Inogwabini, B.I. 2005. Fishes of the Salonga National Park, Democratic Republic of Congo: survey and conservation issues. *Oryx* **39:** 78–81.
173. Eniang, E.A. 2002. The survey of Preuss's Red Colobus (PRC) *Procolobus badius preussi* in Ikpan Forest Block of the Cross River National Park (CRNP), Nigeria. Unpublished report submitted to NCF-WCS Nigeria Biodiversity Conservation Project. p. 21.
174. McClanahan, T.R., E. Verheij & J. Maina. 2006. Comparing the management effectiveness of a marine park and a multiple-use collaborative fisheries management area in East Africa. *Aquat. Conserv.: Marine and Freshwater Ecosystems* **16:** 147–165.
175. Martins, D.J. 2009. Differences in Odonata abundance and diversity in pesticide-fished, traditionally-fished and protected areas in Lake Victoria, Eastern Africa (Anisoptera). *Odonatologica* **38:** 247–255.
176. Ntiba, M.J., W.M. Kudoja & C.T. Mukasa. 2001. Management issues in the Lake Victoria watershed. *Lakes Reservoirs: Res. Manage.* **6:** 211–216.

177. Tweddle, D. 1996. Fish survey of Nkhotakota Wildlife Reserve. Investigational Report no. 53. Report submitted to the Japanese International Cooperation Agency. p. 90.
178. Weiss, E.A. 1973. Some indigenous trees and shrubs used by local fishermen on the East African Coast. *Econ Botany* **27:** 174–192.
179. Abugiche, S.A. 2008. Impact of hunting and bushmeat trade on biodiversity loss in Cameroon: a case study of the Banyang-Mbo wildlife sanctuary. PhD thesis submitted to Brandenburg University of Technology, Germany. p. 207.
180. Ajayi, S.S. 2005. Case study 2: multipurpose forest management for bushmeat production: a success story from West Africa. Cited Nov 19, 2013. www.fao.org/forestry/10258-0c60dbb6d55b4eb656bacabf3808aa4a3.pdf. Accessed on 26 November 2013.
181. Berruti, A., T. Snow & N. van Zijl. 2005. Deliberate poisoning: the biggest threat to gamebirds. *Wingshooter* **11:** 12–15.
182. Lindsey, P., G. Balme, M. Becker, *et al.* 2012. Illegal hunting and the bush-meat trade in savanna Africa: drivers, impacts and solutions to address the problem. Panthera/Zoological Society of London/Wildlife Conservation Society report, New York. p. 74.
183. Mbotiji, J. 2002. Sustainable use of wildlife resources: the bushmeat crisis. Wildlife Management Working Paper No. 5. p. 20.
184. Maphasa, L.J. 1966. Cultural and socio-economic aspects of the decline in Helmeted Guineafowl *Numida meleagris* populations in KwaZulu-Natal, South Africa. MSc thesis. University of Cape Town, South Africa.
185. Botha, A.J., D.L. Ogada & M.Z. Virani, Eds. 2012. *Pan-African Vulture Summit.* Modderfontein, South Africa: Endangered Wildlife Trust, and The Peregrine Fund, Boise, Idaho, USA. p. 47.
186. Sogbohossou, E.A. 2008. "Research on lions in Benin: review and perspectives." In *Management and Conservation of Large Carnivores in West and Central Africa, Proceedings of an International Seminar.* B. Croes, R. Buij, H. de longh & H. Bauer, Eds.: 29–40. Institute of Environmental Sciences, Leiden.
187. Saidu, Y. & R. Buij. 2013. Traditional medicine trade in vulture parts in northern Nigeria. *Vulture News* **65:** 4–14.
188. McKean, S. *et al.* 2013. The impact of traditional use on vultures in South Africa. *Vulture News* **65:** 15–36.
189. Ogada, D.L. & R. Buij. 2011. Decline of the hooded vulture Necrosyrtes monachus across its African range. *Ostrich* **82:** 101–113.
190. Roberts, K. Personal communication.
191. Botha, A. Personal communication.
192. Bruyns, R.K., V.L. Williams & A.B. Cunningham. 2013. "Finely ground-hornbill: the sale of *Bucorvus cafer* in a traditional medicine market in Bulawayo, Zimbabwe." In *Animals in Traditional Folk Medicine: Implications for Conservation.* R.R. Alves, R. Nóbrega & L. Lucena, Eds.: 475–486. Springer. Berlin/Heidelberg.
193. Sayer, E. Personal communication.
194. IUCN. 2013. Vultures-silent victims of Africa's wildlife poaching. News Release 15 Aug 2013.
195. Herholdt, J.J. 1995. The breeding status (1988 to 1994) and management of raptors in the Kalahari Gemsbok National Park. MTech thesis, Technikon Pretoria.
196. Watson, R.T. 1986. The ecology, biology and population dynamics of the bateleur eagle *Terathopius ecaudatus.* PhD thesis submitted to University of Witwatersrand, Johannesburg.
197. Ogada, D.L. & P.M. Kibuthu. 2012. Breeding ecology of Mackinder's eagle owls *Bubo capensis mackinderi* in farmlands of central Kenya. *J. Raptor Res.* **46:** 327–335.
198. Allan, D.G., S.C. Kruger & A.R. Jenkins. 2014. Cape vulture breeding numbers along the high-Drakensberg escarpment—a comparison between 1981-83 and 2011-12. *Ostrich.* In press.
199. Rondeau G. & J.M. Thiollay. 2004. West African vulture decline. *Vulture News* **51:** 13–33.
200. Abebe, Y.D. 2013. Mass dog poisoning operation in Addis Ababa can have severe repercussions on vulture populations. *Vulture News* **64:** 74–76.
201. Wolstencroft, J. Personal communication.
202. Angelov, I. The Egyptian vulture in Africa: review of status and limiting factors. In preparation.
203. The Africa Report. 2013. Cited Nov 13, 2013. http://www.theafricareport.com/East-Horn-Africa/ethiopia-mass-dog-killing-concerns-hit-addis-ababa.html.
204. Kahumbu, P. 2012. Banned in America killing in Kenya: the story of a poison. *Swara* **3:** 30.