



## Original Research Article

## Commercially-driven lion part removal: What is the evidence from mortality records?



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## ARTICLE INFO

## Article history:

Received 6 August 2020

Received in revised form 6 October 2020

Accepted 8 October 2020

## Keywords:

Lion bones

Wildlife trade

IWT

Snaring

Poisoning

Livestock conflict

## ABSTRACT

Trade-driven killing for body parts has long been a major cause of population decline for a number of big cat species. There are now worrying suggestions that commercialised illegal trade in body parts might become a threat for wild lions in Africa, and recent concerns have been raised that trade in captive-bred lion skeletons from South Africa may have stimulated demand for lion bones, claws, and teeth and thus incentivised commercially-driven, targeted poaching of wild lions for illegal trade. However, analysis of the prevalence of commercially-driven, targeted killing of lions for body parts is currently lacking for most major lion populations. In this study we make use of detailed, long-term records of mortality and body part removal from field sites in two of Africa's lion population strongholds, the Hwange National Park and surrounds, Zimbabwe, within the Kavango Zambezi (KAZA) Transfrontier Conservation Area and the Ruaha landscape in Tanzania, to evaluate potential cases of commercially-driven part removal and targeted killings. We find no evidence of systemic targeted killing of lions for commercial trade at either site and suggest that the majority of part removals are opportunistic and culturally-driven. Nevertheless, we stress the requirement for vigilance around the issue of lion trade and support the development of further range-wide capacity to record wild lion mortality and body part removal data.

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## 1. Introduction

Lions (*Panthera leo*) are classified as vulnerable, having disappeared from ~92% of their historic range and declined by 43% during the two decades between 1993 and 2014, leaving an estimated 23,000–39,000 individuals living in the wild (Bauer et al., 2016). Declines are continuing in all but four African countries (Botswana, Namibia, South Africa, and Zimbabwe) (Bauer et al., 2015). The primary threats faced by many wild lion populations are prey depletion, livestock encroachment, illegal killing due to conflict over livestock, and habitat conversion (Bauer et al., 2015). In addition, there have been recent concerns that commercialised illegal trade in body parts may increasingly become a threat for wild lions in Africa (Williams

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et al., 2017a; Everatt et al., 2019). Commercial, trade-driven poaching for body parts has been, and continues to be, a major cause of population decline for a number of big cats, notably tiger (*Panthera tigris*) (Loveridge et al., 2010; Goodrich et al., 2015). Recent information suggests that targeted, commercially-driven poaching for body parts may threaten the viability of a lion population in the Greater Limpopo Lion Conservation Unit (GLLCU) of southern Mozambique (Everatt et al., 2019). This raises the concern that targeted, commercially-driven poaching for body parts is an emerging threat that has, hitherto, been largely absent from the catalogue of risks faced by contemporary lion populations. In this study we evaluate long-term mortality records of lions in two key lion population strongholds, one in Southern and one in East Africa, for evidence of targeted killings for body parts and commercially-driven body part removals, and any changes over time.

Present-day use of lion parts in Africa comprises a diverse range of largely traditional and culturally derived uses; including zootherapeutic traditional medicines, clothing, ornamentation, and trinkets and curios (Williams et al., 2017a). Specific uses of lion parts vary widely across regional and cultural contexts throughout sub-Saharan Africa, particularly for traditional medicine (e.g. Adeola, 1992; Soewu, 2008; Whiting et al., 2013). In addition, amongst East African pastoralist groups, traditional trophy-taking of lion parts has an important cultural role in signalling honour and prestige linked to the killing of lions (e.g. Goldman et al., 2010; pers. obs.) and specific cultural and social norms govern the removal of body parts for prestige-related purposes (Goldman et al., 2013; pers. obs.).

There is a long history of use of lion products outside of naturally occurring lion ranges (Somerville, 2019) and a variety of uses of lion parts continue to this day and include both legal and illegal uses. Hunting trophies, trinkets, curios, clothing and other regalia are on-going uses of lion parts outside Africa. In recent years the use of lion skeletal parts (bones, teeth, and claws) in East and Southeast Asia has risen in prominence. Lion skeletons are thought to be used in traditional medicinal and cultural preparations, especially medicinal and tonic wine products, which would traditionally contain tiger bone (Williams et al. 2015b, 2017b). However, the interactions of lion and tiger bone are poorly understood in real-world markets (Moorhouse et al., 2020; Coals et al., 2020). In addition to bone there is also demand for lion teeth and claws in Asia, the uses of which are not presently clear (Williams et al., 2017b; Williams & 't Sas-Rolfes, 2019).

Demand in East and Southeast Asia has driven a recently emerged commercial industry in South Africa: the intercontinental trade in lion skeletons (including bones, teeth, claws) (Williams et al., 2015a). This legal trade, permitted under The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) – which lists African lions under Appendix II (Bauer et al., 2018; Hodgetts et al., 2018), has seen over 6000 skeletons shipped to Asia since 2008 (Williams et al., 2015a, 2017b; Coals et al., 2019). Since 2016 the trade has only been permitted to comprise captive-bred lion skeletons (Williams & 't Sas-Rolfes, 2019). In South Africa lions are primarily captive-bred as part of the captive-bred hunting industry, but also contribute to the legal international lion skeleton trade, either as a by-product after captive-bred hunting or, more recently, a primary use (Williams & 't Sas-Rolfes, 2019).

Controversy surrounds the captive-bred lion skeleton trade, and it represents a challenging nexus of conservation, animal welfare, political, and economic considerations (Coals et al., 2019). Specifically, concerns have been expressed that trade in lion skeletons from South Africa may have stimulated demand for lion bones, claws, and teeth in Asia and thus incentivised commercially-driven, targeted poaching of wild lions for illegal trade (Coals et al., 2019).

International trade in lion body parts also exists within the African continent, as well as domestic trade within countries, but these are typically not legal trades (Williams et al., 2017a). Both 'pan-African' and domestic trade in lion parts can be highly commercial industries, especially if syndicated illegal trade is involved (Williams et al., 2017a). However, disentangling levels of commercialisation in lion trade is complex, especially as lion parts may be traded on many commercial levels and the availability of lion parts, access to markets, and purchasing power of consumers is likely to have noticeable influence on levels of commercialisation. For example, in urban traditional markets wildlife products, including lion, are highly commercialised (e.g. Whiting et al., 2013) but similar products are also produced solely for personal use, typically where individuals have readier access to lion material – often through human-lion conflict killings, or trophy hunting mortalities (pers. obs.). Similar situations are seen in the commercialisation of other wildlife products; bush-meat species eaten for subsistence or subject to low-value trade may also fetch premium prices in urban and international markets where sufficient demand and purchasing power exists (Lindsey et al., 2013).

In a 2017 survey, conservation practitioners identified priority countries for monitoring the prevalence of commercial lion part trade, based on their expertly assigned risk (Williams et al., 2017a). In Southern Africa these countries were: South Africa, Zimbabwe, Mozambique, Zambia and Botswana, and in East Africa; Tanzania and Kenya. These countries hold the majority of the remaining major populations of wild lions in Africa and are considered lion population strongholds (Riggio et al., 2013; Bauer et al., 2015). There are well-documented concerns about relying upon expert opinion (e.g. Ayyub, 2001; Burgman, 2001), and, to-date, peer-reviewed information that considers contemporary on-the-ground reports of commercially-driven, targeted killing of lions for body parts is limited to the GLLCU (Everatt et al., 2019). Analysis of the prevalence of commercially-driven, targeted killing of lions for body parts is therefore currently lacking for most of the major African lion populations.

We aimed to contribute knowledge related to the commercially-driven removal of body parts and targeted killing of lions for body parts by making use of detailed lion mortality databases from two long-term field studies, one in Southern and one in East Africa. We attempted to determine whether there was evidence that lions from these major population strongholds had been specifically killed for body parts, and whether patterns in removals of body parts – particularly bones, teeth, and claws, indicated potential commercial motivations.

Many lion body parts have long-standing, and continuing, African uses, and lion killings may be motivated by a wide range of factors (e.g. Hazzah, 2007; Fitzherbert, 2014). Therefore, due to such complexities, we did not expect to be able to determine whether killings were targeted specifically for commercial reasons. We note the difficulty of determining motivation for the killing of lions and accept that interacting and complex motivations are likely to be common. We also acknowledge that, owing to complexities regarding multiple uses and markets for lion parts - both non-commercial and commercial, and national and international, definitively determining what kind of markets, and uses, removed parts contribute to would be largely impossible from mortality data. Nevertheless, detailed assessment of a range of mortalities over time allow us to evaluate potential cases of commercially-driven part removal from mortalities, and targeted killings that appeared to be made for parts, and thus contribute conservation-relevant information for two key lion population strongholds.

## 2. Methods

### 2.1. Study areas

We collated records of mortalities from two long-term studies of lion populations, one in the Hwange landscape, Zimbabwe and the other in the Ruaha landscape, Tanzania. In both study regions detailed mortality records are kept. Both projects work with local communities and employ local community members to monitor lions, prevent human-lion conflict through implementation and support of conflict mitigation initiatives, and report lion mortalities. The two landscapes under consideration showed differences (detailed below). Chief amongst these concern the different cultural contexts between the two regions; specifically relating to lion killing for cultural reasons, which persists in the East African site but not the Southern African site. We also note that land area and nature of land-use across which data were collected differed between the two sites; the Hwange dataset encompassed a large Protected Area complex, including national parks, forestry and hunting areas, privately owned farmland and community areas, and the Ruaha dataset was largely collected from village land, with sporadic records from the National Park and other protected areas.

### 2.2. Southern African landscape (Hwange landscape)

Hwange National Park, located in western Zimbabwe, is surrounded by hunting concessions and forestry and community land with the south-western boundary of the park formed by the Zimbabwe-Botswana border. The site falls within the broader Kavango-Zambezi (KAZA) Transfrontier Conservation Area. Hunting and safari areas are surrounded by community lands of mixed agriculture and pastoralism (Loveridge et al., 2007). A range of ethnic groups are represented in community lands, with people living in Tsholotsho region primarily speaking Ndebele as a first language, and those in Mabale region speaking a mix of Ndebele, Nambya, and numerous other local languages (Loveridge et al., 2017a).

Mortality records have been kept for lions in Hwange National Park and the surrounding area from October 1999 until April 2019 as part of the Hwange Lion Project (now The Trans-Kalahari Predator Programme; [www.wildcru.org/research/tkpp/](http://www.wildcru.org/research/tkpp/)). Within the Hwange landscape, in a core area of c. 4000 km<sup>2</sup>, over 973 lions (including cubs) have been individually identified and most prides have been radio or GPS collared to facilitate monitoring (Loveridge et al., 2016). Where possible, reports of mortalities were investigated by researchers. Cause of mortality was ascertained, along with date of death (estimated to month if not definitely known), sex, and location. If carcasses were found any parts that had been removed were recorded when mode of death and state of carcass decomposition permitted identification of deliberate removal. Any additional available information on circumstances surrounding mortality were also recorded when such information was available. A number of records were available from anti-poaching confiscations, the parts recovered were also treated as mortalities and information surrounding the circumstances of the mortality, including cause of death were determined.

### 2.3. East African landscape (Ruaha landscape)

Mortality records from the Ruaha landscape in central Tanzania were collated spanning a period from April 2006 until October 2018. The Ruaha Carnivore Project ([www.ruahacarnivoreproject.com](http://www.ruahacarnivoreproject.com)), established in 2009, was the source of data for this study. The project's study area includes Ruaha National Park, adjacent Wildlife Management Areas, and village lands, with the mortality data largely collected on village land covering an area of c. 4000 km<sup>2</sup> (Abade et al., 2014), with data being collected from more villages over time. There are 35 ethnic groups within the landscape, the major groups within the study region are the Hehe and Sukuma, which are agriculturalists, and the Maasai and Barabaig which are traditionally pastoralists. Amongst East African pastoralists the killing of lions in a traditional manner (using a spear) and subsequently displaying body parts such as claws and skin can confer honour, prestige, and material wealth upon the killer (Goldman et al., 2013; Hazzah et al., 2017). In human inhabited land in the study area of the Ruaha landscape there are over 20 local villages (Dickman, 2015). High levels of lion predation on livestock, and subsequent human-lion conflict killings are reported for the area (Dickman et al., 2014).

Where possible, reports of mortalities were investigated by researchers; date of mortality was recorded, or estimated when unknown. The number, age and sex of individuals involved in each mortality event was recorded, along with any

instances of body part removal. Descriptions of the context surrounding each mortality event were also provided. From those descriptions causes of mortalities could be ascertained.

#### 2.4. Categorisation of mortalities

Records allowed causes of mortality to be categorised for both landscapes to include: natural, trophy hunting, problem animal control (PAC - the officially sanctioned killing, often by official wildlife management personnel, of lions that posed threats to human safety or had reportedly killed livestock), vehicle collisions, poisoning, shooting (excluding trophy hunting and PAC), snaring, and spearing.

In both study sites lions are killed for a number of complex and often interrelated reasons often related to livestock and pastoral livelihoods (e.g. [Hazzah, 2007](#); [Dickman, 2009](#); [Kuiper et al., 2015](#); [Loveridge et al., 2017a](#)). We attempted to determine causes of mortality for lion killings from examination of carcasses and sites of killings. To an extent, the method of killing indicated whether a killing was deliberate with trophy hunting, shootings, spearings, and problem animal control being more clearly deliberate. However, we could not reliably determine motivations for killings due to the complex nexus of potential motivations which could not be disentangled from information presented in mortality records alone.

Lion parts were known to have present-day, primarily cultural, uses in both of our study regions. In Zimbabwe lion parts such as fat, claws, bone, skin, noses ([Fig. 1](#)), and teeth appear to be predominantly used for traditional medicine, traditional attire, and curios (pers. obs.; [Williams et al., 2017a](#)). In pastoralist regions of East Africa, traditional uses are similar – particularly the use of fat in traditional medicine – while specific body parts are also routinely removed from killed lions, in small quantities, to be used as traditional symbols of honour and prestige by the killers; particularly the right forepaw ([Fig. 2](#)) and/or its claws, strips of skin ([Fig. 2](#)), and the tail (pers. obs.). We thus expected a degree of body part removal from mortalities at both sites. In this study we assume that potentially commercially-motivated removals would be indicated through notable increases in quantity and types of body parts removed – though we are mindful that such a condition could also reflect other, unknown social and cultural changes. Where possible we assessed mortality events on a case-by case basis using local knowledge and intelligence alongside mortality situation reports and records of body parts removed in order to provide further detail, and where possible, determine causes of death, and whether the lions appeared to have been targeted for body parts.

#### 2.5. Search effort and mortality detection

Meaningful assessment of mortality records over time requires some understanding of effort put into detection and investigation of lion carcasses throughout the study period. These factors can be significant, but not insurmountable, barriers to the use of observational data which may not conform to formal study design and hence are subject to hidden bias ([Dobson](#)



**Fig. 1.** Snared lion with nose removed, displayed by an anti-poaching scout in the Hwange landscape (photo credit: Jane Hunt).





**Fig. 2.** Pictures of removals of body parts from lion mortalities, Ruaha landscape

a.) Removal of right forepaw as a traditional trophy (photo credit: Amy Dickman)

b.) Removal of skin strip as a traditional trophy (photo credit: Amy Dickman).

[et al., 2020](#)). In the Zimbabwe study region the dataset was derived from systematic long-term monitoring that was intended to monitor changes in lion population demography over time (see [Loveridge et al., 2016](#)). The Hwange landscape is one of the most extensively monitored large wild lion populations in Africa, nevertheless it is almost inevitable that some mortalities were never recorded or investigated. Field-based population monitoring of wild large carnivores will undoubtedly be imperfect, but as far as possible the monitoring of lion populations across the Hwange landscape has been standardised. Across the Hwange landscape mortalities are recorded to occur most frequently where lions come into contact with anthropogenic threats (see [Loveridge et al., 2017b](#)). Regarding the investigation of mortalities and the recording of body part removals for this study we acknowledge that there is most probably a higher likelihood of discovering and examining the carcasses of lions collared with radio-tracking devices (see Results section).

In the Tanzania study area the focus of monitoring was predominantly across village land adjacent to the Ruaha National Park ([Abade et al., 2014](#)). The vast majority of mortalities in this landscape were identified by community scouts from the area who made use of observational patrols and human-based information. In all, the Ruaha landscape is far less uniformly monitored than the Hwange landscape and we therefore acknowledge a greater spatial bias towards community lands outside the protected area in mortality records. Individual lion prides are less well-known in the Ruaha landscape and the use of radio-tracking collars is not prevalent. Records of mortalities rely heavily upon human reports which may be subject to a range of observer biases ([Dobson et al., 2020](#)). The probability of detection is likely to have increased over time as the resources available to the project have increased. It should be borne in mind that the interpretations of the data presented are applicable to village land south of the Ruaha National Park.

## 2.6. Analysis

Hwange mortalities, which were recorded on an individual level, were grouped into 'mortality events' which represented individuals that died from linked causes in the same location within approximately 24 hours, for example individuals snared in the same snare-line. Ruaha records were already recorded in this mortality event format.

The effect of causes of mortality on the likelihood of body part removal from an event were tested using binary regression with the *nnet* package in R statistical programming language (Venables and Ripley, 2002; R Core Team, 2019). Changes in body-part removal over time were visualised by fitting smoothing splines using the GAM (Generalized Additive Model) function of R-package *ggplot2* (Wickham, 2016).

## 3. Results

### 3.1. Hwange landscape

In the Hwange landscape information was available for whether parts were removed for 123 individual lion mortalities in 56 events. Of those mortalities, 30 (24.4%) were confirmed to have deliberately had parts removed. However, some carcasses could not be physically examined for removal of body parts. Of the mortalities for which carcasses could not be examined: two mortalities were identified from old skulls found at bush-meat poachers' camps, seven skins were confiscated in a local community, the head and paws of an individual were recovered from poachers in an arrest, a skull and a skin (presumed to be from the same lion) were recovered from the arrest of another poacher, and a further lion skin was confiscated in a local community (Appendix 1). We assume the confiscated pieces were likely to be destined for some kind of commercial trade (possibly traditional medicine or regalia). The site of the killings of the confiscated pieces were not known therefore could not be investigated and it was unclear whether the lions had been deliberately targeted. In six additional cases only cut-off radio collars were found in the bush and it appeared that carcasses had been removed. Cause of death could not be assessed in these cases either (Appendix 1).

Throughout the study period only four individuals appeared to have been targeted and killed specifically for body parts, these occurred in two events (Appendix 1). The first, in 2001, comprised three snared individuals from which claws, teeth, and noses were removed. The second, in 2015, was a single individual snared at a buffalo (*Syncerus caffer*) carcass that appeared to have been used as bait. The skull and claws were recorded to have been removed from the lion in the second targeted event. Part removal appeared to be opportunistic in a further 14 cases.

Skin was the most frequently removed body part (taken from 10 individuals) and was significantly more likely to be found in confiscations than other body parts (binomial logit:  $SE = 1.479$ ,  $z = 3.219$ ,  $p = 0.01$ ) (Table 2). All but one of the records of skin removal came from confiscations (a single confiscation totalled seven skins). Skull, claws, teeth, and whole body were the next most frequently removed parts (each recorded as removed from 6 individuals). In addition, complete heads were recorded to have been removed in two instances and paws in one. Claws were the most frequently removed body part from suspected targeted killings (4), but suspected targeted killings did not show any significant difference in the type of body part likely to be removed compared to opportunistic removals. We found that mortalities due to snaring were more likely to have body parts removed than natural mortalities (binomial logit:  $SE = 0.6150$ ,  $z = 4.195$ ,  $p = 0.001$ ) (Table 1). There were no other significant differences in body part removal between mortality causes.

Numbers of mortality events with parts removed peaked between 2005 and 2011; with maximum recorded numbers of four events per year in 2005 and 2011 (Fig. 4). When removal of specific body parts was considered across years removals were sparse. No part showed notable changes in removal frequency across the study period, aside from a spike in skin numbers recorded in 2006 due to a single confiscation event (Fig. 3).

### 3.2. Ruaha landscape

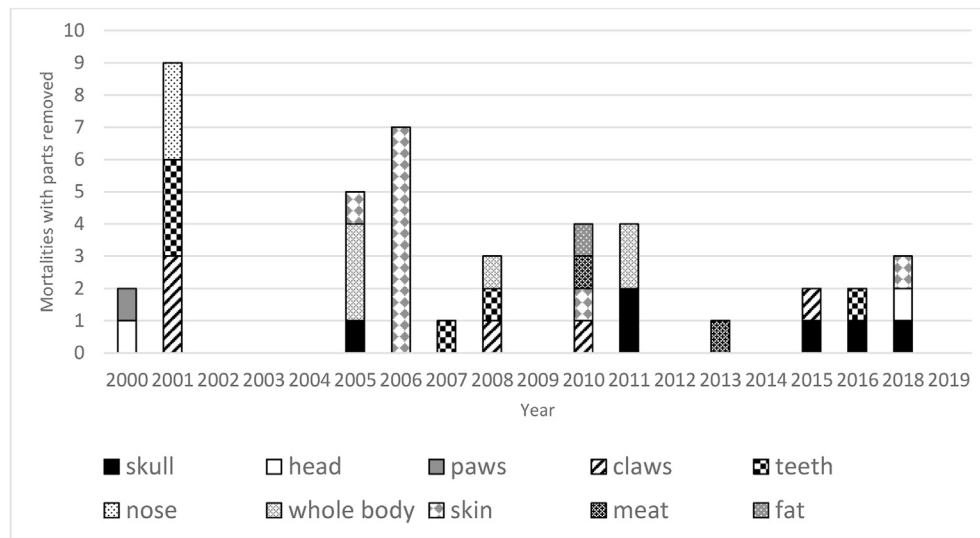
In the Ruaha landscape sufficient information was available to confirm whether body parts had been removed in 87 events (136 individuals). In 56 (64.4%) mortality events (comprising 90 individuals) parts were confirmed to have been removed (Appendix 2). In 43 (78.6%) of those events the parts removed appeared to be associated with traditional use, particularly for display of prestige and honour in lion killing. Indeed, we found that individuals that were killed by spearing were more likely

**Table 1**  
Hwange body part removals by cause of mortality (individuals).

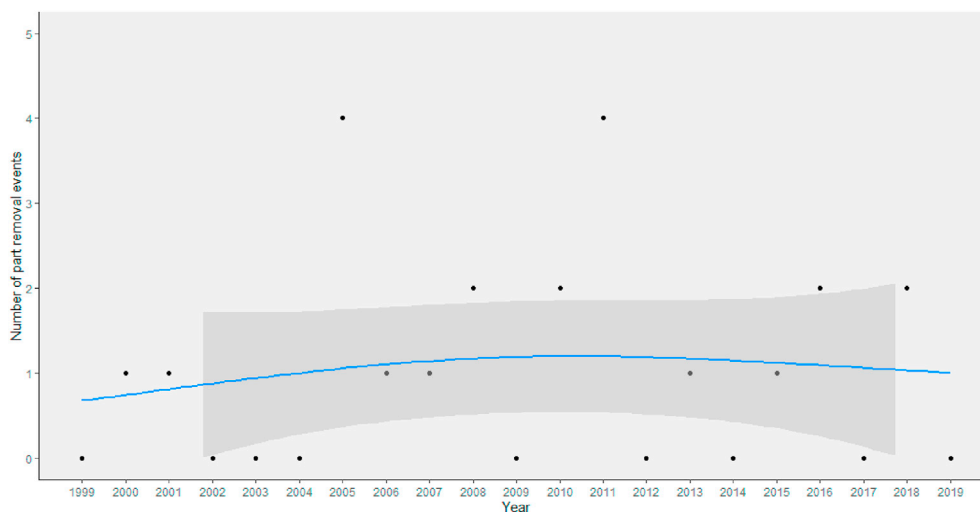
Cause of mortality	skull	head	paws	claws	teeth	nose	whole body	skin	meat	fat
Natural	1			1	3					
Poison							1		1	
Snaring	1	1	1	5	3	3	4	8	1	1
train collision	1	1					1	1		
Unknown	3							1		
Total	6	2	1	6	6	3	6	10	2	1

**Table 2**  
Hwange body part removals by removal-type designation (individuals).

Designation	skull	head	paws	claws	teeth	nose	whole body	skin	meat	fat
found at poaching camp	2									
Opportunistic	2	1		2	3		6	1	2	1
suspected targeted killing for body parts	1			4	3	3				
trade/poacher confiscation	1	1	1					9		
Total	6	2	1	6	6	3	6	10	2	1



**Fig. 3.** Body parts removed from individual mortalities in the Hwange landscape by year.



**Fig. 4.** Generalized additive model (GAM) of body part removal events over time in the Hwange landscape.

to have body parts removed than those that were poisoned (binomial logit:  $SE = 0.8035$ ,  $z = 2.319$ ,  $p = 0.05$ ) or shot (binomial logit:  $SE = 0.8373$ ,  $z = 2.709$ ,  $p = 0.01$ ) (Table 3). Claws were the part most frequently removed from mortality events (28), followed by skin (13), paws (11), and tails (7) (Table 4). These parts were typically removed as traditional trophies or proof-of-kill items to acquire honour and prestige in local communities. Typically, cultural trophies involved the removal of the claws of the right forepaw or the entire paw (rarely a leg: two events). Strips of skin (rarely full pelts) and tails may also be taken as traditional trophies or as proof-of-kill. Meat was removed for food in seven events. Parts were suspected to have been

**Table 3**  
Ruaha body part removals by cause of mortality (events).

Cause of mortality	claws	paws	teeth	jaw	meat	fat	tail	skin	hair	whole body	leg	testicles	intestine
PAC					2			1		1			
poisoned	6	2	4	2		2	3	4					1
poisoned & speared	4	1				1	1		1				
shot	1												
shot & speared					1			1					
snared	1				3					1			
snared & shot					1								
speared	14	7					3	6		2	1	1	
unknown	2	1						1			1		
Total	28	11	4	2	7	3	7	13	1	4	2	1	1

**Table 4**  
Ruaha body part removals by removal-type designation (events).

Designation	claws	paws	teeth	jaw	meat	fat	tail	skin	hair	whole body	leg	testicles	intestine
Food					7								
official removal								3		2			
suspected commercial	2	2	4	2									
traditional trophies	26	9					7	10	1		2		
traditional medicine						3						1	1
Unknown										2			
Total	28	11	4	2	7	3	7	13	1	4	2	1	1

removed for traditional medicine in four events; fat in two, fat and intestine in one, and testicles in one. Whole bodies were removed in four events; reasons for two were unknown and two were official confiscations, body parts were also officially confiscated in an additional instance (Table 4).

During the study period we identified four events (6 individuals) where it appeared that body parts had been removed in quantities that could indicate potential commercial purposes. In three events (2013, 2014, 2016) paws/claws were noted to have been removed in higher quantities than previously seen for traditional trophies, in two events (2013 & 2016) teeth and jaws were taken, and in one event (2017) just teeth (Table 4; Appendix 2). These were the only events in which teeth were taken. All four events used poison and it was suspected that killings of lions were at least in-part retaliation for lion predation upon cattle but additional motivations such as traditional trophies, traditional medicine, and parts for commercial trade cannot be ruled-out.

The number of recorded mortality events with parts removed peaked in 2010 before falling substantially in 2012, rising slightly in 2016 and then fell to 2007 levels in 2018 (Fig. 6). It is probable that seemingly low initial levels represented low detection during establishment of the project as opposed to a genuine peak of killings and detected events in 2012.

The removal of teeth and whole bodies was first recorded in 2013 and had not previously been known to occur in the study area, although very limited data were available before 2010. Removals of teeth from mortalities may represent a new use such as emerging commercial interest, potentially for tourist trade (pers. obs.), as may the removal of bodies. Claw removal from mortality events, indicative of traditional prestige killings, peaked in 2010 and has decreased greatly since, despite expansion of the area over which data were collected. However, as instances of claw removal have decreased over time removal of paws/legs (traditionally a smaller fraction of removals) have increased since 2009 to peak in 2016. Records of removal of other body part types were scattered throughout the time period of the study with no obvious pattern (Fig. 5).

#### 4. Discussion

In response to growing concerns that targeted killing for body parts and commercially-driven removals of body parts represents an emerging threat to African lions we explored mortality records from two long-term field studies located in major lion population strongholds in Southern and East Africa; the Hwange landscape in Zimbabwe, and the Ruaha landscape in Tanzania. Our results identified very few instances of targeted killings for body parts in Hwange where recorded instances of definite targeted killing for parts totalled just two events (4 individuals) over nearly 20 years. However, it was unclear whether those events were commercially-driven as the parts could have been removed for a range of traditional or trade uses. Identifying targeted killings for body parts in Ruaha was challenging and, as in Hwange, complex interactions of potential reasons for lion killings and body part removals complicated assessment of whether lions had been killed for commercially-driven body part removal. However, we identified four events (6 individuals) over approximately a decade in which quantities and types of parts removed indicated potential commercial motivation, although the majority of these events were more likely directed towards tourist trade rather than linked to the intercontinental skeleton trade.

In Hwange many body part removals appeared to be opportunistic. A number of body part removals were from mortalities that occurred as a result of by-catch in bush-meat snares and we found that snaring mortalities were more likely to have body



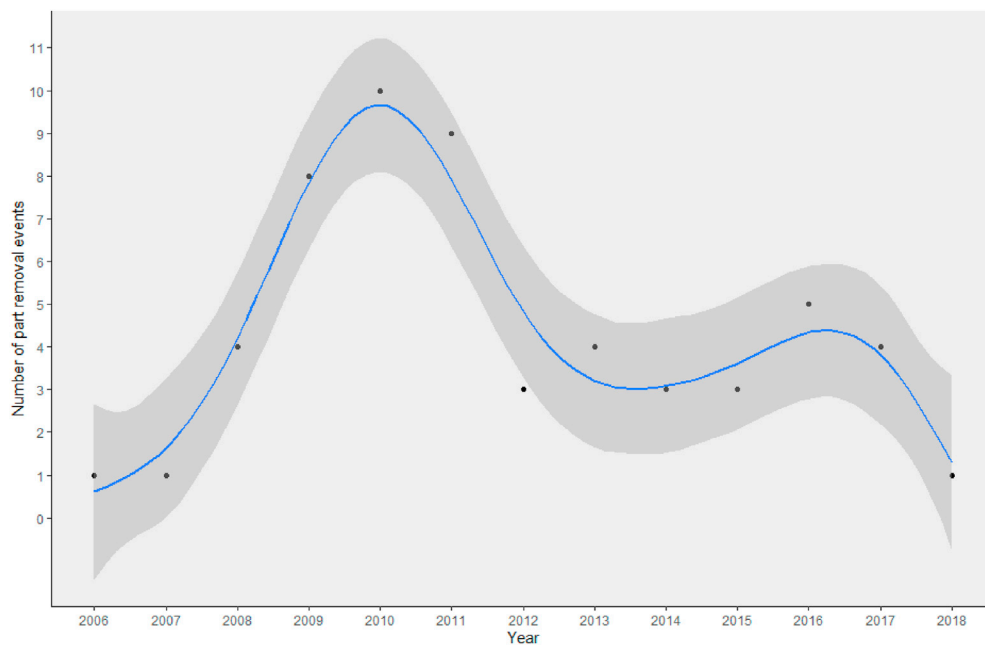


Fig. 5. Generalized additive model (GAM) of body part removal events over time in the Ruaha landscape.

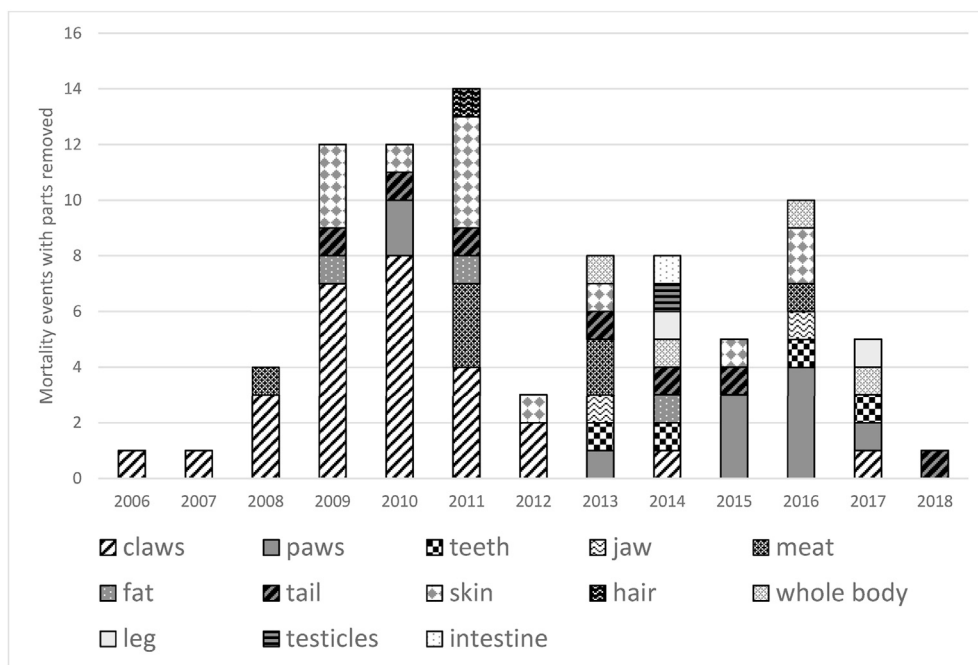


Fig. 6. Body parts removed from mortality events in the Ruaha landscape by year.

parts removed than natural mortalities. This greater likelihood is logical for an opportunistic removal scenario as these mortality events are associated with human agency, thus carcasses are more likely to be available to people with higher frequency.

Untargeted snaring as by-catch from bush-meat hunting represents a significant threat to large African carnivores in savannah ecosystems (Becker et al., 2013) and bush-meat poaching may have even wider ramifications when also considering impacts such as prey depletion (Lindsey et al., 2013). The significant effects of snaring by-catch on lion mortalities have been noted in the Hwange landscape (Loveridge et al., 2016) and have been shown to have highly detrimental demographic

impacts on large carnivores (spotted hyaena *Crocuta crocuta* and lion) across protected areas in the Kavango-Zambezi (KAZA) conservation area in Zimbabwe (Loveridge et al., 2020). We found no evidence for widespread targeted killing of lions for body parts but in the two recorded events where lions were killed in this way snares were used. The ready availability of metal wire and cable, along with ease of manufacture and deployment of snares, bring the immobilizing and killing of lions, either by accident or on purpose, within the capability of unarmed local people. Snaring therefore continues to represent a significant threat to lions and other large carnivores within the Hwange landscape but our analysis suggests that targeted killing for body parts has not been a major driver of past and recent mortalities.

A number of mortality records in the Hwange landscape came from confiscations from poachers or traders. The body parts recorded thus appeared intended for trade purposes but we had no way of knowing whether trade was the primary motivation for the killing of the lions from which those parts were taken. Skins featured predominantly in parts suspected to be for trade from the Hwange landscape. Lion skin has long-standing importance in Southern African traditional medicine and cultural regalia and may be often present in traditional markets (Whiting et al., 2013; Williams et al., 2017b). It is likely that confiscations of skin were destined for such markets, although personal or community use cannot be ruled out. In addition, we note that there is evidence that big-cat skins for commercial markets are sometimes supplied by criminal syndicates in Southern Africa and material sourced over wide international geographical regions (Naude et al. in prep.; pers. obs.).

A higher proportion of investigated mortalities in the Ruaha landscape were found to have parts removed than in the Hwange landscape (Ruaha 64.4%; Hwange 24.4%). Disentangling incentives for the killing of lions is complex and cannot necessarily be attributed to a simple single reason (Goldman et al., 2013; Fitzherbert et al., 2014). Nevertheless, the killing of lions is culturally significant in the Ruaha landscape amongst pastoralist groups (Dickman, 2009) where killing lions can bring prestige and reward to the individuals involved (Hazzah et al., 2017). The removal of parts, as trophies, from killed lions are important as signals of this honour and prestige (Goldman et al., 2013), and are used to prove kills in order to gain gifts of cattle from others in the community (pers. obs.). We found that events where killings were made with the traditional method of a spear were more likely to have body parts removed and a comment appended to a mortality event specifically stated that in that case parts were not taken because a spear was not used: “*Lion attack livestock and killed two goats. Owner put poison and left carcass outside. Lion eat and died but owner does not take parts because he did not kill with spear [sic].*” The majority of body part removals assessed in the Ruaha landscape appeared to be as traditional trophies. However, in four events since 2013 it appeared that body parts had been removed for potentially commercial purposes, based on anecdotal information we suggest that this is perhaps for the tourist trade. Notably, these were the only cases in which teeth and jaws were taken and claws were removed in higher quantities than previously seen. Everatt et al. (2019) found instances of removals, and airport confiscations, of teeth and claws in Southern Mozambique after 2014 and suggest there that potential Asian demand was driving such removals. Asian demand has also been suggested to drive increasing trade in jaguar (*Panthera onca*) teeth in South America (Nijman et al., 2019; Villalva and Moracho, 2019). We do not know what uses the removed parts were put to in the cases we recorded, although anecdotal discussions with local villagers suggest that teeth and claws may be sold within-country to tourists, rather than being destined for more organised international trade (pers. obs.).

Although these studies recorded low numbers of instances suspected to be related to commercial trade, and no evident increase over time, we emphasise the need for vigilance on the part of conservation, trade, and law-enforcement organisations. We also note that our data came from two sites with long-running conservation programmes that, amongst their objectives, aim to reduce human-caused mortalities of lions. It is possible that in sites lacking effective conservation programmes mortalities could be higher and trends could be different.

Following our assessments of the Hwange and Ruaha landscapes we emphasise that regional differences in body part removals preclude range-wide generalisations, and suggest that lion populations should be considered individually in assessments of mortality and body part removal. Previously, Everatt et al. (2019) found lions to be killed specifically for body part removal in Southern Mozambique (GLLCU) which has its own unique local geography, notably, existing poaching syndicates and wide-reaching criminal economies (Huebschle, 2017; Massé, 2019). Such potentially influential local conditions further reduce our ability to meaningfully generalise between regions and we caution against broad-view arguments regarding lion body part removal.

We found no evidence of targeted killing for bone-trade in either Hwange or Ruaha. However, in both sites a number of carcasses were removed in their entirety. In Ruaha whole bodies were only recorded as removed from 2013 (although detailed data on body part removal was lacking before 2009), and we have no data on any link between carcass removal and any kind of use or trade. Given these unknowns, but the risks that emerging trade has posed to other large cats, we call for vigilance and regulation of the future disposal of lion carcasses.

A significant source of lion carcasses for which we had little information were those generated by trophy hunting (*sensu* Loveridge et al., 2009). Typically, trophy hunters will remove parts of the lion for taxidermy; often the head including skin (cape-mount) or the full skin. Hunt operators or their staff are then left to dispose of the remainder of the carcass. In hunting areas in both the Hwange and Ruaha landscapes we received occasional reports of hunt operators receiving requests from local people for body parts after hunts (pers. obs.). Such requests included parts such as lion fat and meat that were likely for local consumption and traditional medicinal use (pers. obs.). On a wider scale across Tanzania, following problem animal control and trophy hunting, lion fat appears to be particularly desirable and is often extracted for use in traditional medicine – for both personal use and to be sold in local markets (pers. obs.). We have also received unconfirmed reports of instances of the bones of buried lion carcasses being dug up in order to be traded illegally (pers. obs.). Both trophy hunting and conflict

mortalities represent a potentially large source of carcasses from which parts could opportunistically be removed with little knowledge or regulation and is deserving of further research attention.

Risks posed to wild lion populations by intercontinental, international, and local trades in lion body parts are of growing concern (Williams et al., 2017a). These perceived risks have, to-date, been largely determined from expert opinion and not on-the-ground mortality data (with the exception of Everatt et al., 2019). We are mindful that in unpredictable situations in which conditions change over time and little empirical information is available, as is the case with lion body part trade, 'expert' assessment is of very limited value (Ayyub, 2001; Trivers, 2011). Linking trade volumes of lion parts and targeted killing of lions is not straightforward and may be fraught with complications and uncertainties. Notable amongst these is that an increase in trade volumes does not necessarily equate to an increase in targeted killing. In this study we suggest that the majority of killings in Hwange and Ruaha were not targeted for commercially-driven body part removals. However, there were potential indications in Ruaha that a small number of commercially-driven removals had occurred in recent years, likely for the tourist trade. Nevertheless, in both systems there are pre-existing lion mortalities and part removals that could be exploited to increase trade volumes without increasing targeted killings. In addition, oft-unquantifiable biases and missed evidence in the detection of illegal trade (see Gavin et al., 2010) complicate assessment of the extent to which body part removals are linked to trade. Indeed, the same body parts may be removed for a range of reasons, for example; teeth and claws are used in local ornamentation, traditional African medicine, and are present in intercontinental trade (Williams et al., 2015a). Therefore, we limit our interpretation of patterns and trends to commenting that, lacking any substantial additional evidence (especially regarding lion part trade chains), we believe that any more detailed inferences of causal linkages are liable to fall into the error of narrative fallacy (Menashe and Shamash, 2005; Taleb, 2007).

Similarly, attempting to predict whether serious upscaling of targeted lion killing for the body part trade will occur is nigh-on-impossible. Nevertheless, recent increases in poaching and trade of wildlife products have had huge ramifications for the populations involved (e.g. rhino horn, elephant ivory, and pangolin scales). Therefore, although we found little indication of past targeted killing in two lion population strongholds it is important to remember that past data may not adequately predict future events in lion part removals. We also acknowledge the difficulty in recording and/or investigating every mortality in the landscapes we considered. Thus there is a possibility that evidence may have been missed, especially in the case of whole carcasses being removed. However, the majority of lion prides at least in the Hwange landscape are known individually, and have been extensively monitored for long time periods. We are therefore confident that the data presented are a good representation of mortalities and body part removals in that landscape, and that they are a good representation for village land south of Ruaha. We remain mindful that it is only through long-term monitoring and detailed knowledge of lion populations that post-hoc assessments of potentially emerging threats such as killing for body parts are possible and we highlight the requirement for more extensive record keeping regarding mortalities and body part removals across lion ranges. We stress the utility of a collaborative range-wide database of lion mortalities and body part removals in efforts to provide detailed information and assessment of targeted killings and commercial trade. Finally, we highlight a requirement for more complete understanding of the role of lion parts and their trade in local communities, particularly with respect to traditional practices and local economies.

## 5. Conclusion

We made use of long-term mortality records to assess past removals of body parts from two key lion populations; one in the Hwange landscape, Zimbabwe, and the other in the Ruaha landscape, Tanzania. In these records there were few instances of targeted killings for body parts, but we did find some possible indications of a small number of limited body part removals for potentially commercial purposes within-country. We emphasise the need for careful monitoring of both targeted killings and body part removals for further indications of commercially-driven impacts upon lion populations. In this study we did not focus on the ultimate destination of removed parts: in other recent instances in other areas removals have been recorded to end up in intercontinental trade (Everatt et al., 2019), although there was no evidence for that here. Although we found little past evidence for targeted commercially-driven killings, in both sites there exists a supply of body parts from mortalities that could potentially contribute to wider trade. Future work should therefore focus on ascertaining the contribution of such by-products of non-targeted mortalities to lion body part trade (preferably through the use of physical traceability techniques that minimize the requirement for human speculation). We conclude by urging vigilance regarding the potential threat of targeted killing to lion populations and highlight the need to avoid complacency with regard to the future likelihood of such events.

## Funding

This analysis was carried out at the University of Oxford Wildlife Conservation Research Unit and received no additional funding. Details of funding for the work of The Hwange Lion Project (The Trans-Kalahari Predator Programme) can be accessed at <https://www.wildcru.org/research/tkpp-support/> and that of The Ruaha Carnivore Project at <https://www.ruahacarnivoreproject.com/friends-of-rcp/>.

**Ethics approval**

Not applicable.

**Consent to participate**

Not applicable.

**Consent for publication**

All authors consent to publication.

**Availability of data and material**

Summary data are included as appendices and full records may be requested directly from the authors.

**Code availability**

Not applicable.

**CRediT authorship contribution statement**

**Peter Coals:** Conceptualization, Formal analysis, Investigation, Writing - original draft, Writing - review & editing. **Amy Dickman:** Conceptualization, Data curation, Writing - review & editing. **Jane Hunt:** Data curation, Writing - review & editing. **Ana Grau:** Data curation, Writing - review & editing. **Roseline Mandisodza-Chikerema:** Writing - review & editing. **Dennis Ikanda:** Writing - review & editing. **David W. Macdonald:** Writing - review & editing. **Andrew Loveridge:** Conceptualization, Data curation, Supervision, Writing - review & editing.

**Declaration of competing interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Acknowledgments**

We are grateful for the hard work of the staff of The Hwange Lion Project (The Trans-Kalahari Predator Programme) and the Ruaha Carnivore Project as well as the Zimbabwe Parks and Wildlife Management Authority and the Tanzania Wildlife Research Institute. We thank BenJee Cascio for his thoughts on the manuscript.

**Appendix A. Supplementary data**

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.gecco.2020.e01327>.

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