Kent Academic Repository

Full text document (pdf)

Citation for published version

Garriga, Rosa M. and Marco, Ignasi and Casas-Díaz, Encarna and Amarasekaran, Bala and Humle, Tatyana (2017) Perceptions of challenges to subsistence agriculture, and crop foraging by wildlife and chimpanzees Pan troglodytes verus in unprotected areas in Sierra Leone. Oryx . pp. 1-14. ISSN 0030-6053.

DOI

https://doi.org/10.1017/S0030605316001319

Link to record in KAR

http://kar.kent.ac.uk/61748/

Document Version

Author's Accepted Manuscript

PERCEPTIONS OF CHALLENGES TO SUBSISTENCE AGRICULTURE, CROP FORAGING BY WILDLIFE AND CHIMPANZEES IN UNPROTECTED AREAS IN SIERRA LEONE

Rosa M. Garriga[1,2], Ignasi Marco[1], Encarna Casas-Díaz[3], Bala Amarasekaran[2],Tatyana Humle[4]

Word count: 6,990

[1] Servei d'Ecopatologia de Fauna Salvatge, Facultat de Veterinària, Universitat Autònoma de Barcelona, Spain

[2] Tacugama Chimpanzee Sanctuary, Sierra Leone

[3] Departament de Sanitat i Anatomia Animals, Facultat de Veterinària, Universitat Autònoma de Barcelona, Spain

[4] Durrell Institute of Conservation and Ecology, School of Anthropology and Conservation, University of Kent, UK

Corresponding author's email: rosagarriga@yahoo.com

ABSTRACT

The Sierra Leone National Chimpanzee Census Project (SLNCCP) estimated a population of 5,580 individuals distributed across the country with >50% occurring outside protected areas. This census also highlighted the significance of human-chimpanzee competition for resources in areas dominated by farming activities where wild chimpanzees forage on crops. For the purpose of this study, we selected four study areas in two districts in Sierra Leone with high chimpanzee density in agricultural dominated habitats far from any protected areas. The objectives were to assess farmers' perceptions of the main challenges to their agricultural yields and wildlife involved in crop foraging, the main crop protection measures used and to understand farmers' perception of chimpanzees. For this purpose, we conducted 257 semi-structured interviews with local farmers across the four study areas. The results showed that: a) farmers reported wild animals as their main agricultural problem; b) most complaints concerned cane rats Thryonomys swinderianus, which targeted almost all crop types (20/23), especially rice and cassava; c) chimpanzees reportedly targeted 21/23 crops but less often than cane rats, focusing particularly on oil palm, cassava and domestic fruits; d) overall chimpanzees were not reported among the top three most destructive animals; e) chimpanzees were generally perceived as more destructive than dangerous and as having declined since before the civil war; f) the main reported crop protection measure employed was fencing interspersed with traps. Our study illustrates the importance of investigating farmers' perceptions before developing appropriate conservation strategies aimed at promoting people-wildlife co-existence in highly degraded landscapes.

Key words: anthropogenic landscape, crop-raiding, farming, human-wildlife co-existence, Pan troglodytes verus

INTRODUCTION

Competition for resources between wildlife and people is a widespread concern occurring in all sorts of landscapes around the world where wild animals and people co-exist (Woodroffe et al., 2005). Although wild animals represent an important part of the life and diet of many local people in developing countries (Hoffman & Cawthorn, 2012), habitat loss, agricultural expansion (Maxwell et al., 2016) and human encroachment into wildlife habitat are key drivers of wildlife population decline or even local extinction (Vliet et al., 2012). Such anthropogenic landscapes can compel wildlife species to consume cultivated foods or prey on domesticated animals to survive (McLennan, 2008; Hockings et al., 2009; Inskip & Zimmermann, 2009). Competition between wildlife and people is highly problematic in areas where farmers depend solely or mostly on subsistence agriculture and natural resources, as it can affect peoples' livelihoods and their relationship with, and perceptions of, wildlife (Naughton-Treves, 1998; Webber & Hill, 2014; Humle & Hill, 2016).

Sierra Leone is home to the western chimpanzee Pan troglodytes verus, which is listed as Critically Endangered (Humle et al., 2016). Côte d'Ivoire has seen catastrophic declines of up to 90% of its wild chimpanzee population in recent years (Campbell et al., 2008). This dramatic situation highlights the importance of Sierra Leone for chimpanzee conservation in West Africa. However, chimpanzees face serious threats in Sierra Leone, including habitat loss, hunting and retaliation as a result of resource competition with humans (Brncic et al., 2010). The chimpanzee is protected by law across all range states where the species occurs in the wild (Humle et al., 2016). However, the laws protecting this great ape species are often neither applied nor enforced across most of its range as evidenced by the continued influx of orphan chimpanzees across African sanctuaries or rehabilitation centres, often by-products of bushmeat hunting (Faust et al., 2011) and the persistence in the illegal trade in live individuals (Stiles et al., 2013). Conservation efforts are often placed into protecting areas of high value for biodiversity that contain endangered species of international concern. Most studies to date have therefore been carried out near or around protected areas and comparatively few have investigated sympatry between chimpanzees and farmers in agricultural dominated landscapes (e.g. Halloran et al., 2013; McLennan & Hill, 2013; Hockings et al., 2015).

Tacugama Chimpanzee Sanctuary (TCS) coordinated the Sierra Leone National Chimpanzee Census Project (SLNCCP) from 2009 to 2010. This census estimated a total population of 5,580 chimpanzees (range: 3,052-10,446) spread across the country with more than half located outside protected areas (Brncic et al., 2010). The SLNCCP highlighted the extent of human-chimpanzee competition for resources, with 88% of the villages, which reported local presence of chimpanzees, mentioning that chimpanzees locally foraged on crops. The Population and Habitat Viability Assessment (PHVA) that followed recommended a better understanding of (i) the costs and benefits of co-existence for both people and chimpanzees, (ii) the threats faced by chimpanzees in such landscapes, (iii) the attitude and perception of the farmers towards chimpanzees, and (iv) how and why these change over time (Carlsen et al., 2012).

Conservation efforts to protect biodiversity are often seen by local people living nearby as a threat to their livelihoods (Redpath et al., 2013; Madden & McQuinn, 2014). However, not all wildlife cause the same amount of damage and farmers may hold biased perceptions of damage linked to species attributes such as its size, temporal and spatial activity patterns, sociality and/or traditional and related cultural taboos and beliefs (Humle & Hill, 2016). Understanding local perceptions, attitudes and concerns regarding wildlife is crucial for appropriate conservation and management strategies to reduce conflict and promote a sustainable coexistence between people and wildlife (Redpath et al., 2013; Madden & McQuinn, 2014). Non-human primates are often cited as one of the main culprits of crop feeding in the geographical ranges where they occur (Humle & Hill, 2016). Chimpanzee foraging on crops has also been reported across Africa (Hockings & Humle, 2009; McLennan & Hockings, 2014). Studies have to date primarily focused on evaluating the crops targeted by chimpanzees and their dietary contribution relative to wild foods (Hockings et al., 2009; Hockings & McLennan, 2012; McLennan & Hockings, 2014), as well as chimpanzees' responses to interactions with people and associated infrastructures such as roads (McLennan & Hill, 2010 & 2012; Hockings, 2011; Cibot et al., 2015; McLennan & Asiimwe, 2016). Although reports of chimpanzees wounding people fatally are rare, there have also been a growing number of accounts of chimpanzees behaving aggressively towards people (McLennan & Hockings, 2016). Even if often attributable to prior provocation by people (Hockings et al., 2010), such instances can elicit or increase peoples' negative attitude towards chimpanzees, generate resentment, and accentuate the fear of attack (McLennan & Hockings, 2016). Nevertheless, still only a few studies have explored people's perceptions and attitudes towards chimpanzees. Costa et al. (2013) found that chimpanzees in Tombali, Guinea–Bissau, were perceived as human-like and inedible, but they were also considered as pests due to their crop foraging behaviour. In this region, non-Muslims appeared to be more tolerant than Muslims and men perceived chimpanzees more positively than women. In the Budongo forest of Uganda, farmers perceived chimpanzees more positively than other primates such as baboons, although some farmers indicated that they were afraid of chimpanzees (Webber & Hill, 2014). McLennan & Hill (2012) found that in general farmers in Bulindi, Uganda, hold a positive perception of chimpanzees and tolerate occasional foraging of domestic fruits but not cash crops. This latter study emphasized that alterations to the habitat and human encroachment can negatively affect chimpanzee behaviour towards people thus 'challenging residents' traditionally benign attitude towards them*'* (p. 219).

For the purpose of this study, we selected four areas in unprotected landscapes with hardly any forest cover but with a high density of chimpanzees and with reported issues of human-chimpanzee resource competition based on Brncic et al. (2010) national census data. The aims were to identify the key challenges to agricultural productivity for people in these landscapes, to assess the mitigation strategies currently used by farmers to protect their crops from wildlife, and to understand the perceptions of farmers towards chimpanzees, how farmers perceive the current status of chimpanzees in their locality and to evaluate the perceived impact of crop losses caused by chimpanzees relative to other wildlife in each study area.

STUDY SITES AND METHODS

Study areas

The study took place across four distinct locations in Sierra Leone: Lawana (LA) and Moseilelo (MO) in the Moyamba district and Porto Loko South (PL-S) and Porto Loko North (PL-N) in the Porto Loko district (Fig. 1 and Table 1). Active and fallow farms at various stages of growth dominate these four areas. Wild or feral oil palms Elaeis guineensis are the most frequently encountered tree species across these agricultural matrixes together with rough skin plum trees Parinari excels (Fig. 2). Oil palms represent an important non-cultivated resource which people harvest locally to obtain palm oil, palm wine, nuts and construction materials. However, these sites do differ in several ways: LA is located between mangroves and swamp areas (Fig. 2); MO harbours a small and highly degraded secondary forest area, known as the Kasillah hills; PL-N is dominated by grassland and woodland savannah, and also harbours small-scale oil palm plantations, while PL-S is more swampy and harbours a higher number of small scale commercial oil palm plantations located primarily near human settlements. Both PL areas have multiple narrow riverine forests spanning the landscape. The MO and both PL areas are also delimited by two large rivers forming a fork potentially acting as barrier to wildlife dispersal (Fig. 3). Both men and women are involved in farming activities in these areas where they cultivate mainly seasonal crops (Garriga, pers. obs.). Aside the SLNCCP (Brncic et al. 2010), there has been no previous chimpanzee research in these areas.

Semi-structured interviews

We performed 257 semi-structured interviews with farmers across 61 villages i.e. 23 villages in the Moyamba district and 38 villages in the Port Loko district between December 2012 and January 2014 (Table 1). The average time to complete an interview was 27 minutes (range: 9-77, SD: 9.0). Among the participants, 80.2% were males and 19.8% were females. Due to this significant sex-bias (Table 1), we refrained from conducting any analysis exploring gender differences. The mean age of the participants was 43 years old (range=19-90, SD=14.08). The majority of the participants (93.9%) were farmers, 3.8% of them combined farming with other occupations which included trading (N=4), teaching (N=3), fishing (N=2) and pot making (N=1). The dominant ethnicity varied across sites (Table 2), although the majority (95.7%) described themselves as Muslims. Nearly two-thirds (63.4%) of the participants reported not having received any formal education (Table 2). This study was approved by the Research Ethics' Committee of the School of Anthropology and Conservation at the University of Kent, UK, and adhered to the code of best practises for field primatology issued by the International Society of Primatology. The interviews were anonymous and voluntary. We conducted one individual interview per household. We first asked permission from the village chief; interviewers then scattered in opposite directions from the centre to the periphery of each village, randomly selecting households. The interviewers were four Sierra Leoneans from the TCS field team trained by the main researcher and the interviews were performed in the local language. In order to cover a wide geographical area in each locality, we performed interviews in every second village as we passed through. The interviews were designed to determine: 1) the socio-cultural profile of participants; 2) the types of crops cultivated locally and the causes of crop losses (this last question was unfortunately omitted in the questionnaire in the MO area which was therefore not included in this analysis); 3) the local occurrence of wildlife by means of a field guide and the type of crops that identified wildlife were reported to consume; 4) which three species of animals were considered causing the most crop damage; 5) the measures of protection employed locally to deter wildlife from feeding on crops; and 6) people's perceptions of chimpanzees i.e. do they perceive them to be dangerous and why and how they react when encountered in fields and the farmers' view of the changes in chimpanzee numbers over the last two decades, i.e. at the time of the study and before the civil war (1991-2002).

The compiled animal guide used for the interviews contained 43 drawings of different West African mammal species (Kingdon, 2001; Oates, 2010). The selection of images was piloted with 10 Sierra Leoneans before the start of the study to ensure that people recognised the species portrayed. When the participants identified an animal they believed to exist in their area, we asked whether the animal in question consumed crops and which type. We then tallied the number of times each crop was reported as being consumed by all animals to calculate percentages of reported crop foraging.

Data Analysis

Maps were designed using ARC-GIS 10.3. Data were analysed using Statistical Package for Social Sciences IBM® SPSS® Statistics v. 23. Chi-square tests were used to explore differences between sites in the types of crops grown, crop protection measures used, the perceived changes in the number of chimpanzees since before the civil war, people's perception of chimpanzees as being 'dangerous' and reports of how chimpanzees react when encountered in cultivated fields. For chi-square tests with more than a 2 x 2 contingency design, the z-scores based on the adjusted standardised residuals were used to assess the cell contribution to significant chi-square results with values > ± 1.96 yielding statistical significance at $p<0.05$. All descriptive data across study sites are reported as mean percentage ±1 standard deviation.

RESULTS

Crops cultivated and reported causes of crop losses

Farmers reported to cultivate a mixture of seasonal crops using intercropping practises. Unlike swamp fields which were exclusively planted with rice, upland farms were cultivated simultaneously with a mixture of crops (Table 3). Seasonal crops were the most reported cultivars grown by farmers in all areas (82.7±6.7%). There was a significant difference in the reported type of crops grown across sites (Chi-square test: $X(6)=41.163$; $p<0.001$), with the z-scores indicating a significantly higher frequency of domestic fruit crops and cash tree crops at PL-S relative to the other sites and significantly fewer than expected cash tree crops in both LA and MO. There was, however, no significant difference in the reporting of seasonal crops being cultivated across the four sites (Table 3). The harvests were in all cases used for subsistence, although 66.1% (170/257) of participants reported selling any surplus, with LA reporting selling the least (25.5%) compared to the other three sites (MO: 60.5%; PL-N: 78.9%; PL-S: 80.4%).

In the LA area, the reported challenges to agricultural productivity were crop foraging by wild mammals (76.5%), poor soil quality (51%), and grasshopper plagues (9.8%), while in the Porto Loko district crop foraging by wild mammals (PL-N: 98.6%; PL-S: 96.9%), grasshoppers (PL-N: 78.9%; PL-S: 83.5%), birds feeding on crops (PL-N: 7%; PL-S: 7.2%), poor soil quality (PL-N: 4.2%; PL-S: 14.4%) and lack of fertiliser (PL-N: 1.4%; PL-S: 4.1%) were the issues raised by farmers. Foraging by domestic animals was only mentioned once as an issue in PL-S.

Rice and cassava, the two most reported cultivated crops (Table 3), were also the most reported as being damaged by wild mammals. In contrast, sesame and sorghum were rarely reported as being consumed by wild mammals (Table 3). Other cultivars, such as chilli pepper and okra, attracted fewer species with duikers and bushbucks being most often mentioned as feeding on the leaves. Domestic fruits crops represented only on average 9.6±2.9% of the cultivars reported to be cultivated across all four areas, with primates considered the main consumers (75.6±12.7%) with 32.8±16.6% attributed to chimpanzees. Cash tree crops represented on average only 7.7±3.9% of the total cultivars reported. Small commercial oil palm plantations were common in both PL areas but not in LA and MO. However, farmers in all four areas regarded oil palm losses to wildlife as a serious issue and the oil palm was reported as the third most frequently 'raided' species in all areas except in MO where it ranked fifth (Table 4). Chimpanzees were the most commonly mentioned 'culprit', although up to 30 different species of animals were reported to exploit oil palms.

Chimpanzees reportedly targeted 21 different crops but with a lower frequency compared to cane rats, which were reported to target up to 20 different types of crops (Table 5). Cane rats were reported to feed mainly on rice and cassava and in less measure maize and peanuts, damaging all stages of the plants' growth. The giant-pouched rat Cricetomys emini, the green monkey Chlorocebus aethiops sabaeus and the fire-footed rope squirrel Funisciurus pyrropus consumed a similar number of crops (20-21) with a similar frequency. Green monkeys and sooty mangabeys Cercocebus atys were reported to target the same number of crops; however, sooty mangabeys were more frequently reported in LA and MO and green monkeys in PL. Regardless, across all four areas, monkeys as a group were reported to consume similar cultivars, primarily maize, rice, cassava and peanuts.

The average number of animal species identified per interview was 11 (range: 2-26; SD: 4.25). Adding each identified species that was considered a crop forager, cane rats, chimpanzees, giant pouched rats and fire-footed rope squirrels emerged as the top most mentioned species (Fig. 4). However based on the famers' perception of the top three most destructive animals, cane rat ranked first and caused the most damage to crops in all four areas (Fig. 5). Overall chimpanzees ranked only as the fourth most destructive mammal. However, there were some variations across sites. In LA, chimpanzees were ranked second and in MO fourth, whereas chimpanzees were ranked seventh in PL-N and fifth in PL-S. One important and regular complaint of the farmers in PL sites was also the destruction of crops by grasshoppers Zonocerus variegatus, which was at the time of the study never mentioned in the Moyamba district sites (Fig. 5).

Crop protection measures

All of the participants but eight (249/257) reported using one or more mitigation measures against animal crop foraging. More mitigation measures were reported at the PL sites than at LA and MO (Table 6). Fencing (223/249) and traps (208/249) were the most common deterrents used to prevent animals from entering cultivated farms. Usually fences are hand-made with palm leaves and/or sticks interspersed with snares. Hunting with dogs was more common in the Port Loko district area with 49.4% (81/164) of reported use compared to only 7% (6/85) in the Moyamba district. However if one categorises each measure as (potentially) lethal versus non-lethal (Table 6), there were no differences among sites (Chi-square test: X(3)=2.243; p=0.523).

Farmers' perception of chimpanzees

Nearly all of the participants (253/257; 98%) stated that chimpanzees entered their farms before the civil war (1991-2002) and 63% (160/253) felt that there were fewer chimpanzees now than before the war mostly due to deforestation and hunting (118/160). Only 36.4% (92/253) felt there were more chimpanzees now and the only reason stated in 45% (41/92) of the responses was because they were not hunted. No other reasons were given. However, there was a significant difference among sites as to whether people perceived there to be more or less chimpanzees since before the civil war (Chi-square test: X(3)=82.255; p<0.001). While significantly more people than expected felt there were more chimpanzees than before the civil war in LA, there was no significant difference for MO and the reverse was noted at both PL sites.

Eighty seven per cent (224/257) of the participants considered chimpanzees to be 'dangerous'. The most common reason for why people viewed them as dangerous was that chimpanzees are destructive to crops (48.7%, 109/224), destructive and frightening (5.8%, 13/224), frightening (28.1%, 63/224) or just aggressive (2.7%, 6/224). There was, however, no significant difference among sites as to whether people perceived chimpanzees as dangerous or not (Chi-square test: X(3)=2.601; p=0.457).

Ninety four per cent (241/257) of participants reported currently encountering chimpanzees in their fields with little variation across study areas (LA: 96%, MO: 94.7%, PL-N: 90.1%, PL-S: 96.9%). When asked what the chimpanzees do when they are encountered, 81.7% (197/241) of the participants reported that chimpanzees run away and 12.9% (31/241) that they threaten people. There was, however, a significant difference among sites in how people reported chimpanzees to react when seen in fields (Chi-square: X(3)=9.702; p=0.021). Although there was no significant difference in reports of chimpanzees running away, fewer people than expected reported chimpanzees threatening people when seen in their fields at LA and significantly more at PL-S.

DISCUSSION

Our study revealed that cane rats were perceived as the most problematic mammal for farmers. Arlet & Molleman (2007) found that this same species was causing the most severe damage to crops around a forest reserve in Cameroon. Naughton-Treves & Treves (2005) also noted cane rats as a 'problem' animal. Cane rats are nocturnal, dependent on water, with high reproductive rates and can thrive extremely well in areas with abundant grasses (Hoffmann, 2008); the agricultural dominated habitat present at our study sites is highly suited to their needs, explaining why they thrive in such landscapes.

Chimpanzees were never ranked as the first most destructive mammal species and other species such as the cane rat, red river hog, monkeys and grasshoppers were overall perceived as causing most damage. Nevertheless, there was variation across sites in the ranking of chimpanzees. This difference could be linked to variation in the occurrence and abundance of other destructive wildlife species and people's perceptions across sites. However, our results also suggest that farmers' perceptions vary depending on crops grown and their dependence on agriculture for subsistence. There was indeed a gradient with chimpanzees being ranked higher (LA and MO) where farmers mentioned growing more seasonal crops and fewer cash crops and also reporting selling fewer surpluses, indicating a higher dependency of seasonal cultivation for subsistence. The degree to which farmers viewed chimpanzees as a threat to their agricultural yield may also be related to the extent of overlap between the chimpanzees' home range and farmlands in the landscape, the contribution of different crop species to chimpanzees' diet locally (McLennan & Hill, 2012) or whether farmers have direct experience of chimpanzee crop foraging (although there was no reported variation across sites in this study), and their level of tolerance of chimpanzee offtake (although chimpanzees were reportedly less likely to threaten people at LA which would indicate that perhaps farmers are more tolerant of chimpanzee crop-foraging at this site) (Webber & Hill, 2014). These alternative explanations warrant further investigation to reveal patterns of similarity or differences across sites.

We recorded significant evidence of chimpanzees using oil palms across all four study areas. The most visible and common use by chimpanzees was nesting. Commercial oil palms are predominantly cultivated in the two PL areas compared to LA and MO (Table 3), but during our time in the field, we did not record any evidence of chimpanzees using them. Usually these plantations are cultivated near human settlements potentially reducing chimpanzee accessibility. Based on our in situ observations, competition for oil palm mainly concerns wild oil palms which are widespread and are an important resource to farmers. Chimpanzees at other sites have also demonstrated extensive reliance on the oil palm for food and nesting (e.g. Bossou, Guinea: Humle & Matsuzawa, 2004; Guinea-Bissau: Sousa et al., 2011; Bessa et al., 2015). Further research is needed to assess to what extent chimpanzees across different landscapes depend on the oil palm for food and nesting.

Hockings & McLennan (2012) found that cassava was not widely eaten by chimpanzees across their range and that they preferred sugar fruits. In our study, chimpanzees were reported to frequently forage on cassava probably because of its wider and easier availability compared to other types of cultivars, such as banana, mango, pineapple or papaya. Domestic fruit crops represented less than 10% of the crops cultivated in all four areas, although farmers tended to underreport these as being cultivated (Table 3). Chimpanzees may also avoid coming close to the villages and prefer to consume cassava from the more distant fields. Indeed, in spite of occasional reports of farmers seeing chimpanzees near their villages foraging on domestic fruit trees in MO and in PL-S, such events were rarely reported. However, it is also possible that farmers were potentially more likely to report chimpanzee foraging on a valuable staple crop such as cassava than domestic fruits because these are in most villages typically grown around individual households and harvested mainly for self-consumption. A similar situation was described by McLennan and Hill (2012) in Uganda where farmers tolerated consumption of fruits by chimpanzees like guavas but not cash crops like sugarcane, cocoa or bananas. Still, farmers in our study reported domestic fruits as being targeted especially by chimpanzees and monkeys. Monkeys seem to be more daring in approaching villages to feed on domestic fruit trees than chimpanzees, as we witnessed on several occasions during our field work. In Guinea and Uganda, however, Hockings & Humle (2009) and McLennan (2013) described respectively chimpanzees entering villages to consume tree fruits. This 'bold' behaviour is potentially linked to people's tolerance of and behaviour towards chimpanzees and the extent to which wild foods allow them to meet their dietary requirements; habituation could also play a role in influencing the prevalence of such a behaviour (Naughton-Treves et al., 1998; Hockings et al., 2009; McLennan, 2013), although it is not a precondition (McLennan & Hill, 2010). Interestingly, sesame, which was widely cultivated across all four areas, and sorghum in LA and MO, were rarely reported as being consumed by wild mammals. This suggests that these crops either may act as potential low-conflict crops (Hockings & McLennan, 2012) or else farmers are more tolerant of these crops being consumed by wildlife. The intercropping system used in Sierra Leone provides wildlife with a choice of crops to feed on and further assessment is required to differences between real and perceived damage between mixed versus mono-cultivated fields.

In our study areas, chimpanzees share the habitat with people but are not habituated; usually they run away during accidental encounters with farmers. The absence or limited presence of forest cover at these sites potentially explains why wildlife is highly dependent upon cultivated and/or abandoned crops for their survival. Local farmers cannot recall seeing large tracks of forests in their area, suggesting that these landscapes were cleared many decades ago. The remaining wild fauna, including chimpanzees, appear to have adapted to this anthropogenic environment. We remain unsure as to why chimpanzees still persist in these degraded areas; future studies should help us identify more precisely the conditions favouring their persistence.

Almost all farmers interviewed reported adopting crop protection measures. The most common included snares, traps and fences. Fences are erected to prevent larger herbivores from entering cultivated fields and snares and traps are aimed at small mammals. The traps are made of sticks and thin rope or wire. The use of mitigation measures was more prevalent at the PL sites where most farmers reported selling any harvest surplus, potentially indicating a relationship between monetary income and the ability to protect crops, corroborating findings elsewhere in Africa (Hill & Wallace, 2012) and South-east Asia (Campbell-Smith et al., 2012). Although some mammals, especially chimpanzees, might be able to escape by dislodging the wire from the trap, the wire could remain tight around the trapped limb and cause severe injury (Quiatt et al., 2002). The impact of wire traps on chimpanzees and other wildlife still, however, needs to be assessed in our study areas. Farmers also reported occasionally hiring hunters to get rid of some pests feeding on their crops, typically monkeys, as they are more difficult to catch with snares. Encouraging sustainable and more species-specific hunting practises using more specialised devices to capture rodents could not only decrease crop feeding, but could also help improve yields, and protect endangered chimpanzees and other mammal species, whilst providing a supplementary source of protein to local villagers. Cane rats indeed represent an important favoured highly nutritious source of protein for local people (Hoffman & Cawthorn, 2012).

Farmers from both PL areas reported grasshopper plagues as an important agricultural challenge, destroying entire cassava and potato fields. A biologic insecticide called Green Muscle™ (Becker Underwood, South Africa) is available from the central government but a lack of resources to implement the project is preventing the product from reaching farmers across the country. Finding solutions to the distribution and implementation of this preventive crop protection measure could help farmers obtain better yields; this could potentially promote a higher tolerance of farmers towards key species like chimpanzees. However, as highlighted by Knight (2000), a heightened expectation of preventability of crop loss could also backfire and could run the risk of lowering farmers' tolerance levels of damage caused by other species. Therefore project implementation will require careful monitoring of farmers' tolerance levels of damage. Furthermore, human population growth, which translates into a higher demand for resources (Barnes, 2002), forces farmers to shorten fallow periods which ends up impoverishing the soil and impacts future agricultural productivity (Gaiser et al., 2011). Altogether such agricultural practises are detrimental to human wellbeing, as people rely on natural resources provided by these forests and habitat conversion can cause a decrease in animal abundance and diversity which people also depends on for protein (Fa & Brown, 2009). Indeed, farmers in three out of four of our study areas stated that chimpanzee numbers have decreased over the last 20 years due to deforestation and hunting. To protect wild chimpanzees under such habitat conditions, we see the need to work closely with the local communities to help them develop more efficient and sustainable farming techniques, so their yields are improved, soil fertility is maintained and to minimise habitat loss via slash and burn agriculture.

Almost all participants (94%) claimed to have sighted chimpanzees in their fields. Farmers predominantly stated that chimpanzees run away when encountered in the fields, although some stated that chimpanzees could threaten people because they are not afraid and could cause injury or lethal attacks. However, only four participants reported chimpanzee physical aggression on people (one case in LA and 3 in PL-S), adults in all cases, in contrast to Bossou, Guinea, where such attacks mainly concern children (Hockings et al., 2010). Each of these participants felt that chimpanzees were dangerous. Difference between sites may be related to differences in encounter rate between people and chimpanzees (McLennan & Hockings, 2016) and/or people's behaviour towards chimpanzees (Hockings et al., 2010) and chimpanzees' perception of risk within their environment (Humle & Hill, 2016). Most participants (87%) considered chimpanzees to be 'dangerous'. However, almost half of them argued that it was because chimpanzees were destructive of the crops rather than frightening or aggressive. Nearly two thirds (63%) of the participants also felt that there were fewer chimpanzees now than before the war; however, only in LA, farmers felt that there were more chimpanzees now. This result could either be linked to a real local increase of the chimpanzee numbers or, alternatively, to higher rates of chimpanzee crop foraging and people sighting of chimpanzees in this area compared to other sites.

While we only focused on a subset of locations within Sierra Leone, these findings provide us with a better understanding of human-wildlife co-existence in agricultural landscapes and the factors influencing variability in sympatric relations between people, chimpanzees and other wildlife. This study highlights variations across study areas, probably linked to differences in habitat types and crops cultivated and historical patterns of habitat loss. We argue that actions need to be context-specific based on an understanding of local people's perceptions, concerns, and attitudes, as well as chimpanzee ecology and ranging in these landscapes. Conservation strategies should benefit and support farmers at the same time as promoting a positive co-existence between humans and chimpanzees, therefore favouring their protection and long-term survival. However, we still need to develop and assess with local and national stakeholders which actions can most effectively improve co-existence between people and chimpanzee and improve tolerance levels towards crop-foraging.

ACKNOWLEDGEMENTS

We are grateful to the Ministry of Agriculture, Forestry and Food Security of the Sierra Leone Government for granting us the permission to conduct this research. This work would not have been possible without the collaboration of the people in the communities who volunteered to partake in our interviews. We also would like to thank the TCS's outreach and management teams, in particular Yirah Koroma, Joseph Marah, David Momoh and Konkofa Marah for their assistance in the field. We also would like to acknowledge the Fundació Barcelona Zoo, the Rufford Small Grant Foundation, the Mohamed bin Zayed Species Conservation Fund and the Tacugama Chimpanzee Sanctuary for having provided the financial support to conduct this research. Finally, we also would like to thank Matthew McLennan and an anonymous referee for their helpful comments.

Author contributions: Conceived and designed the research: RG, BA, TH. Performed the research: RG. Analysed the data: RG, TH. Wrote the paper: RG, TH. Contributed with revisions: IM, EC.

REFERENCES

ARLET, M.E. & MOLLEMAN, F. (2007) Rodents damage crops more than wildlife in subsistence agriculture on the northern periphery of Dja Reserve, Cameroon. International Journal of Pest Management, 53, 237–243.

BARNES, R.F.W. (2002) The bushmeat boom and bust in West and Central Africa. Oryx, 36, 236–242.

BESSA, J., SOUSA, C. & HOCKINGS, K.J. (2015) Feeding ecology of chimpanzees (Pan troglodytes verus) inhabiting a forest-mangrove-savanna-agricultural matrix at Caiquene-Cadique, Cantanhez National Park, Guinea-Bissau. American journal of primatology, 77, 651–665.

BRNCIC, T., AMARASEKARAN, B. & MCKENNA, A. (2010) Sierra Leone National Chimpanzee Census. Tacugama Chimpanzee Sanctuary, Freetown, Sierra Leone. Final report, pp.115.

CAMPBELL, G., KUEHL, H., N'GORAN KOUAMÉ, P. & BOESCH, C. (2008) Alarming decline of West African chimpanzees in Côte d'Ivoire. Current biology, 18, R903–R904.

CAMPBELL-SMITH, G., SEMBIRING, R. & LINKIE, M. (2012) Evaluating the effectiveness of human-orangutan conflict mitigation strategies in Sumatra. Journal of Applied Ecology, 49, 367–375.

CARLSEN, F., LEUS, K., TRAYLOR-HOLZER, K. & MCKENNA, A. (2012) Western Chimpanzee Population and Habitat Viability Assessment for Sierra Leone: Final Report. IUCN/SSC. Conservation Breeding Specialist Group – Europe (CBSG), Copenhagen, Denmark.

CIBOT, M., BORTOLAMIOL, S., SEGUYA, A. & KRIEF, S. (2015) Chimpanzees facing a dangerous situation: a high-traffic asphalted road in the Sebitoli area of Kibale National Park, Uganda. American Journal of Primatology, 77, 890–900.

COSTA, S., CASANOVA C. & SOUSA C., L.P. (2013) The Good, The Bad and The Ugly: Perceptions of Wildlife In Tombali (Guinea-Bissau, West Africa). Journal of Primatology, 2:110.

FA, J.E. & BROWN, D. (2009) Impacts of hunting on mammals in African tropical moist forests: a review and synthesis. Mammal Review, 39, 231–264.

FAUST, L.J., CRESS, D., FARMER, K.H., ROSS, S.R. & BECK, B.B. (2011) Predicting Capacity Demand on Sanctuaries for African Chimpanzees (Pan troglodytes). International Journal of Primatology, 32, 849–864.

GAISER, T., JUDEX, M., IGUÉ, A.M., PAETH, H. & HIEPE, C. (2011) Future productivity of fallow systems in Sub-Saharan Africa: Is the effect of demographic pressure and fallow reduction more significant than climate change? Agricultural and Forest Meteorology, 151, 1120–1130.

HALLORAN, A.R., CLOUTIER, C.T. & SESAY, P.B. (2013) A previously undiscovered group of chimpanzees (Pan troglodytes verus) is observed living in the Tonkolili district of Sierra Leone. American journal of primatology, 75, 519–523.

HILL, C.M. & WALLACE, G.E. (2012) Crop protection and conflict mitigation: reducing the costs of living alongside non- human primates. Biodiversity and Conservation, 21, 2569–2587.

HOCKINGS, K. & HUMLE, T. (2009) Best practice guidelines for the prevention and mitigation of conflict between humans and great apes. IUCN/SSC Primate Specialist Group. Gland, Switzerland.

HOCKINGS, K.J., ANDERSON, J.R. & MATSUZAWA, T. (2009) Use of wild and cultivated foods by chimpanzees at Bossou, Republic of Guinea: feeding dynamics in a human-influenced environment. American journal of primatology, 71, 636–646.

HOCKINGS, K.J., YAMAKOSHI, G., KABASAWA, A. & MATSUZAWA, T. (2010) Attacks on local persons by chimpanzees in Bossou, Republic of Guinea: long-term perspectives. American journal of primatology, 72, 887–896.

HOCKINGS, K.J., (2011). Behavioral flexibility and division of roles in chimpanzee road-crossing. In The chimpanzees of Bossou and Nimba (eds. T. Matsuzawa, T. Humle, & Y. Sugiyama), pp.221-229. London: Springer.

HOCKINGS, K.J. & MCLENNAN, M.R. (2012) From forest to farm: systematic review of cultivar feeding by chimpanzees-Management implications for wildlife in anthropogenic landscapes. PloS ONE, 7 (4).

HOCKINGS, K.J., MCLENNAN, M.R., CARVALHO, S., ANCRENAZ, M., ET AL. (2015) Apes in the Anthropocene: flexibility and survival. Trends in Ecology & Evolution, 30, 215-222

HOFFMANN, M. (2008) Thryonomys swinderianus. The IUCN Red List of Threatened Species 2008: e.T21847A9323360.http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T21847A9323360.en. Downloaded on 14 September 2016.

HOFFMAN, L.C. & CAWTHORN, D.M. (2012) What is the role and contribution of meat from wildlife in providing high quality protein for consumption? Animal Frontiers, 2, 40–53.

HUMLE, T. & MATSUZAWA, T. (2004) Oil palm use by adjacent communities of chimpanzees at Bossou and Nimba mountains, West Africa. International Journal of Primatology, 25, 551–581.

HUMLE, T. & HILL, K. (2016) People-primate interactions: implications for primate conservation. In Introduction to Primate Conservation (eds. S. Wich & A. Marshall), pp. 219–240. Oxford University Press.

HUMLE, T., BOESCH, C., CAMPBELL, G., JUNKER, J., KOOPS, K., KUEHL, H. & SOP, T. (2016) Pan troglodytes ssp. verus. The IUCN Red List of Threatened Species 2016: e.T15935A17989872. Downloaded on 14 September 2016.

INSKIP, C. & ZIMMERMANN, A. (2009) Human-felid conflict: a review of patterns and priorities worldwide. Oryx, 43, 18.

KINGDON, J. (2001) The Kingdon field guide to African mammals. 4th Ed. A&C Black Publishers Ltd. London

KNIGHT, J. (2000) Introduction. In: Natural enemies: people-wildlife conflicts in anthropological perspective. (ed J Knight), pp 1-35. Routledge, London.

MADDEN, F. & MCQUINN, B. (2014) Conservation's blind spot: The case for conflict transformation in wildlife conservation. Biological Conservation, 178, 97–106. Elsevier Ltd.

MAXWELL, S. L., FULLER, R.A., BROOKS, T. M. & WATSON, J.E.M. (2016) Biodiversity: The ravages of guns, nets and bulldozers. Nature News, 536, 143–145.

MCLENNAN, M.R. (2008) Beleaguered Chimpanzees in the Agricultural District of Hoima, Western Uganda. Primate Conservation, 23, 45–54.

MCLENNAN, M.R. & HILL, C.M. (2010) Chimpanzee responses to researchers in a disturbed forest-farm mosaic at Bulindi, western Uganda. American journal of primatology, 72, 907–918.

MCLENNAN, M.R. & HILL, C.M. (2012) Troublesome neighbours: Changing attitudes towards chimpanzees (Pan troglodytes) in a human-dominated landscape in Uganda. Journal for Nature Conservation, 20, 219–227.

MCLENNAN, M.R. (2013) Diet and Feeding Ecology of Chimpanzees (Pan troglodytes) in Bulindi, Uganda: Foraging Strategies at the Forest-Farm Interface. International Journal of Primatology, 34, 585–614.

McLennan, M.R. & Hill, C.M. (2013) Ethical issues in the study and conservation of an African great ape in an unprotected, human-dominated landscape in western Uganda. In Ethics in the field: contemporary challenges (eds. J. MacClancy & A. Fuentes), pp 42-66. Bergham, New York.

McLennan, M.R. & Hockings, K.J. (2014) Wild chimpanzees show group differences in selection of agricultural crops. Scientific reports, 4, 5956.

McLennan, M.R. & Asiimwe, C. (2016) Cars kill chimpanzees: case report of a wild chimpanzee killed on a road at Bulindi, Uganda. Primates, 1–12.

McLennan, M.R. & Hockings, K.J. (2016) The Aggressive Apes? Causes and Contexts of Great Ape Attacks on Local Persons. In Problematic Wildlife pp. 373–394. Springer International Publishing, Cham.

Naughton-Treves, L. (1998) Predicting patterns of crop damage by wildlife around Kibale National Park, Uganda. Conservation Biology, 12, 156–168.

Naughton-Treves, L., Treves, A., Chapman, C. & Wrangham, R. (1998) Temporal patterns of crop-raiding by primates: linking food availability in croplands and adjacent forest. Journal of Applied Ecology, 35, 596–606.

Naughton-Treves, L. & Treves, A. (2005) Socio-ecological factors shaping local support for wildlife: crop-raiding by elephants and other wildlife in Africa. In People and wildlife: conflict or coexistence? (eds R. Woodroffe, S. Thirgood & A. Rabinowitz), pp. 252–277. Cambridge University Press.

Oates, J.F. (2010) Primates of West Africa. Pocket identification guide (eds. R.A. Mittermetier & A.B. Rylands) Conservation International.

Quiatt, D., Reynolds, V. & Stokes, E.J. (2002) Snare injuries to chimpanzees (Pan troglodytes) at 10 study sites in east and West Africa. African Journal of Ecology, 40, 303–305.

Redpath, S.M., Young, J., Evely, A., Adams, W.M., Sutherland, W.J., et al. (2013) Understanding and managing conservation conflicts. Trends in ecology & evolution, 28, 100–109.

Sousa, J., Barata, A. V, Sousa, C., Casanova, C.C.N. & Vicente, L. (2011) Chimpanzee oil-palm use in southern Cantanhez National Park, Guinea-Bissau. American journal of primatology, 73, 485–497.

Statistics Sierra Leone (2016) Provisional results: Sierra Leone 2015 Population and housing census. Retrieved data from www.statistics.sl

Stiles, D., Redmond, I. Cress, D., Nellemann, C.& Formo, R.K. (2013) Stolen Apes – The Illicit Trade in Chimpanzees, Gorillas, Bonobos and Orangutans. A Rapid Response Assessment. United Nations Environment Programme, GRID-Arendal. www.grida.no

VLIET, N. VAN, MERTZ, O., HEINIMANN, A., LANGANKE, T., ET AL. (2012) Trends, drivers and impacts of changes in swidden cultivation in tropical forest-agriculture frontiers : A global assessment. Global Environmental Change, 22, 418–429. Elsevier Ltd.

WEBBER, A.D. & HILL, C.M. (2014) Using participatory risk mapping (PRM) to identify and understand people's perceptions of crop loss to animals in Uganda. PLoS ONE, 9 (7)

WOODROFFE, R., THIRGOOD, S.J. & RABINOWITZ, A. (eds.) (2005) People and wildlife conflict or co-existence? Cambridge University Press, Cambridge.

BIOGRAPHICAL SKETCHES

ROSA GARRIGA is a wildlife veterinarian and conservation researcher focusing her work on chimpanzee conservation in Sierra Leone. IGNASI MARCO is interested in wildlife ecology and diseases, with a particular interest in those diseases at the human-livestock-wildlife interface. ENCARNA CASAS is a veterinarian working in wildlife management with an interest in animal stress evaluation. BALA AMARASEKARAN is the founder and director of the TCS. He has dedicated the last 30 years to protect and conserve chimpanzees and their habitats in Sierra Leone. TATYANA HUMLE is primatologist expert in chimpanzees, who embraces an interdisciplinary approach to exploring co-existence issues between wildlife and people.

Tables

Table 1: Description of the four study areas spanning two districts (Moyamba with 46 people/km^2 and Porto Loko with 104 people/km^2) (Statistics Sierra Leone, 2016). LA: Lawana, MO: Moseilelo, PL-N: Port Loko North, PL-S: Port Loko South.

Study area	Coordinates	Study period	Area span	Altitude a.s.l.	No of villages visited - District	No of interviews	Ratio male/female of the participants	Land characteristics	Type of cultivars
LA	8°0'2.98"N, 12°48'39.51"W	12/2012 - 02/ 2013	80 km^2	7 - 27 m	13 - Moyamba	51	42/9	Swamp areas, cultivated and fallow farm land. Abundance of wild oil palms throughout.	Swamps with rice, upland farms with rice and cassava intercropped with sesame, sorghum, beans, maize.
MO	7°51'11.26"N, 12°26'39.38"W	02-03/ 2013	35 km^2	20-182 m	10 - Moyamba	38	36/2	The Kasillah hills lie in the centre of the study area characterised by a highly degraded secondary forest. The surrounding landscape is made up of swamps, cultivated and fallow farm land. Wild oil palms throughout.	Swamps with rice, upland farms with rice and cassava intercropped with sesame, sorghum, maize and potato.
PL-N	9°9'18.63"N, 12°36'46.24"W	12/2013 - 01/ 2014	86 km^2	40-80 m	14 – Port Loko	71	53/18	Landscape dominated by grassland and woodland savannah. Cultivated and fallow farms. Wild oil palms throughout.	Upland farms are cultivated with cassava and upland rice intercropped with maize, sesame and sorghum. Peanut farms. Small scale commercial oil palm plantations. Cattle farming.
PL-S	9°3'43.90"N, 12°38'58.61"W	10-11/ 2013	108 km^2	30-75 m	24 – Port Loko	97	75/22	Swamps, cultivated and fallow farm land. Riverine forests. Small scale oil palm farms. Wild oil palms throughout.	Swamps with rice, upland farms with cassava and rice intercropped with maize, sesame and sorghum in the upland farms. Peanut farms. Abundant small scale commercial oil palm plantations.

Table 2: Socio-cultural profile of farmers interviewed across the four study areas with frequency and percentages in brackets. LA: Lawana, MO: Moseilelo**,** PL-N: Port Loko North, PL-S: Port Loko South.

Area code	LA	MO	PL-N	PL-S	Total
Total Interviews	51	38	71	97	257
EDUCATION					
No formal education	36 (70.6)	27 (71.1)	53 (74.6)	47 (48.9)	163 9 (63.4)
Arabic school	7 (13.7)	6 (15.8)	11 (15.5)	31 (32)	55 (21.4)
English school	8 (15.7)	5 (13.2)	7 (9.9)	19 (19.6)	39 (15.2)
RELIGION					
Christian		2 (5.3)	7 (9.9)		9 (3.5)
Muslim	51 (100)	34 (89.5)	56 (78.9)	96 (99)	237 (92.2)
N/A		2 (5.3)	8 (11.3)	1 (1)	11 (4.3)
ETHNIC GROUP					
Krio			2 (2.8)		11 (4.3)
Limba			42 (59.2)	3 (3.1)	45 (17.5)
Mende	1 (2)	33 (86.8)	1 (1.4)		35 (13.6)
Shabro	42 (82.4)	3 (7.9)			45 (17.5)
Temne	8 (15.7)	2 (5.3)	25 (35.2)	94 (96.9)	129 (50.2)
N/A			1 (1.4)		1 (1.4)

Table 3: Frequency of reporting, with percentages in parenthesis, of crops cultivated in each study area. (*) Crops reported to be consumed by chimpanzees (this does not necessarily coincide with the crops people reported to cultivate, as people sometimes omitted to mention domestic fruit such as mangoes, oranges and papaya). LA: Lawana, MO: Moseilelo**,** PL-N: Port Loko North, PL-S: Port Loko South.

	LA	MO	PL-N	PL-S
Domestic fruit crops	**13 (5.7)**	**15 (7.6)**	**47 (8.3)**	**90 (12.5)**
Banana	4 (7.8)*	11 (28.9)*	14 (19.7)*	42 (43.3)*
Pineapple	6 (11.8)*	4 (10.5)*	5 (7)*	21 (21.6)*
Orange	2 (3.9)*	-*	8 (11.3)*	11 (11.3)*
Papaya	1 (2)*	-*	10 (14.1)*	7 (7.2)*
Mango	-	-*	7 (9.9)*	8 (8.2)*
Others	-	-	3 (4.2)	1 (1)
Cash tree crops	**5 (1.6)**	**7 (3.6)**	**40 (7.6)**	**76 (10.9)**
Oil palm	3 (5.9)*	2 (5.3)*	34 (47.9)*	66 (68)*
Kola nuts	1 (2)*	-	3 (4.2)	7 (7.2)
Cacao	1 (2)	4 (10.5)	1 (1.4)*	2 (2.1)
Others	-	1 (2.6)	2(2.8)	1 (1)
Seasonal crops	**212 (92.2)**	**175 (88.8)**	**479 (84.5)**	**556 (76.9)**
Rice	50 (98)*	37 (97.4)*	71 (100)*	92 (94.8)*
Cassava	45 (88.2)*	35 (92.1)*	66 (93)*	81 (83.5)*
Sesame	32 (62.7)*	30 (78.9)*	41 (57.7)*	47 (48.5)*
Chilli Pepper	4 (7.8)	2 (5.3)*	54 (76.1)	65 (67)
Peanuts	9 (17.6)	2 (5.3)*	48 (67.6)*	65 (67)*
Maize	9 (17.6)*	16 (42.1)*	35 (49.3)*	48 (49.5)*
Beans	16 (31.4)*	4 (10.5)*	40 (56.3)*	42 (43.3)*
Potato	5 (9.8)*	14 (36.8)	34 (47.9)	38 (39.2)*
Sorghum	31 (60.8)	25 (65.8)	7 (9.9)	8 (8.2)
Okra	7 (13.7)	-	26 (36.6)	30 (30.9)*
Yam	1 (2)	9 (23.7)*	15(21.1)	14 (12.4)
Pumpkin	2 (3.9)*	-*	14 (19.7)	12 (12.4)*
Others	1 (2)	1 (2.6)	28 (39.4)	14 (14.4)

Table 4: Reported frequency of species foraging on cultivars (n), frequency of reported foraging (FF %) and cultivation (FC%) as percentages in each study area. The top three crops most affected by wild mammals and the three crops most reported as being cultivated are bolded. LA: Lawana, MO: Moseilelo**,** PL-N: Port Loko North, PL-S: Port Loko South.

Common name	**Scientific name**	**LA**			**MO**			**PL-N**			**PL-S**		
		n	**FF %**	**FC %**	**n**	**FF %**	**FC %**	**n**	**FF %**	**FC %**	**n**	**FF %**	**FC %**
Aubergine	Solanum melongena	3	0.4	2	-	-	2.6	-	-	11.3	1	0.04	3.1
Banana	Musa spp.	16	6.2	7.8	14	3.8	28.9	11	1.9	19.7	15	3.1	43.3
Bean	Phaseolus spp.	12	3.1	31.4	15	1.9	10.5	8	2.1	56.3	10	1.5	43.3
Cocoa	Theobroma cacao	-	-	2	2	0.1	10.5	4	0.3	1.4	-	-	2.1
Cassava	**Manihot esculenta**	28	**29.6**	**88.2**	25	**28.8**	**92.1**	26	**19.3**	**93**	27	**17.5**	**83.5**
Chilli pepper	Capsicum spp.	3	2.0	7.8	7	2.1	5.3	13	4.7	76.1	15	3.8	67.0
Coffee	Coffea sp.	-	-	-	-	-	2.6	-	-	2.8	1	0.04	-
Cucumber	Cucumis sativus	2	0.2	-	10	1.1	-	4	0.5	23.9	1	0.04	7.2
Kola nut	Cola sp.	8	2.8	2	3	0.4	-	9	1.3	4.2	6	0.5	7.2
Maize	Zea mays	10	3.1	17.6	17	**12.9**	42.1	15	8.4	49.3	14	6.2	49.5
Mango	Mangifera spp.	2	0.2	-	5	0.4	-	9	2.0	9.9	12	2.1	8.2
Millet	Pennisetum sp.	-	-	-	-	-	-	3	0.3	4.2	3	0.2	4.1
Oil palm	**Elaeis guineensis**	14	**10.5**	5.9	15	5.9	5.3	21	**11.6**	47.9	27	**14**	**68**
Okra	Abelmoschus esculentus	5	3.8	13.7	5	2.6	-	7	1.5	36.6	7	1.6	30.9
Oranges	Citrus sinensis	9	4.6	3.9	4	0.3	-	9	2.7	11.3	11	3.5	11.3
Papaya	Carica papaya	5	1.1	2	5	0.6	-	8	1.3	14.1	5	1.1	7.2
Peanuts	Arachis hypogaea	14	10.3	17.6	18	9.6	5.3	19	11.6	**67.6**	22	13.9	67
Pineapple	Ananas comosus	6	1.3	11.8	3	0.8	10.5	1	0.3	7	8	0.9	21.6
Plum	Prunus spp.	-	-	-	-	-	-	7	0.8	4.2	9	0.6	-
Potato	Solatum tuberosum	10	1.9	9.8	13	2.4	36.8	17	6.7	47.9	18	5.2	39.2
Pumpkin	Cucurbita spp.	7	1.2	3.9	9	1.3	-	7	2	19.7	19	2.6	12.4
Rice	**Oryza spp.**	22	**14**	**98**	25	**18.4**	**97.4**	29	**17.3**	**100**	27	**19.3**	**94.8**
Sesame	Sesamum sp.	5	0.6	**62.7**	8	1.1	**78.9**	8	1.4	57.7	7	1	48.5
Sorghum	Sorghum bicolor	8	3.3	60.8	8	1.4	65.8	1	9.9	0.1	2	0.1	8.2
Yam	Dioscorea spp.	-	-	2	16	4.1	23.7	9	2.1	21.1	7	1.2	14.4

Table 5: Number of different crops reported by farmers as foraged by wild animals (CF) and their frequency (FR%) for the 13 most reported animal species. LA: Lawana, MO: Moseilelo**,** PL-N: Port Loko North, PL-S: Port Loko South.

Mammal species	Scientific name	ALL areas		LA		MO		PL-N		PL-S	
		CR	**FR %**	**CR**	**FR %**	**CR**	**FR %**	**CR**	**FR %**	**CR**	**FR %**
Cane rat	Thryonomys swinderianus	20	14	9	11.2	12	10.7	13	15	19	15.6
Chimpanzee	Pan troglodytes verus	21	11.2	13	13	15	9.3	15	9.6	17	12.5
Giant pouched rat	Cricetomys emini	20	9.4	6	4.6	10	6.6	13	10.2	17	11.6
Green monkey	Chlorocebus aethiops sabaeus	21	8.8	9	2.1	13	5.6	16	9.9	20	11.7
Fire-footed rope squirrel	Funisciurus pyrropus	20	7.8	7	6.9	10	6	17	8.9	13	7.9
Bushbuck	Tragelaphus scriptus	14	6.3	9	9.2	8	7.4	7	6.1	12	5
Crested porcupine	Hystrix cristata	17	4.9	7	4.5	11	2.9	13	6.7	12	4.5
Sooty mangabey	Cercocebus atys	21	4.9	13	6.5	10	8.4	14	3.7	14	3.7
Red river hog	Potamochoerus porcus	11	4.7	3	1.8	5	4.1	6	5.3	11	5.5
Brush-tailed porcupine	Atherurus africanus	15	3.8	5	2.8	11	7.1	11	3.9	10	2.5
Giant forest squirrel	Protoxerus stangeri	18	3.5	8	2.9	6	2	15	4.3	13	3.7
Maxwell duiker	Cephalophus maxwellii	14	3	8	3.5	9	5.3	8	3.1	5	1.6
Giant forest hog	Hylochoerus meinertzhageni	12	2.7	7	5.9	5	2	7	2.8	7	1.9

Table 6: Percentages of reported adopted measures to protect farms in each study area categorised as (potentially) lethal versus non-lethal.

Protection measure	Type	LA	MO	PL-N	PL-S
Fencing (N=223)	Non-lethal	92.2	71.1	97.2	82.5
Traps (N=208)	Lethal	88.2	86.8	74.6	79.4
Hunting with dogs (N=91)	Lethal	7.8	15.8	39.4	54.6
Scarecrows (N=24)	Non-lethal		2.6	12.7	14.4
Sling (N=26)	Lethal	7.8	5.3	9.9	13.4
Nets (N=17)	Non-lethal		5.3	8.5	9.3
Guarding (N=7)	Non-lethal				7.2
Poison (N=9)	Lethal			2.8	7.2
Stones (N=7)	Lethal				7.2
Brushing (N=5)	Non-lethal				5.2
Hunting with guns (N=4)	Lethal	2.0			3.1
Shouting (N=8)	Non-lethal	2.0	2.6	4.2	3.1

Figures

Fig. 1: Map of Sierra Leone showing the location of the four selected study areas. PL-N: Port Loko North, PL-S: Port Loko South, LA: Lawana, MO: Moseilelo.

Fig. 2: Aerial photo showing the characteristic landscape of the Lawana study area comprised of agricultural land and swamp areas with abundant wild oil palms all across. (Photo: Josep M. Fortuny)

Fig. 3: Detail of the four study areas. Stars indicate the villages where the interviews were conducted. PL-N: Port Loko North, PL-S: Port Loko South, LA: Lawana, MO: Moseilelo.

Fig. 4: Relative percentage of identified animal species considered crop raiders in each study area with the percentage of reports at each site noted along each bar. N indicates the total number of participants across the four study areas citing the animal species. PL-N: Port Loko North, PL-S: Port Loko South, LA: Lawana, MO: Moseilelo.

Fig. 5: Ranking of the three most destructive animals per study area with the times reported at each site noted along each bar. Mesh pattern = 1st ranked, dot pattern = 2nd ranked, solid black = 3rd ranked. G. f. hog = Giant forest hog; S. mangabey = Sooty mangabey; F. f. r. squirrel = Fire-footed rope squirrel. Monkeys = species was not determined. PL-N: Port Loko North, PL-S: Port Loko South, LA: Lawana, MO: Moseilelo.

Fig. 1

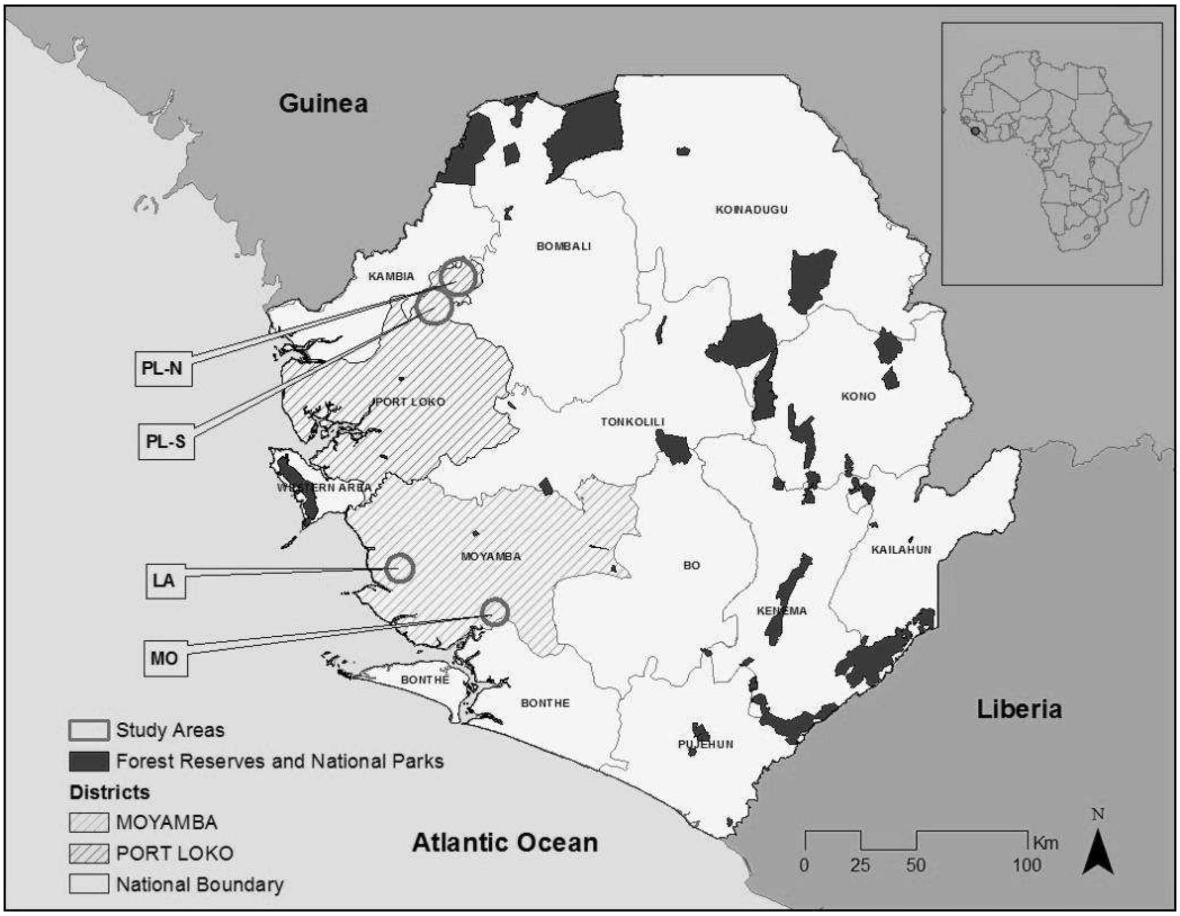

Guinea
KAMBIA
BOMBALI
KOINADUGU
PL-N
PL-S
PORT LOKO
TONKOLILI
KONO
WESTERN AREA
LA
MOYAMBA
BO
KAILAHUN
MO
KENEMA
BONTHE
BONTHE
PUJEHUN
Liberia
Study Areas
Forest Reserves and National Parks
Districts
MOYAMBA
PORT LOKO
National Boundary
Atlantic Ocean
0 25 50 100
Km
N

Fig. 2

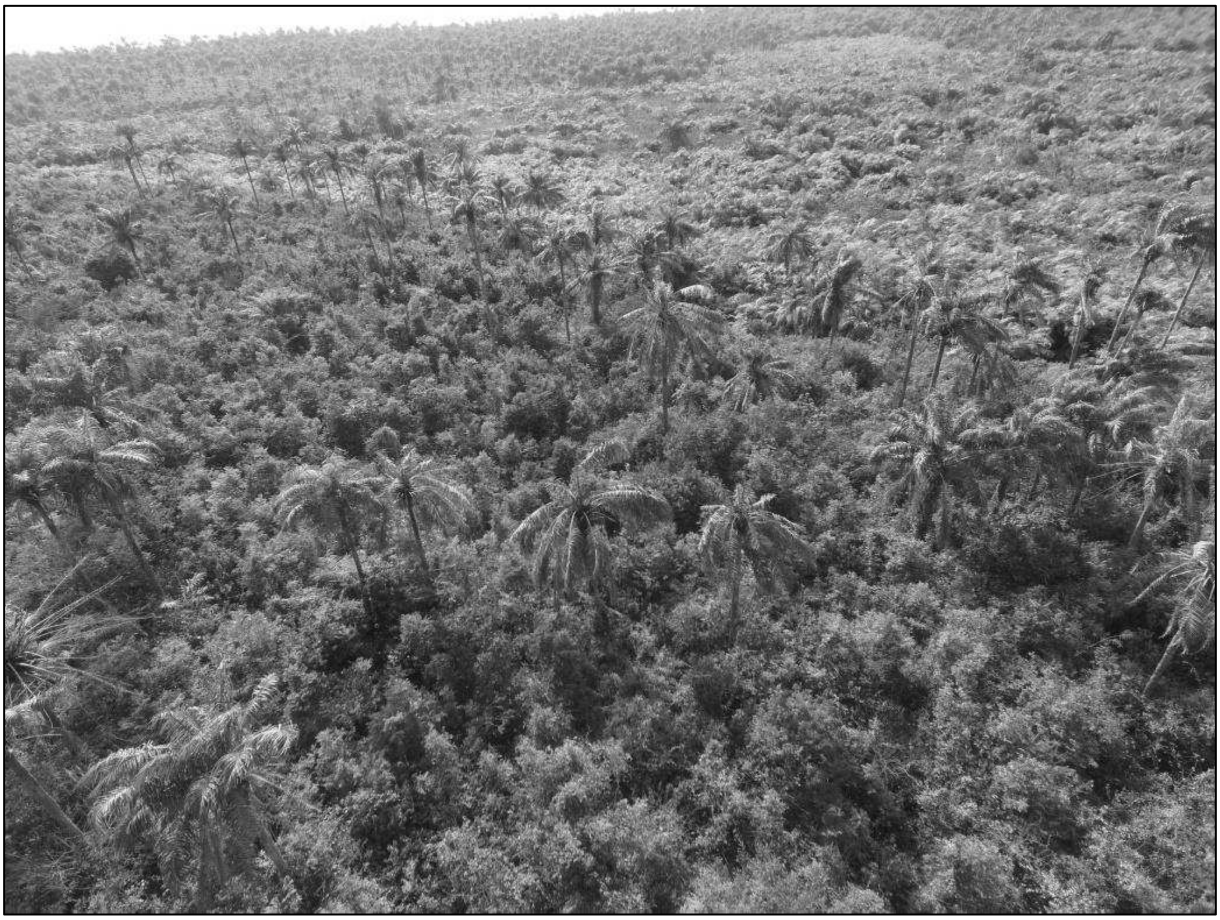


Fig. 3

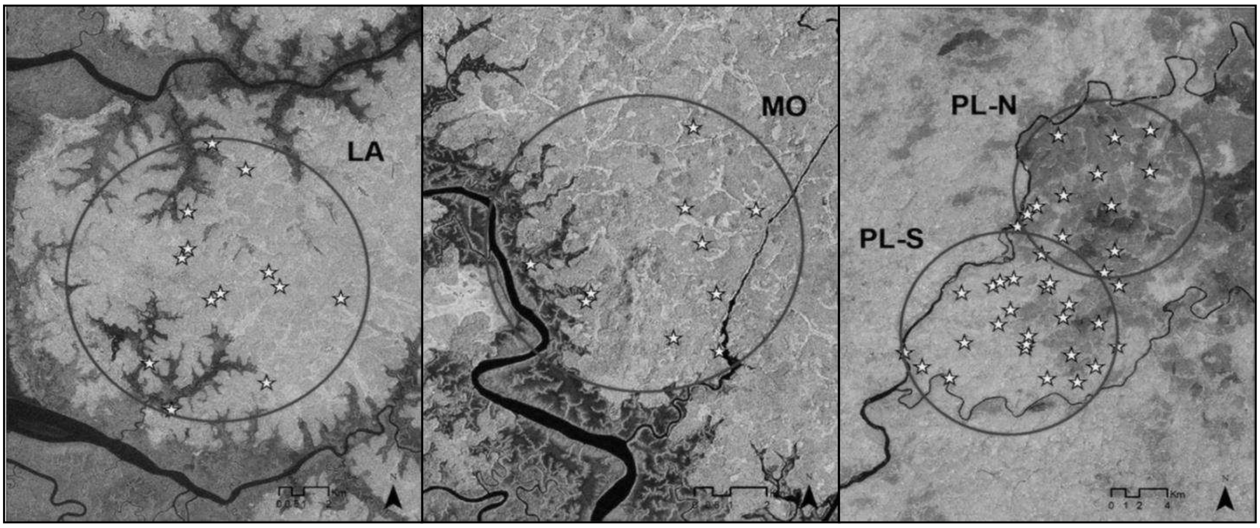
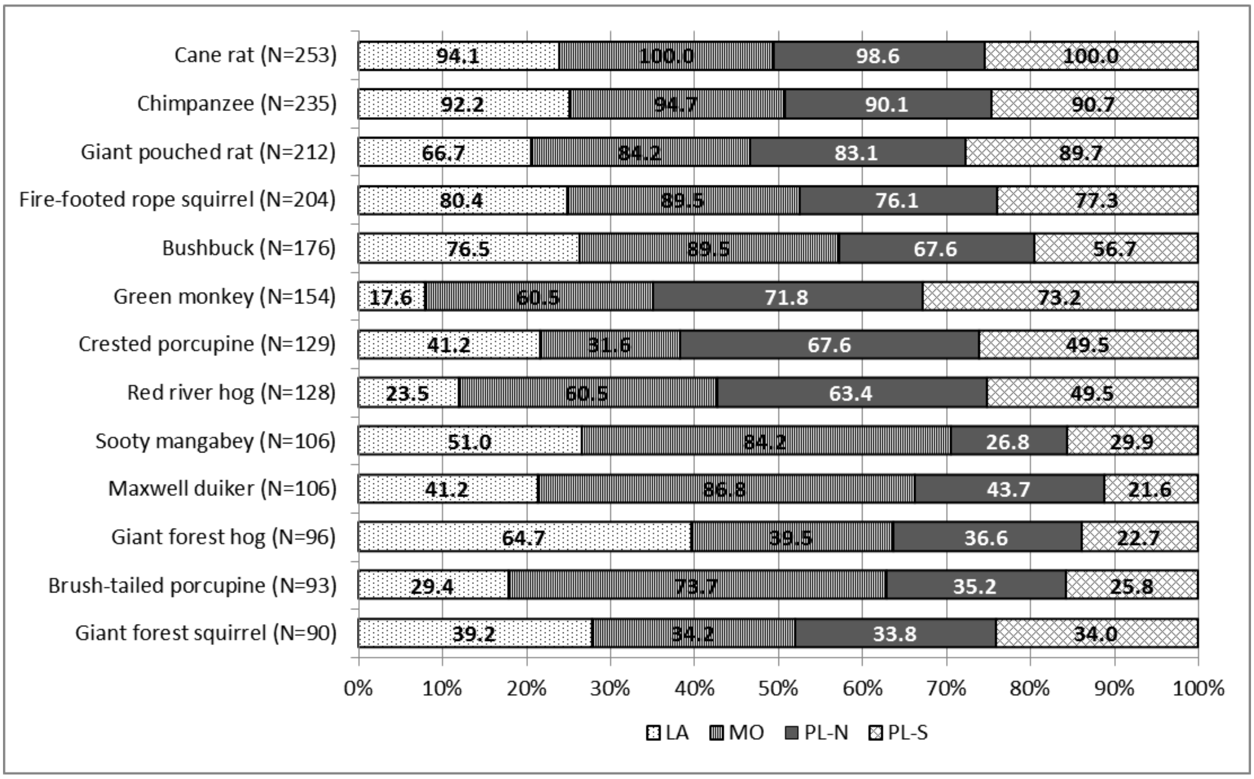
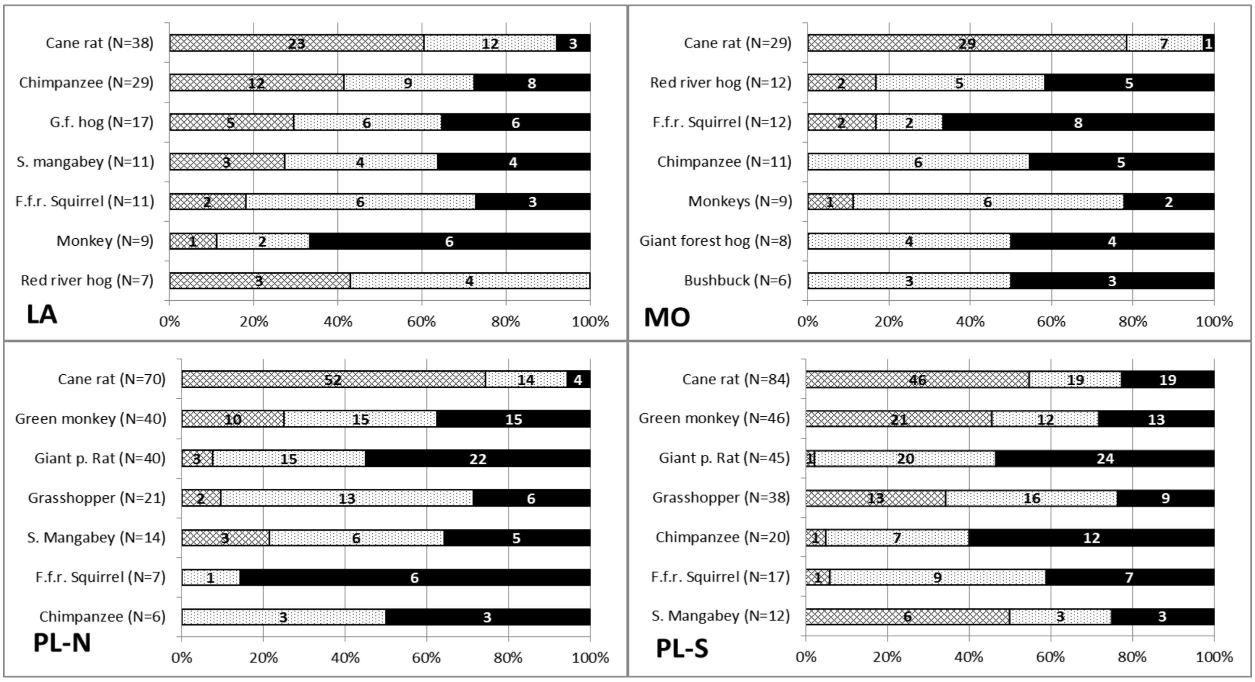


Fig. 4



Cane rat (N=253)
Chimpanzee (N=235)
Giant pouched rat (N=212)
Fire-footed rope squirrel (N=204)
Bushbuck (N=176)
Green monkey (N=154)
Crested porcupine (N=129)
Red river hog (N=128)
Sooty mangabey (N=106)
Maxwell duiker (N=106)
Giant forest hog (N=96)
Brush-tailed porcupine (N=93)
Giant forest squirrel (N=90)
94.1 100.0 98.6 100.0
92.2 94.7 90.1 90.7
66.7 84.2 83.1 89.7
80.4 89.5 76.1 77.3
76.5 89.5 67.6 56.7
17.6 60.5 71.8 73.2
41.2 31.6 67.6 49.5
23.5 60.5 63.4 49.5
51.0 84.2 26.8 29.9
41.2 86.8 43.7 21.6
64.7 39.5 36.6 22.7
29.4 73.7 35.2 25.8
39.2 34.2 33.8 34.0
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
LA MO PL-N PL-S

124 Fig. 5


LA
Cane rat (N=38)
Chimpanzee (N=29)
G.f. hog (N=17)
S. mangabey (N=11)
F.f.r. Squirrel (N=11)
Monkey (N=9)
Red river hog (N=7)
MO
Cane rat (N=29)
Red river hog (N=12)
F.f.r. Squirrel (N=12)
Chimpanzee (N=11)
Monkeys (N=9)
Giant forest hog (N=8)
Bushbuck (N=6)
PL-N
Cane rat (N=70)
Green monkey (N=40)
Giant p. Rat (N=40)
Grasshopper (N=21)
S. Mangabey (N=14)
F.f.r. Squirrel (N=7)
Chimpanzee (N=6)
PL-S
Cane rat (N=84)
Green monkey (N=46)
Giant p. Rat (N=45)
Grasshopper (N=38)
Chimpanzee (N=20)
F.f.r. Squirrel (N=17)
S. Mangabey (N=12)
0% 20% 40% 60% 80% 100%