# Inappropriate Use of Agrochemicals Poses Potential Threats to Botswana Vultures: A Call for Research and Legal Instruments

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## Abstract

Agrochemicals are widely used across the world to serve different purposes. However, inappropriate use of agrochemicals affects wildlife particularly non-target species such as vultures. In this paper, we discuss the potential threats posed by inappropriate use of agrochemicals to vultures in Botswana. We discuss the ecosystem services provided by vultures, recent incidents of potential vulture poising in Botswana, why vultures are vulnerable to agrochemical poisoning and status of the use of chemicals in Botswana. We show that incidents of vulture mortalities possible due to deliberate and accidental poisoning of livestock and wildlife carcasses by farmers and poachers, respectively, are increasing since 2009 in Botswana. In Botswana, the distribution of agrochemicals is not well regulated although the Agrochemicals Act of 1999 and subsidiary 2003 legislation are in place to assist in this endeavour. In addition, factors contributing to vulture declines are not well documented and researched. The lack of information on factors contributing to vulture poisoning calls for collaborate multidisciplinary research to assess vulture population dynamics and the drivers of their population change, including poisoning to inform policies on use of agrochemicals in Botswana.

**Keywords:** Agrochemical, raptors, vultures, poisoning, pesticides, Botswana

## Introduction

The increase in the use of agro-chemicals worldwide has increased due to escalating world population growth and subsequent demand for food (Melrose *et al.* 2015). While agro-chemicals are essential to help in intensifying agricultural productivity (McDermott & Grace 2011) by reducing the effects of pests and parasites on crops and farm animals (Melrose *et al.* 2015), their inappropriate use can have negative impact on the environment (Mollah & MacGregor 2002; Bhandari 2014), posing threat to untargeted species (Kendall & Akerman 1992; Little *et al.* 1997). Carnivorous animals are most affected by inappropriate use of agrochemicals (Thiollay 2007) because of their position in the food chain. In particular, carnivorous scavenger populations, such as vultures, are reportedly declining significantly due to inappropriate use of agrochemicals in the agricultural sector (Virani *et al.* 2011; Ogada *et al.* 2012). Widespread contamination and toxic effects of persistent organic pollutants (POPs) in humans and wildlife have been of great concern and have received considerable attention during the past four decades by environmentalists (Behrooz *et al.* 2008), and have been identified as one of the main groups of environmental contaminants in land-based and aquatic ecosystems (Martınez-Lopez *et al,* 2009). Organochlorine compounds are well known as toxic and persistent contaminants that accumulate in the upper trophic levels of the food chain due to their persistence and lipophilic properties (Length 2011). In recent years there has been increasing concern by conservationists about these chemicals, mainly with regard to their oestrogenic properties (Martınez-Lopez *et al.* 2009). These compounds often cause secondary poisoning to vultures (Snow 2006).

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The era for green technologies in trying to provide the world population with food emphasizes the greater use of agrochemicals such as fertilizers and pesticides. However, pesticides overuse is a serious threat to ecosystems and wildlife, human health, and agricultural sustainability. Several studies indicate that farmers do not have basic knowledge on the application of agrochemicals, hence misuse pesticides and cause poisoning of non-targeted species (Brader 1982; Fianko *et al.* 2011; Ogada 2014; Schaefers 1990). Changes in prices of agrochemicals affect farmer's actions and behaviour hence more agrochemical usage (Higashida, 2006). In addition, an African subsistence farmer study indicated that in most cases farmers are engaged in illegal actions to protect their livelihoods (Hill.C.M, 2004). On another note, a study conducted in Ghana stated that about 87 percent of farmers use agrochemicals, especially pesticides, in controlling pests and diseases on their vegetables and fruits (Fianko *et al.,* 2011).

In this paper, we discuss the potential threats posed by inappropriate use of agrochemicals in Botswana. We first discuss the ecosystem services provided by vultures, recent incidents of potential vulture poisoning in Botswana, why vultures are vulnerable to agrochemical poisoning, status of the use of chemicals in Botswana, farmers' perspectives and knowledge on the use of agrochemicals and their effects on non-targeted species, and recommendations for the success conservation of vultures in Botswana.

*Ecosystem services provided by vultures*

The ecological role played by vultures in ecosystem processes and functions has attracted the attention of conservatisms worldwide (Baral & Gautam 2007; Markandya *et al.* 2008; Whelan *et al.* 2008; Wenny *et al.* 2011). In particular, vultures play and important role in providing supporting, regulating and cultural services (Moleón *et al.* 2014; Moleón *et al.* 2015). The ecological and mobile linkages roles, through transportation of seeds, played by vultures have been suggested as stabilizing services in food webs (Wilson & Wolkovich 2011). As obligate scavengers, vultures mobilize a large part of nutrients and energy from carcasses of dead animals that could otherwise contaminate the environment (Becker *et al.* 2005; Scholte 2011), and as such they keep the environment free of carcasses and reduce the prevalence of diseases (Markandya *et al.* 2008; Ogada *et al.* 2012). A significant decline in vulture population could change the carcases consumption rates and patterns, which will lower energy nutrient flow in the ecosystem (DeVault *et al.* 2003; Ogada *et al.* 2012). In most cases, a decline in vulture populations increases stray dogs in the wild that are capable of causing chronic and zoonotic diseases, such as rabies (Markandya *et al.* 2008). Furthermore, a decline in vultures could lead to an abundance of otherwise redundant, less specialized scavengers to fill the vacant niche space, leading to hyper-predation (Sebastián-González *et al.* 2016).

The consumption patterns of carrions make specialized scavengers, such as vultures, having no functionally similar genus compensating for their decline (Ogada *et al.* 2012). Instead, other vertebrates, invertebrates, and microorganisms are expected to use carrion at higher rates when vultures' scavengers are absent or scarce. Because most carrion biomass is consumed by vertebrates scavengers (mostly vultures) (DeVault *et al.* 2003), important indirect effects related to wildlife and human health would likely result from the loss of scavengers (Deygout *et al.* 2009; DeVault *et al.* 2016). Food web changes associated with the extirpation of non-vulture (facultative) avian scavengers are expected to be more profound outside vultures' distributional ranges, where they normally visit more carcasses than they do in vulture-dominated environments (Ogada & Keesing 2010; Sebastián-González *et al.* 2016).

*Vulture declines*

Botswana still has a diversity of vulture species in the wild (Hancock and Welersby 2016) and all are listed as globally threatened by the Wildlife Conservation and National Parks, Act of 1992. However, vultures have been reported to be significantly declining in unprotected areas in Botswana due to many factors including drought (Herremans 2004), land use change (Herremans & Herremans-Tonnoeyr 2000), and elephant habitat modification (Herremans 1995).

Recently there have been recorded cases of vulture mortalities at wildlife and livestock carcasses in Northern Botswana (Figure 1). In 2009, around 50 White-backed (*Gyps africanus*) and Hooded Vultures (*Necrosyrtes monachus*) were found dead at giraffe (*Giraffa camelopardalis*) carcases, suspected to have been poisoned because an empty Carbofuran container was found at the scene. The following years, 110 vultures died near Lesoma in 2011 after feeding on an elephant (*Loxodonta africana*) carcass. Although no clinical examinations were conducted, it was suspected that the elephant was poison by farmers around that area. Carnivore predation on livestock in this area is high (personal Observation) and farmers might have been targeting large carnivores. In 2013, about 589 vultures were found dead at three elephant cases (Mcnutt & Bradley 2013). The authors further reported that all three elephant carcasses had all their tusks removed, possible by chopping them out. In the same year, seven and close to 600 dead vultures were found dead around poisoned buffalo (*Syncerus caffer*) and elephant carcasses, respectively, in the nearby Zambezi Provence in Namibia. In 2016, at least 60 and more than 120 vultures have been found dead near two carcasses of cattle, at Palapye and Maun, respectively. Although most of these incidents were not tested for toxicology, the trend suggests that poisoning is becoming another threat to Botswana vultures' survival. This calls for rapid and rigorous research that will inform policies on the potential threats of inappropriate use of agrochemicals on untargeted species.

*Vulture vulnerability to agrochemicals*

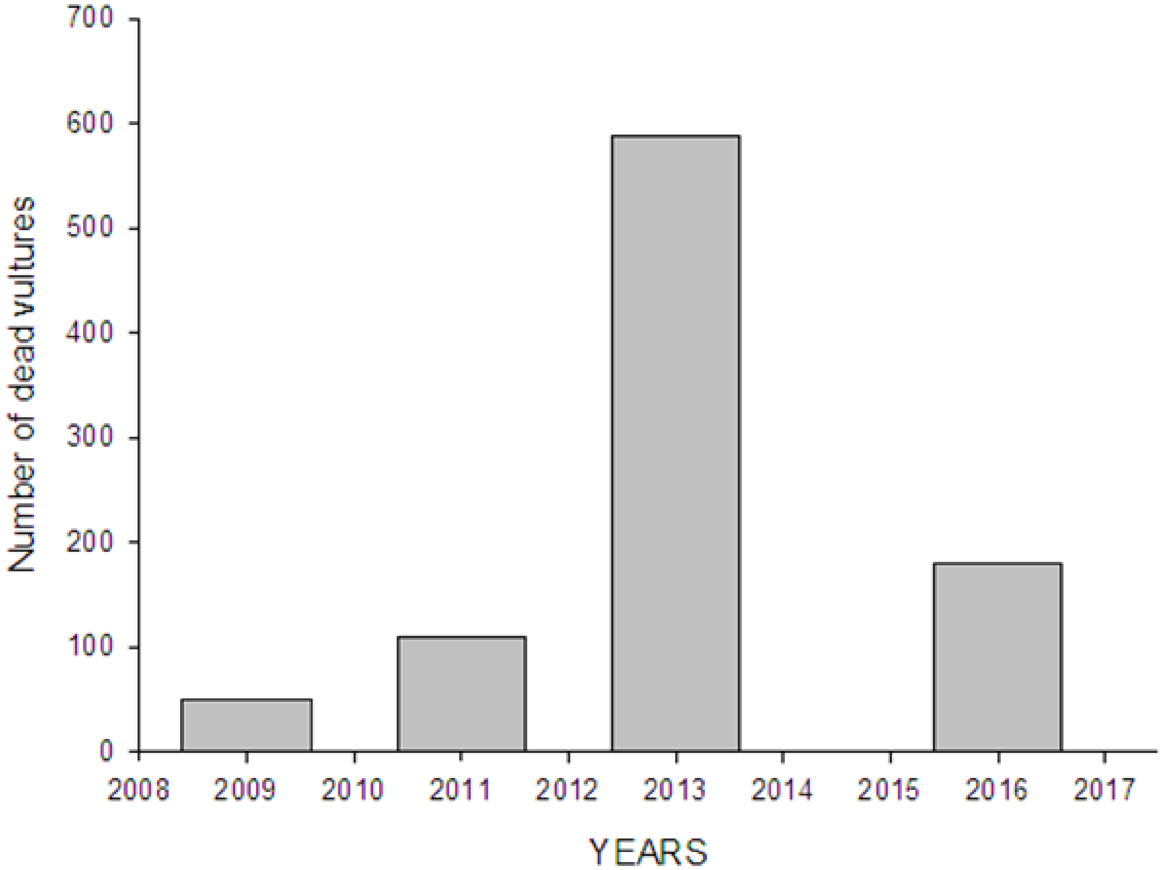
Vultures are vulnerable to agrochemical poising because of their obligatory scavenging behaviour. As obligate scavengers, vultures depend on meat for survival and reproduction, and as such need to find carcasses from great distances using their senses of sight and smell (Houston 1979; DeVault *et al.* 2003). Vultures have developed several adaptations that enable them to efficiently use meat as a food source. Compared with other carnivores (Deygout *et al.* 2009), vultures possess efficient locomotion (Ruxton and Houston 2004a; Shivik 2006) and their efficient travel allows them to increase their search area (Kane *et al.* 2014). In addition, vultures use gliding flight that takes advantage of air speed and direction (Ogada *et al.* 2012). These adaptations increase vultures' searching and feeding range compared to other carnivores, often enabling them to be first on carcasses. The above adaptations together with their ability to consume carcasses in a short period make them vulnerable to poisoned carcasses.

Exposure among terrestrial vertebrates occurs through ingestion of contaminated biotic or abiotic matter, contaminant absorption through skin, or via inhalation of volatile, aerosolised, or particle bound contaminants.

Like other vertebrates, vultures are exposed to environmental contaminants via four pathways: ingestion (oral exposure), dermal contact, inhalation, and maternal transfer (Figure 1). Ingestion is the primary pathway of contaminant exposure in vultures and occurs directly through the consumption of free chemicals (primary exposure – e.g. pesticide spray drift) or, more commonly, indirectly through consumption of contaminated food, water, or environmental media (secondary exposure).

To estimate human health risks, identify food-chain contaminants, determine levels of environmental contamination and identify the adverse effects on animals associated with agrochemicals compounds, sentinel animals, such as raptors, have been used in risk assessment. Vultures are primarily at risk to poison since many pesticides are applied in the form of granules that they feed on directly as they search for food. Birds, in particular, are at risk of feeding on poison because of their mobile feeding behaviour. Globally, vultures are one of the fastest declining groups of birds, especially outside of protected areas, in West and Southern Africa (Anderson 2000, Brandl *et al.* 1985, Herremans & Herremans-Tonnoeyr 2000). Also in South Asia vulture numbers have declined by more than 95 percent since the early 1990s (Prakash *et al.* 2003; Green *et al.* 2004 in Swan *et al.* 2005). The leading factor is reported to be the use of diclofenac drug to treat livestock (Cuthbert *et al.* 2011).

**Figure 1:** Number of vultures found dead around wildlife and livestock carcasses in northern Botswana




Deliberate and accidental poisoning by farmers and poachers has been suggested as the top threats to vultures. Incidents where vultures and other carnivores have been victims to carcasses from treated animals (Herremans & Herremans-Tonnoeyr 2000; Scholte 2011; Botha *et al.* 2012) and contaminated water from runoff of water (Kenny *et al.* 2015) from sprayed fields have been reported. In recent years, two drivers of intentional poising of vultures and other carnivores have been observed; human-wildlife conflict (Ogada & Keesing 2010; Botha *et al.* 2012; Mateo-Tomás *et al.* 2012) and poaching (Botha *et al.* 2008; Roxburgh & McDougall 2012; Ogada 2014). In the former, farmers target large mammalian carnivores that have killed their livestock by poisoning the carcass, but kill vultures instead of the targeted carnivore. In the later, poachers poison killed animals, targeting vultures to keep them from disclosing locations of kills.

*Use and management of agrochemicals*

Certain uses of agricultural pesticides is illegal in many countries, hence the need to enforce the laws and regulations governing use (Table 1). Attempts to manage and deal with agrochemicals, particularly pesticides, include policies and legislation to mitigate and deal with the misuse of agrochemicals, thereby reducing their impact on non-targeted species. One difficulty with investigating the causes of animal poisoning is that neither the veterinarian nor the animal owner is legally obliged to report the case or to send samples for chemical analysis (Vandenbroucke *et al.* 2010). St John *et al* (2011) opine that farmers do not have valid permits, allowing them to kill carnivores to the extent that they end up disregarding the rules and regulations.

**Table 1:** List of Southern Africa countries, which have legislation on illegal poisoning of wildlife

| Country | Name of legislation | Year enacted | Illegal to hunt wildlife | Comments |
|---|---|---|---|---|
| Angola | Decree No.40.040 | 1955 | Yes | |
| Botswana | Wildlife Conservation & 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. |
| Lesotho | Environmental Act Forestry Act | 2001 | No | |
| South Africa | Fertilizers, farm feeds, Agricultural Remedies and stock remedies Act | 1947 | Yes | |
| Swaziland | Protection of fresh water fish Act | 1938 | Yes | |
| Zambia | Wildlife Act | 1998 | Yes | |
| Zimbabwe | Parks and Wildlife Act | 1975 | No | Minister can issue permit to fish with poison. |

Modified from Odaga (2004)

Such illegal actions call for better enforcement of wildlife laws. Several studies indicate that farmers do not have basic knowledge on the proper application of agrochemicals, hence misuse pesticides and cause poisoning of non-targeted species (Brader, 1982; Fianko *et al.* 2014; Schaefers, 1990). Also, changes in prices of agrochemicals affect farmer's actions and behaviour, often resulting in more agrochemical usage (Higashida, 2006). A study on African subsistence farmers indicated that in most cases farmers are engaged in illegal actions to protect their livelihoods (Hill.C.M, 2004). Another study in Ghana stated that about 87 percent of farmers use agrochemicals, especially pesticides, in controlling pests and diseases on their vegetables and fruits (Fianko *et al.* 2011).

In Botswana, the distribution of agrochemicals is not well regulated although the Agrochemicals Act of 1999, and subsidiary 2003 legislation is in place to assist in this endeavour. The use of agrochemicals in Botswana, especially pesticides, is fairly recent in agricultural production. Farmers who grow field crops in traditional farms do not use pesticides during the pre-harvest period, although a few use pesticides for post-harvest pest control (FAO, 2005). However, those cultivating crops use pesticides to control major pests, such as Bagrada bug (*Bagrada hilaris*), diamond back moth (*Plutella xylostella*), red spider mites (*Tetranychus urticae*), rootknot nematodes *Meloidogyne* species). Large–scale production occurs on larger farms that can reach 500 ha in size (FAO, 2005). Currently commercial horticultural production is limited to the Tuli Block area to the east while rain–fed commercial production is mainly in the Pandamatenga area in the northern part of the country. Agrochemicals use is significant both in commercial, rain-fed and irrigated production (FAO, 2005). When the Pandamatenga farms were first established, a number of persistent, highly toxic pesticides were used, including organophosporous compounds such as fenthion for control of weaver birds (*Quelea Quelea*), demethoate (aphids), prothoate (American bollworm, *Helicoverpa armigera*) and aldrin (termites and ants) (Ehes, 2007). FAO (2005) anticipated that an average of 885 mega tonnes of pesticides would be imported annually in Botswana. In addition, it is anticipated that the drive to increase agricultural production under The National Agricultural Master Plan for Arable Agricultural and Dairy Development (NAMPAAD) and The Integrated Support Programme for Arable Agriculture Development (ISPAAD), would increase agrochemicals' use dramatically. Therefore, governments must to respond to the laws and regulations of agrochemicals that have adverse effects on untargeted animals, but also contribute significantly to mitigating pests, weeds and diseases. Policy makers and regulators need to recognise the importance of Integrated Pest Management and so have a balanced and efficient way of allowing the use of agrochemicals that can be used for agricultural purposes without causing significant harm to untargeted species and wildlife.

**Table 2.** Number and percentage of companion animals killed annually by various poisons between 200 and 2009

| | 2000 (%) | 2001 (%) | 2002 (%) | 2003 (%) | 2004 (%) | 2005 (%) | 2006 (%) | 2007 (%) | 2008 (%) | 2009 (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of animals | 2155 | 2277 | 2191 | 2154 | 2253 | 2417 | 2367 | 2660 | 2700 | 2478 |
| Agrochemicals | 40.4 | 40.7 | 41.2 | 43.4 | 42.4 | 40.7 | 39.6 | 41.5 | 38.0 | 35.6 |
| Household | 25.7 | 24.4 | 23.9 | 22.2 | 22.7 | 23.3 | 21.0 | 19.6 | 19.2 | 19.5 |
| Drugs | 16.5 | 16.3 | 18.0 | 16.2 | 16.5 | 19.7 | 21.9 | 19.3 | 23.0 | 23.4 |
| Plants | 7.0 | 6.9 | 6.8 | 7.1 | 6.7 | 5.7 | 6.3 | 8.3 | 6.7 | 7.0 |
| Veterinary Drugs | 1.7 | 1.5 | 1.8 | 1.9 | 2.8 | 2.6 | 2.6 | 2.5 | 3.0 | 4.1 |
| Others | 8.8 | 10.2 | 8.4 | 9.2 | 8.9 | 2.6 | 8.5 | 8.8 | 10.1 | 10.3 |

Some countries, particularly developing countries, still use hazardous pesticides that are re-stricted, thus they are sold without any regulation (Francis *et al.*, 2013). In addition, a study in India indicated that some companies promote the sale of pesticides without licenses (Shetty, 2004). That study found that about half of the respondents purchased agrochemicals from private dealers. Ogada (2014) highlights South Africa as the only country with an organisation aimed at fighting poisoning of wildlife. Currently, regulation, uses and disposal of agrochemicals are not well regulated in Botswana pending some amendments to the legislation controlling their use.

Data collected from other studies (Cuthbert *et al.,* 2011; Oaks *et al.*, 2004; Prakash *et al.* 2012) showed that poisoning vultures within the Indian sub-continent resulted from the use of diclofenac pesticide to treat livestock. Diclofenac negatively affects the renal system of vultures, leading to high mortality and population declines. Alternatively, studies conducted in Africa (Ogada, 2014; Otieno *et al.,* 2010) indicate the carbofuran is the most commonly used agrochemical impacting vultures (Vandenbroucke *et al.,* 2010). Table 2 shows that agrochemicals are the most commonly used poisons since 2000.

## Conclusions

Increasing numbers of incidents show that poisoning is on the rise and is particularly affecting vultures in Botswana due to their vulnerability to poisoned carcasses. No effective monitoring or investigating of the flow of agrochemicals distribution, use and the illegal sale of agro-chemicals, occur in Botswana. Unpublished statistics of the high mortality of vultures in Botswana could stem from a lack of reports, hence limiting investigations. Nonetheless, Botswana and other countries need policy reviews for agrochemicals use and sale routes. Policy makers and regulators should balance the use of agrochemicals for agricultural purposes without causing any harm to untargeted species and wildlife. It appears again that in most cases farmers are not aware of the negative outcomes to vultures of the inappropriate use of agrochemicals. Therefore, community awareness campaigns and education should be intensified. In addition to awareness campaigns, collaborative, multidisciplinary research involving all stakeholders needs to be intensified. Continuous monitoring population dynamics, including movement, effects of environmental and human induced factors on their population ecology, breeding success need to be explored. A vulture research and monitoring group coordinated by the Department of wildlife and National Parks, Birdlife Botswana and Raptors Botswana and including all relevant government departments (Department of Veterinary Services, Department of Animal Production, Department of Crop production and Department of Agricultural Research), community Based Organisations, Non-government organisations and academic institutions need to be established with the aim of providing information on vulture conservation in the country.

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