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*Welfare concerns associated with captive lions (*Panthera leo*) and the implications for commercial lion farms in South Africa*

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Abstract

*Breeding and housing wild animals in captive environments can pose challenges for their welfare. In South Africa, thousands of lions (*Panthera leo*) are bred and raised at commercial captive breeding facilities, so called 'lion farms', for use in tourism, trophy hunting and traditional medicine. To gain a better understanding of the potential welfare challenges faced by lions on farms we reviewed 91 peer-reviewed articles relating to lion welfare, identified via a systematic review of the scientific literature. Across these studies, we identified 170 different terms relating to negative behaviours and physical health afflictions. The majority of these terms were associated with disease and injury (124; 73%), followed by negative behaviours (19; 11%), negative mental experiences (15; 9%), nutritional concerns (7; 4%), and environmental challenges or discomfort arising from the animal's surroundings (5; 3%). Of the 91 articles, 32 (35%) focused on data concerning captive lions. Only two studies focused specifically on data obtained from lion farms in South Africa, whilst the remainder reported on data collected from zoos, wildlife parks, sanctuaries, game reserves and private ownership. Our preliminary review of the scientific literature draws attention to some of the challenges associated with caring for lions in captivity, and outlines the potential significance of these welfare challenges for commercial lion farms. Our data highlight the apparent lack of scientific research involving captive lion welfare generally, particularly data collected at commercial breeding facilities in South Africa and the consequences this could have for the welfare of thousands of lions within the industry.*

Keywords: *animal welfare, captive wildlife, lion farms,* Panthera leo*, South Africa, wildlife farming*

Introduction

African lions (*Panthera leo*) are bred in captivity at hundreds of facilities across South Africa for a range of commercial purposes (Coals *et al* 2019). An estimated 7,800 lions registered at nearly 400 facilities are bred for tourism (eg cub petting and voluntourism), trophy hunting or to harvest their body parts (predominantly bones) for local and international traditional medicine practices (Coals *et al* 2019). The remit of these commercial facilities differs distinctly from venues that focus on *ex situ* conservation and animal rehabilitation (eg zoological institutions, rehabilitation and rescue centres, and sanctuaries), because their primary purpose is to breed lions for financial profit (Green *et al* 2021).

Large volumes of lion bones have been exported as part of a multinational trade with South-East Asia for use in traditional medicine remedies containing tiger and lion bone ingredients (Williams *et al* 2015a,b). Between 2007–2016, South Africa exported 70 metric tonnes of lion bones to South-East Asia, peaking at more than 1,700 skeletons in 2016 (Williams *et al* 2017a).

Within South Africa, domestic legislation allows for the commercial captive breeding of lions under a patchwork of complex laws and regulations at both national and provincial levels (Williams *et al* 2015b; Wilson 2019a; Green *et al* 2021). The international trade in lions and their derivatives is governed by the Convention on International Trade of Endangered Species (CITES). African lions are the only species of the *Panthera* genus to be listed on Appendix II of CITES, allowing managed international commercial trade, authorised by the granting of an export permit from the relevant authorities when pre-specified criteria have been met (Hutchinson & Roberts 2020). South Africa is currently the only country permitted under CITES regulations to legally trade lion bones, provided they are sourced from the captive-bred population, within annual quota limits (Hutchinson & Roberts 2020). The South African Department of Forestry, Fisheries and the Environment (DFFE) is required to establish annual export quotas and report these to the CITES Secretariat annually (Williams & 't Sas-Rolfes 2019). The nine provincial authorities are

mandated with the subsequent issuing of the CITES export permits in the absence of a centralised permitting system (Wilson 2019b). No export quotas were published for 2019 or 2020, following a High Court ruling that the setting of the 2017 and 2018 export quotas was unlawful and constitutionally invalid (SAFLII 2019).

With regards to its impact on wild lion populations, South Africa's commercial captive lion breeding is a contentious issue that is subject to ongoing international scrutiny and scientific debate (Coals *et al* 2019; Hutchinson & Roberts 2020). On the one hand, there are suggestions that the industry could have direct economic and practical benefits to lion conservation efforts (Lindsey *et al* 2012; Van der Merwe *et al* 2017), and that industries reliant on captive-bred lions (eg canned hunting) could provide indirect benefit by incentivising the retention of wildlife habitat that might otherwise be lost to agriculture (Macdonald 2016).

On the other hand, there are concerns that the industry could have unintended negative impacts on lion conservation efforts. For example, the continuous supply of lion bones from breeding facilities could potentially increase wild lion poaching and trafficking, and even indirectly sustain the poaching of tigers (*Panthera tigris*) in Asia, due to a perpetuation or expansion of the market for felid bones (Williams *et al* 2017a; High level panel report 2021). Ultimately, a peer-reviewed, cost-benefit analysis quantifying the economics of the lion industry is currently lacking (Harvey 2019), and the potential impact on wild populations is not yet fully understood (Williams *et al* 2017b; Bauer *et al* 2018; Hinsley & Rust 2019). In acknowledgement of this information gap, research was commissioned by the South African Scientific Authority to obtain further information on lions bred and maintained in captivity and the consequences of trade for wild lions, that will inform policy recommendations to DFFE (Williams & 't Sas-Rolfes 2019).

Furthermore, criticism has focused on the negative animal welfare impacts and unregulated nature of the industry (eg Environment Investigation Agency 2017; Born Free Foundation 2018; EMS Foundation 2018; World Animal Protection 2019). Breeding and trading wildlife is associated with a range of potential welfare concerns (Baker *et al* 2013), and some wild felids have been specifically identified as species facing challenges in captive environments (Clubb & Mason 2003, 2007). In addition, details of extremely poor conditions and consequent suffering at some lion breeding facilities have been reported in the media (Fobar 2019a,b; Katz 2019), raising further cause for concern. Welfare concerns arising from such media reports are evidenced by inspections conducted by South Africa's National Council of Societies for the Prevention of Cruelty to Animals (NSPCA 2017). NSPCA inspections of 95 lion farms during 2016–2017 found that nearly half were housing lions in substandard conditions.

In 2019, the Minister of DFFE initiated a high-level panel (HLP) to review the policies, legislation and practices regarding the management, breeding, hunting, trade and general handling of four wildlife species (including lions) in South Africa. The panel was made up of a range of relevant experts including traditional leaders, farmers and scientists, but received early criticism due to a lack of representation of veterinarians, zoonotic disease specialists, animal welfare experts, environmental lawyers, and species ecologists (Xasa 2019; Pinnock 2020). The panel reported their recommendations to the Minister of DFFE in December 2020 and received Cabinet approval in April 2021. In May, the Minister of DFFE publicly announced her intent to adopt the HLP majority recommendations, which included to halt and reverse the domestication of lions, immediately halt the sale of captive lion derivatives, and to stop the hunting and interactive tourism use of captive-bred lions. These changes will effectively end the commercial captive lion farming industry in South Africa, subject to policy implementation (Green *et al* 2021).

Given the large number of captive-bred lions held on commercial farms across South Africa, the potential welfare challenges faced by carnivores in such captive environments (Clubb & Mason 2003), as well as information reported by the NSPCA and in the media, this study aims to review the academic literature for research focused on welfare implications for lions in captivity. We reviewed a dataset of published, peer-reviewed articles to identify what welfare challenges captive lions could face and the implications this could have for the thousands of lions that are currently involved in South Africa's commercial captive breeding industry.

Materials and methods

The methods used here are akin to those applied in our recent study reviewing pathogenic organisms associated with captive lions (Green *et al* 2020). To provide a preliminary insight into the animal welfare concerns associated with lions in captivity, a systematic review of scientific literature was conducted using the academic journal database Web of Science (Philadelphia, USA). A total of nine search terms relating to lion welfare were searched on the database (Anxiety, Distress, Fear, Harm, Injury, Pain, Suffering, Welfare, Health). Each search term was employed with the Boolean operator 'AND', with the additional term *Panthera leo*. Searches were conducted for the time-period 2009–2019 and returned a total of 92 academic papers. Our search did not limit papers by language, but all returned papers were published in English.

Of the 92 papers identified in the literature search, one could not be obtained and was excluded from this review. The environment in which the lions were studied was recorded for the remaining 91 papers (wild or captive), with specific details on the type of captivity lions were housed in (commercial enterprises, zoos, private ownership or mixed purpose). For the purpose of this study, we define 'zoos' as facilities maintaining a collection of wild animals for a combination of research, conservation and public display, 'commercial enterprises' as facilities maintaining wild animals for commercial purposes to gain financial profit (not for conservation), and 'private ownership' as animals kept in personal possession by members of the public.

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Each paper was read by one of six reviewers. Reviewers searched each paper in its entirety and recorded any terms relating to: (i) malnutrition or food and water deprivation; (ii) environmental challenge or discomfort; (iii) disease or injury; (iv) behavioural restriction; or (v) negative mental experiences. For terms that had some degree of overlap between health and behaviour, clinical terms were included as 'disease or injury', and terms that described a behaviour caused by clinical conditions were included as 'behavioural restriction.' These categories are adapted from the Five Domains Model of animal welfare (Mellor 2016). Reviewers did not search the reference sections of included articles to identity additional studies previously unidentified via the nine search terms listed above.

Results

Of the 91 scientific papers reviewed, 32 (35%) focused on data from captive lions (including live animals and samples from deceased specimens) with the majority of those (26; 81%) reporting on data collected from zoos, wildlife parks and sanctuaries. A further four (13%) studies researched lions under private ownership or at privately owned game reserves. Only two studies focused on data from commercial lion farms in South Africa (Hartman *et al* 2015; Smitz *et al* 2018).

A total of 170 different terms relating to negative aspects of captive lion welfare were identified from the 32 scientific papers focused on data from captive lions identified in this review (Table 1). The majority of these terms cited disease and injury (124; 73%), followed by negative behaviours (19; 11%). The remaining 16% of these terms were spread across the other three categories; 15 (9%) to negative mental experiences (eg fear, anxiety and frustration), seven (4%) to nutrition (eg malnutrition or food and water deprivation), and five (3%) to environmental challenges or discomfort arising from the animals' surroundings, respectively. Figure 1 depicts the proportion of welfare concerns in each category.

Discussion

Our preliminary review of the scientific literature draws attention to some of the challenges associated with caring for lions in captivity. Our compilation of 170 different terms relating to negative behaviours and physical health afflictions across the reviewed literature provides an initial, yet broad, insight into the range of veterinary challenges for both physical and psychological conditions associated with keeping lions in captivity.

The majority (124; 73%) of terms cited relate to physical health, with a broad spectrum of clinical symptoms, diseases, and injuries affecting a wide range of lion anatomy, including (but not limited to) their autoimmune, gastrointestinal, respiratory, musculoskeletal and neurological systems (Table 1). Both pathogenic and non-pathogenic health conditions can emerge as a consequence of inadequate environmental conditions. For example, lack of appropriate space can cause abnormal behaviours or increased aggression leading to injury or negative mental experiences (Khan *et al* 2018), and poor hygiene has been suggested as the reason for increased prevalence in some viral diseases among captive carnivores (Lane *et al* 2016).

Only seven terms (4%) referred to nutrition-related concerns in captive lions, including anaemia, dehydration and nutrient deficiencies (Table 1). However, it is apparent that successfully fulfilling the dietary requirements of captive lions can be a significant management challenge. For example, the mechanical properties of an improper diet have been cited as the main cause of poor oral health in felids (Kapoor *et al* 2016), and nutritional deficiencies have previously lead to malformation and spinal cord degeneration in captive lions (Chandra *et al* 1999; Maratea *et al* 2006). Although only seven terms referred explicitly to nutrition-related concerns, we note that several terms in the 'Disease/Injury' category (for example 'dental calculus' and 'tooth decay' are likely analogous to nutritional concerns).

The 19 terms (11%) relating to behavioural restrictions in captive lions included negative behaviours such as self-mutilation, abnormal pacing, unnatural aggression and antagonistic behaviour (Table 1). Such behaviour exhibited in captive lions can lead to fighting, resulting in injuries (eg tail-bone fractures and bite wounds), which can cause severe pain if left untreated (Olatunji-Akioye *et al* 2010). In addition, some of the 15 terms (9%) relating to negative experiences in the mental domain, chronic stress, anxiety, irritation and neuroticism have been cited as possible causative factors for abnormal behaviours (Suárez *et al* 2017).

Implications for commercial lion farms in South Africa

Given the evidence in this review that lions can face a range of welfare challenges in captivity (see also Figure 2), it is imperative to consider the impact of the lion farming industry on the health and well-being of thousands of lions across South Africa. We found that only two studies in our review focused on data from lion farms in South Africa. One of these studies was a veterinary paper comparing surgical sterilisation techniques in lionesses (Hartman *et al* 2015). The other involved genetic samples taken from three dead lions that had been legally hunted, in order to trace their taxonomic lineage (Smitz *et al* 2018). Neither study focused specifically on lion welfare and no other studies included in this review reported on the welfare of lions housed on commercial facilities (or lion 'farms') in South Africa or elsewhere.

However, welfare concerns raised by NGOs and media reports for lions at commercial breeding facilities in South Africa (Fobar 2019b; Katz 2019) are evidenced by findings from facility inspections (Tables 2 and 3). During 2016–2017, the NSPCA Wildlife Protection Unit inspected 95 lion breeding and holding facilities across South Africa. Nearly half were found to house animals in substandard conditions; 32 were issued non-compliance welfare notices along with 18 warnings of misconduct according to the Animal Protection Act of 1962 (NSPCA 2017). Poor hygiene protocols, insufficient diet, unsatisfactory enclosures, lack of enrichment, insufficient provision of shelters and lack of veterinary treatment for injured or unhealthy lions were among the issues encountered at inspected facilities (NSPCA 2017), demonstrating the reality of the welfare concerns raised.

Table 1 Welfare concerns associated with captive lions (welfare concerns in studies of wild lions were excluded).

Welfare concern	Terms from source papers
Malnutrition/Deprivation of food/Deprivation of water	**Dehydration, obesity** (Norton *et al* 2018), **weight loss** (Harrison *et al* 2010; Viljoen *et al* 2015), **mild to severe anaemia, loss of condition and body weight** (Harrison *et al* 2010), **advanced emaciation** (Viljoen *et al* 2015), **vitamin A deficiency** (Righton *et al* 2011)
Environmental challenge	**Reduction in effective space of the enclosure** (Suárez *et al* 2017), **stress from surrounding environment** (Zucca *et al* 2011), **range restriction, restriction of normal activity, restriction of opportunity for social contact** (Kohari *et al* 2017)
Behavioural restriction/expression of negative behaviours	**Disturbed day-time and night-time behaviours** (Kohari *et al* 2017), **abnormal pacing** (Kohari *et al* 2017; Khan *et al* 2018), **observable stress caused by visitor presence** (Suárez *et al* 2017), **display of aggression** (Martínez-Macipe *et al* 2015; Khan *et al* 2018), **abnormal behaviour** (Zucca *et al* 2011; Khan *et al* 2018), **self-harm, head tossing, auto mutilation, faeces licking, unnatural aggressiveness** (Khan *et al* 2018), **refusal of food stuff** (Olatunji-Akioye *et al* 2010; Khan *et al* 2018), **agonistic behaviour, reduction in overall activity, reduction in complex and exploratory behaviour** (Suárez *et al* 2017), **stress, behavioural abnormalities with level of alertness, dragging of the hind paws** (Zucca *et al* 2011), **withdrawn** (Olatunji-Akioye *et al* 2010)
Negative experiences in the mental domain	**Neuroticism, impulsiveness, fright, distress, frustration, boredom, fearful, suspicious, tense, insecure, constrained, fearful of conspecifics, timid** (Gartner *et al* 2016), **irritation, anxiety** (Soso & Koziel 2017)
Injury/Disease	**Abscess, capsular vasculature, chronic renal disease, echinococcosis, enlarged kidney, fibrous omental adhesions, granuloma, haematoma, lymphoma, mid-abdominal mass, perirenal cyst, polycystic kidney disease, renal cystadenoma, renal neoplasia, subclinical kidney disease, thickened capsule** (Eustace *et al* 2017), **adenocarcinoma (lung, adrenal gland, and eye), adrenal cortical carcinoma, anaplastic squamous cell carcinoma, aural disease, autoimmune disease, basal cell carcinoma, broken teeth, canine distemper virus, cardiac mesothelioma, cardiovascular disease, clinical hypertension with symptoms consistent with stroke, congenital disease, dental disease, dental trauma, dermatologic issues (such as foot-pad cracks and lesions), endocrine disease, endocrine tumours, endometrial carcinomas, enteric adenocarcinoma, feline distemper, fibrosarcoma (ribcage), gastrointestinal disease, genetic disease, GI parasites/infection, haematologic disease, haemolymphatic tumours, hepatic disease, hepatobiliary tumours, histiocytic sarcoma of the spleen, hypertrophic cardiomyopathies, hypertrophic cardiomyopathy (HCM) pericarditis, integument disease, interspecific infection, interspecific trauma, leiomyosarcoma of the uterus, leiomyosarcomas, mammary gland adenocarcinoma, mammary tumours,metastatic adrenal cortical carcinoma (lung and liver), metastatic cardiac mesothelioma, multicentric lymphosarcoma (lymph nodes, liver, spleen), myosarcoma of the subcutis, ocular disease, rabies, renal disease, reproductive disease, reproductive tract related disease (such as pyometra), reproductive tumours, respiratory disease,toxicosis disease, trauma, tubulointerstitial nephritis, wear and tear stress on joints and integuments** (Norton *et al* 2018), ***Aelurostrongylus abstrusus* (lungworm infection)** (Di Cesare *et al* 2016), **anorexia, bilateral pulmonary disease, dyspnoea, corneal opacity, lameness caused by *Mycobacterium bovis* infection, marked alopecia, old/poorly healed bite wounds, tachypnoea** (Viljoen *et al* 2015), **ataxia** (Zucca *et al* 2011; Viljoen *et al* 2015), **bones lodged in canine teeth, gingivitis, tooth decay and fractures, oral cavity disorders** (Whitten *et al* 2019), **congenital biliary cystadenoma** (Caliendo *et al* 2012), **cysts on liver and kidney** (Gerhauser *et al* 2009), **dental calculus** (Kapoor *et al* 2016; Whitten *et al* 2019), **dental fractures** (Norton *et al* 2018; Whitten *et al* 2019), **feline immunodeficiency virus** (Chaber *et al* 2017), **generalised muscle atrophy, head and neck abnormalities, lordosis, lumbar kyphosis, lumbar lordosis, nutritional diseases, paraparesis, parasitic infections or disease, paresis of the tail, proprioceptive deficit hind limbs, spinal ataxia, weakness, chronic diseases** (Zucca *et al* 2011), **hypermetria** (Zucca *et al* 2011; Viljoen *et al* 2015), **infectious disease** (Zucca *et al* 2011; Norton *et al* 2018), chronic stress (Suárez *et al* 2017)*, **lymphocytosis suggesting possible leukaemia, malignant lymphoma bone marrow, malignant lymphoma liver, malignant lymphoma of lymph nodes, malignant lymphoma pharynx, splenomegaly** (Harrison *et al* 2010), **malignant lymphoma of spleen** (Harrison *et al* 2010; Norton *et al* 2018), **mammalian orthoreovirus** (Ahasan *et al* 2019), **musculoskeletal disease** (Zucca *et al* 2011; Norton *et al* 2018), **neoplasia** (Eustace *et al* 2017; Norton *et al* 2018), **neurologic disease** (Zucca *et al* 2011; Norton *et al* 2018), **periodontal disease** (Kapoor *et al* 2016; Norton *et al* 2018), **poor oral health** (Kapoor *et al* 2016), **skull malformation, spinal cord degeneration** (Righton *et al* 2011), **tail-bone fracture, tail wound** (Olatunij-Akioye *et al* 2010), ***Toxascaris leonina*** (Moudgil *et al* 2016)

* Chronic stress included in 'disease/injury' category, according to definition provided in Beausoleil *et al* (2018).

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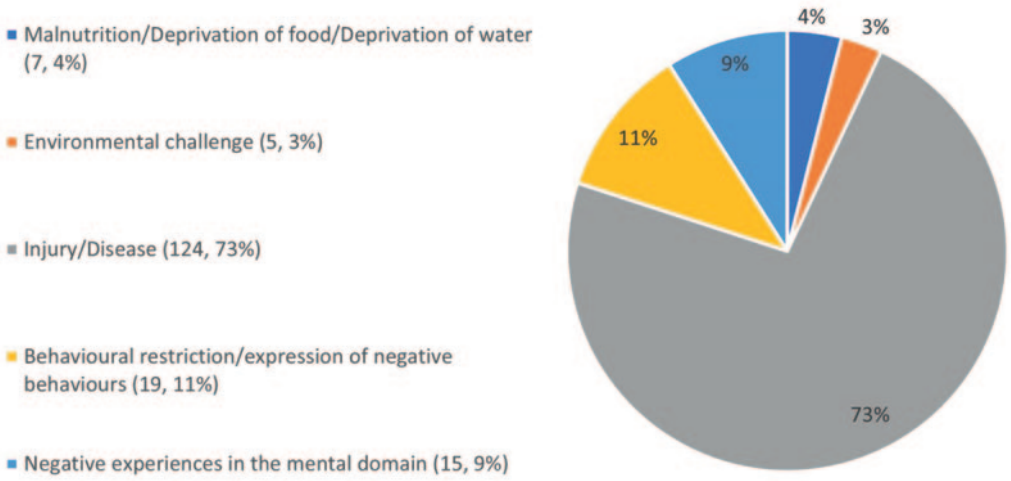
Figure 1



Welfare concerns relating to captive lions (n = 170) by category as adapted from the Five Domains Model (Mellor 2016).

Figure 2

Environments provided for lions at commercial captive breeding facilities in South Africa have frequently been reported as low welfare, involving large numbers of lions, often in unhygienic conditions and in over-crowded spaces. Water provided for the lions is dirty and covered with algae (top left). A severely emaciated lion (top right). Lions in barren enclosures with no shelter or enrichment (bottom left) and housed in overcrowded conditions (bottom right). Images provided and reproduced with permission from Blood Lions.

Lions involved in commercial breeding operations are likely to face far greater challenges than in any other captive environment, such as zoos and sanctuaries (Green *et al* 2021, 2020). Specifically, lion farms comprise a higher number of lions housed in greater densities, which can present challenges in meeting baseline hygiene, space and diet requirements as well as providing required veterinary care. In addition, the intensive breeding that occurs as a result of pressure to produce a large number of cubs has serious consequences for the health and welfare of the animals involved. For example, high stress following repeated pregnancy can increase susceptibility to infectious disease (Viljoen *et al* 2015) as well as cystic ovaries and other uterine and ovarian issues (Peter Caldwell, personal communication 2020). Breeding lions within small captive populations can also lead to inbreeding, which increases susceptibility to infectious diseases such as bovine tuberculosis (Trinkel *et al* 2011).

Table 2 Non-compliance welfare notices issued by the NSPCA Wildlife Protection Unit during the period of March 2016–June 2017 (NSPCA 2017).

Poor hygiene protocols	More regular cleaning of adult lion and cub holding camps to remove excessive faeces, litter and/or uneaten carcases
	More regular cleaning of water bodies in camps
Insufficient dietary requirements	Improved diet for adult lions and to make use of carnivore specialised diets
	Improvement to cub diets, use of specialised milk formulas instead of dairy
	Cubs must be provided with additional supplements to ensure necessary nutrition is received
	Adjusting diet of over-/underweight animals
Lack of shelter	Provision of adequate shelters to accommodate all animals in camps
Unsatisfactory enclosure designs	Construction of feeding camps to facilitate safe feeding of lions
	Repair cage furniture
	Enlarging of camps/night rooms used for nursing lionesses and cubs
	Construction of feeding camps to facilitate safe maintenance of enclosures
	Access to drains and filling of water troughs from outside of camps to facilitate easier maintenance
	Supply of smaller more manageable water troughs to eliminate neglect of larger dams
	Imbalance in male to female ratio in pride
Lack of veterinary treatment	Improve parasite control and fly deterrent methods
	More regular visits from veterinarians to ensure health of animals
	Provision of environmental enrichment, especially in camps without natural vegetation
Lack of continual enrichment	Provision of environmental enrichment for young animals in the form of climbing structures, stumps, hiding areas, etc

Table 3 Warnings issued in terms of the Animal Protection Act of 1962 by the NSPCA Wildlife Protection Unit during the period of March 2016–June 2017 (NSPCA 2017).

Poor hygiene protocols	All animals must have access to fresh potable water and water containers must be cleaned and algae removed in terms of Section 2 (1) (c)
	Improvement of hygiene and more regular cleaning of adult and cub holding camps in terms of Section 2 (1) (e) of the APA
	Remove all uneaten food and decomposing carcases from the enclosure in terms of Section 2 (1) (e) of the APA
	Implementation of a disinfectant protocol for cub interactions in terms of Section 2 (1) (e) of the APA
Insufficient dietary requirements	Improvement of diet and feeding routine in terms of Section 2 (1) (c) of the APA
	Food provided to animals must be of good quality and fresh. No rotting meat may be fed to animals in terms of Section (2) (c) of the APA
Lack of shelter	Insufficient and/or lack of shelters and shade for all animals in camp in terms of Section 2 (1) (b) of the APA
Unsatisfactory enclosure designs	Large numbers of cubs kept in a small living environment and must be moved to a more suitable environment with sufficient space in terms of section 2 (1) (b) of the APA
	Repair of shelters which had dangerous protruding objects, removing of rubble and wire from camps in terms of Section 2 (1) (b)
	Predator and prey species may not be kept in adjacent enclosures and partitioning must be placed in between enclosures in terms of Section 2 (1) (g)
Lack of veterinary treatment	Veterinary care must be provided to animals in terms of Section 2 (1) (e) of the APA
	Implementation of fly control measures and veterinary treatment of fly strike in terms of Section 2 (1) (e) of the APA

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Furthermore, the premature separation of mothers and cubs and the subsequent bottle-feeding of cubs on alternative milk formula that lacks essential amino acids, such as taurine, and is deficient in Vitamin A, is a reported practice at commercial breeding facilities (Peter Caldwell, personal communication 2020). Nutritional deficiencies can compromise the immune system and leave animals more susceptible to pathogens (Beck & Levander 2000). An example of such health ramifications was published in a media report of two lion cubs that were confiscated by the NSPCA from a breeder in the North-West Province in early 2019. The cubs suffered from bacterial meningoencephalitis with long-term health implications, as well as three different skin conditions, namely mange, pyoderma and alopecia (Fobar 2019b).

Tourism activities offered at captive lion facilities also pose unique challenges, for example, the handling of wild animals for use as 'photo props' can severely compromise their well-being (eg Carder *et al* 2018). Similar welfare challenges have been reported for big cats housed at commercial tourist venues across Asia, for example, the controversial practices exposed at a popular tourist venue 'The Tiger Temple' in western Thailand and reports of 'factory farming' conditions associated with severe welfare concerns at several commercial breeding facilities in China (Cohen 2013; World Animal Protection 2019). Therefore, the lack of studies reporting data from lions housed at commercial facilities indicates a research gap that should be addressed.

Finally, in the absence of norms and standards for the slaughter of wild animals, the manner and conditions in which lions are euthanased and slaughtered for their bones is not immediately apparent and is therefore of additional potential animal welfare concern. There are anecdotal reports of 'lion abattoirs' in the media (Welz 2018; Katz 2019) reporting the slaughter of groups of lions by tranquilising and shooting them through the ear rather than the cranium to preserve the integrity of the skull for buyers. But there does not appear to be any further publicly available information about these abattoir facilities or the standards of practice they adhere to.

Following the Minister of DFFE's announcement of her intent to adopt the HLP recommendations to end the commercial use of lions in South Africa (High level panel report 2021), attention should be focused on the welfare of lions on farms during the transition from its current state (Green *et al* 2021). For example, the provision of adequate veterinary care and humane euthanasia practices, when necessary, for the benefit of the animal (Table 2) and prohibiting activities that involve direct interaction between people and lions. Increased transparency on the conditions provided at lion farms as well as access to these facilities would ensure proper animal welfare standards are continuously met and that relevant regulations are adhered to during the transition away from the current state of the industry (Green *et al* 2021).

Limitations

We acknowledge that restricting our search to a limited time-period (2009–2019) and to one academic database will limit the number of relevant articles in our review. However, our intention was only to provide a preliminary insight into the welfare challenges faced by captive lions and their significance for lion farming. Furthermore, we recognise that information about the welfare of lions at commercial breeding facilities is also widely reported in the media and in reports produced by animal-centred NGOs, and that our study could be considered limited by only including peer-reviewed literature in our analysis. While we recognise our review may omit some relevant welfare concerns, we hope that this initial snapshot provides useful information and highlights knowledge gaps that can help guide future policy.

Furthermore, we note that some of the welfare concerns and health conditions outlined in our review could also potentially occur in lions in the wild, and thus they cannot be considered exclusively a symptom of captivity. However, this does not detract from the scope of welfare concerns that present management challenges in captive environments, which was the focus of our review. Future studies in this field providing a more in-depth analysis of the welfare concerns outlined here, with particular attention to the prevalence of each welfare concern throughout different captive environments, would provide valuable further insight.

Conclusion

It is clear from this initial review of the relevant scientific literature available that a multitude of animal welfare challenges are associated with caring for lions in captivity. It is reasonable to assume that, in comparison to captive breeding for conservation purposes and in light of recent inspections (NSPCA 2017), the management challenges faced by keeping lions in captivity are amplified under commercial farming conditions, where intensive breeding practices are employed for consumer-driven end 'use' and income generation. The HLP report confirms that although some operators may implement acceptable standards of welfare, there are major welfare contraventions in the industry in general (High level panel report 2021). With this in mind, the apparent lack of scientific research focused on the extent to which commercial captive breeding impacts negatively on lion welfare is a cause for concern. We recommend that increased research attention on this subject would aid efforts to minimise negative animal welfare impacts during the planned phase out of commercial lion farming in South Africa.

Declaration of 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. JG, EA, AP, and NDC hold research-related roles with the NGO World Animal Protection. NDC also holds research associate status at WildCRU, University of Oxford. CJ and LdW hold positions with the NGO Blood Lions. All authors were involved in either study design; collection, analysis and interpretation of data; writing of the paper; and/or decision to submit to *Animal Welfare*.

References

Ahasan MS, Subramaniam K, Sayler KA, Loeb JC, Popov VL, Lednicky JA, Wisely SM, Krauer JMC and Waltzek TB 2019 Molecular characterization of a novel reassortment Mammalian orthoreovirus type 2 isolated from a Florida white-tailed deer fawn. *Virus Research 270*: 197642. https://doi.org/10.1016/j.virusres.2019.197642

Baker SE, Cain R, Van Kesteren F, Zommers ZA, D'Cruze N and Macdonald DW 2013 Rough trade: animal welfare in the global wildlife trade. *BioScience 63*: 928-938. https://doi.org/10.1525/bio.2013.63.12.6

Bauer H, Nowell K, Sillero-Zubiri C and Macdonald DW 2018 Lions in the modern arena of CITES. *Conservation Letters 11*: e12444. https://doi.org/10.1111/conl.12444

Beausoleil NJ, Mellor DJ, Baker L, Baker SE, Bellio M, Clarke A, Dale A, Garlick S, Jones B, Harvey A, Pitcher B, Sherwen S, Stockin K and Zito S 2018 "Feelings and fitness' not 'feelings or fitness' – the raison d'etre of conservation welfare, which aligns conservation and animal welfare objectives'. *Frontiers in Veterinary Science 5*: 296. https://doi.org/10.3389/fvets.2018.00296

Beck MA and Levander OA 2000 Host nutritional status and its effect on a viral pathogen. *The Journal of Infectious Diseases 182*: S93-S96. https://doi.org/10.1086/315918

Born Free Foundation 2018 *Cash Before Conservation: An overview of the breeding of lions for hunting and bone trade.* https://www.bornfree.org.uk/storage/media/content/files/Publications/Born_Free_Lion_Breeding_Report.pdf

Caliendo V, Bull AC and Stidworthy MF 2012 Congenital biliary tract malformation resembling biliary cystadenoma in a captive juvenile African lion (*Panthera leo*). *Journal of Zoo and Wildlife Medicine 43*: 922-926. https://doi.org/10.1638/2011-0065R1.1

Carder G, Plese T, Machado FC, Paterson S, Matthews N, McAnea L and D'Cruze N 2018 The impact of 'selfie' tourism on the behaviour and welfare of brown-throated three-toed sloths. *Animals 8*: 216. https://doi.org/10.3390/ani8110216

Chaber A-L, Cozzi G, Broekhuis F, Hartley RW and McNutt J 2017 Serosurvey for selected viral pathogens among sympatric species of the African large predator guild in northern Botswana. *Journal of Wildlife Diseases 53*: 170-175. https://doi.org/10.7589/2015-11-302

Chandra AS, Papendick RE, Schumacher J, Homer BL and Wollenman P 1999 Cerebellar herniation in captive lions (*Panthera leo*). *Journal of Veterinary Diagnostic Investigation 11*: 465-468. https://doi.org/10.1177/104063879901100514

Clubb R and Mason G 2003 Animal welfare: captivity effects on wide-ranging carnivores. *Nature 425*: 473. https://doi.org/10.1038/425473a

Clubb R and Mason GJ 2007 Natural behavioural biology as a risk factor in carnivore welfare: How analysing species differences could help zoos improve enclosures. *Applied Animal Behaviour Science 102*: 303-328. https://doi.org/10.1016/j.applanim.2006.05.033

Coals P, Burnham D, Loveridge A, Macdonald DW, Sas-Rolfes M, 't Williams VL and Vucetich JA 2019 The ethics of human-animal relationships and public discourse: A case study of lions bred for their bones. *Animals 9*: 52. https://doi.org/10.3390/ani9020052

Cohen E 2013 'Buddhist compassion' and 'animal abuse' in Thailand's Tiger Temple. *Society & Animals 21*: 266-283. https://doi.org/10.1163/15685306-12341282

Di Cesare A, Laiacona F, Iorio R, Marangi M and Menegotto A 2016 *Aelurostrongylus abstrusus* in wild felids of South Africa. *Parasitology Research 115*: 3731-3735. https://doi.org/10.1007/s00436-016-5134-y

EMS Foundation 2018 *The extinction business: South Africa's 'lion' bone trade.* EMA Foundation and Ban Animal Trading. https://ems-foundation.org.za/wp-content/THE-EXTINCTION-BUSINESS-South-Africas-lion-bone-

Environment Investigation Agency 2017 *The lion's share: South Africa's trade exacerbates demand for tiger parts and derivative.* Environment Investigation Agency. https://eia-international.org/wp-content/uploads/The-Lions-Share-FINAL-1.pdf

Eustace R, Rubin J, Thompson KA, Snowdon K, Sikarskie JG, Monahan C and Smedley RC 2017 Diagnosis and treatment of a unilateral renal cystadenoma in an african lion (*Panthera leo*). *Journal of Zoo and Wildlife Medicine 48*: 906-909. https://doi.org/10.1638/2016-0242.1

Fobar R 2019a *More than 100 neglected lions found in a South African breeding facility.* National Geographic. https://www.nationalgeographic.co.uk/animals/2019/05/more-100-neglected-lions-discovered-south-africa-breeding-facility

Fobar R 2019b *Exclusive: Inside a controversial South African lion farm.* National Geographic. https://www.nationalgeographic.co.uk/animals/2019/11/exclusive-inside-controversial-south-african-lion-farm

Gartner MC, Powell DM and Weiss A 2016 Comparison of subjective well-being and personality assessments in the clouded leopard (*Neofelis nebulosa*), snow leopard (*Panthera uncia*), and African lion (*Panthera leo*). *Journal of Applied Animal Welfare Science 19*: 294-302. https://doi.org/10.1080/10888705.2016.1141057

Gerhauser I, Philipp U, Distl O and Beineke A 2009 Multiple cyst formation in the liver and kidneys of a lion (*Panthera leo*): a case of polycystic kidney disease? *European Journal of Wildlife Research 55*: 433-437. https://doi.org/10.1007/s10344-009-0260-9

Green J, Jakins C, Asfaw E, Bruschi N, Parker A, de Waal L and D'Cruze N 2020 African lions and zoonotic diseases: Implications for commercial lion farms in South Africa. *Animals 10*: 1692. https://doi.org/10.3390/ani10091692

Green J, Jakins C, de Waal L and D'Cruze N 2021 Ending commercial lion farming in South Africa: A gap analysis approach. *Animals 11*: 1717. https://doi.org/10.3390/ani11061717

https://doi.org/10.7120/09627286.31.2.005 Published online by Cambridge University Press

Harrison TM, McKnight CA, Sikarskie JG, Kitchell BE, Garner MM, Raymond JT, Fitzgerald SD, Valli VE, Agnew D and Kiupel M 2010 Malignant lymphoma in African lions (*Panthera leo*). *Veterinary Pathology 47*: 952-957. https://doi.org/10.1177/0300985810375054

Hartman MJ, Monnet E, Kirberger RM and Schoeman JP 2015 Effect of portal access system and surgery type on surgery times during laparoscopic ovariectomy and salpingectomy in captive African lions and cheetahs. *Acta Veterinaria Scandinavica 58*: 18

Harvey R 2019 *The economics of captive predator breeding in South Africa.* South African Institute of International Affairs: Johannesburg, South Africa

High level panel report 2021 https://www.environment.gov.za/sites/default/files/reports/2020-12-22_high-levelpanel_report.pdf

Hinsley A and Rust N 2019 Lion and tiger farming may be inhumane, but we don't know if it increases poaching. *The Conversation.* https://theconversation.com/lion-and-tiger-farming-may-be-inhumane-but-we-dont-know-if-it-increases-poaching-120040

Hutchinson A and Roberts DL 2020 Differentiating captive and wild African lion (*Panthera leo*) populations in South Africa, using stable carbon and nitrogen isotope analysis. *Biodiversity and Conservation*: 1-19. https://doi.org/10.1007/s10531-020-01972-0

Kapoor V, Antonelli T, Parkinson JA and Hartstone-Rose A 2016 Oral health correlates of captivity. *Research in Veterinary Science 107*: 213-219. https://doi.org/10.1016/j.rvsc.2016.06.009

Katz B 2019 *108 neglected lions found on South African breeding farm.* Smithsonian Magazine. https://www.smithsonianmag.com/smart-news/108-neglected-lions-found-south-african-breeding-farm-180972146/

Khan BN, Ahmad R, Ali Z, Mehmood S, Raza H, Azhar M and Zakir A 2018 Impact of different captive environmental conditions on behavior of African Lions and their welfare at Lahore Zoo and Safari Zoo, Lahore. *Pakistan Journal of Zoology 50(2).* https://doi.org/10.17582/journal.pjz/2018.50.2.523.531

Kohari D, Sunada A, Matsui Y, Ootaki A and Hori H 2017 Behavioral restriction effects on activity motivation of a captive lion (*Panthera leo persica*). *Journal of Veterinary Behavior 17*: 14-18. https://doi.org/10.1016/j.jveb.2016.11.002

Lane EP, Brettschneider H, Caldwell P, Oosthuizen A, Dalton DL, du Plessis L, Steyl J and Kotze A 2016 Feline panleukopaenia virus in captive non-domestic felids in South Africa. *Onderstepoort Journal of Veterinary Research 83*: 1-8. https://doi.org/10.4102/ojvr.v83i1.1099

Lindsey P, Alexander R, Balme G, Midlane N and Craig J 2012 Possible relationships between the South African captive-bred lion hunting industry and the hunting and conservation of lions elsewhere in Africa. *South African Journal of Wildlife Research 42*: 11-22. https://doi.org/10.3957/056.042.0103

MacDonald D 2016 *Report on lion conservation with particular respect to the issue of trophy hunting.* WildCru: Oxford, UK

Maratea KA, Hooser SB and Ramos-Vara JA 2006 Degenerative myelopathy and vitamin A deficiency in a young black-maned lion (*Panthera leo*). *Journal of Veterinary Diagnostic Investigation 18*: 608-611. https://doi.org/10.1177/104063870601800617

Martínez-Macipe M, Lafont-Lecuelle C, Manteca X, Pageat P and Cozzi A 2015 Evaluation of an innovative approach for sensory enrichment in zoos: semiochemical stimulation for captive lions (*Panthera leo*). *Animal Welfare 24*: 455-461. https://doi.org/10.7120/09627286.24.4.455

Mellor DJ 2016 Updating animal welfare thinking: Moving beyond the 'Five Freedoms' towards 'a Life Worth Living.' *Animals 6*: 21. https://doi.org/10.3390/ani6030021

Moudgil AD, Singla LD and Singh MP 2016 An issue of public health concern due to emerging drug resistance against *Toxascaris leonina* (Linstow 1909) in Asiatic lions (*Panthera leo persica*). *International Journal of Infectious Diseases 45*: 105. https://doi.org/10.1016/j.ijid.2016.02.271

Norton BB, Tunseth D, Holder K, Briggs MC, Hayek L-A and Murray S 2018 Causes of morbidity in captive African lions (*Panthera leo*) in North America, 2001-2016. *Zoo Biology 37*: 354-359. https://doi.org/10.1002/zoo.21435

NSPCA 2017 *Overview of inspection to lion breeding farms by the National Wildlife Protection Unit Inspectorate during the period March 2016–June 2017.* National Society for Prevention of Cruelty to Animals (NSPCA): Alberton, South Africa

Olatunji-Akioye AO, Omobowale OT, Olaifa AK and Abiola JO 2010 Tail docking in an african lion (*Panthera leo*). *Israel Journal of Veterinary Medicine 65*: 75-76

Pinnock D 2020 *Wildlife experts spurn invite to serve on environmental panel, indicating bias and co-optio.* The Conversation. https://conservationaction.co.za/media-articles/wildlife-experts-spurn-invite-to-serve-on-environmental-panel-indicating-bias-and-co-optio/

Righton AL, St Leger JA, Schmitt T, Murray MJ, Adams L and Fascetti AJ 2011 Serum vitamin A concentrations in captive sea otters (*Enhydra lutris*). *Journal of Zoo and Wildlife Medicine 42*: 124-127. https://doi.org/10.1638/2010-0011.1

Smitz N, Jouvenet O, Ligate FA, Crosmary W-G, Ikanda D, Chardonnet P, Fusari A, Meganck K, Gillet F and Melletti M 2018 A genome-wide data assessment of the African lion (*Panthera leo*) population genetic structure and diversity in Tanzania. *PLoS One 13*: e0205395. https://doi.org/10.1371/journal.pone.0205395

Soso SB and Koziel JA 2017 Characterizing the scent and chemical composition of *Panthera leo* marking fluid using solid-phase microextraction and multidimensional gas chromatography-mass spectrometry-olfactometry. *Scientific Reports 7*: 1-15. https://doi.org/10.1038/s41598-017-04973-2

Suárez P, Recuerda P and Arias-de-Reyna L 2017 Behaviour and welfare: The visitor effect in captive felids. *Animal Welfare 26*: 25-34. https://doi.org/10.7120/09627286.26.1.025

The Southern African Legal Information Institute (SAFLII) 2019 *The Southern African Legal Information Institute (SAFLII)*. http://www.saflii.org/za/cases/ZAGPPHC/2019/337.html

Trinkel M, Cooper D, Packer C and Slotow R 2011 Inbreeding depression increases susceptibility to bovine tuberculosis in lions: an experimental test using an inbred-outbred contrast through translocation. *Journal of Wildlife Diseases 47*: 494-500. https://doi.org/10.7589/0090-3558-47.3.494

Van der Merwe P, Saayman M, Els J and Saayman A 2017 The economic significance of lion breeding operations in the South African Wildlife Industry. *International Journal of Biodiversity and Conservation 9*: 314-322

Viljoen IM, Van Helden PD and Millar RP 2015 *Mycobacterium bovis* infection in the lion (*Panthera leo*): Current knowledge, conundrums and research challenges. *Veterinary Microbiology 177*: 252-260. https://doi.org/10.1016/j.vetmic.2015.03.028

Welz A 2018 *The Ongoing Disgrace of South Africa's Captive-Bred Lion Trade*. Yale Environment 360, Yale School of Forestry & Environmental Studies: USA. https://e360.yale.edu/features/the-ongoing-disgrace-of-south-africas-captive-bred-lion-trade

Whitten C, Vogelnest L, D'Arcy R, Thomson P and Phalen D 2019 A retrospective study of reported disorders of the oral cavity in large felids in Australian zoos. *Journal of Zoo and Wildlife Medicine 50*: 16-22. https://doi.org/10.1638/2016-0170

Williams V, Loveridge AJ, Newton DJ and Macdonald DW 2015 'Skullduggery': lions align and their mandibles rock! *PLoS One 10*: e0135144. https://doi.org/10.1371/journal.pone.0135144

Williams V, Newton D, Loveridge A and Macdonald D 2015 Bones of contention: As assessment of the South African trade in African Lion (*Panthero leo*) bones and other body parts. TRAFFIC and WildCRU. https://www.traffic.org/site/assets/files/2474/bones-of-contention-report-pdf

Williams VL, Loveridge AJ, Newton DJ and Macdonald DW 2017a A roaring trade? The legal trade in *Panthera leo* bones from Africa to East-Southeast Asia. *PLoS One 12*: e0185996. https://doi.org/10.1371/journal.pone.0185996

Williams VL, Loveridge AJ, Newton DJ and Macdonald DW 2017b Questionnaire survey of the pan-African trade in lion body parts. *PLoS One 12*: e0187060. https://doi.org/10.1371/journal.pone.0187060

Williams VL and 't Sas-Rolfes MJ 2019 Born captive: A survey of the lion breeding, keeping and hunting industries in South Africa. *PLoS One 14*: e0217409. https://doi.org/10.1371/journal.pone.0217409

Wilson A 2019a *South Africa's fallen pride: How law and government fail to protect lions*. The Revelator, Center for Biological Diversity. https://therevelator.org/lion-hunting-south-africa

Wilson A 2019b *Animal Law in South Africa: Until the lions have their own lawyers, the law will continue to protect the hunter (No Vol 10/1)*. dA.Derecho Animal, Forum of Animal Law Studies. https://doi.org/10.5565/rev/da.399

World Animal Protection 2019 *Trading cruelty - how captive big cat farming fuels the traditional Asian medicine industry*. https://d31j74p4lpxrfp.cloudfront.net/sites/default/files/int_files/trading_cruelty_report.pdf

Xasa F 2019 *Committee Report on Colloquium on Captive Lion Breeding for Hunting in SA 21 & 22 August 2018 ATC181108: Report of the Portfolio Committee on Environmental Affairs on the Colloquium on Captive Lion Breeding for Hunting in South Africa: harming or promoting the conservation image of the country, held on 21 and 22 august 2018, dated 8 November 2018*. Parliamentry Monitoring Group. https://pmg.org.za/committee-meeting/294351

Zucca P, Baciadonna L, Masci S and Mariscoli M 2011 Illness as a source of variation of laterality in lions (*Panthera leo*). *Laterality 16*: 356-366. https://doi.org/10.1080/13576501003690025

https://doi.org/10.7120/09627286.31.2.005 Published online by Cambridge University Press