Peasant farmer–raptor conflicts around Chembe Bird Sanctuary, Zambia, Central Africa: poultry predation, ethno–biology, land use practices and conservation

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Abstract

Peasant farmer–raptor conflicts around Chembe Bird Sanctuary, Zambia, Central Africa: poultry predation, ethno–biology, land use practices and conservation.— Raptors provide ecosystem services to African rural communities by: (1) preying on rodents, (2) regulating harmful snake populations, (3) shaping cultural beliefs, and (4) being part of tourist attractions. Peasant farmers, however, connect them with poultry depletion, telepathic omens, and traditional witchcraft. Consequently, raptors suffer human–induced persecution. Using a qualitative content analysis technique, we investigated the interaction between farmers and raptors in areas adjoining the Chembe Bird Sanctuary. Our results unravel negative perceptions, attitudes and practices that could threaten the extinction of five raptors in the study area. We propose the use of transformative cognitive measures (*e.g.,* raising stakeholder awareness, ensuring stringent law enforcement for raptors and protecting their habitat, and strengthening relational social capital) and physical measures (*e.g.*, providing appropriate fencing and poultry breeding of high resilient phenotypes) to improve the co–existence between farmers and raptors.

Key words: Social–ecological system, Stakeholder participation, Technical ecological knowledge, On–farm counter–measures, Ecosystem services

Resumen

Los conflictos entre campesinos y rapaces alrededor del refugio de Chembe Bird, en Zambia, África central: depredación de aves de corral, etnobiología, prácticas de uso de la tierra y conservación.— Las rapaces prestan servicios ecosistémicos a las comunidades rurales de África: (1) depredando roedores, (2) regulando las poblaciones de serpientes dañinas, (3) configurando las creencias culturales y (4) formando parte de las atracciones turísticas. Sin embargo, los campesinos las relacionan con la disminución de las aves de corral, las profecías telepáticas y la brujería tradicional. En consecuencia, las rapaces son perseguidas por los humanos. Mediante una técnica de análisis cualitativo de contenido, analizamos la interacción entre los campesinos y las rapaces en zonas adyacentes al refugio de Chembe Bird. Nuestros resultados revelan las prácticas, actitudes y percepciones negativas que podrían poner en peligro de extinción a cinco rapaces en la zona de estudio. A fin de mejorar la coexistencia entre agricultores y rapaces, proponemos utilizar medidas transformadoras de carácter conceptual (por ejemplo, sensibilizar a las partes interesadas, garantizar el cumplimiento riguroso de la legislación relativa a las rapaces y proteger su hábitat, así como reforzar el capital social relacional) y medidas prácticas (como proporcionar cercados apropiados y aves de corral de fenotipos de alta resistencia).

Palabras clave: Sistema socioecológico, Participación de partes interesadas, Conocimiento técnico–ecológico, Contramedidas en las explotaciones agrícolas, Servicios ecosistémicos

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Introduction

Human–wildlife conflicts commonly arise when humans encroach into previously uninhabited areas and disrupt animal habitat (Lamarque et al., 2009; Treves et al., 2009) through competition for space and food resources (Balmford et al., 2001; Okello, 2005). Increasing populations of humans at the human–wildlife interfaces such as park boundaries exacerbate such conflict (Wittemyer et al., 2008). Social and human dimensions such as cultural values, beliefs, and experiences with wildlife contribute to negative local perceptions and attitudes against wildlife (Dickman, 2010). Due to their carnivorous feeding habits, raptors are usually resented for their opportunistic predation on poultry (Fowler et al., 2009) even though some raptors have beneficial social–ecological roles. For instance, owls help farmers control rodents that forage crops and stored food (Magige & Senzota, 2006; Kopij et al., 2014). The greater the poultry losses, the less local communities support wildlife conservation (Gadd, 2005). Such losses prompt farmers to use lethal, illegal control methods such as retaliatory killings of the raptors considered 'pests' (Etheridge et al., 1997; Lamarque et al., 2009). These persecutions translate to species extirpation as raptor breeding rates and density decrease within large geographical ranges (Graham et al., 2005; Thirgood et al., 2005; Peterson et al., 2010). Such decreases may have perceived and actual economic impacts associated with the incurred losses (Sarasola et al., 2010; Margalida et al., 2014).

From a theoretical perspective, human–raptor conflicts are influenced by prevailing ecological traps in human–dominated landscapes. Ecological traps, which are attractive habitats of choice, yet poor quality habitats to fauna for their survival and population growth, are a management concern as they may result in species decline or local extinction (Battin, 2004). According to Schlaepfer et al. (2002), organisms can become ecologically trapped by their evolutionary responses to environmental cues by making decisions regarding behavioural and life–history habitat selection, thus decreasing survival or reproduction. According to Kokko & Sutherland (2001), human–modified landscapes may become ecological traps if species, using indirect cues, miscalculate the habitat suitability when making preferences. Consequently, raptors succumb to several environmental stressors such as destruction of their habitats through poisoning (Kramer & Redig, 1997; Henny & Elliott, 2007), electrocution on power–lines (Harness, 2007), disease (Rodríguez et al., 2010), trapping (Duncan et al., 2002; Romulo et al., 2009), road kills, and land conversions (Meunier et al., 2000; Jaarsma et al., 2006). These anthropogenic disturbances extend towards protected areas such as national parks and wildlife reserves (Gill & Sutherland, 2000). However, the ecological impact on specific groupings of birds is still poorly understood. Resolving human–raptor conflicts would contribute positively to human–raptor coexistence (Gibson et al., 2000; Riley et al., 2003; Fernandez–Juricic et al., 2004) and foster benefits from ecological services such as cultural and tourism development for local communities.

Dealing with peasant farmer–raptor conflicts requires the analysis of long–term empirical data on an array of socio–economic aspects concerning those affected and also on the ecological aspects of species considered pests. However, empirical data are rarely available, particularly in developing countries where research is limited due to technical and financial constraints and the conservation status of numerous species in such a setting is usually unknown (Costello et al., 2013). Therefore, the use of traditional ecological knowledge (TEK) can be helpful to develop and implement conservation plans when scientific information is scarce (Freeman, 1992; Usher, 2000). TEK refers to 'common' knowledge and resulting perceptions shaping attitudes and practices, locally passed on through generations (Berkes, 2004).

In this study, we explored TEK, resultant perceptions, attitudes and practices by peasant farmers to determine anthropogenic threats to raptor conservation in an important bird area. The study addressed two broad questions: (1) what are the perceived factorial conditions for occurrence of poultry losses caused by steppe buzzards (*Buteo vulpinus*) and black kites (*Milvus migrans*) and (2) what is the perceived underlying proximate nature of peasant farmer–raptor conflicts in terms of poultry predation, ethno–biology (*i.e.* cultural treatment and usage of raptors by peasant farmers) and land use practices. We hypothesised that entrenched TEK shaped perceptions, attitudes and practices among peasant farmers, who either negated or supported avian raptor conservation. Steppe buzzards, black kites and owls are protected under Zambia wildlife legislation, which implements the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) regulations. All these birds are CITES Appendix II species and, as such, are protected internationally. Unlike steppe buzzards and black kites, none of the four owls (Barn owls, *Tyto alba;* spotted eagle owls, *Bubo africanus*; pearl spotted owls, *Cilaucidium perlatum* and giant eagle owls, *Bubo lacteus)* inhabiting the study area predate on poultry, yet they are persecuted due to local myths associated with them.

Material and methods

Study area

The study was conducted within a 20 km radius area around Chembe Bird Sanctuary (539 ha in dimension; with central coordinates of 27.9955º E, 12.8302º S) in Kalulushi District, Zambia (fig. 1). Chembe Bird Sanctuary is renowned for its high diversity of resident and migratory birds, attracting numerous visitors and tourists. Raptors such as steppe buzzards, black kites, barn owls, spotted eagle owls, pearl spotted owls and giant eagle owls use the park and proximate areas for physiological purposes such as foraging, breeding and roosting. However, peasant farmers, originating from diverse *Bantu* ethnic and cultural groups occupy much of the original raptor habitat around Chembe Bird Sanctuary. Peasant farmers rear 'village' free–ranging

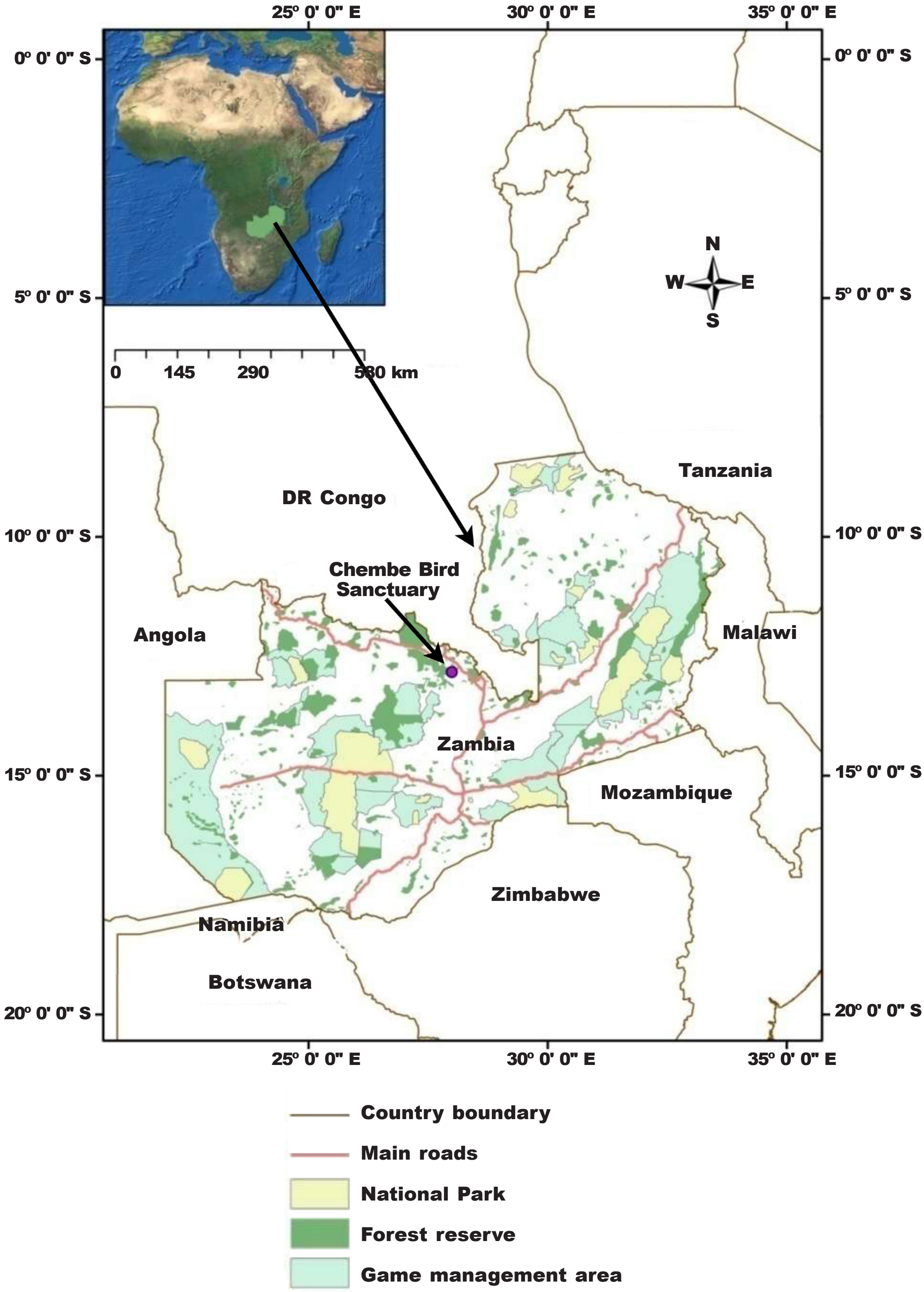

Fig. 1. Location of the study area in the peripherals of Chembe Bird Sanctuary, Zambia.

Fig. 1. Localización geográfica de la zona de estudio en la periferia del refugio de Chembe Bird, en Zambia.

chickens (*Gallus gallus domesticus*), crested guinea fowls (*Guttera pucherani*), helmeted guinea fowls (*Numida meleagris*), and common domestic ducks (*Anas platyrhynchos domesticus*). Other livestock reared are goats (*Capra aegagrus hircus),* sheep *(Ovis aries*) and cattle (*Bos taurus*).

Data collection protocols

Data were collected from 15 IX 2015 to 23 XI 2015, coinciding with the peak breeding activities of the raptors. This period was the off–peak farming season, guaranteeing successful interviews with 138 peasant farmers, the survey participants. We used a semi–structured questionnaire (supplementary material) and adopted the purposive sampling approach described by Coetzee et al. (2014), but integrated within the interviews with only refereed, knowledgeable adult informants (> 35 years old, either males or females) with antecedents. We used the 'peer reference system' in the multi–stage sampling method as stipulated by Emery & Purser (1996), where the participant selection was iterative and based on knowledge, area of residence, longevity of residence, and involvement with poultry rearing. The purposive sampling strategy enabled the collection of the informants' own detailed viewpoints, serving as a social learning platform and enabling development of threads of grounded concepts as postulated by Strauss & Corbin (1998) and Muro & Jeffrey (2008). The participants, both males and females, were inductively identified and interviewed. The questions covered perceived TEK, attitudes, and practices, allowing us to gain an in–depth and broad understanding of the nature of peasant farmer–raptor conflicts and to obtain practical insights for the development of management strategies.

The objective, contents, and applications of the research were explained to respondents before obtaining their individual, free and informed consent. The six potential participants that declined to participate on the grounds of suspicions that the researchers could be devil agents, working through raptors, were excused from further questioning. Vernacular language (*i.e.* Bemba) was used in place of English, the official language. Respondents were asked to prioritise and rank their responses based on their knowledge and experiences. The responses were probed until information given was clear and exhaustive. Participants were shown coloured pictures of prevalent raptors in the region to help identification. A WS–853 Olympus Voice Recorder device was used to capture participants' views on local perceptions, attitudes and practices. These recordings were later transcribed for analyses. Interviews were discontinued once responses were complete and nonce no further new information was provided.

Data analyses

We used the content analysis approach to analyse the qualitative data as described by Coetzee et al. (2014). This approach allowed categorising and condensing of similar thematic issues, from which we derived the topology of issues that culminated into underlying local perceptions, attitudes and practices associated with raptorial species.

Results

Factorial conditions for occurrence of human–raptor conflicts: the multi–factorial theory

Peasant farmers perceived four factorial conditions relating to peasant farmer–raptor conflicts in areas adjacent to the Chembe Bird Sanctuary:

(1) Motivation: most peasant farmers (94.20%, n = 130) indicated that the raptors were more likely to predate on poultry when energetic demands were highest, particularly when providing for newly hatched chicks, as the predation peaked during their breeding season in September–October. The raptors tended to prey on seemingly weak and highly nutritious small, free–range chickens of less than eight weeks that were easier to lift and more tender than older chickens;

(2) Anti–internal inhibition: many peasant farmers (81.88%, n = 113) perceived that restraint measures would reduce prey frequency on poultry. They contended that the raptors would instead prey on substitutes such as small wild birds, snakes and snails;

(3) Anti–external inhibition: most peasant farmers (97.83%, n = 135) perceived that raptors, however, find ways of circumventing interventions by humans against poultry predation, such as trappings and fences. All survey participants indicated that tall trees and vegetated anthills within reach of the raptors (tens of meters) on the premises facilitated predation by steppe buzzards. However, they perceived that the presence of people and pet domestic dogs (*Canis lupus*) at home combined with shouting, use of metals for noise, and stoning were deterrents to the marauding steppe buzzards and black kites in more than 75% of predation events (fig. 2). Furthermore, preponderance of peasant farmers (96.38%, n = 133) perceived that bare and cleared surroundings of chicken–holding panes increased exposure of chickens to raptors, amounting to a loss o of 20–45% more chickens than where tree cover and other escape features were available. However, all the respondents contended that raptors are a great challenge to poultry, as expressed in the following viewpoints: "Despite adaptive changes in the chicken behaviour and implementation of multiple counter–measures, raptors remain a major threat to chickens' survival and cause considerable economic loss to us." Tina Mwamba, female, 63 years old.

(4) Anti–victim resistance factor: majority of peasant farmers (85.51%, n = 118) perceived that the raptors must overcome chickens' defence behaviour from motherly palliative care such as taking swift cover upon detecting danger.

Raptor predation seasonality and their perceived underlying causes

The preponderance of respondents (95.65%, n = 132) found most chicken predation by raptors occurred

Fig. 2. Use of domestic dogs as deterrents against raptor attacks on free–ranging chickens in the peripherals of the Chembe Bird Sanctuary, Zambia.

Fig. 2. Utilización de perros domésticos para disuadir a las rapaces de atacar pollos criados en libertad en la periferia del refugio de Chembe Bird, en Zambia.

in the hot dry season, coinciding with the breeding season for the raptors, though it may occur at any time of year. All respondents had had chicken losses, especially birds less than four months old. Though raptor–chicken predation occurred mainly in the mornings and evenings, it could take place any time of the day (fig. 3). Many peasant farmers (92.03%, n = 127), however, perceived that this poultry loss was due to the type of counter–measures used and phenotype–based selective harvesting by size and colour. Furthermore, a large number of respondents (73.19%, n = 101) considered that distances from

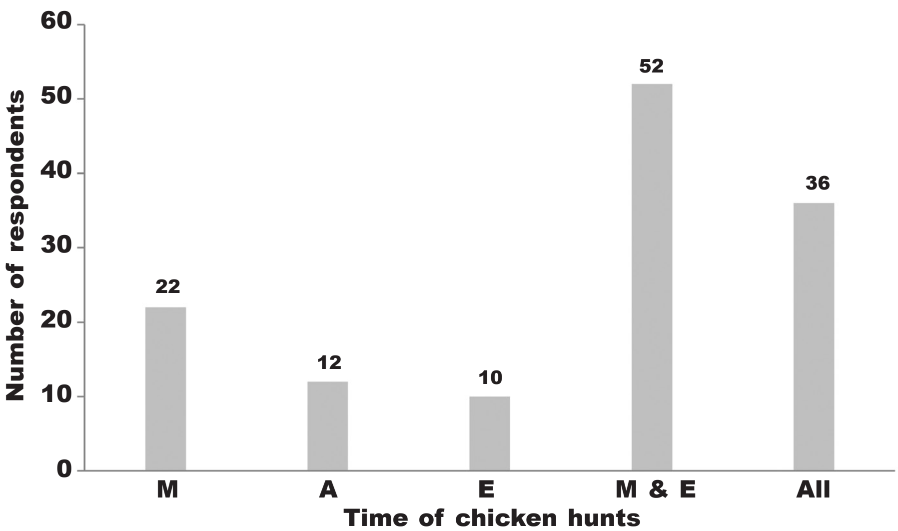

Fig. 3. Diurnal predation times of chickens by raptors in the peripherals of the Chembe Bird Sanctuary, Zambia: M. Morning; A. Afternoon; E. Evening; All. All the time.

Fig. 3. Depredación de pollos por rapaces según el momento del día en la periferia del refugio de Chembe Bird, en Zambia: M. Mañana; A. Tarde; E. Anochecer; All. Todo el día.

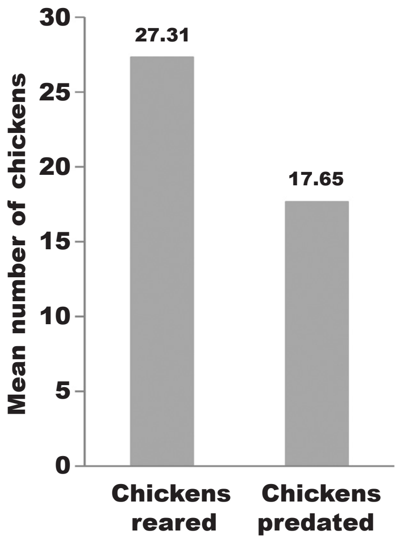

Fig. 4. Chickens predated by raptors from the total reared chickens per month estimated by peasant farmers in areas surrounding Chembe Bird Sanctuary, Zambia.

Fig. 4. Pollos depredados por rapaces del total de pollos criados por mes, según las estimaciones de los campesinos en zonas adyacentes al refugio de Chembe Bird, en Zambia.

Chembe Bird Sanctuary, the core raptor habitat, to their homesteads was inconsequential as raptors covered considerably large territorial areas.

Life history traits

Most respondents (81.16%, n = 112) had witnessed steppe buzzards predating small–medium sized chickens. Many respondents (72.46%, n = 100) had seen black kites predating chicks only. Raptors predated many free–ranging chickens (64.44%) before they were old enough for domestic consumption, for sale or as gifts to friends and relatives (fig. 4). Most respondents (94.20%, n = 130) reported a greater loss (> 90%) to raptors of white chickens than brown or black chickens that were camouflaged by the colour of the ground.

Costs of raptor–poultry predation

Raptor predation amounted to a loss for peasant farmers of K25.73 (USD 1.84) and K53.89 (USD 3.85) per chicken had they reached adult size. A single farmer would lose an average of 17.65 ± 1.35 chickens monthly to raptors (fig. 4). Peasant farmers (100%, n = 138) did not report any of the poultry predation incidents to authorities such as traditional leaders and wildlife agency, but they may have shared information socially among peers, the young and the elderly, relatives, and neighbours. Over half of the respondents (65.22%, n = 90) used preventive or counter–measures such as fencing, provision of cover and housing, and traditional measures (*e.g.*, shouting, stoning, metal banging and domestic dogs), whereas the rest allowed the chickens to roam around premises unattended during the day. Providing housing for chickens was prohibitively expensive for peasant farmers, especially if materials such as fencing wire had to be sourced from elsewhere. In addition, peasant farmers (87.68%, n = 121) incurred opportunity costs by forgoing other chores to keep vigil over their poultry.

More than half of the 90 respondents (57.78%, n = 52) who acknowledged using preventive and counter–measures to mitigate raptor loss considered wire fencing was more effective than other methods to manage raptor–chicken predation on their premises (figs. 5, 6). Furthermore, most respondents (97.10%, n = 134) recognised that raptor shooting was illegal but that it was occasionally applied as a retaliatory counter–measure. However, the respondents (94.93%, n = 131) indicated that a combination of preventive and counter–measures was more effective than a single method. They further contended that the effectiveness of a given method also depended on how well the local farmers implemented the method.

Traditional ecological knowledge and attitudes associated with steppe buzzards and black kites

The peasant farmers (70.29%, n = 97) emphasized that they would occasionally find chicken carcasses on their premises and would blame raptors based on evidence from claw marks left on them, especially on the necks, or the heads having been cut off. They further indicated that the decision to throw away or eat the chicken remains left by raptors depended on the condition of the carcass; decaying carcasses and cases of suspected poisoning were discarded, while the size of the chicken and the damaged part were not considered. The peasant farmers had no direct anthropogenic uses for steppe buzzards and black kites. Locally, the mere presence of steppe buzzards and black kites signified emergent poultry depletion and perpetual poverty among the impoverished peasant farmers. Not surprisingly, 36.23% (n = 50) expressed resentment and considered these raptors should be eradicated due to considerable damage they caused. On the contrary, respondents (63.77%, n = 88) that supported raptor conservation based their response on conservation awareness and a religious belief of stewardship. Those in support of conservation perceived that enclosures and keeping raptors off their premises could reduce the economic loss resulting from raptor predation of their chickens.

Traditional ecological knowledge of owls

All the peasant farmers (100%, n = 138) who suffered poultry losses from steppe buzzards and black kites also regularly encountered four species of owls: barn owls, spotted eagle owls, pearl spotted owls and giant eagle owls. While their encountering circumstances varied across time and individuals, the owl

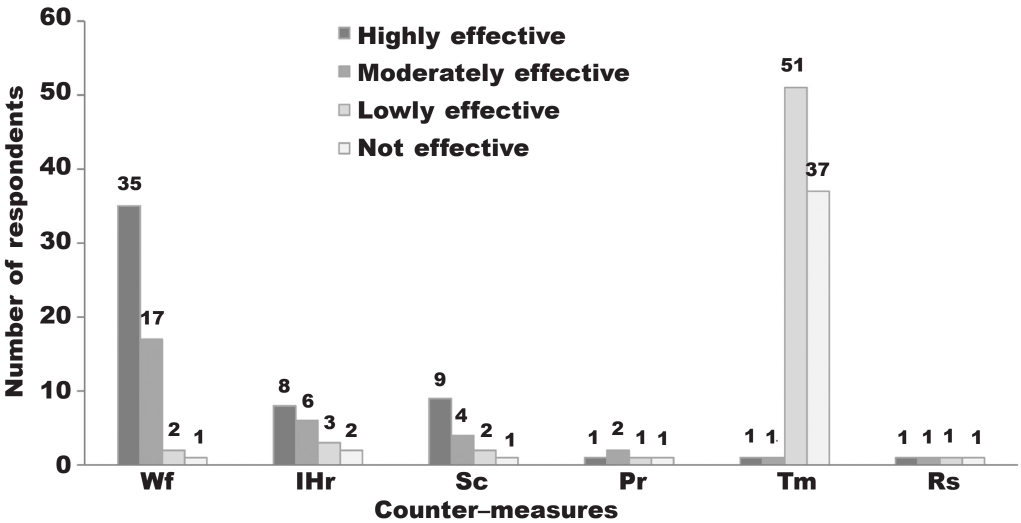

Fig. 5. Rating by respondents of effectiveness of counter–measures used in the peripherals of Chembe Bird Sanctuary, Zambia against chicken predation by raptors: Wf. Wire fencing; IHr. In–housing rearing; Sc. Stick caging: Pr. Prolonged release in mornings; Tm. Traditional methods; Rs. Raptor shooting.

Fig. 5. Clasificación de la eficacia de las contramedidas empleadas en la periferia del refugio de Chembe Bird, en Zambia, contra la depredación de pollos por parte de rapaces, según los encuestados: Wf. Cercas de alambre; IHr. Cría en lugares cerrados; Cs. En jaula: Pr. Liberación prolongada por las mañanas; Tm. Métodos tradicionales; Rs. Disparo a las rapaces.

raptors were commonly encountered by respondents (77.61%, n = 104) perched on trees in proximity to their homesteads, within farmlands. However, most of the respondents (92.75%, n = 128) perceived that the primary habitats for owls were the nearby thick forests and secondary habitats were the anthills within

Fig. 6. Wire fencing successfully implemented at one of the farms in the peripherals of the Chembe Bird Sanctuary, Zambia, where small chicks are confined to the fowl run and larger birds are free ranging within the enclosure.

Fig. 6. Cercado de alambre instalado en una de las explotaciones situadas en la periferia del refugio de Chembe Bird, en Zambia, donde los polluelos quedan confinados en el corral y las aves más grandes viven en libertad dentro del cercado.

their farmlands. They also saw them on the ground, on rooftops, along the roads, and in proximity with the water bodies like dams or rivers. Though peasant farmers generally perceived habitat losses and low productivity rates as threats to raptors, a number of the respondents (63.77%, n = 88) perceived that lethal counter–measures such as killing by use of shotguns, catapults and trappings against owls were the greatest conservation threats to raptors. Furthermore, respondents (97.10%, n = 134) reported that harvesting and destruction of raptor eggs as acts of aggression were common. Besides, 72.46% (n = 100) perceived short fallow periods (less than three years) which do not support tree recruitment, and that opening up of new farming areas, and charcoal production accounted for much of the habitat destruction for owls and other raptors. Many respondents (98.55%, n = 136) attributed the perceived reduction in owls to anthropogenic activities such as habitat conversions. Despite the antagonistic tendencies against raptors, all the respondents acknowledged the important ecological role owls play in regulating rodents which positively contributes to their food security. All the respondents (100%, n = 138) stated no they had no knowledge of owls attacking their poultry.

Traditional uses of owls

According to respondents (100%, n = 138), the use of owl parts such as feathers, feet and faces was secretive among local community members. They highlighted that owl parts were used to fortify persons from witchcraft attacks, and to protect crops, food and other property from magic. Respondents (86.21%, n = 100) held entrenched myths that encountering owls was a taboo, the debut of the demise of a family member.

Local perception, attitudes and practices related to owls

Perceptions were mixed as to what respondents felt they should do: whether they should take part in conservation of the owls or have owls removed by means such as killing them or translocation. While over half of the respondents (57.97%, n = 80) indicated willingness to participate in avian conservation, a considerable number of respondents (42.03%, n = 52) declared that they would rather have owls removed. The various local perceptions have led to strong intolerance and attitudes towards owls as expressed here:

"Owls are enemies to humankind and should be chased away or better still killed on encounter at all cost." Veronica Kabinda, female, 75 years old.

"We fear owls for the bad omens and so they should not be allowed near people...." Florence Lufino, female, 46 years old.

However, those (57.97%, n = 80) in support of owl conservation proffered their support based on belief that owls were God's creation, worthy of good stewards' care. Such a positive perception is reflected in the following quote:

"Owls are God's creation, and humanity has the responsibility to preserve them for their own sake." Dawson Chinyama, male, 57 years old.

Most respondents (94.20%, n = 130) revered the owl hunters and shared information with the traditional leaders about the killing of owls by owl hunters but rarely reported the incidents to the wildlife agency for punitive consequences for infractions. Most respondents (95.65%, n = 132) confirmed they were not culturally attached to owl conservation, despite the benefits owls provide, such as their warning of imminent death, and their impact on food protection by preying on rodents.

All respondents (100%, n = 138) indicated that there are local unpublished 'by–laws' governing owl conservation and prohibiting wanton destruction of wildlife in general, but that these are not specific and lack sanctions. If they find an owl carcass, most respondents (89.86%, n = 124) either leave it, or throw it away. If they find a live owl, however, most (97.83%, n = 135) chase it and often even kill it on the belief that owls are a bad omen and ugly. However, most respondents (88.40%, n = 122) envisioned that conservation measures such as sensitisation of local communities coupled with law enforcement by the wildlife agency increase benefits to local communities and that their involvement in conservation strategies could be critical for owl conservation.

Discussion

Poultry predation, ethno–biology and land use practices

Traditional ecological knowledge (TEK) about raptor–driven poultry predation, ethno–biology and land use practices is generated and shared laterally among the clan and friends as well as in a hierarchical manner with affiliates and collaborators across local communities and other stakeholders. TEK of predator behaviour, and the determination of blood stains and claw marks on dead or injured chickens is based on social memory and social learning by societal members (Muro & Jeffrey, 2008) and prevails from challenges about a social–ecological landscape in social fabrics (Wenger, 1998). Consequently, based on the various constructs of realities by the local communities, social learning influences stakeholders' participation in natural resource management by shaping their identity and attitude (Glasser, 2010). The retention and dissemination of formal and informal channels of information can thus play a vital role in natural resource management (Berkes, 2004). For instance, peasant farmers know that steppe buzzards (being relatively large and conspicuous) often mimick poultry, mixing with free–ranging chickens and foraging together with them before attacking them. They also know black kites may predate in pairs, approaching the target chicken one behind the other to maximise the chances of catching their prey. Such innovative mechanisms clearly increase their effectiveness in predation. Relying on swiftness and strong sharp talons, the raptors likely harvest a chick in any predation event. Local knowledge also tells that peak predation coincides with the breeding season in September–October, when steppe buzzards and black kites hatch their young and supplement their food with chicken protein.

It is unlikely that peasant farmers yet realize that environmental stressors such as climate change could prompt raptors to increase poultry depletion. Several studies have already highlighted the possibility that climate change influences extinction of fauna and flora (Myers et al., 2000; Sinervo et al., 2010), and may consequently negatively impact on raptors. More local micro–data collection and analysis may be critical to determine the quality of extension services to peasant farmers on raptor ecology.

In response to the actual and perceived human–raptor conflicts, peasant farmers have implemented several preventive and counter–measures, predominantly traditional methods. In addition, some farmers have adopted non–lethal methods, such as training dogs to protect their poultry. If well trained, dogs can effectively be used for poultry protection from predators (Gehring et al., 2010). There is a need to adopt a combination of effective methods to lessen the prevailing and underlying apprehensions between peasant farmers and wildlife agency staff due to wildlife based conflicts. According to Marshall et al. (2007) and Hill (2015), inter–human relationships are equally important in human–wildlife conflict resolution and management because of epitomised differences in management objectives among parties. As poultry has multiple uses even a few minor events of losses can be devastating to impoverished peasant farmers. As a result, some peasant farmers have resorted to clearing vegetation from their properties to prevent raptors from resting and perching before they attack their poultry, reinforcing their cultural belief that having trees within their yards signifies low sanitation. On the contrary, clearing vegetation around the premises increases the risk of chicken loss to raptors because limited cover enhances the visibility of chickens to predatory birds. Some peasant farmers have employed illegal lethal methods such as retaliatory shooting of raptors with shotguns and catapults. In some localities, education and Christian beliefs may help support conservation as local people have an entrenched understanding about wildlife stewardship, in contrast with areas where negative traditional beliefs and low conservation appreciation overshadow conservation efforts. Furthermore, the prohibitive costs of establishing and maintaining wire fencing counteracted the willingness by peasant farmers to adopt novel preventive interventions. Fencing material and labour cost about USD 15–USD 20 per meter, an expense that is out of reach of many peasant farmers.

The prolonged dry season (May–November) probably puts the poultry at greater risk than in the rainy season, when raptor predation events decrease considerably. Preventive and counter–measures that take seasonality into consideration may help reduce human–raptor conflicts. Given that poultry predation by raptors takes place at any time of the day, the most highly recommend measures, such as wire fencing, that are effective day long are those most recommended in resolving of human–raptor conflicts. White phenotypic traits in chickens risk extirpation if not protected and only brown, black and other dull earthly coloured chickens —which express adaptation to the environment of the chickens— would persist in accordance with natural selection postulated by Sinclair et al. (2006). However, further detailed ecological empirical data are needed to understand the evolutional mechanisms that increase raptors' ability to predate their prey in human–dominated, poor quality sink habitats while more innovative preventive counter–measures are being explored.

Implications for local participation in avian conservation

Local peasant farmers build their knowledge base about the environment around them, through long–term social learning, which is critical for avian conservation (Araya et al., 2009; Novotny et al., 2012). Though TEK has inherent limitations in some cases, such as a potentially significant degree of inaccuracy, it influences and shapes the local status of conservation (Becker & Ghimire, 2003; McGregor, 2004). Based on local knowledge, peasant farmers whose poultry has been preyed on develop negative perceptions and attitudes towards wildlife conservation and may retaliate by killing raptors and destroying their habitat, as described by Treves et al. (2009). Irrational emotions by peasant farmers and an often exaggerated magnitude of economic losses often account for illegal and destructive counter–measures such as animal poisoning, shooting and trappings (Nyirenda et al., 2013). Innovative techniques to identify illegal activities can be critical in generating relevant information for policy making (Cross et al., 2013), given that the magnitude of illegal killings of raptors is usually unknown.

Local participation in conservation can be increased if conservationists and researchers integrate the understanding of ecological traps into conservation planning (Battin, 2004). For instance, in addition to land conversion and forest fragmentation, the inappropriate and indiscriminate use of fires for anthropogenic activities (such as traditional hunting of small animals for local consumption (Eriksen, 2007) and the use of unsustainable harvesting methods (such as cutting of trees to harvest edible caterpillars (Mbata et al., 2002) reduce habitat quality for raptors. Such unsustainable anthropogenic activities may affect physiological aspects of raptors by reducing forage and nesting resources. Furthermore, phenotype–based selective poultry predation may have evolutionary implications for poultry in the long term in favour of non–white chickens. Use of appropriate and exclusionary countermeasures such as fencing would minimise poultry predation and consequently, improve avian conservation. Effective interventions would negate the intolerance that would otherwise develop among the affected people through such means as poisoning, shooting and trappings (Treves et al., 2009). The lethal effects of such methods have great repercussions for target and even non–target species due to their non–selective nature (Berny et al., 1997; Anderson, 2000; Brakes & Smith, 2005).

The development of effective interventions such as establishing raptor–proof fowl runs to address human–raptor conflicts therefore requires systematic participatory approaches. The responsible implementation of a combination of effective deterrents is recommended, such as: (1) well maintained and managed fence enclosures to keep raptors away from poultry; (2) healthily managed poultry which evade predation; (3) use of more aggressive guard dogs such as Anatolian shepherd guard dogs; and (4) consistent presence of people, especially during the peak raptor attack periods. Integration of multi–level analyses of empirical data, with the participation of multi–stakeholders, can be critical for human–raptor conflict resolution and management (Canavelli et al., 2014). And lastly, emerging tourism based on diverse avian populations is likely to stimulate economic benefits and local support for raptor conservation (Snyman, 2012).

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Supplementary material

Questionnaire with serial numbers per individual interviewed (Ethics letter detailing the study presented to the individual participants, followed by a brief explanation and consent from individual participants before conducting of interviews).

1. What is your name?.. (optional)

2. How old are you?
   ____ years

3. Gender? [noted]
   a. Male [ ] b. Female [ ]

4. What is your marital status?
   a. Married [ ] c. Single [ ]
   b. Divorced [ ] d. Widowed [ ]

5. What is the highest level of education you attained?
   a. Primary [ ] c. Junior secondary [ ]
   b. Senior secondary [ ] d. College/university [ ]

6. What is your religion? (specify, if any) ....

7. What ethnic grouping do you belong to? specify ....

A. Conditions for occurrence of human–raptor conflicts

1. What conditions would you attribute to the occurrence of peasant farmer–raptor conflicts in the peripherals of Chembe Bird Sanctuary?

B. Diurnal times and seasonality

2. In which season is poultry predation most prevalent?
   a. Rainy season
   b. Cold dry season
   c. Hot dry season

3. Why do you think poultry predation is most prevalent in that season?

4. At what age in their growth were the chickens most vulnerable to raptors?

5. During which diurnal time was chicken predation most common?
   a. Morning
   b. Afternoon
   c. Evening
   d. Morning and evening
   e. All the time

6. Explain why the predation was most prevalent during the diurnal time you have indicated in Q5 above

7. Do you consider the distance from Chembe Bird Sanctuary to influence the quantum of chicken losses to raptors?

C. Life history traits

8. What size of chicken is predated most by steppe buzzards?
   a. Small (< 8 weeks)
   b. Medium (8–12 weeks)
   c. Large (> 12 weeks)

9. What size of chicken is predated most by black kites?
   a. Small (< 8 weeks)
   b. Medium (8–12 weeks)
   c. Large (> 12 weeks)

10. State on average how many chickens are usually reared per month?

11. How many of those chickens reared are usually predated per month?

12. Indicate the colour of chickens lost to raptors?

13. Can you explain relationship that exists between colour and the chicken losses, if any?

D. Costs of raptor–poultry predation

14. How much does each chicken cost at the point of disposal?

15. Do you report the poultry losses to any of the authorities?

16. If yes to Q15, where do you report to?

17. What actions are taken if reported?

18. What counter–measures do you deploy against raptors that prey on poultry?

19. How effective are the counter–measures?
   a. Effective (*i.e.* eliminate >75% of the risks)
   b. Moderate (*i.e.* eliminate 50–75% of the risks)
   c. Not effective (*i.e*. fail to eliminate half of the risks)

20. Do you incur any opportunity costs relating to protection of your poultry?
   a. Yes
   b. No
   c. Not sure
   d. Do not know at all

21. If yes to Q20, explain

22. Explain the mechanism of reducing the cost of losing poultry to raptors?

E. Traditional ecological knowledge and attitudes associated with steppe buzzards and black kites

23. What evidence do you seek to indicate that raptors are responsible for the loss of the poultry at your farm?

24. What do you do to the dead chickens left behind by the raptors?

25. What determines your actions?

26. What are the uses for raptors that predate your chickens?

27. What is the significance of human co–existence with the raptors predating the chickens?

28. Do you support conservation of the raptors?

29. If yes to Q28, explain

F. Traditional ecological knowledge over owls

30. State which owls you encounter in your area?

31. What are the owls doing at the time of encounter?

32. In what habitats are the owls encountered?

33. State the major threats to owls in your area?

34. Do you view that the mentioned threats (in Q33) have negative impacts on owls? explain

35. Explain the ecological roles of owls, if any?

36. Is there any known owl that attack poultry in your area?
   a. Yes
   b. No

G. Traditional uses of owls

37. What is the nature of use of owl parts?

38. How are parts of owls used, if any?

39. What do owls signify in your life?

H. Local perception, attitudes and practices related to owls

40. Must owls be conserved or not? explain

41. Were any incidences of owl killings by local people reported to authorities?

42. How are your contemporary actions towards owls?

43. Are there local 'by–laws' for the protection of owls?

44. If yes to Q43, where do you report to?

45. What do you do to owls found dead?

46. How do you respond when you encounter owls?

47. What do you suggest should be done to ensure owls are conserved?

Thank you very much!