Article title: A review of spotted hyaena population estimates highlights the need for greater utilisation of spatial capture-recapture methods

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Table S1. Summary of the 60 publications found in the literature search that reported spotted hyaena (*Crocuta crocuta*) population estimates and the survey methods used. The survey method used is denoted as: call in (CI), track count (TC), total count (TO), spatial capture-recapture (SCR), capture-recapture (CR), distance sampling (DS). The country and region of Africa where the study was conducted is also presented.

ID	Year	Authors	Journal	Title	Method	Country	Region
1	2019	Rich et al.	Biological Conservation	Sampling design and analytical advances allow for simultaneous density estimation of seven sympatric carnivore species from camera trap data	SCR	Botswana	Southern
2	2016	M'soka et al.	Biological Conservation	Spotted hyaena survival and density in a lion depleted ecosystem: the effects of prey availability, humans and competition between large carnivores in African savannahs	CR	Zambia	Southern
3	2020	Fouché et al.	African Journal of Ecology	Density estimates of spotted hyaena (*Crocuta crocuta*) on arid farmlands of Namibia	SCR	Namibia	Southern
4	2012	Höner et al.	Journal of Animal Ecology	The impact of a pathogenic bacterium on a social carnivore population	TO	Tanzania	East
5	2017	Kirsten et al.	African Journal of Ecology	Lion (*Panthera leo*) and spotted hyena (*Crocuta crocuta*) abundance in Bouba Ndjida National Park, Cameroon; trends between 2005 and 2014	CI	Cameroon	Central
6	2007	Bauer	African Journal of Ecology	Status of large carnivores in Bouba Ndjida National Park, Cameroon	CI	Cameroon	Central
7	2015	Bauer et al.	African Journal of Ecology	Large carnivore abundance in the Benoue Ecosystem, North Cameroon	TC	Cameroon	Central
8	2013	Cozzi et al.	Biodiversity Conservation	Density and habitat use of lions and spotted hyenas in northern Botswana and the influence of survey and ecological variables on call-in survey estimation	CI	Botswana	Southern
9	2011	Croes et al.	Biological Conservation	The impact of trophy hunting on lions (*Panthera leo*) and other large carnivores in the Bénoué Complex, northern Cameroon	TC	Cameroon	Central
10	2015	Yirga et al.	Wildlife Research	Spotted hyena (*Crocuta crocuta*) concentrate around urban waste dumps across Tigray, northern Ethiopia	CI	Ethiopia	East
11	2005	Ogutu et al.	Journal of Zoology	The effects of pastoralism and protection on the density and distribution of carnivores and their prey in the Mara ecosystem of Kenya	CI	Kenya	East

12	2009	Watts & Holekamp	Journal of Mammalogy	Ecological determinants of survival and reproduction in the spotted hyena	TO	Kenya	East
13	2002	Höner et al.	Journal of Animal Ecology	The response of spotted hyaenas to long-term changes in prey populations: functional response and interspecific kleptoparasitism	TO	Tanzania	East
14	2005	Höner et al.	Oikos	The effect of prey abundance and foraging tactics on the population dynamics of a social, territorial carnivore, the spotted hyena	TO	Tanzania	East
15	2002	Creel & Creel	Book	The African wild dog	CI	Tanzania	East
16	2009	Trinkel	Canadian Journal of Zoology	A keystone predator at risk? Density and distriubtion of the spotted hyena (*Crocuta crocuta*) in the Etosha National Park, Namibia	CI	Namibia	Southern
17	2009	Graf et al.	Acta Theriologica	Heterogeneity in the density of spotted hyaenas in Hluhluwe-iMfolozi Park, South Africa	CI	South Africa	Southern
18	2008	Kiffner et al.	African Journal of Ecology	Response of lions (*Panthera leo* LINNAEUS 1758) and spotted hyaenas (*Crocuta crocuta* ERXLEBEN 1777) to sound playbacks	CI	Tanzania	East
19	2001	Mills et al.	Animal Conservation	Estimating the size of spotted hyaena (*Crocuta crocuta*) populations through playback recordings allowing for non-response	CI	South Africa	Southern
20	2016	Ferreira & Funston	African Journal of Wildlife Research	Population estimates of spotted hyaenas in the Kruger National Park, South Africa	CI	South Africa	Southern
21	2014	Groom et al.	Oryx	Surveys of lions *Panthera leo* in protected areas in Zimbabwe yield disturbing results: what is driving the population collapse	CI	Zimbabwe	Southern
22	2012	Mbizah et al.	South African Journal of Wildlife Research	Diet of four sympatric carnivores in Save Valley Conservancy, Zimbabwe: implications for conservation of the African wild dog (*Lycaon pictus*)	TC	Zimbabwe	Southern
23	2014	Omoya et al.	Oryx	Estimating population sizes of lions *Panthera leo* and spotted hyaenas *Crocuta crocuta* in Uganda's savannah parks, using lure count methods	CI	Uganda	East
24	2011	Durant et al.	Journal of Applied Ecology	Long-term trends in carnivore abundance using distance sampling in Serengeti National Park, Tanzania	DS	Tanzania	East
25	2013	Yirga et al.	Mammalian Biology	Spotted hyena (*Crocuta crocuta*) coexisting at high density with people in Wukro district, northern Ethiopia	CI	Ethiopia	East
26	2014	Yirga et al.	Momona Ethiopian Journal of Science	Status of lion (*Panthera leo*) and spotted hyena (*Crocuta crocuta*) in Nechisar National Park, Ethiopia	CI	Ethiopia	East
27	2014	Yirga et al.	Mammalian Biology	Local spotted hyena abundance and community tolerance of depredation in human-dominated landscapes in Northern Ethiopia	CI	Ethiopia	East
28	2017	Yirga et al.	Mammalian Biology	Densities of spotted hyaena (*Crocuta crocuta*) and African golden wolf (*Canis anthus*) increase with increasing anthropogenic influence	CI	Ethiopia	East
29	2011	Yirga et al.	European Journal of Wildlife Research	Peri-urban spotted hyena (*Crocuta crocuta*) in northern Ethiopia: diet, economic impact, and abundance	CI	Ethiopia	East
30	2020	Aebischer et al.	Biological Conservation	Apex predators decline after an influx of pastoralists in former Central African Republic hunting zones	TC, CI	Central African Republic	Central

31	2014	Keeping	Animal Conservation	Rapid assessment of wildlife abundance: estimating animal density with track counts using body mass-day range scaling rules	TC	South Africa	Southern
32	2018	Green et al.	Biodiversity Conservation	Anthropogenic disturbance induces opposing population trends in spotted hyenas and African lions	TO	Kenya	East
33	2020	Henschel et al.	African Journal of Ecology	Census and distribution of large carnivores in the Tsavo national parks, a critical east African wildlife corridor	TC	Kenya	East
34	2011	O'Brien & Kinnaird	Ecological Applications	Density estimation of sympatric carnivores using spatially explicit capture-recapture methods and standard trapping grid	SCR	Kenya	East
35	2019	Green et al.	Philosophical Transactions B	Can hyena behaviour provide information on population trends of sympatric carnivores?	TO	Kenya	East
36	2019	Farr et al.	Ecological Applications	Multispecies hierarchical modeling reveals variable responses of African carnivores to management alternatives	DS	Kenya	East
37	2011	Fewster	Biometrics	Variance estimation for systematic designs in spatial surveys	DS	Tanzania	East
38	2019	Rafiq et al.	Current Biology	Tourist photographs as a scalable framework for wildlife monitoring in protected areas	SCR, TC, CI	Botswana	Southern
39	2020	Stratford et al.	African Journal of Ecology	Dyadic associations reveal clan size and social network structure in the fission-fusion society of spotted hyaenas	CR	Namibia	Southern
40	2008	Watts & Holekamp	Journal of Zoology	Interspecific competition influeces reproduction in spotted hyenas	TO	Kenya	East
41	2010	Funston et al.	Journal of Zoology	Substrate and species constraints on the use of track incidences to estimate African large carnivore abundance	TC	South Africa	Southern
42	2019	Ahlswede et al.	African Journal of Ecology	Using the Formozov-Malyshev-Pereleshin formula to convert mammal spoor counts into density estimates for long-term community-level monitoring	TC	Namibia	Southern
43	2019	Mohammed et al.	African Journal of Ecology	Lion and spotted hyaena abundance in Dinder National Park, Sudan	CI	Sudan	East
44	2020	Davis et al.	Journal of Zoology	Spatial partial identity model reveals low densities of leopard and spotted hyaena in a miombo woodland	SCR	Malawi	Southern
45	2014	Henschel et al.	Journal of Mammalogy	The status of savanna carnivores in the Odzala-Kokoua National Park, northern Republic of Congo	CR	Republic of Congo	Central
46	2020	Mbise et al.	Global Ecology and Conservation	Do carnivore surveys match reports of carnivore presence by pastoralists? A case of the eastern Serengeti ecosystem	CI	Tanzania	East
47	2017	Ogutu et al.	PLOS ONE	Wildlife population dynamics in human-dominated landscapes under community-based conservation: the example of Nakuru Wildlife Conservancy, Kenya	TO	Kenya	East
48	2021	Vissia et al.	Journal of Zoology	Co-occurrence of high densities of brown hyena and spotted hyena in central Tuli, Botswana	SCR	Botswana	Southern
49	2018	Keeping et al.	Biological Conservation	Can trackers count free-ranging wildlife as effectively and efficiently as conventional aerial survey and distance sampling? Implications for citizen science in the Kalahari, Botswana	TC	Botswana	Southern

50	2019	Dunnick et al.	Oryx	A socio-ecological landscape analysis of human-wildlife conflict in northern Botswana	TC	Botswana	Southern
51	2013	Funston et al.	PLOS ONE	Insights into the management of large carnivores for profitable wildlife-based land uses in African Savannas	TC	Zimbabwe	Southern
52	2021	Sonowane, Yirga & Carter	Journal of Applied Ecology	Public health and economic benefits of spotted hyenas *Crocuta crocuta* in a peri-urban system	CI	Ethiopia	East
53	2021	Faure et al.	Oryx	Estimates of carnivore densities in a human-dominated agricultural matrix in South Africa	SCR	South Africa	Southern
54	2022	Braczkowski et al.	PeerJ	Leopard and spotted hyena densities in the Lake Mburo National Park, southwestern Uganda	SCR	Uganda	East
55	2021	Mwampeta et al.	Scientific Reports	Lion and spotted hyena distributions within a buffer area of the Serengeti-Mara ecosystem	CI	Tanzania	East
56	2022	Deneke et al.	Global Ecology and Conservation	Population estimation and livestock loss by spotted hyena (*Crocuta crocuta*) in Damota community managed forest, Southern Ethiopia	DS	Ethiopia	East
57	2022	Gueye et al.	European Journal of Wildlife Research	Conflicts between large carnivores and local pastoralists around Niokolo Koba National Park, Senegal	CI	Senegal	West
58	2022	Ferreira & Viljoen	African Journal of Wildlife Research	African large carnivore population changes in response to a drought	CI	South Africa	Southern
59	2020	Tamrat et al.	Wildlife Biology	Human-wildlife conflict and coexistence: a case study from Senkele Swayne's Hartebeest Sanctuary in Ethiopia	CI	Ethiopia	East
60	2019	Everatt, Kokes & Lopez Pereira	Biodiversity and Conservation	Evidence of a further emerging threat to lion conservation; targeted poaching for body parts	CI	Mozambique	Southern

Table S2. Literature reviewed on leopard (*Panthera pardus*) population estimates and methods used to estimate density in sub-Saharan Africa between 2000 and 2022.

Authors	Year	Title	Journal	Method	Country
Aebischer et al.	2020	Apex predators decline after an influx of pastoralists in former Central African Republic hunting zones	Biological Conservation	Track	CAR
Allen et al.	2020	Counting cats for conservation: seasonal estimates of leopard density and drivers of distribution in the Serengeti	Biodiversity and Conservation	SCR	Tanzania
Amin et al.	2022	Assessing the status of leopard in the Cape Fold Mountains using a Bayesian spatial capture-recapture model in Just Another Gibbs Sampler	African Journal of Ecology	SCR	South Africa
Balme et al.	2019	Big cats at large: density, structure, and spatio-temporal patterns of a leopard population free of anthropogenic mortality	Population Ecology	SCR	South Africa
Balme et al.	2009	Impact of conservation interventions on the dynamics and persistence of a persecuted leopard (*Panthera pardus*) population	Biological Conservation	CR	South Africa
Balme et al.	2010	Edge effects and the impact of non-protected areas in carnivore conservation: leopards in the Phinda-Mkhuze Complex, South Africa	Animal Conservation	CR	South Africa

Balme et al.	2009	Evaluating methods for counting cryptic carnivores	Journal of Wildlife Management	CR/Track/Telemetry	South Africa
Bauer et al.	2015	Large carnivore abundance in the Benoue Ecosystem, North Cameroon	African Journal of Ecology	Track	Cameroon
Boast & Houser	2012	Density of large predators on commercial farmland in Ghanzi, Botswana	South African Journal of Wildlife Research	Track	Botswana
Braczkowski et al.	2016	Scent lure effect on camera-trap based leopard density estimates	PLOS ONE	SCR/CR	South Africa
Braczkowski et al.	2022	Leopard and spotted hyena densities in the Lake Mburo National Park, southwestern Uganda	PeerJ	SCR	Uganda
Chapman & Balme	2010	An estimate of leopard population density in a private reserve in KwaZulu-Natal, South Africa, using camera-traps and capture-recapture models	South African Journal of Wildlife Research	CR	South Africa
Chase Grey et al.	2013	Evidence of a high density population of harvested leopards in a montane environment	PLOS NE	SCR	South Africa
Croes et al.	2011	The impact of trophy hunting on lions (*Panthera leo*) and other large carnivores in the Bénoué Complex, northern Cameroon	Biological Conservation	Track	Cameroon
Davis et al.	2020	Spatial partial identity model reveals low densities of leopard and spotted hyaena in a miombo woodland	Journal of Zoology	SCR	Malawi
Devens et al.	2021	Estimating leopard density across the highly modified human-dominated landscape of the Western Cape, South Africa	Oryx	SCR	South Africa
Devens et al.	2018	Counting the spots: the use of a spatially explicit capture-recapture technique and GPS data to estimate leopard (*Panthera pardus*) density in the Eastern and Western Cape, South Africa	African Journal of Ecology	SCR/GPS	South Africa
du Preez et al.	2014	To bait or not to bait: a comparison of camera-trapping methods for estimating leopard *Panthera pardus* density	Biological Conservation	SCR	Zimbabwe
Dunnick et al.	2019	A socio-ecological landscape analysis of human-wildlife conflict in northern Botswana	Oryx	Track	Botswana
Edwards et al.	2016	Leopard density estimates from semi-desert commercial farmlands, south-west Namibia	African Journal of Ecology	CR	Namibia
Faure et al.	2021	Estimates of carnivore densities in a human-dominated agricultural matrix in South Africa	Oryx	SCR	South Africa
Funston et al.	2013	Insights into the management of large carnivores for profitable wildlife-based land uses in African Savannas	PLOS ONE	Track	Zimbabwe
Funston et al.	2010	Substrate and species constraints on the use of track incidences to estimate African large carnivore abundance	Journal of Zoology	Track	South Africa/Zimbabwe
Havmøller et al.	2019	Reserve size and anthropogenic disturbance affect the density of an African leopard (*Panthera pardus*) meta-population	PLOS ONE	SCR	Tanzania
Henschel et al.	2020	Census and distribution of large carnivores in the Tsavo national parks, a critical east African wildlife corridor	African Journal of Ecology	Track	Kenya

Henschel et al.	2011	Leopard prey choice in the Congo Basin rainforest suggests exploitative competition with human bushmeat hunters	African Journal of Ecology	Track	Gabon
Keeping	2014	Rapid assessment of wildlife abundance: estimating animal density with track counts using body mass-day range scaling rules	Animal Conservation	Track	South Africa
Keeping et al.	2018	Can trackers count free-ranging wildlife as effectively and efficiently as conventional aerial survey and distance sampling? Implications for citizen science in the Kalahari, Botswana	Biological Conservation	Track	Botswana
Mann et al.	2020	A leopard's favourite spots: habitat preference and population density of leopards in a semi-arid biodiversity hotspot	Journal of Arid Environments	SCR	South Africa
Maputla et al.	2013	Calibrating a camera trap-based biased mark-recapture sampling design to survey the leopard population in the N'wanetsi concession, Kruger National Park, South Africa	African Journal of Ecology	CR	South Africa
Miller et al.	2018	Lions and leopards coexist without spatial, temporal or demographic effects of interspecific competition	Journal of Animal Ecoogy	SCR	South Africa
Morris et al.	2021	Population density estimate of leopards (*Panthera pardus*) in north-western Mpumalanga, South Africa, determined using spatially explicit capture-recapture methods	Mammalian Biology	SCR	South Africa
Müller et al.	2021	Population size, density, and ranging behaviour in a key leopard population in the Western Cape, South Africa	bioRxiv	SCR	South Africa
Noack et al.	2019	Leopard density estimation within an enclosed reserve, Namibia using spatially explicit capture-recapture models	Animals	SCR	Namibia
O'Brien & Kinnaird	2011	Density estimation of sympatric carnivores using spatially explicit capture-recapture methods and standard trapping grid	Ecological Applications	SCR	Kenya
Rafiq et al.	2019	Tourist photographs as a scalable framework for wildlife monitoring in protected areas	Current Biology	SCR/Track	Botswana
Ramesh et al.	2017	Low leopard populations in protected areas of Maputaland: a consequence of poaching, habitat condition, abundance of prey, and a top predator	Ecology and Evolution	SCR	South Africa
Rich et al.	2019	Sampling design and analytical advances allow for simultaneous density estimation of seven sympatric carnivore species from camera trap data	Biological Conservation	SCR	Botswana
Rogan et al.	2019	The influence of movement on the occupancy-density relationship at small spatial scales	Ecosphere	SCR	South Africa
Rogan et al.	2022	Troubled spots: human impacts constrain the density of an apex predator inside protected areas	Ecological Applications	SCR	South Africa
Rosenblatt et al.	2016	Effects of a protection gradient on carnivore density and survival: an example with leopards in the Luangwa valley, Zambia	Ecology and Evolution	CR	Zambia
Searle et al.	2021	Leopard population density varies across habitats and management strategies in a mixed-use Tanzanian landscape	Biological Conservation	SCR	Tanzania
Stein et al.	2011	Leopard population and home range estimates in north-central Namibia	African Journal of Ecology	CR	Namibia

Strampelli et al.	2020	Leopard *Panthera pardus* density in southern Mozambique: evidence from spatially explicit capture-recapture in Xonghile Game Reserve	Oryx	SCR	Mozambique
Swanepoel et al.	2015	Density of leopards *Panthera pardus* on protected and non-protected land in the Waterberg Biosphere, South Africa	Wildlife Biology	SCR	South Africa
Swanepoel et al.	2015	Functional Responses of Retaliatory Killing versus Recreational Sport Hunting of Leopards in South Africa	PLOS ONE	SCR	South Africa
Tarugara et al.	2019	Cost-benefit analysis of increasing sampling effort in a baited-camera trap survey of an African leopard (*Panthera pardus*) population	Global Ecology and Conservation	CR	Zimbabwe
Vinks et al.	2021	Leopard *Panthera pardus* density and survival in an ecosystem with depressed abundance of prey and dominant competitors	Oryx	CR	Zambia
Williams et al.	2017	Population dynamics and threats to an apex predator outside protected areas: implications for carnivore management	Royal Society Open Science	SCR	South Africa

* Methods: Capture-recapture (CR); use of GPS/satellite collars (GPS); Spatial capture-recapture (SCR); Track count surveys (Track).

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