Long distance African lion dispersal between two protected areas

Anele U. Matshisela[1, 2], Nicholas Elliot[3], Exeverino Chinoitezvi[4], Norman J. Monks[1], Andrew Loveridge[3]

[1] African Lion & Environmental Research Trust, Chizarira National Park, Zimbabwe

[2] Department of Animal Science and Rangeland Management, Lupane State University, Lupane, Zimbabwe

[3]Wildlife Conservation Research Unit, Department of Zoology, University of Oxford

[4]Scientific Services, Chizarira National Park, Zimbabwe Parks and Wildlife Management Authority, P.O. Box: 13, Binga, Zimbabwe

1.0 Introduction

Anthropogenic pressures on African wildlife populations have resulted in increased fragmentation and isolation. This can impact long term population viability due to genetic, environmental and demographic stochasticity (Lande 1988). The immigration of even a single individual into an isolated population may mitigate the effects of inbreeding, and thus maintain connectivity between metapopulations is a conservation priority (Rudnick et al. 2012, Åkesson et al. 2016).

African lions (*Panthera leo*) illustrate this conservation challenge: Historically, lions were distributed across sub-Saharan Africa, but have lost 92% of this range (Bauer et al. 2016), and are now largely limited to a metapopulation structure, consisting of sub-populations with limited movement between them, and this has resulted in a significant loss of genetic diversity within the last century (Curry et al. 2020). Only 10 populations may hold the minimum number of prides (50-100) required to maintain long-term genetic diversity (Bjorklund 2003, Riggio et al. 2013, Curry et al. 2020). Lions can maintain connectivity between metapopulations via dispersal , typically undertaken by male natal dispersers (Elliot et al. 2014b), but also via secondary dispersal of displaced territorial males (e.g. Roberts 2012). Females are frequently philopatric or disperse relatively short distances, and thus gene flow is generally male-mediated (Curry et al. 2020, Dures et al. 2021). Movements between sub-populations are risky, and dispersing lions are prone to human-wildlife conflict and high mortality (Elliot et al. 2014b, Elliot et al. 2014c). One strategy to minimize the inherent risk of large displacements or movements within human dominated landscapes is to adopt faster and straighter movements (e.g. Oriol-Cotterill et al. 2015, Klarevas-Irby et al. 2021).

Here we report long-distance dispersal of lions between Hwange and Chizarira National Parks in Zimbabwe a human-dominated landscape that previous lion connectivity modelling suggests offers relatively low resistance to lion movement and high potential for connectivity (Elliot et al. 2014b, Cushman et al. 2018).

2.0 Methods

Two concurrent studies on lions were conducted within Hwange and Chizarira National Parks (Figure 1) and lions in both areas were captured using approved animal handling protocols and fitted with GPS collars. These unfenced areas are separated by more than 100km and lie within the KAZA Transfrontier Conservation Area (TFCA), an initiative to ensure biodiversity conservation, poverty reduction and securing peace (Duffy 2006, Stoldt et al. 2020). TFCA’s help secure free movement for wildlife and increase wildlife dispersal areas through different land uses by recognizing the significance of ecological, physio-geographic and socio-cultural, anthropogenic factors that influence an area (Sandwith et al. 2001).

3.0 Results

3.1 Lion CATaM1: Hwange to Chizarira

This lone sub-adult male was ~2.8 years old when fitted with a collar on the 4th October 2011 (Argos GPS collar, Sirtrack). His only sibling, also a male, died at ~4months and he remained with his mother (by then, a solitary lioness) until early 2012 in the north-eastern part of the Hwange ecosystem. Once he dispersed, he frequently left the wildlife areas and engaged in livestock killing (unpublished data). On the 26th February 2012 he was translocated a short distance back to Hwange NP, but continued to engage in livestock killing outside the park. On 30th March 2012 he was translocated ~83km west of his natal home range, to the Robins area in Hwange NP. However, within 13 days he returned to the capture site and again engaged in livestock killing. A little over one month later, on 19th May 2012, he left the Hwange ecosystem and his mean nightly distance travelled and net displacement (distance between first and last GPS fix) both increased considerably and his movement became more directional. After 24 days he had travelled a total of 241km and traversed the 108km separating his exit from the Hwange NP and arrival in the

Chizarira NP (Figure 1, Video S1, Table 1). Thereafter his movement reverted to similar, home-range-like patterns observed prior to departing Hwange and over the next 183 days he spent time in Chizarira NP, Sijarira FR, and Chete and Chirisa SAs. His collar failed on 12th December 2012.

3.2 Lion CHZM1: Chizarira to Hwange

Part of a coalition of three males all of whom were ~3 years old when fitted with a collar on the 12th of July 2017 (Iridium satellite collar, African Wildlife Tracking). Their movements were largely constrained to Chizarira NP, particularly along the northern boundary, which was never crossed. On four occasions they briefly exited Chizarira NP on the south-western boundary. After leaving for a fifth time on 7th May 2018, they never returned and arrived in the Hwange ecosystem at the beginning of July (Figure 1, Video S2, and Table 1). An on the ground follow-up of the route they took revealed they killed at least 8 cattle and 15 donkeys but were largely undetected apart from one instance where a herdsman saw them during the day. As with CATaM1 (Hwange Male), his movement patterns changed considerably after leaving Chizarira NP, but curiously did not revert to shorter, more convoluted paths upon arrival in the Hwange ecosystem, perhaps due to being disturbed by resident males. Upon arrival in Hwange on the 4th of July 2018, he was observed with the other two coalition members, but was killed by a buffalo in December 2018 in the Tshebe Tshebe area of Hwange National Park. The remaining two males were killed in snares in ranchland adjacent to Hwange National Park in September 2020.

4.0 Discussion

The data presented here further strengthen the predictions of lion connectivity models which suggest that connectivity between these areas persists (Elliot et al. 2014b, Cushman et al. 2018). While the lions did not follow the actual least cost paths identified by Cushman et al. (2018), the landscape is characterized by relatively low resistance to sub-adult male lion movement (Elliot et al. 2014b). Both lions spent considerable time outside the protected areas to the north of Hwange NP and the south of Chizarira NP, corroborating a previous analysis of human-lion conflict risk (Cushman et al. 2018). The distinct movement behaviours during transience (travelling further and straighter) may reduce the costs of large displacements and is consistent with other studies (Elliot et al. 2014a, Klarevas-Irby et al. 2021). While we have no evidence of additional lion movement between these two areas, these are potentially not unique events given the small proportion of dispersing lions collared in the two areas. The immigration events documented here by sub-adult males likely represents gene flow between the two populations. While Hwange NP contains a relatively large and well connected transboundary lion population (Morandin et al. 2014, Dures et al. 2021), the lion population within Chizarira NP and its surrounding PAs is relatively small and may benefit extensively from genetic inflow. The protection of biological corridors may help to minimise the risk of local extirpations and should be included in policies by government and international communities.

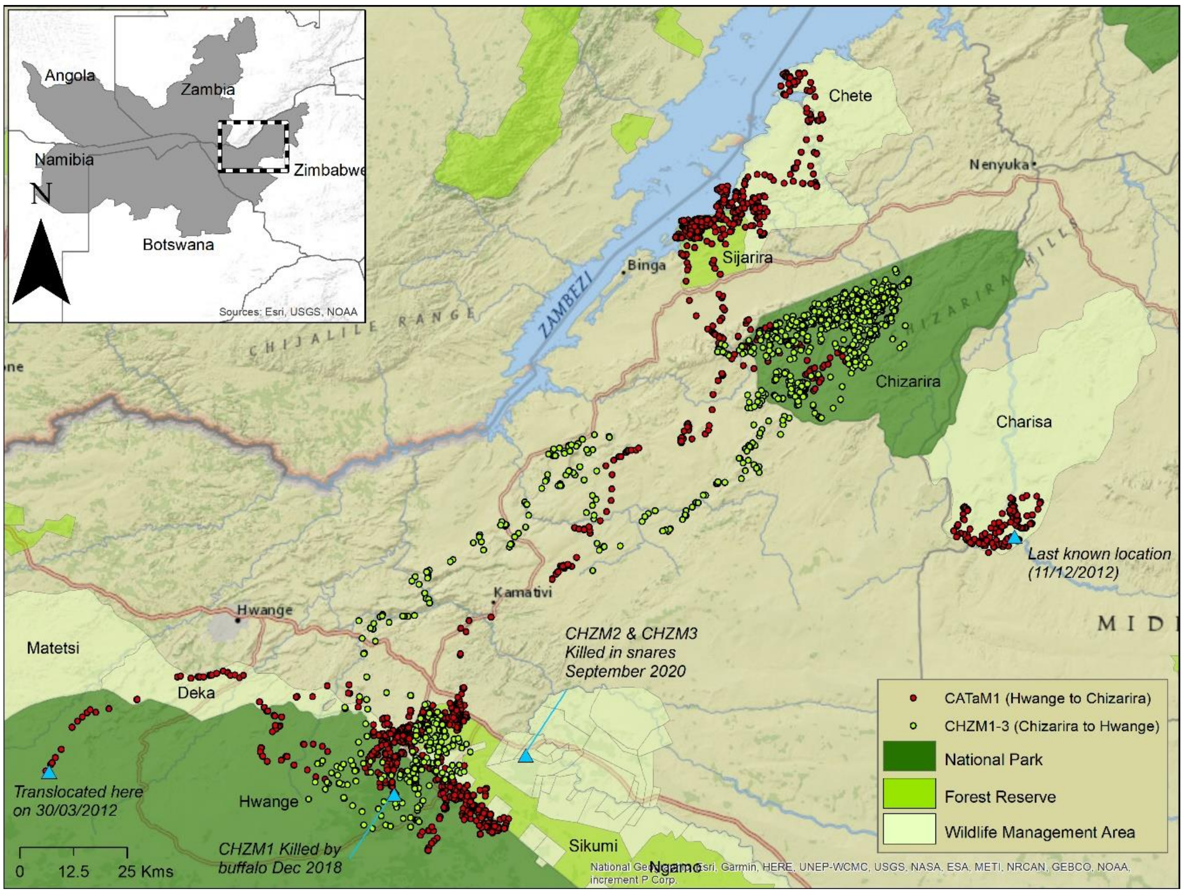

Figure 1: Point locations showcasing long-distance bi-directional movement of lions between Hwange and Chizarira National Parks in Zimbabwe. The area is part of KAZA, a transfrontier conservation area (highlighted in grey in inset map). The intervening landscape largely consists of rural communities engaged in subsistence agro-pastoral farming practices.

Table 1: Summary of lion movements before, during and after their dispersal between Hwange and Chizarira ecosystems. Parameters shown are net displacement (ND = distance between first

and last fix), path length (PL = distance travelled) and straightness index (SI=ND/PL where 1 indicates a straight line and 0 the most tortuous route).

		Before	During	After
CATaM1 Hwange Male	Dates	05/10/2011	19/05/2012	12/06/2012
	Days	227	24	183
	Mean nightly ND (km)	3,204	4,611	3,516
	Mean nightly PL (km)	6,321	10,490	7,005
	Mean nightly SI	0.45	0.40	0.45
	Total PL (km)	935	241	848
	Total ND (km)	19.43	108	75.75
	Overall SI	0.02	0.45	0.09
CHZM1 Chizarira Male	Dates	01/09/2017	07/05/2018	02/07/2018
	Days	248	56	60
	Mean nightly ND (km)	3,449	3,811	5,185
	Mean nightly PL (km)	5,090	6,000	8,523
	Mean SI	0.64	0.60	0.57
	Total PL (km)	1,303	342	597
	Total ND (km)	34	105	6
	Overall SI	0.03	0.31	0.01

Conflict of Interest

The authors declare that they have no conflict of interest

Data Availability Statement

The data that support the findings of this study are available from the authors upon reasonable request.

5.0 References

Åkesson, M., O. Liberg, H. Sand, P. Wabakken, S. Bensch, and Ø. Flagstad. 2016. Genetic rescue in a severely inbred wolf population. Molecular Ecology **25**:4745-4756.

Bauer, H., C. Packer, P. F. Funston, P. Henschel, and K. Nowell. 2016. *Panthera leo*. (errata version published in 2017). IUCN Red List of Threatened Species. International Union for Conservation of Nature, Gland, Switzerland.

Bjorklund, M. 2003. The risk of inbreeding due to habitat loss in the lion (*Panthera leo*). Conservation Genetics **4**:515-523.

Curry, C. J., B. W. Davis, L. D. Bertola, P. A. White, W. J. Murphy, and J. N. Derr. 2020. Spatiotemporal Genetic Diversity of Lions Reveals the Influence of Habitat Fragmentation across Africa. Molecular Biology and Evolution **38**:48-57.

Cushman, S. A., N. B. Elliot, D. Bauer, K. Kesch, H. Bothwell, M. Flyman, G. Mtare, D. W. Macdonald, and A. J. Loveridge. 2018. Prioritizing core areas, corridors and conflict hotspots for lion conservation in southern Africa. PloS ONE **13**:e0196213.

Duffy, R. 2006. The potential and pitfalls of global environmental governance: The politics of transfrontier conservation areas in Southern Africa. Political geography **25**:89-112.

Dures, S., C. Carbone, A. J. Loveridge, G. Maude, N. Midland, and D. Gottelli. 2021. Population connectivity across a transboundary conservation network: potential for restoration? Research Square.

Elliot, N. B., S. A. Cushman, A. J. Loveridge, G. Mtare, and D. W. Macdonald. 2014a. Movements vary according to dispersal stage, group size, and rainfall: the case of the African lion. Ecology **95**:2860-2869.

Elliot, N. B., S. A. Cushman, D. W. Macdonald, and A. J. Loveridge. 2014b. The devil is in the dispersers: predictions of landscape connectivity change with demography. Journal of Applied Ecology **51**:1169-1178.

Elliot, N. B., M. Valeix, D. W. Macdonald, and A. J. Loveridge. 2014c. Social relationships affect dispersal timing revealing a delayed infanticide in African lions. Oikos **123**:1049-1056.

Klarevas-Irby, J. A., M. Wikelski, and D. R. Farine. 2021. Efficient movement strategies mitigate the energetic cost of dispersal. Ecology Letters **n/a**.

Lande, R. 1988. Genetics and demography in biological conservation. Science **241**:1455-1460.

Morandin, C., A. J. Loveridge, G. Segelbacher, N. B. Elliot, H. Madzikanda, D. W. Macdonald, and J. Höglund. 2014. Gene flow and immigration: genetic diversity and population structure of lions (Panthera leo) in Hwange National Park, Zimbabwe. Conservation Genetics **15**:697-706.

Oriol-Cotterill, A., D. Macdonald, M. Valeix, S. Ekwanga, and L. Frank. 2015. Spatiotemporal patterns of lion space use in a human-dominated landscape. Animal Behaviour **101**:27-39.

Riggio, J., A. Jacobson, L. Dollar, H. Bauer, M. Becker, A. Dickman, P. Funston, R. Groom, P. Henschel, H. Iongh, L. Lichtenfeld, and S. Pimm. 2013. The size of savannah Africa: a lion's (*Panthera leo*) view. Biodiversity and Conservation **22**:17-35.

Roberts, P. 2012. The Livingstone Lion. Zambezi Traveller, available at: https://issuu.com/zambezi_traveller/docs/zt08mar2012.

Rudnick, D., S. Ryan, P. Beier, S. Cushman, F. Dieffenbach, C. Epps, L. Gerber, J. Hartter, J. Jenness, J. Kintsch, A. Merenlender, R. Perkl, D. Preziosi, and S. Trombulak. 2012. The role of landscape connectivity in planning and implementing conservation and restoration priorities. Issues in ecology **16**:1-20.

Sandwith, T., C. Shine, L. Hamilton, and D. Sheppard. 2001. Protected areas for peace and co-operation. Best practice protected area guidelines series.

Stoldt, M., T. Göttert, C. Mann, and U. Zeller. 2020. Transfrontier conservation areas and human-wildlife conflict: the case of the Namibian component of the Kavango-Zambezi (KAZA) TFCA. Scientific Reports **10**:1-16.