Etosha National Park Carnivore Monitoring Project Update, Unofficial Report

Re: Lion GPS-Satellite Monitoring, 2018 Lion Population Call-Up Survey

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Project Summary

Carnivore populations face threats from increasing human populations and rapidly diminishing, suitable habitat. Large carnivores such as African lions (Panthera leo) commonly attack livestock on lands adjacent to protected areas. This can lead to human-wildlife conflict (HWC) events that result in retaliatory lion killings. Conflict is a primary driver of wild lion population declines which are estimated to have decreased by 43% in the last 20 years. Etosha National Park (ENP) in Namibia is an IUCN designated Lion Conservation Unit and is home to the country's largest surviving and only stable lion population (last estimated ~481 individuals, 2014). However, Etosha lions still face increasing threats that accompany human and lion coexistence in and around protected areas such as the pressures of habitat loss and fragmentation and declining natural prey populations, as well as more direct threats such as commercial exploitation, disease epidemics from increased contact between domestic animals and wildlife, and mortalities resulting from human-carnivore conflict (HCC; Treves & Karanth 2009, Bauer et al. 2015). In addition to increased retaliatory killings driven by HCC, an increase in poaching has been a growing concern for MET staff, given the presence of multiple "high-value" species within the park, including lions themselves. Beginning in 2016, MET collaborated with researchers at WWF-Namibia and Etosha Ecological Institute to support the initiation of a Large Carnivore Monitoring Program in and around Etosha National Park. The project seeks to better monitor carnivore populations within the park and HCC on neighboring farms and communal conservancies in the surrounding area using lion GPS satellite collar data.

Project Status: October 2018

- The 2018 lion population call-up survey results **estimated the Etosha lion population at 335 individuals** for a survey area of 18,000 km^2 ; lion density = 1.86 lions per 100 km^2.
- **2018 survey shows a ~30% decrease in lion population abundance and density from the 2014 call-up** survey estimates (est= 481 individuals, density=2.67 lion/100 km^2)
- **Recommended to adjust call-up survey design to ensure representative sample of waterholes** are within range of calling stations in order due to water-driven landscape
- **30 satellite collars have been placed on lions since 2016.**
    - 16 are presently active
    - 9 have been lost, removed or failed due to conflict situations,
    - 7 have completed a full wet/dry season of data collection suitable for analyses
- **No significant difference in home range size between seasons**.
- Visible difference in home range shape, structure and pattern between wet and dry seasons.
- **Lions most frequently (>80%) use the landscape around annual waterpoints**
- Noticeable expansion of lion high intensity use areas to **include additional waterholes, broader core range in wet season compared to dry**

2018 Lion Population Call-Up Survey

Introduction

Despite their importance to conservation and tourism, there has not been regular, park-wide monitoring of the Etosha lion population for 40+ years. In 2010 and 2014, MET staff conducted initial surveys/ calibration exercise to develop a call-up (play back) population survey method for ENP. Although this lion population survey method was developed in Kruger National Park, South Africa (Ferreira and Funston 2010), it was determined by MET to be suitable for estimating lion numbers given Etosha's large land mass and difficult terrain are similar to conditions in Kruger. The two completed surveys show the lion population has nearly doubled in the last 30 years from an estimate of 271 individuals (Stander 1991) to an estimate of 450 individuals in the 2010 initial, park-wide call-up survey. The population remained stable in the 2014 call-up survey at an estimated 481 individuals (±24 SE, 434-528 ±95%CI; Etosha Lion Survey Report 2015). A park wide lion population survey using call-up methods was scheduled for July 2017, however, due to the challenges of moving around the park at night, it was rescheduled and conducted in July-August of 2018.

Methods

The 2018 call-up survey employed identical methods to those established in the 2014 call-up survey (Etosha Lion Survey Report 2015). Lion call response was calibrated at standard radius of 4.28 km distance in the 2010 survey (per Ferriera &Funston 2010; Appendix A) thus 132 survey locations, i.e. "calling stations", were selected along park roads, in even distribution across the park using a 9.56 km buffer distance between stations to ensure sound call areas did not overlap and prevent potential double-counting of individual lions (Figure 1). Counts were collected at points with best visibility <500 m from established 2014 calling station GPS coordinates. Two observers would play the sound of a dying buffalo calf in distress on continuous loop for 60 minutes using two 4-ohm horn speakers(diameter=40cm) + a 12V amplifier powered by a 12V battery, connected in a series and mounted on the roof of a vehicle (~2.5 m height), facing 180 degrees direction from each other such that rotating the speaker system 90° every 15 minutes allowed equal distribution of the call sound in each direction. The number, age, and sex of carnivore species that approached the car or were visible with a red LED lamp and/or night vision (FLIR) device during the 60 minute call time were noted at each calling station.

Results

Survey points where lions were counted in 2018 are shown in Figure 2 (n=31 stations with lions, n=77 lions). The 2018 survey results estimated the Etosha lion population at 335 individuals for a survey area of 1 8,000 km^2 (±16 SE, 304-366 ±95%CI; Table 1). This equals a density of 1.86 lions per 100 km^2.

Conclusions

Survey estimates from 2018 show ~30% decrease in estimated lion population size and density from the 2014 survey (population 481 to 335 individuals, and density 2.67 to 1.86 lions/100 km^2 respectively). It should be noted that 2018 survey technique did not take into account the effects of some variables considered to affect call-up results; lunar cycle, low-moderate wind speeds, or low visibility in dense vegetation (i.e. when a "good visibility" point could not be found within 500 m of a designated calling station location, low visibility was noted in 27 of 132 call station data sheets for 2018). The survey design also does not include the proximity of calling stations to waterholes, some stations were >25 km from a water source. Etosha lion home range and space use (see May Carnivore project report & collars update below) show frequent landscape use at seasonal waterpoints, negating the assumption of "equal" lion distribution that was used to determine calling station

locations (from Ferreira & Funston (2010)). Furthermore, annual rainfall has decreased and begun later since 2014, the landscape was noticeably drier/ with less water volume in many waterpoints during this survey. It is possible that this has significantly constricted lion occupancy to smaller habitat area within ENP around a smaller number of annual waterpoints, some of which may have been excluded from sampling in survey call radii (i.e. see exclusion of Gemsbokvlakte waterhole from survey buffer area in Figure 1, a waterhole at which >10 individual lions have frequently been documented at once during observations from 2017-2018). Using a random, evenly distributed sampling method in a nonparametric study area may be creating sample bias in Etosha's highly water-dependent habitat today. This may be responsible for the 2018 survey's lowered abundance and density estimates, constituting a potential false decrease in lion population size. Further "definitive" interpretation of results should be approached with caution keeping confounding study design variables in mind given Etosha's changing landscape.

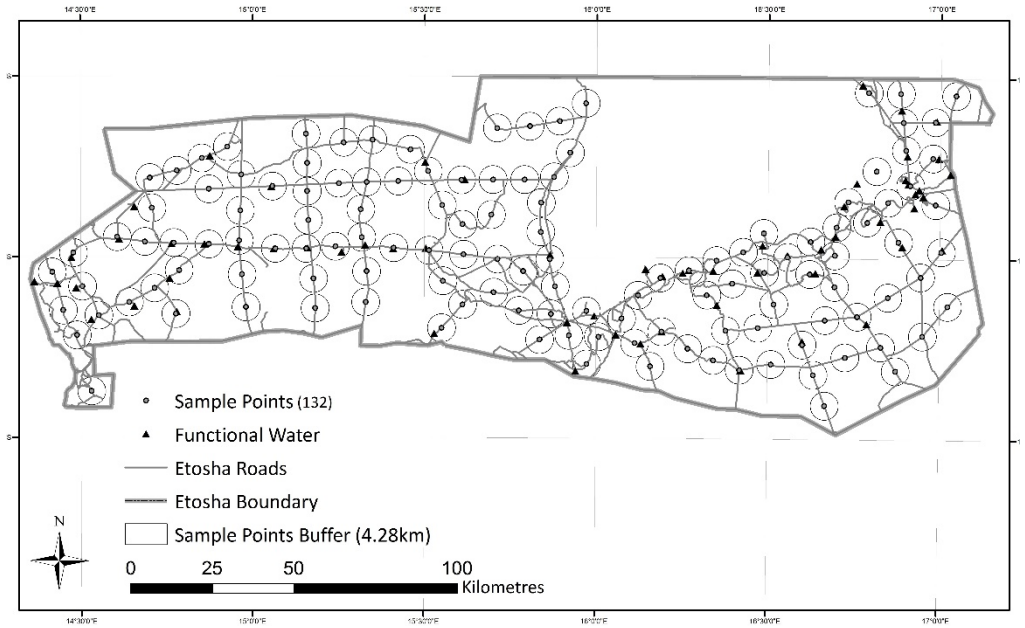

Figure 1. Map of Lion population survey calling stations (n=132) showing call sound distance buffers for each point (r=4.28 km) for surveys in 2014 and 2018

Table 2. Total lions seen in 2018 Call-Up Survey for Etosha National Park and corresponding population estimates using calibration from (Ferriera & Funston 2010).

2018 Lion Call-Up Survey Data		Calling stations where no cubs arrived	Calling stations where cubs arrived
Number of call-up stations	n	130	2
Sum Number of lions (no cub stations-cub stations; total survey)	sum(f)	65	12
Variance of mean number lions per call-up station	Var(f)	1.79	1.88
Total area of interest	At	17727	273
Proportion of area surveyed	Psurv	0.424	0.424
Variance in Psurv	Var(Psurv)	0.244	0.244
Variance estimation			
Mean number of lions per call-up	Ave(f)	0.5	6
CV squared for total number of lions at a call-up	cv^2(sum f)	0.000423669	0.0130556
X - new defined variable (see below)	X	98.16683614	43.909091
X=sum(f)/(Pp*Pi)			
CV squared for X	cv^2(X)	0.118885396	0.4819406
CV squared for N for each group type	cv^2(N?)	0.305108623	0.6681638
Variance estimate for each group	var(N?)	16386.32013	7179.4173
CV squared for X's added	cv^2(Xc+Xnc)	0.102788858	
CV squared for estimate	cv^2(N)	0.289012085	
Variance for estimate	var(N)	32512.79947	

Output		No Cubs	Cubs	Total
Population estimate	Est	232	104	335
Standard Error of the estimate	SE	11	60	16
95% Lower Confidence Limit	LCL	210	-14	304
95% Upper Confidence Limit	UCL	254	221	366
Percentage Confidence Limit	PCL	9%	113%	9%

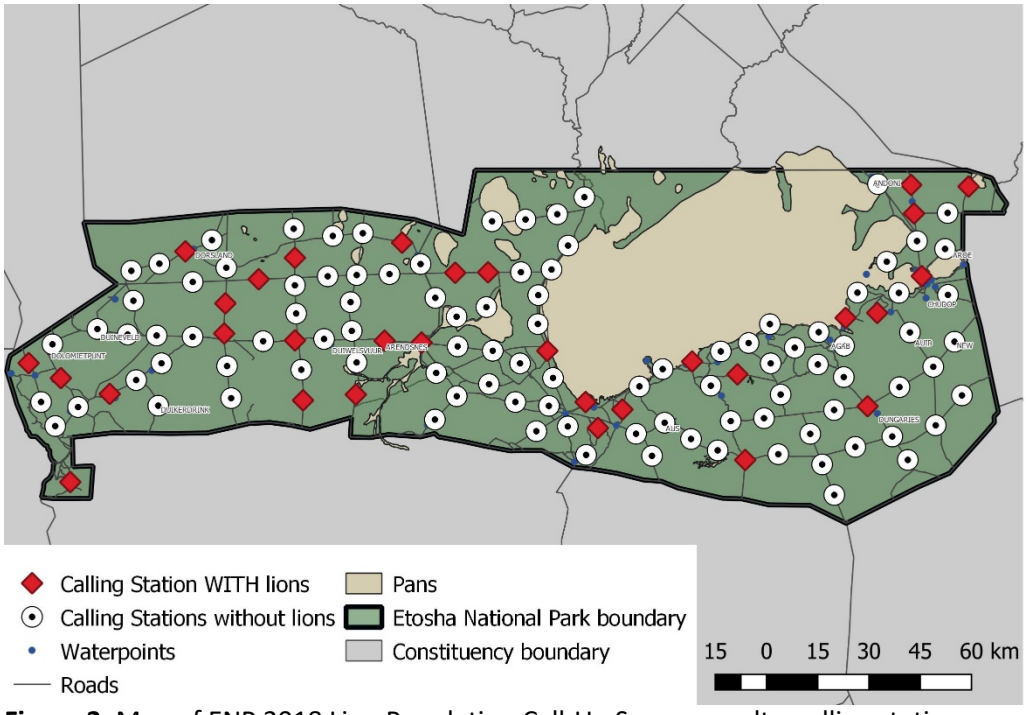

Figure 2. Map of ENP 2018 Lion Population Call-Up Survey results, calling stations counted with lions (n=31) and without lions (n=101).

Lion GPS-Satellite Collar Monitoring

Thirty GPS satellite collars have been placed on lions since 2016, predominantly in Southern and Western boundary areas of ENP where the most conflict is occurring (Table 2). Lion home range size and landscape use were estimated for 7 lions with >1 continuous year of data (minimum of 1 full wet and dry season) using a kernel density estimation (KDE) producing landscape utilization distribution (UD) for each animal for wet and dry seasons as well as an annual range estimate (Appendix B). Home range area (km^2) was calculated from KDE UDs for 3 isopleth contours indicative of an animal's true range: 99.99% contour, i.e. "Total Range/Extent"; 95% contour, i.e. "Animal Home Range"; 50% contour, i.e. "Animal Core Range" (Appendix B). Utilization distribution surfaces indicate the intensity of landscape use across a lion's total range using a color heat map (examples of two lion's UDs in Figures 3-4).

Results

Home range size in wet season (mean= 637±393 km^2, range 297-1336 km^2) was higher than dry season (mean=474±274 km^2, range 181-835 km^2) however total, home and core range size did not significantly differ between wet and dry seasons across all animals respectively (Wilcoxon signed rank test; W=20,20,16; n=6,6,6, p=0.0625, 0.0625, 0.3125 respectively) (Appendix B). Annual lion home range size (95% isopleth) varied greatly for all individuals (mean=632 ± 406 km^2, range 254 -1331 km^2) but annual "total range" size (99.99% isopleth) varied the most (mean=1497 ±832 km^2, range 616-3002 km^2 (Appendix B). Core areas with the highest fix density are represented by "high UD" values (represented by red areas in Figures 3-4) and were visibly concentrated around waterholes for all subjects, with expansion of core range and shape to include more waterholes in wet season.

Conclusions

There was considerable variation in lion home range size and ranging behavior outside of park boundaries between individuals, as well as visible difference in home range shape, structure and pattern between wet and dry seasons. These home range sizes are within the standard large range typical of lion in arid, dry savanna biomes for sub-Saharan African lion range (Funston et al. 2001, HR range=266-4532 km^2; Zehnder et al. 2018, 275-1200 km^2). However, there was no significant difference in size or overlap of ranges between seasons. Home range utilization distributions showed a consistent, frequent use of the landscape around known annual waterpoints suggesting that lion landscape use is driven by water availability inside ENP. The influence of changes in annual waterhole availability to lion occupancy in ENP may be reflected in analysis with a larger sample size (i.e. using more collars to compare where lions using the same waterholes are in relation to each other if water is becoming a limiting resource) or across a longer sampling duration (if drought conditions persist and water becomes scarcer from 2018 forward). Further research should investigate the influence of individual environmental variables on lion space use to better understand lion home range and habitat selection (i.e. vegetation cover, land use type, distance to water points, seasonal variation).

Table 2. **Lion GPS Satellite collars deployed in Etosha National Park** from June 2016-August 2018 (n=30). "Collar ID" Number indicates collars placed on animal as follows: **^^** a collar that was previously placed on another animal and being reused on a new animal (n=2), ***** animal was previously collared and original collar was being replaced with new collar (n=4). "Current Status" column indicates collar is active/inactive as follows: "Conflict Loss"= collar inactive, lost/removed due to conflict or mortality(n=4, red); **^** collar inactive and was retrieved (n=3); "Removed"= inactive collar, no further data collection (n=5); "Failed"=collar failure, location unknown (n=4); "Replaced" or **= collar was removed from this individual and a new collar was later placed on the same individual (n=4); "Active"=collar is actively collecting data (n=16).

Collar ID	Date Collared	Sex	Area	Current Status
1678	18/06/2016	F	Gaseb	Removed
1679	17/07/2016	M	Ombika	Failed
2069	19/09/2016	F	Gemsbokvlakte	Removed-Replaced**
1821	26/12/2016	M	Aus to main road	Removed-Replaced**
1823	26/12/2016	F	Aus to main road	Conflict Loss
1822	26/12/2016	F	Olifantsbad	Removed-Replaced**
1820	14/04/2017	M	Okaukuejo	Failed^-Replaced**
2078	23/06/2017	F	Dorsland area	Removed
2120	08/08/2017	M	Duikerdrink	Failed
2121	08/09/2017	M	Nomab	Active
2118	08/09/2017	F	Nomab	Active
2119	08/10/2017	M	Sonderkop	Conflict loss^
2136	18/08/2017	M	Namutoni Airstrip	Failed
2183	28/08/2017	M	Kameeldoring	Active
2185	27/10/2017	M	Agab	Active
2109	27/10/2017	F	Agab	Active
2108	28/10/2017	M	Gobaub	Active
2181	28/10/2017	F	Gobaub	Active
2182	30/10/2017	M	Dungaries	Conflict loss
2119^^	17/11/2017	M	Sonderkop	Active
2560	24/03/2018	M	Olifantsrus/Okawao	Active
2560	24/03/2018	M	Olifantsrus/Okawao	Active
2561	18/05/2018	M	Mbari/Charles Marais Dam	Active
2562*	18/05/2018	M	Ombika	Active
2567*	17/05/2018	F	Olifantsbad	Conflict Loss^
2568*	19/05/2018	F	Ombika	Active
2563	19/05/2018	F	Dorsland	Active
2566	20/05/2018	F	Dolomite/Klippan	Conflict Loss^
2566^^	16/06/2018	F	Okondeka	Active
2565*	16/08/2018	M	Gemsbokvlakte	Active

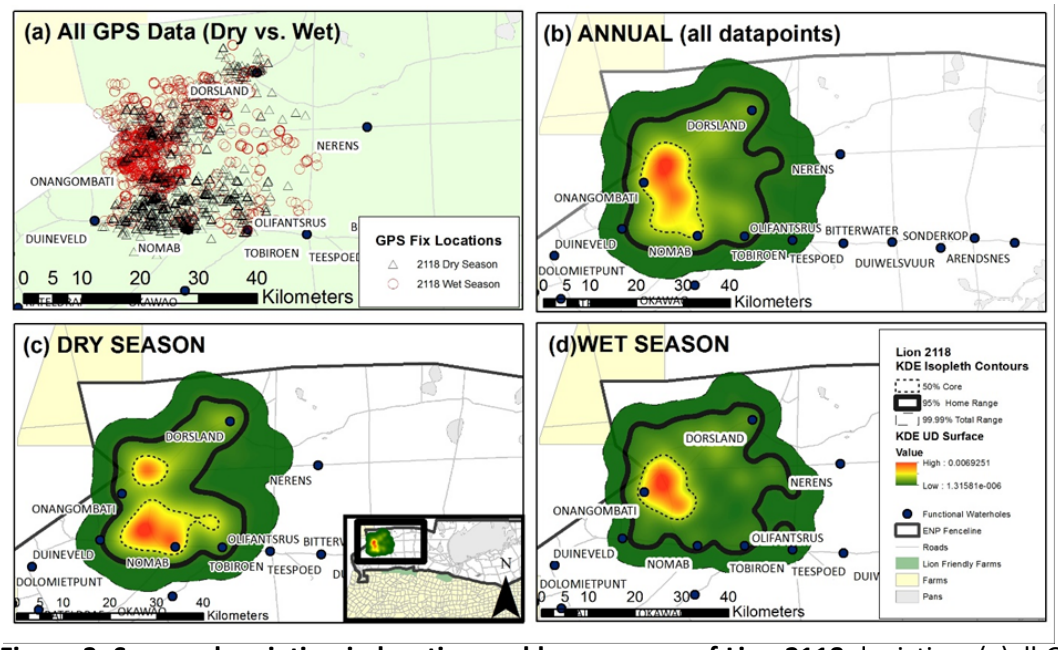

Figure 3. Seasonal variation in location and home range of Lion 2118 depicting (a)all GPS location data subset by wet and dry season and kernel density estimation home range estimates for isopleth contours 99.99% Total Range, 95% Home Range, and 50% Core habitat for (b) all data in the annual extent dataset (c) dry season and (d) wet season respectively.

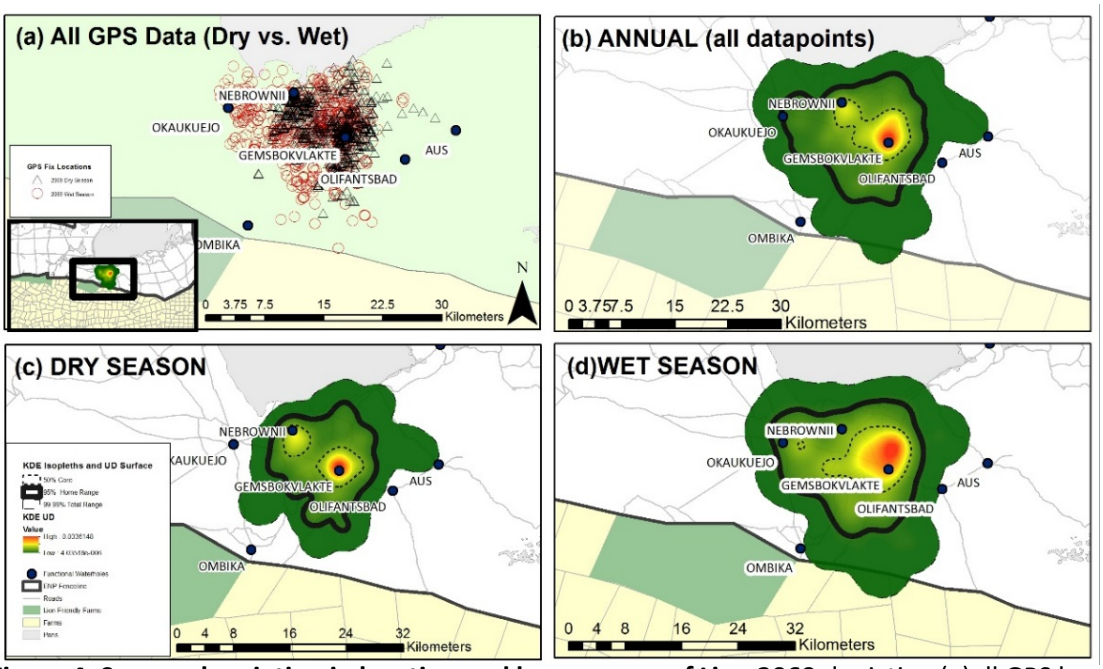

Figure 4. Seasonal variation in location and home range of Lion 2069 depicting (a)all GPS location data subset by wet and dry season and kernel density estimation home range estimates for isopleth contours 99.99% Total Range, 95% Home Range, and 50% Core habitat for (b) all data in the annual extent dataset (c) dry season and (d) wet season respectively

Appendix A. Call-Up Survey calibration for lion estimation per Ferriera&Funston (2010)

Callibration Corrections				
			Stations with No Cubs	Stations with Cubs
Probability that a pride will turn up		Pp	0.734	0.286
	Variance in Pp	Var(Pp)	0.006	0.035
	CV squared	cv^2(Pp)	0.010	0.423
	Standard Deviation of Pp	SD(Pp)	0.075	0.452
	Number of prides in callibration	n Prides	28.000	9.000
Probabilty that a lion in a responding pride will turn up		Pi	0.902	0.957
	Variance in Pi	Var(Pi)	0.088	0.042
	CV Squared	cv^2(Pi)	0.108	0.045
	Standard Deviation of Pi	SD(Pi)	0.297	0.204
	Number of lions in the callibration	n Lions	109.000	61.000
Distance from which lions responded		Rad	4.288	4.288
	Variance in Rad	Var(Rad)	0.807	0.807
	Standard Deviation of Rad	SD(Rad)	0.898	0.898
Effective area sampled by a call-up station		A	57.763	57.763
	Variance in A	Var(A)	621.346	621.346
	CV squared	cv^2(A)	0.186	0.186
	Standard Deviation of A	SD(A)	24.93	24.93

Appendix B. Lion home range sizes (km^2) for KDE Analysis by season. Analysis performed in HRT 2.0 for ArcGIS 10.2, Kernel Density Estimation, smoothing bandwidth (h)= adhoc selection method, 100 m^2 resolution. Percent overlap is expressed as % of dry season area overlapping matched wet season area per individual.

			HR Size (km^2)								
			Wet Season			Dry Season			Annual$_{(all\ data)}$		
Lion	**Sample Period**	**$N_{wet}(N_{dry})$**	**99.99%**	**95%**	**50%**	**99.99%**	**95%**	**50%**	**99.99%**	**95%**	**50%**
1822	12/26/16-04/29/18	942(584)	1226.79	563.85	122.90	1187.97	568.60	108.24	1421.9300	599.8450	120.7400
1821	12/26/16-04/29/18	1362(833)	2944.92	1335.52	218.50	1799.49	834.84	124.21	3001.9326	1330.9723	194.3649
1679	07/20/16-05/03/17	3657(3203)	1108.02	439.46	84.67	597.11	235.62	40.26	1107.0500	395.1690	60.4079
1820	04/17/17-03/18/18	649(823)	935.45	345.74	67.26	800.57	299.44	58.96	1063.3949	346.6645	63.4389
2069	09/19/16-11/09/17	826(1046)	680.52	297.48	73.16	432.60	181.24	38.61	615.5125	254.2451	52.7827
2118	08/11/17-08-10-18	1359(1253)	1545.16	838.70	119.29	1547.32	726.00	174.15	1770.2003	865.6357	189.4872
	Mean	1466 (1290)	1406.81	636.79	114.30	1060.84	474.29	90.74	1496.67	632.09	113.54
	(±SD)	1111(964)	807.00	393.21	56.11	543.31	274.10	54.15	832.13	406.05	65.39

	%Overlap(dry over wet)		
	99.99%	**95%**	**50%**
	77.66	85.42	71.35
	54.43	51.41	42.39
	50.24	49.56	46.27
	67.70	71.79	76.71
	60.09	59.52	36.28
	87.86	73.16	43.59
Mean	66.33	65.14	52.76
(±SD)	14.38	14.02	16.88

REFERENCES

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Etosha Lion Survey Report, Ministry of Environment and Tourism, 2010

Ferreira, S. M., & Funston, P. J. (2010). Estimating lion population variables: prey and disease effects in Kruger National Park, South Africa. *Wildlife Research*, *37*(3), 194. https://doi.org/10.1071/WR09030