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Human-carnivore conflict mitigation and lion population viability in Uganda's Queen Elizabeth National Park

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The Uganda Carnivore Program (UCP), located in Queen Elizabeth National Park (QENP), has—among other large carnivore research and conservation measures—engaged in human-carnivore conflict mitigation and prevention efforts since 2015. UCP's experiential lion tourism program funds compensation to local communities for livestock losses to promote carnivore tolerance and conservation. But while UCP's conflict mitigation and prevention trials—through direct payments in response to forensically determined cases of livestock depredation by lion (*Panthera leo*)—may be aiding in the goal of maintaining lion viability in QENP and the greater Queen Elizabeth Conservation Area (QECA), compensation does not preclude ongoing challenges. These include unsustainable resource uses from human population growth and illegal expansions, subsequent land use changes, illegal livestock grazing and related husbandry practices, and compensation financing shortages. Of note regarding compensation is assessing whether claims of livestock depredation are genuine or not. Nevertheless, disruption to UCP's experiential lion tourism and compensation programs could result in increased retaliatory killings of lions, thus further reducing an already low lion population. As compensation includes the area's large carnivore guild, disruption could also mean further reductions in leopard (*Panthera pardus*) and spotted hyena (*Crocuta crocuta*) populations from retaliatory killings. Based on a perspective of UCP's compensation trials and related challenges, several recommendations, including the introduction of compensation percentage rates based on rewards-based frameworks, would strengthen human-carnivore conflict mitigation as part of lion and other large carnivore conservation. This would benefit QENP, greater QECA, and other protected areas where people, livestock, and large carnivores share space.

KEYWORDS

lion (*Panthera leo*), conservation, human-carnivore conflict, Uganda, Queen Elizabeth National Park, Queen Elizabeth Conservation Area, compensation, carnivore

Introduction

While Africa's large carnivores are often viewed as charismatic and therefore highly valued by Western society, they are frequently negatively valued at the local level due to the costs they impose (Dickman et al., 2011). Such costs include livestock depredation and attacks on people, both of which often result in severe injury or death (Packer et al., 2005).

The economic value of large carnivores from tourism can also be locally overlooked or disregarded (Macdonald et al., 2010) given resource use preferences by agro-pastoral communities living near or within protected areas (PAs). For pastoralists, the priority is maximizing returns from domestic stock regarding herd size and protein (Bourn and Blench, 1999). Consequently, obligate carnivores like lions (*Panthera leo*) are seen as a threat in lieu of an economic asset by livestock owners, and are many times treated with punitive action (Felix et al., 2022). It should, however, be stressed that the degree of tolerance by people across Africa toward lions and other large carnivores where livestock depredation occurs greatly varies (Gebresenbet et al., 2018).

In Uganda, remaining lions living in unfenced PAs (Packer et al., 2013) that kill livestock are often killed in retaliation by methods such as the poisoning of livestock carcasses (Ochieng et al., 2015; Somerville, 2021). The use of the pesticide carbofuran against lions and other carnivores is particularly common (Omoya et al., 2014; Somerville, 2021), both preemptively and in reaction to suspected or determined depredation. This exists in addition to lions that are incidentally maimed or killed by snares used for bushmeat poaching, which by depleting a wild prey base (Khan et al., 2018), forces lions to increasingly and opportunistically target nearby livestock.

Though ecologically and economically important, conserving lions in Uganda remains challenging, particularly in areas of heterospecific cohabitation (Durant et al., 2022). Considering the high rate of unemployment in rural areas, rapid population growth signifies additional resource demands in the absence of growth in, and enhancement of, livestock and agricultural value chain productivity. Livestock and agricultural expansion and growing settlements have already reduced the range of Uganda's lions (Guggisberg, 1963) to the extent that *P. leo* was almost extirpated during the 20th century (Treves et al., 2009).

The greater Queen Elizabeth Conservation Area (QECA) in western Uganda has seen a 30% reduction in lions since the 1990s, with concerns about their long-term viability (Omoya et al., 2014). Within the greater QECA, Queen Elizabeth National Park (QENP) is a historically known hotspot for human-carnivore conflict (HCC) due to continued human encroachment (Nicole, 2019).

Despite being viewed as a lion stronghold and lion conservation unit (IUCN, 2006; Treves et al., 2009; Omoya et al., 2014), the lion population in QENP has declined precipitously. Given lion fission-fusion behavior, reproductive value, and fecundity, the Uganda Carnivore Program (UCP) estimates the northern QENP population to currently be between 50 and 65 individuals, while estimating the southern Ishasha QENP population to be no greater than 20 individuals. UCP acknowledges that the south Kazinga lion population estimate may not be as accurate owing to financial constraints.

Basongora herding communities in the northern sector of QENP such as Hamukungu and Nyakatonzi have a history of carnivore killing (particularly the killing of lions) due to a historically higher density of lion populations near to those communities, a reliance on livestock as an economic source of income (particularly Nyakatonzi), no barriers to protect people and their livestock from lions and other large carnivores, and being geographically located within the park (Tumusiime, 2021). The same is true for the pastoralist communities of Kasenyi and Busunga.

UCP found that < 70% of lion deaths between 2004 and 2013 were HCC related, and that 54% of lion deaths between 2014 and 2020 were due to HCC. While a 16% reduction in lion deaths is significant, resident lions remain at risk for extirpation given low population estimates and ongoing conflict. Wild prey population losses by rising anthropogenic activity have also increased carnivore attention to local livestock (Gebresenbet et al., 2018).

As elsewhere, successful lion conservation in QECA and QENP requires balancing predator resource needs with human livelihoods while fostering and promoting coexistence. This is especially challenging with ± 45,000 residents within the park (Uganda Wildlife Authority, 2011) and larger populations living outside it. While financial compensation for livestock depredation by carnivores is a regular method used throughout sub-Saharan Africa, its effectiveness is often varied (Braczkowski et al., 2020). Whereas some programs have reported a sharp drop in retaliatory killings against lions (Hazzah et al., 2014), others question compensation effectiveness (Maclennan et al., 2009).

Of note in QENP and greater QECA is UCP's Human-Carnivore Conflict Mitigation and Prevention program. As a key component of large carnivore conservation is human tolerance (Rust and Marker, 2013), UCP's experiential lion tourism and community conservation fund provides financial compensation to QECA's communities after forensically determined cases of livestock depredation. Several obstacles exist, however, including compensation costs, fraudulent claims of carnivore depredation in expectation of payment, overvaluation, lack of sufficient evidence, and challenging response times to conflict events given the large geographical area (Bauer et al., 2015). These exist in addition to the strain on resources resulting from illegal expansions, husbandry methods, and land use changes. Given these challenges, it is key to revisit the current methodology of compensation in QENP and greater QECA and adaptively modify it to meet them. This could include 1) shifting to compensation based on improved livestock husbandry and sustainable natural resource management to incentivize depredation mitigation; 2) examining the application of modified compensation for lion conservation to include assessments of leopard (*Panthera pardus*) and spotted hyena (*Crocuta crocuta*) conflict mitigation; and 3) an expanded compensation effort in the Ishasha sector where lion population density is low.

Uganda Carnivore Program conflict mitigation and prevention advancements

UCP's conflict mitigation and experiential tourism programs have been in place since 2015. Following a report of conflict to both the Uganda Wildlife Authority (UWA) and UCP, the latter community scout will investigate the site. Depredation determination is based on forensic evidence gathered. Data sheets are then filled out, followed by financial compensation being negotiated and distributed via UCP's community conservation fund. In the absence of sufficient evidence, or if the scene is determined to have been fraudulent, compensation is not issued.

UCP's compensation program is implemented throughout QECA's 11 enclave communities. UCP community scouts are available 24 hours a day, seven days a week, and can be reached by cell phone when a livestock depredation event by a carnivore is either seen or suspected.

While 100% of tourism revenues from UCP's experiential lion tourism program ($100 USD fee per individual) are paid directly to UWA's Revenue Sharing Agreement for community allocation, a suggested donation of $10 USD by UCP is given directly to UCP's community conservation fund. These donations are held in trust to be used for compensation. While UCP cannot issue 100% of the estimated value of lost livestock, average compensation payments range between 50% and 80%. UCP's experiential tourism program has, to date, generated 1.013 billion UGX for UWA. In addition to UCP compensation, communities have received a total of $220 million UGX from experiential tourists and $55 million UGX from a UCP-funded grant called the Hamukungu-Safe Kraal and Community Conservation Fund. UCP has also educated 896 local people and 5,165 tourists about large carnivore conservation challenges in QECA and QENP.

Notwithstanding the downward trend in lion numbers from HCC, there exists a potential correlation between the 16% reduction in lion deaths since 2014 and the introduction of financial compensation in 2015 by UCP. While sufficient data is not yet available to test this, if such a correlation does exist, this potentially means that UCP's compensation program, generated by experiential tourism and supplemental partners, may be having a positive impact on lion conservation.

Present challenges

Even if prey levels were at sufficient carrying capacity within QENP and greater QECA, it is likely that HCC would remain given lion, leopard, and spotted hyena attention to nearby domestic livestock. Among the different livestock varieties, maintaining cattle biosecurity is of particular importance to Basongora communities (Chenais and Fischer, 2018; Wolff et al., 2019). It is significant to also acknowledge that the Basongora traditionally occupied the Kasese district lowlands before it was gazetted as QENP in 1952 by the British colonial administration (Moghari, 2009). It is noteworthy, then, to emphasize that people here have historically coexisted with wildlife, though a dramatic rise in the human population and the subsequent strain on natural resources has increased HCC rates.

Not unlike other PAs throughout sub-Saharan Africa, QENP's enclave communities remain permitted to stay within park boundaries, though what began as legally established settlements now includes substantial illegal expansions (Uganda Wildlife Authority, 2011). Moreover, the human population has grown significantly, with the average population density surrounding the park rising from 46 individuals per km2 to 107 individuals per km2 between 1959 and 2014 (Uganda Bureau of Statistics, 2014). Climate-induced droughts in 2007 led to illegal encroachments by Basongora herdsmen in 2007 and 2008 who, already having been displaced from the Democratic Republic of Congo (DRC) due to regional instability, spread and settled farther into QENP, reportedly poisoning numerous lions, spotted hyenas, and leopards along the Nyamusagani River (Harrison et al., 2015).

UCP's primary role is the research and conservation of Uganda's large carnivores—lions, leopards, and hyenas—in QENP and greater QECA. Despite UWA's oversight, UCP are not government employees, nor are they paid by UWA. However, UCP is often called on by UWA to perform various services, including radio collaring and monitoring of carnivores, interventional operations for injured wildlife, and additional forensic analyses. As such, the expectation of UCP's involvement in the compensation effort is high, often at the cost of its ability to fully reimburse all livestock owners.

The primary compensation challenge in the effort to protect globally valued lions and other large carnivores is providing effective economic incentives to sustain them at the local level (Nelson, 2009). As UCP is a direct service organization for conflict mitigation in QECA, responses to reports of depredation and compensation are heavily dependent on donations. Donations usually come from various stakeholders from abroad (individuals, organizations, etc.), including visiting tourists, many of whom contribute more than the minimum $10 USD requested by UCP when they are taken into the park to see lions and other large carnivores. Given the volatility of tourism, a key focus will always be maintaining steady revenue to continue compensation.

In addition to compensation being costly, UCP finds that livestock owners will financially inflate their losses in hopes of larger payments. Arguably, and despite crucial forensic investigations, one of the most difficult scenarios involves differentiating between reported livestock loss and actual livestock loss. The distinguishing of livestock theft from depredation is another major hurdle of forensic investigation as a precondition for genuine compensation claims. A frustrated and desperate owner, for example, could possibly retaliate for refusal to compensate in the absence of a convincing diagnosis. UCP has also seen on several occasions' carcass remains being moved from the original conflict scene inside the park (illegal grazing) into an enclave village to qualify for compensation. Though difficult to diagnose, if these and similar cases are determined to be fraudulent, UCP does not issue compensation.

Critics may highlight these previously mentioned shortcomings of compensation to promote lion and other large carnivore tolerance by local communities. Importantly, it is recognized that

despite compensation, retaliatory killings can and still do occur, while at the same time acknowledging the heavy dependency of compensation on tourism and other outside donations. Yet when considering that people living in QECA will be there for the foreseeable future, and in addition to UCP being an active, on-the-ground conflict mitigation organization, it is likely that any long-term disruption to the compensation program would have negative consequences for QECA's resident large carnivore population, especially its lions. Put another way, frustrated community members could resort to increasing frequencies of lethal retaliation against lions for suspected or actual cases of livestock depredation were compensation to be halted.

While recently installed fences around certain communities may be credited to UWA for a reduction in human-wildlife conflict generally (Uganda Wildlife Authority, 2023), conflict will no doubt continue, especially in hotspots such as Hamukungu, Kasenyi, and Nyakatonzi. Not only do these communities remain unfenced, but illegal livestock grazing outside of community land occurs regularly, evidenced by respondents to informal interviews conducted by UCP researchers who admitted to taking part in such activities. Leopards can also adapt to fenced areas, such as in South Africa, where predator-proof fencing only limits lions and spotted hyenas from unrestricted movements (Tshabalala et al., 2021).

The future of conflict mitigation in Queen Elizabeth National Park and Conservation Area

Given the above-mentioned challenges, determining how compensation payments are distributed is of the utmost importance (Dickman et al., 2011). Compensation should ideally dovetail with improved natural resource management throughout QECA. Improved livestock husbandry, for example, would not only minimize depredation events, but could help livestock owners qualify for a reward-based compensation system. The sustainable management of resources by communities would also create employment opportunities and enhance incomes while maintaining cultural and social ties to wildlife (DeGeorges and Reilly, 2009). This means a greater focus on livestock production quality (Chenais and Fischer, 2018). This also includes restricting livestock from illegal grazing (e.g., within park boundaries), training on alternate grazing husbandry methods to address tropical feed fluctuation challenges associated with dry seasonal weather (Ruvuga, 2016), and clearing thickets on community land which, when left to grow uninhibited, creates a conflict genesis by unintentionally inviting opportunistic predators such as leopards that use stealth and surprise from close quarters to kill prey.

An adaptive management strategy worth exploring is compensation percentage rates issued based on improved community livestock management. This includes local efforts to structurally secure cattle kraal and goat pens, additional improvements in livestock husbandry and resource use, and attempts made to safely secure the carcass (Bauer et al., 2015) for forensic examination. A rewards-based framework and enhanced indicators for compensation, then, should be considered as modified compensation methodology whenever conflict events are reported by community members to UCP and UWA. This may also help cut down on fraudulent claims so that UCP scouts can focus their time visiting actual conflict events.

A comprehensive analysis by Bauer et al. (2015) of the Wildlife Pays programme, with data obtained between 2008 and 2013 from Kenya's Maasailand Preservation Trust and Maasai Wilderness, found that the number of lions poisoned and killed significantly dropped per year after compensation was introduced to community rangelands. Of importance was the study's compensation parameters, including if livestock owners were practicing good livestock husbandry methods. This includes recovery of the carcass (intact) and percentage rate payments issued for good domestic stock husbandry after loss is determined, such as 70% reference price for loss without negligence, 50% retention and 35% payment of market value in bomas deemed substandard, 77% retention and 23% payment of market value when negligence outside of the boma is determined, and no compensation following cases of negligence occurring in the same location following prior compensation (Bauer et al., 2015).

As this perspective is primarily on lions, and while UCP's compensation program may be beneficial for lions in the conservation area, it would be of equal importance to further assess the impact, if any, of enhanced compensation methods on leopard and spotted hyena populations in QECA. It should, however, be stressed that leopard and spotted hyena population estimates can be more difficult given A) leopard cryptic coloration; B) leopard solitary behavior and elusiveness; C) leopard nocturnal activity; and D) the adaptiveness of spotted hyenas with respect to diurnal-nocturnal plasticity (Kolowski et al., 2007).

Based on low population estimates of lions in Ishasha, research should be undertaken to assess whether an expanded rollout of compensation should be included in the area, though livestock conflict does not appear to be as prevalent. This would still be important given A) the anthropogenically prey-depleted area; B) the geographical proximity to DRC and related bushmeat poaching challenges; C) the potential for future events of lions engaging in livestock depredation resulting from a depleted wild prey base; and D) the UCP-estimated number of no more than 20 possible lions in Ishasha, suggesting the population is reaching critically low numbers, leading to the potential for local extinction.

Conclusion

Human-carnivore conflict will continue posing a struggle for the protection of people, their livestock, and lions in Queen Elizabeth National Park and the greater Queen Elizabeth Conservation Area. While Uganda Carnivore Program's mitigation and prevention initiative and its experiential lion tourism program remains an intrinsic part of the lion conservation matrix, it is necessary to explore improved compensation strategies. A rewards-based system would ensure more efficient responses to conflicts, the ability to better compensate for livestock losses, the incentivizing of sound

livestock husbandry and resource uses, the safeguarding of domestic stock, and helping maintain meaningful relationships with local communities who, to their credit, continue sharing land with wildlife. Results from revisions to compensation may also provide insight into future conflict research and application in other remaining lion strongholds in sub-Saharan Africa. As the Uganda Carnivore Program has maintained an on-the-ground presence, it provides a service that is integral for the future of western Uganda's lions, as well as its leopards and spotted hyenas as part of the conservation area's large carnivore guild.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Bauer, H., Müller, L., van der Goes, D., and Sillero-Zubiri, C. (2015). Financial compensation for damage to livestock by lions Panthera leo on community rangelands in Kenya. *Oryx* 51, 106–114. doi: 10.1017/s003060531500068x

Bourn, D., and Blench, R. (1999). "Livestock and wildlife in sustainable rural livelihoods," in *Can livestock and wildlife Co-exist?: An interdisciplinary approach: Livestock, wildlife and people in the semi-arid rangeland of eastern Africa* (London: Overseas Development Institute), 40.

Braczkowski, A., Fattebert, J., Schenk, R., O'Bryan, C., Biggs, D., and Maron, M. (2020). Evidence for increasing human-wildlife conflict despite a financial compensation scheme on the edge of a Ugandan national park. *Conserv. Sci. Pract.* 2, 2. doi: 10.1111/csp2.309

Chenais, E., and Fischer, K. (2018). Increasing the local relevance of epidemiological research: Situated knowledge of cattle disease among Basongora pastoralists in Uganda. *Front. Vet. Sci.* 5. doi: 10.3389/fvets.2018.00119

DeGeorges, P., and Reilly, B. (2009). The realities of community based natural resource management and biodiversity conservation in sub-Saharan Africa. *Sustainability* 1, 734–788. doi: 10.3390/su1030734

Dickman, A. J., Macdonald, E. A., and Macdonald, D. W. (2011). A review of financial instruments to pay for predator conservation and encourage human-carnivore coexistence. *Proc. Natl. Acad. Sci.* 108, 13937–13944. doi: 10.1073/pnas.1012972108

Durant, S. M., Marino, A., Linnell, J. D., Oriol-Cotterill, A., Dloniak, S., Dolrenry, S., et al. (2022). Fostering coexistence between people and large carnivores in Africa: Using a theory of change to identify pathways to impact and their underlying assumptions. *Front. Conserv. Sci.* 2. doi: 10.3389/fcosc.2021.698631

Felix, N., Kissui, B. M., Munishi, L., and Treydte, A. C. (2022). Retaliatory killing negatively affects African lion (Panthera Leo) male coalitions in the Tarangire-Manyara ecosystem, Tanzania. *PloS One* 17, e0272272. doi: 10.1371/journal.pone.0272272

Gebresenbet, F., Bauer, H., Vadjunec, J. M., and Papeş, M. (2018). Beyond the numbers: Human attitudes and conflict with lions (Panthera leo) in and around Gambella National Park, Ethiopia. *PloS One* 13, e0204320. doi: 10.1371/journal.pone.0204320

Guggisberg, C. A. (1963). *Simba, the life of the lion* (New York, NY: Bailey Bros. & Swinfen).

Harrison, M., Roe, D., Baker, J., Mwedde, G., Travers, H., Plumptre, A., et al. (2015). *Wildlife crime: a review of the evidence on drivers and impacts in Uganda* Vol. 43 (London: International Institute for Environment and Development).

Hazzah, L., Dolrenry, S., Naughton, L., Edwards, C. T., Mwebi, O., Kearney, F., et al. (2014). Efficacy of two lion conservation programs in Maasailand, Kenya. *Conserv. Biol.* 28, 851–860. doi: 10.1111/cobi.12244

IUCN (2006). *Conservation strategy for the lion Panthera leo in Eastern and Southern Africa* (Gland: IUCN/SSC Cat Specialist Group).

Khan, U., Lovari, S., Ali Shah, S., and Ferretti, F. (2018). Predator, prey and humans in a mountainous area: Loss of biological diversity leads to trouble. *Biodivers. Conserv.* 27, 2795–2813. doi: 10.1007/s10531-018-1570-6

Kolowski, J. M., Katan, D., Theis, K. R., and Holekamp, K. E. (2007). Daily patterns of activity in the spotted hyena. *J. Mammal.* 88, 1017–1028. doi: 10.1644/06-mamm-a-143r.1

Macdonald, D. W., Loveridge, A. J., and Rabinowitz, R. (2010). "Felid futures: Crossing disciplines, borders and generations," in *The biology and conservation of wild felids* (Oxford University Press, Oxford), 599–649.

Maclennan, S. D., Groom, R. J., Macdonald, D. W., and Frank, L. G. (2009). Evaluation of a compensation scheme to bring about pastoralist tolerance of lions. *Biol. Conserv.* 142, 2419–2427. doi: 10.1016/j.biocon.2008.12.003

Moghari, N. M. (2009). *A survey of Queen Elizabeth National Park (QENP) communities' attitudes toward human-lion conflict and lion conservation (Doctoral dissertation).* Washington, DC: George Mason University.

Nelson, F. (2009). Developing payments for ecosystem services approaches to carnivore conservation. Human. *Dimensions. Wildlife.* 14, 381–392. doi: 10.1080/10871200903045228

Nicole, B. F. (2019). "An assessment of the human-wildlife conflict across Africa," in *Wildlife population monitoring* (London: Books on Demand).

Ochieng, A., Ahebwa, W. M., and Visseren-Hamakers, I. J. (2015). "Hunting for conservation? The re-introduction of sport hunting in Uganda examined," in *Institutional arrangements for conservation, development and tourism in eastern and southern Africa* (Springer, Dordrecht), 139–155.

Omoya, E. O., Mudumba, T., Buckland, S. T., Mulondo, P., and Plumptre, A. J. (2014). Estimating population sizes of lions Panthera leo and spotted hyaenas Crocuta crocuta in Uganda's savannah parks, using lure count methods. *Oryx* 48, 394–401. doi: 10.1017/s0030605313000112

Packer, C., Ikanda, D., Kissui, B., and Kushnir, H. (2005). Lion attacks on humans in Tanzania. *Nature* 436, 927–928. doi: 10.1038/436927a

Packer, C., Loveridge, A., Canney, S., Caro, T., Garnett, S., Pfeifer, M., et al. (2013). Conserving large carnivores: Dollars and fence. *Ecol. Lett.* 16, 635–641. doi: 10.1111/ele.12091

Rust, N. A., and Marker, L. L. (2013). Cost of carnivore coexistence on communal and resettled land in Namibia. *Environ. Conserv.* 41, 45–53. doi: 10.1017/s0376892913000180

Ruvuga, P. (2016). Goat production in the tropics and mitigation to feed shortage in different production systems in Eastern Tanzania *[Master's thesis]* (Uppsala: ProQuest Dissertations and Theses Global).

Somerville, K. (2021). *Humans and hyenas: Monster or misunderstood* (New York, NY: Routledge).

Treves, A., Plumptre, A. J., Hunter, L. T., and Ziwa, J. (2009). Identifying a potential lion Panthera leo stronghold in Queen Elizabeth National Park, Uganda, and Parc national des Virunga, Democratic Republic of Congo. *Oryx* 43, 60–64. doi: 10.1017/s0030605309990561

Tshabalala, T., McManus, J., Treves, A., Masocha, V., Faulconbridge, S., Schurch, M., et al. (2021). Leopards and mesopredators as indicators of mammalian species richness across diverse landscapes of South Africa. *Ecol. Indic.* 121, 107201. doi: 10.1016/j.ecolind.2020.107201

Tumusiime, D. (2021). *An investigative research report into the triggers and motivations for lion killings by communities living adjacent to Queen Elizabeth protected area. Wildlife Conservation Society* (Kampala, Uganda: Wildlife Conservation Society).

Uganda Bureau of Statistics (2014). Uganda Bureau of Statistics (UBoS) National population and housing census 2014*: Provisional results*.

Uganda Wildlife Authority (2011). *Queen Elizabeth National Park, Kyambura Wildlife Reserve, Kigezi Wildlife Reserve general management plan, (2011 - 2021)* (Kampala, Uganda: Uganda Wildlife Authority Ministry of Tourism, Wildlife and Antiquities).

Uganda Wildlife Authority (2023). *Investing in forests and protected areas for climate-smart development (IFPA-CD) - P170466). For the proposed construction of Queen Elizabeth Protected Area (QEPA) electric fence in Kasese, Kitagwenda and Rukungiri districts* (Kampala: Uganda Wildlife Authority). Available at: https://Ugandawildlife.org/wp-content/uploads/2023/07/IFPA-CD-Project-Brief-for-Queen-Elizabeth-National-Park-Electric-Fence.pdf.

Wolff, C., Abigaba, S., and Sternberg Lewerin, S. (2019). Ugandan cattle farmers' perceived needs of disease prevention and strategies to improve biosecurity. *BMC Vet. Res.* 15, 1–11. doi: 10.1186/s12917-019-1961-2