Desert Lion Conservation

Research Report - 2009

Movement patterns and activity of desert-adapted lions in Namibia: GPS radio collars

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Introduction

Understanding the movement and activity patterns of lions in the northern Namib is essential to the development and implementation of conservation efforts. The unique population of desert-adapted lions is valuable to tourism in Namibia, but not to the local communities and livestock farmers. The lions prey on domestic livestock and farmers respond by shooting lions to protect their livelihood. Through the Namibian Government's innovated conservancy programme, local communities benefit from the wildlife resources on their land. If these local conservancies can receive direct financial benefits from lions, perhaps through organised and controlled eco-tourism, the losses from lion predation on livestock could arguably be tolerated.

Recent advances in radio-telemetry technology led to the availability of affordable GPS radio-collars. With these new GPS radio-collars, accurate data on movements, that has not previously been possible, could be collected. Through a generous donation Desert Lion Conservation acquired six GPS collars. During 2007-2009 these GPS radio-collars were fitted to eight different lions in order to collect accurate data on their movements and activities.

Results

This report presents the results from GPS radio-collars fitted to eight different lions for the period: June 2007 to February 2009. During any 24-hour period the GPS collars collected accurate location data (latitude/longitude) at frequencies that ranged from 15-minute to 2-hour intervals. In total, 44,599 data points were recorded over 1381 lion-days (Table 1). Since lions are nocturnal "lion-days" are hereafter referred to as "nights" and constitute a 24-hour period from midday Day^{-1} to midday Day^{-2}.

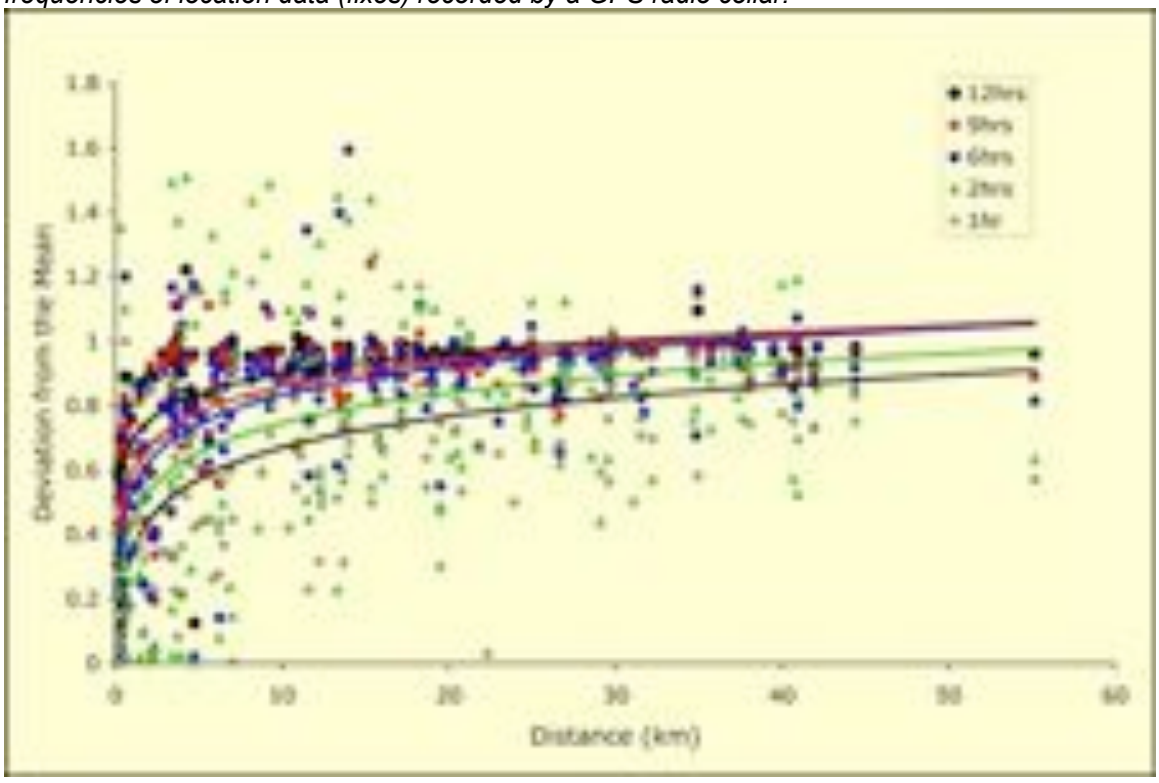
Table 1. Sample sizes and distances moved per night (24-hours) of eight lions (= males, = females) fitted with GPS radio collars in the northern Namib.

	Xpl-3	Xpl-16	Xpl-35	Xpl-44	Xpl-17	Xpl-18	Xpl-25	Xpl-47	Total
N (points)	5576	1360	3731	15128	12801	1081	1848	3034	44599
N (nights)	294	108	147	197	161	104	182	188	1381
Start	15/5/08	23/4/08	3/9/08	13/5/08	4/2/08	11/7/07	15/3/08	5/5/08	
End	Ongoing	9/8/08	Ongoing	Ongoing	13/7/08	22/10/07	3/9/08	Ongoing	
Night distance Mean (km)	14.0	9.0	11.6	10.3	6.5	8.3	9.9	9.4	10.3
SE	0.73	0.92	0.71	0.66	0.38	0.57	0.66	0.48	0.25
Min	0	0.1	0.2	0.7	0.8	0.1	0.1	0.5	0
Max	55.2	36.9	35.9	53.2	25.7	24.1	47.7	36.3	55.2

Sampling

Deciding on the best sampling intensity when programming the GPS radio collars was difficult, because an increase in data quality (frequent fixes – as high as every 10 minutes) resulted in reduced battery life of the collar. For example, by recording position data (fixes) every 10 minutes a collar will run for 1.1 years, whereas hourly fixes will extend the battery life to 3.9 years. The primary objective for this study is to collect accurate data on the movements of lions over a time scale of 24-hours (nights). Data from Xpl-3 were examined, using a bootstrap-type analysis, for the ideal sampling intensity (Figure 1). Considering the trade-off between sampling intensity and battery life, a sampling regime of hourly fixes produced sufficient precision. Sampling frequencies of a fix every 2, 3 and 4 hours also produced good results when lions moved >15 km/night. However, when lions moved short distances (<10 km/night) lower sampling regimes produced erroneous results.

Figure 1. The accuracy of calculating distances moved per night (24-hours) using various frequencies of location data (fixes) recorded by a GPS radio collar.



Activity patterns

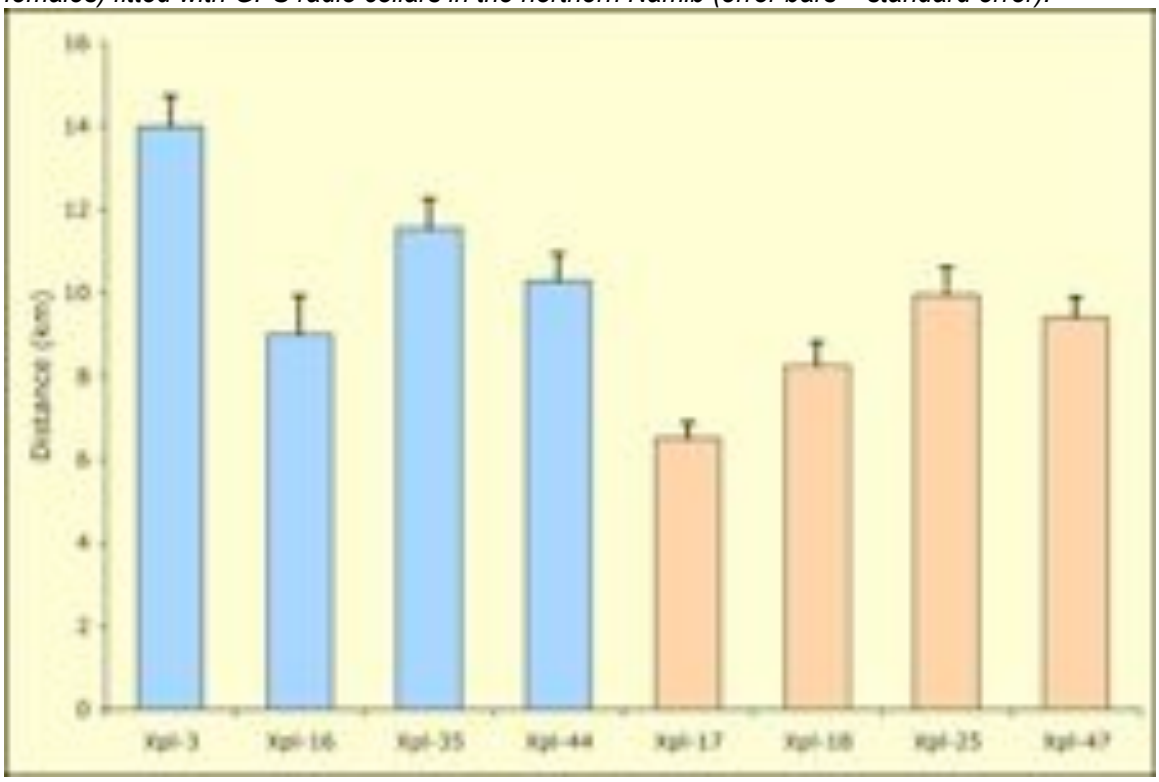
Data from five GPS collars, where the sampling frequency was ≥1 fix/hour, were included to assess patterns of activity. Distances moved per hour were used as an index of activity. To control for individual biases (e.g. mean distances moved by different lions per night) the distance moved per hour was expressed as a proportion of the total distance moved by the lion on that night. The patterns of activity are remarkably similar for all five lions (Figure 2). A sharp peak of activity occurred from between sunset and 20h00, followed by a drop in activity between 21h00 and 22h00. Activity increased again around midnight, but thereafter the pattern became less uniform although activity decreased towards daybreak, especially amongst the females. After sunrise activity increased and peaked between 07h00 and 08h00, followed by a uniformly sharp decline, and by 11h00 all five lions had stopped moving.

Figure 2. Activity patterns of five lions (males = blue/green, females = red/orange) in the northern Namib.

Distances

The distance that a lion moves per night is a function of home range size and habitat use. Accurate information on this is important to the conservation process, and essential when developing tourism activities. On average the eight lions moved 10.3 km/night (Table 1). Male lions, however, moved longer distances per night (x = 11.7 km, SE = 0.39) than did lionesses (x = 8.6, SE = 0.28, t = -6.28, P < 0.001, Figure 3).

Figure 3. Average distances travelled per night (24-hours) by eight lions lions (= males, = females) fitted with GPS radio collars in the northern Namib (error bars = standard error).



The range of the distances travelled by lions per night was large (0 – 55 km, Table 1). This is true, in part, because lions, when feeding on a large prey animal may not move for several days (range: 1 – 12 days). But when they have not been successful they would move with increasing intensity until they succeed. It was therefore necessary to separate the data into six distance categories (<1km, 1-5km, 6-10km, 11-15km, 16-20km, >20km, Figure 4). Interestingly, the lions moved less than 5 km/night on 42% of the total sample of 1381 nights. Male lions appeared to move <1km & >20km/night more often than did female lions (Figure 4). When the data were further separated into only three distance classes (<5km, 5-15km, >15km, Figure 5) the pattern became clear. Both sexes moved <5 km/night at the same frequency, but lionesses moved more often between 6 and 15 km/night, than did males, and males regularly moved >15 km/night (χ^2 = 64.1,

d.f. = 2, $P < 0.001$). This discrepancy explains the difference between and the mean distances travelled by males and females.

Figure 4. The proportion of distances travelled per night (24-hours) in six distance categories by eight lions fitted with GPS radio collars in the northern Namib.

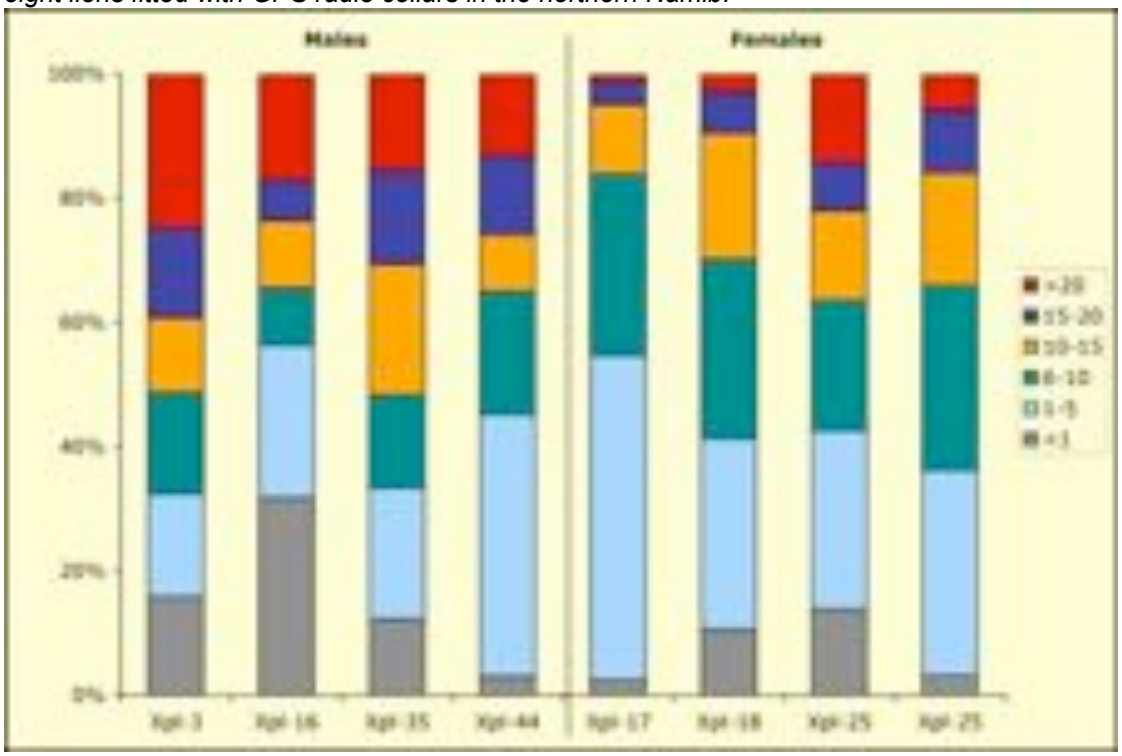
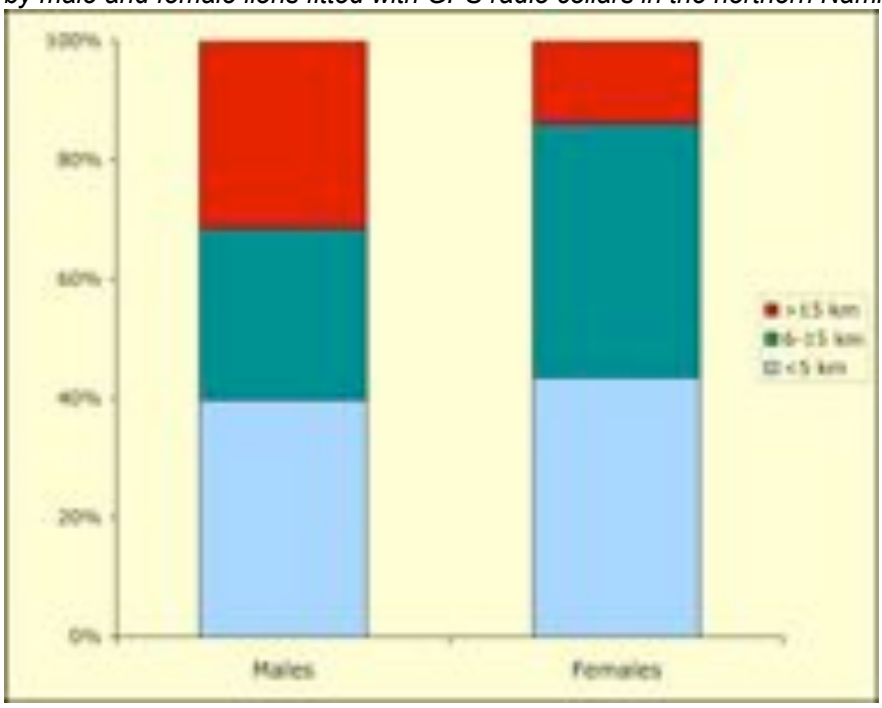


Figure 5. The proportion of distances travelled per night (24-hours) in three distance categories by male and female lions fitted with GPS radio collars in the northern Namib.



Home ranges

Understanding the spatial and temporal patterns of movements and how lions utilise their home ranges have not been previous been possible in this study. The data from GPS radio collars, however, provided new insights. Figure 6 displays a map of the areas occupied by the radio-collared lions. Calculating the size of home ranges is difficult. There are many different methods, and depending on the movement patterns of an animal, some are more suitable than others. In this analysis the home range size of lions marked with GPS radio collars were calculated using the Minimum Convex Polygon (MCP) and the Kernel contour techniques (Table 2). The home ranges of males were on average larger than those of females for both the MCP and Kernel methods. Figures 7 – 14, presents a map displaying the MCP and Kernel contours of the home ranges of each of the marked lions.

Table 2. Home range estimates (km^{-2}), using Minimum Convex Polygon (MCP) and Kernel contour techniques, of eight lions fitted with GPS radio collars in the northern Namib (= males, = females).

HR estimate	Xpl-3	Xpl-16	Xpl-35	Xpl-44	Xpl-17	Xpl-18	Xpl-25	Xpl-47
MCP	5,600.3	4,196.9	10,493.7	1,699.4	2,561.5		3,604.3	864.1
Kernel 95%	2,910.2	1,865.7	5,895.3	583.7	648.4	613.6	1,431.5	579.9

Figure 6. Layout of the areas utilised by lions fitted with GPS radio collars in the northern Namib.

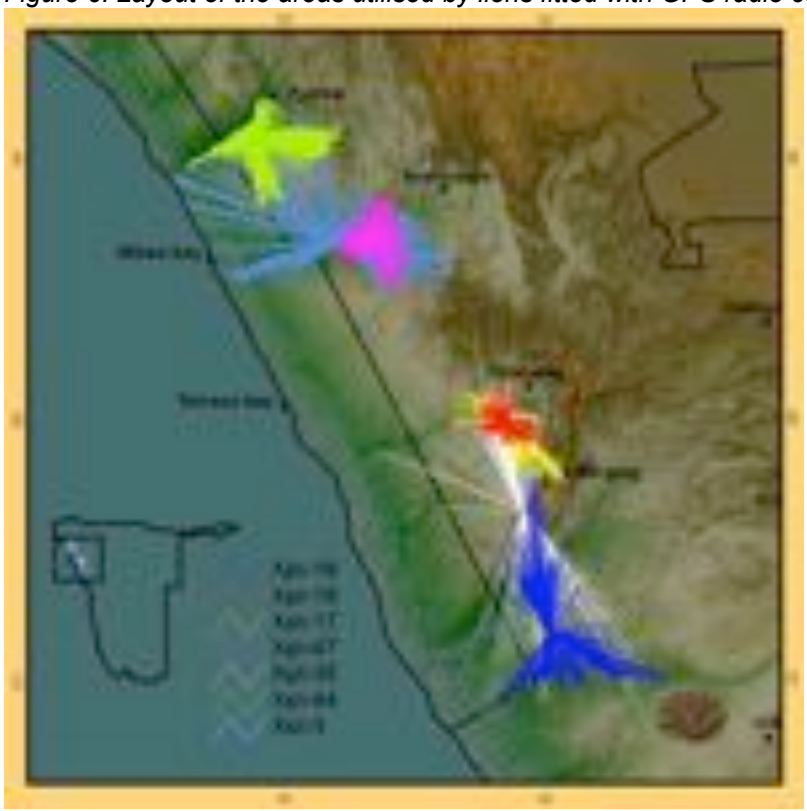


Figure 7. The home range area of Xpl-3 (male).

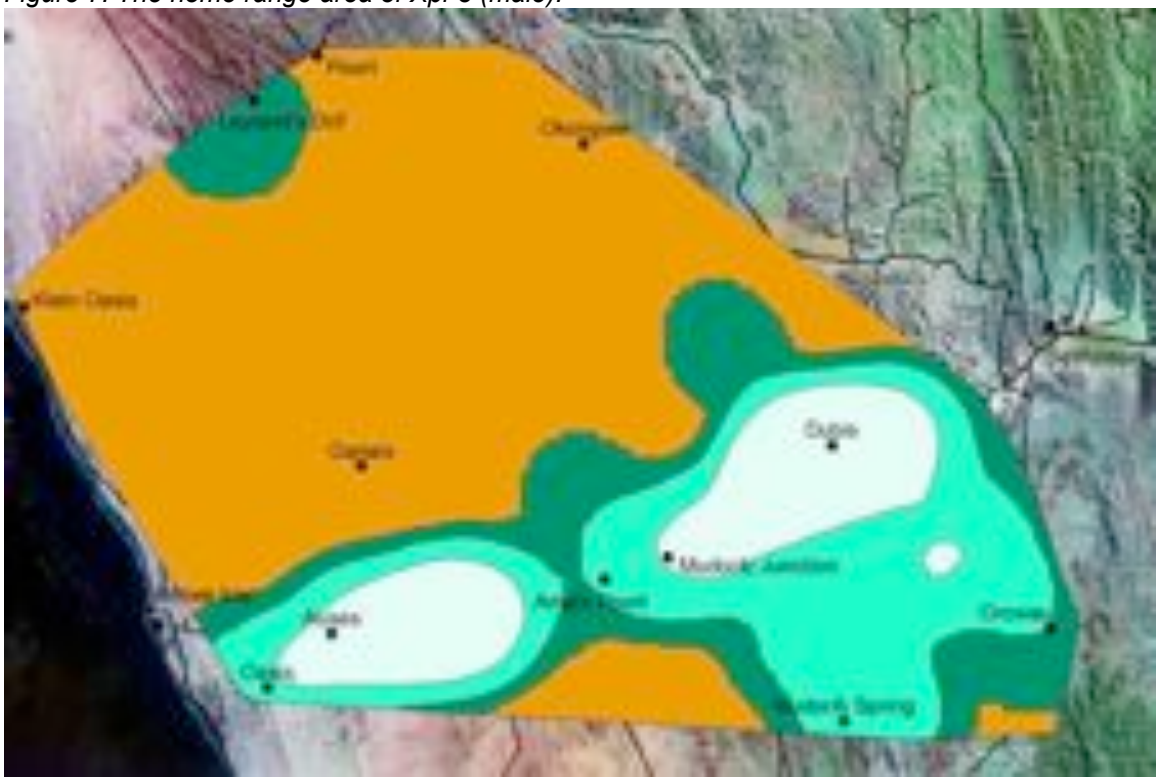


Figure 8. The home range area of Xpl-16 (male).

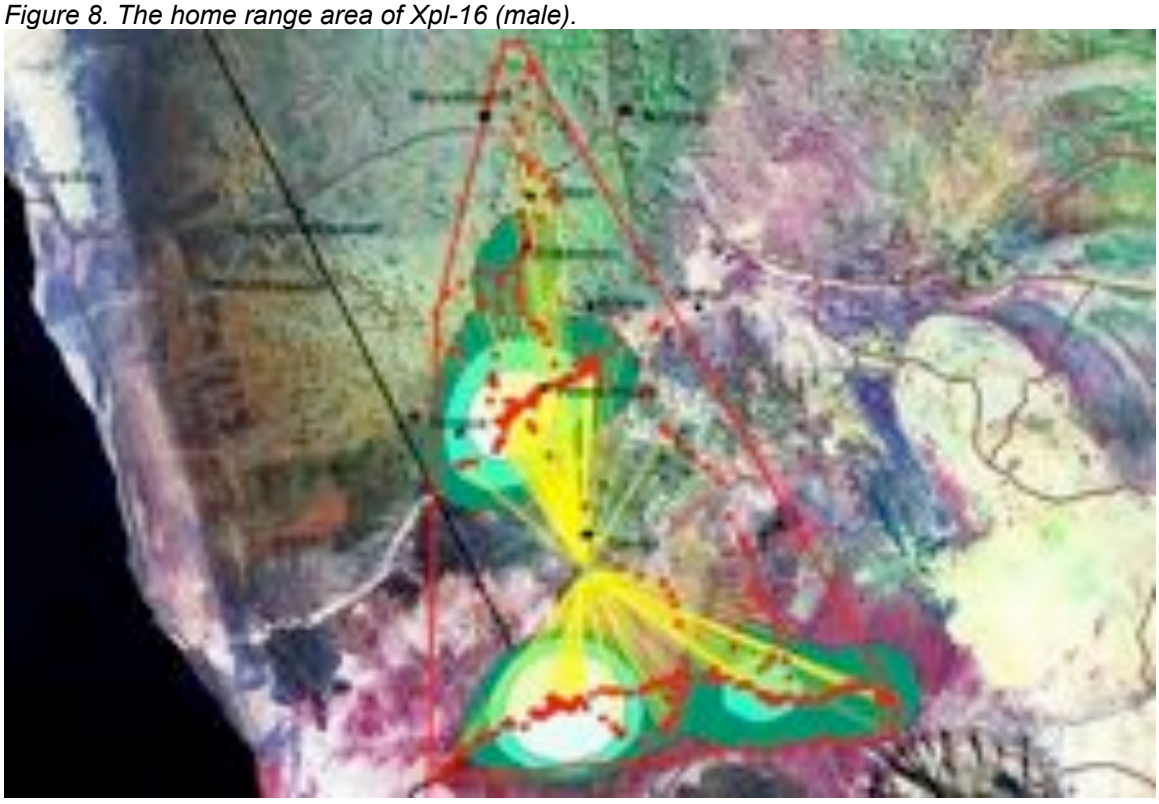


Figure 9. The home range area of Xpl-35 (male).

Figure 10. The home range area of Xpl-44 (male).

Figure 11. The home range area of Xpl-17 (female).

Figure 12. The home range area of Xpl-18 (female).

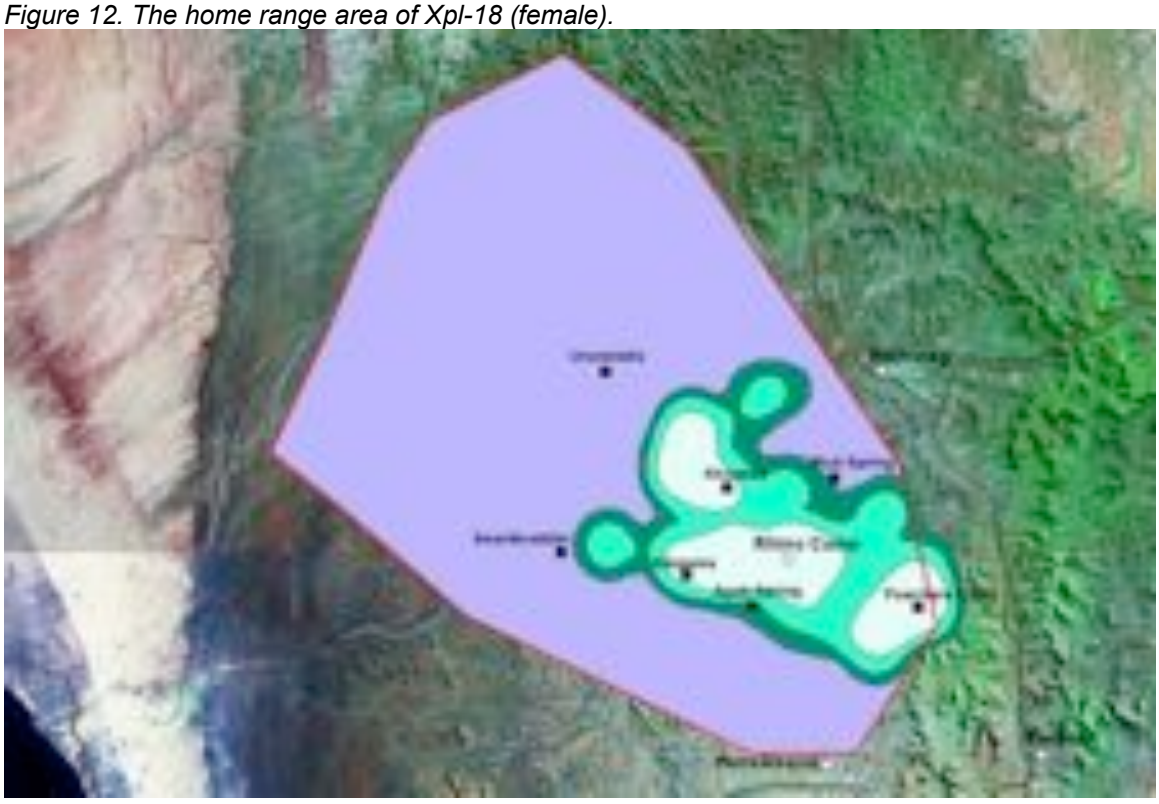


Figure 13. The home range area of Xpl-25 (female).

Figure 14. The home range area of Xpl-47 (female).

Movement patterns

There are three main factors that is believed to influence the movements of desert-adapted lions of the northern Namib: a) prey availability, b) the interaction between habitat and prey availability, and c) inter-specific social interactions. Since the distribution of prey animals, in a heterogeneous habitat, is a function of patchy and unpredictable rainfall, it is to be expected that the movement patterns of lions will not be uniform.

The large sample sizes and quality of the data collected by the GPS radio collars, provided an opportunity to look at the movement patterns of six lions (3 males & 3 females) within their home range. Using GIS software it was possible to calculate the centre-point (CP) of a lion's home range. This point does not necessarily fall in the centre of the home range (due to the heterogeneity of the habitat), but represents the part of the range that the lion visits most often. The movement patterns of the six lions were thus evaluated in relation to the CP, as the reference-point.

Since lions are nocturnal, one day-time (resting) location was selected for each lion, and the average distance from the CP was calculated for the period of observation (Table 3). The range of distances from the CPs for all six lions was large. By plotting the actual distance from the CP during sequential days for the observation period of each lion (Figures 15 – 20), the fluctuations as they move towards and away from the CP, are demonstrated.

Table 3. Average distances from the centre-point (CP) of their respective home ranges of eight lions fitted with GPS radio collars in the northern Namib (= males, = females).

	Xpl-3	Xpl-16	Xpl-44	Xpl-17	Xpl-18	Xpl-47
Mean (km)	24.1	31.1	7.8	11.5	9.1	9.4
SE	0.74	1.75	0.63	0.90	0.44	0.40
N (nights)	294	108	197	161	104	188
Range (km)	1-68	3-96	0-37	0-40	0-17	0-27

The frequency of lions returning to the CP was calculated on a time-scale of days between visits of <1 km of the CP (Figure 21). With the exclusion of Xpl-16, whose movement patterns were markedly different, the lions returned to the CP of their respective home ranges every 6.6 days, on average (range 1-36 days). Male lions (excluding Xpl-16) returned to the CP (x = 7.9 days, SE = 1.0) less often than did lionesses (x = 5.6 days, SE = 0.86), although the difference was not significant (t = -1.76, P = 0.08).

Figure 15. Daily distances of Xpl-3 (male) from the centre-point (CP) of his home range.

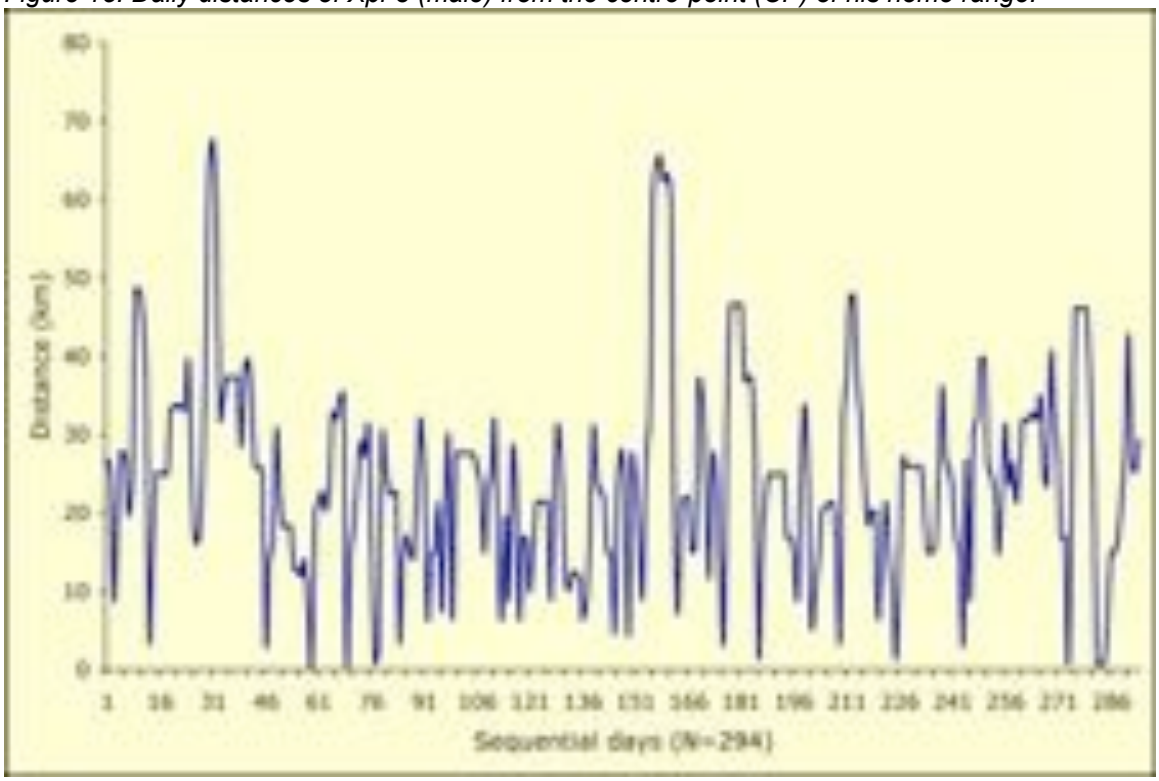


Figure 16. Daily distances of Xpl-16 (male) from the centre-point (CP) of his home range.

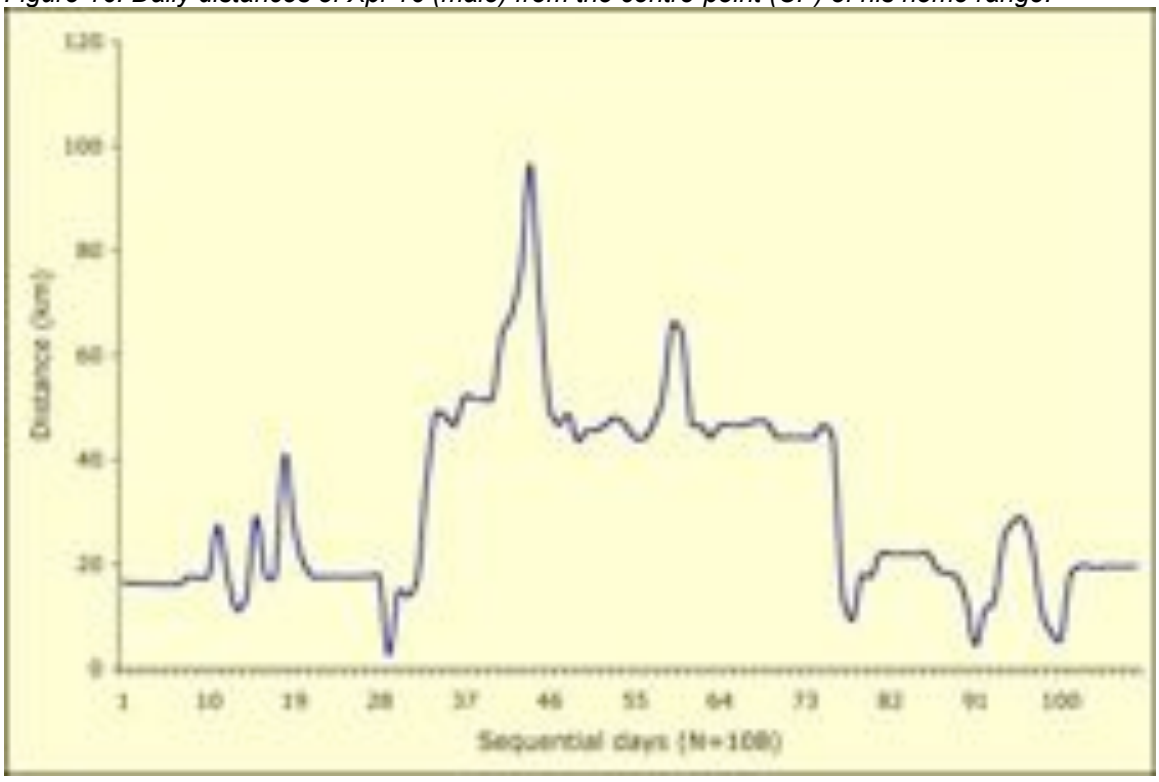


Figure 17. Daily distances of Xpl-44 (male) from the centre-point (CP) of his home range.

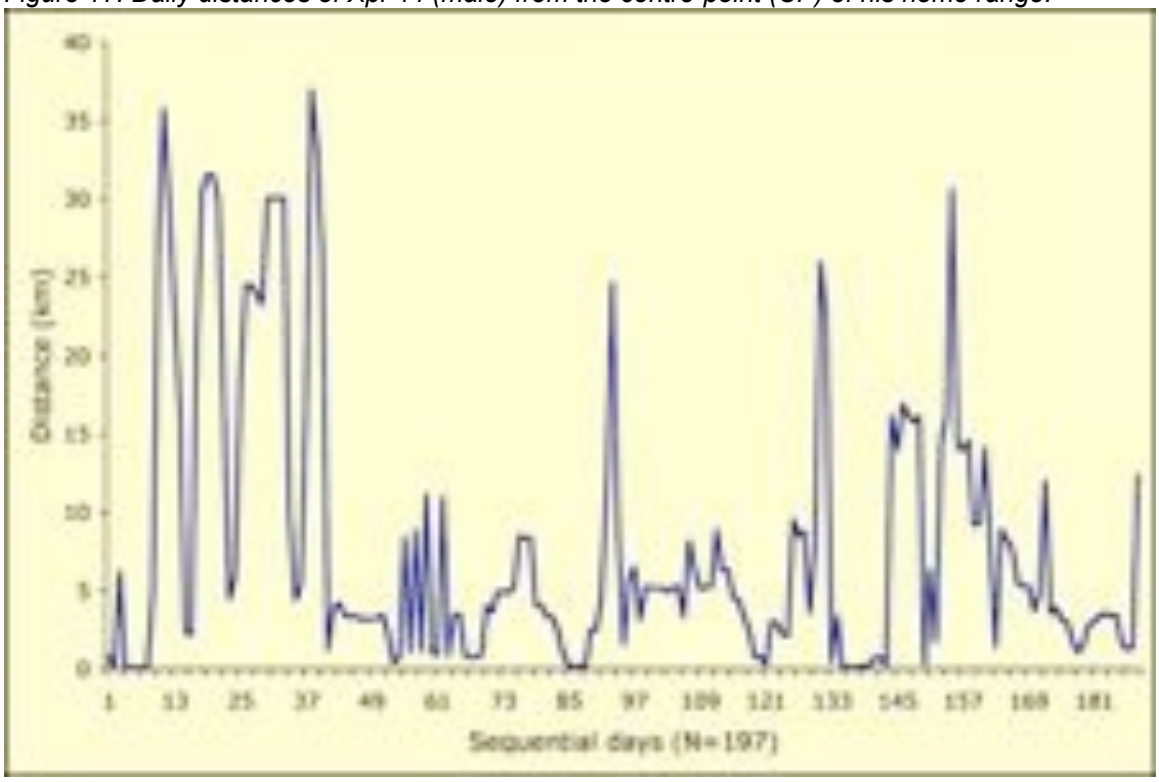


Figure 18. Daily distances of Xpl-17 (female) from the centre-point (CP) of her home range.

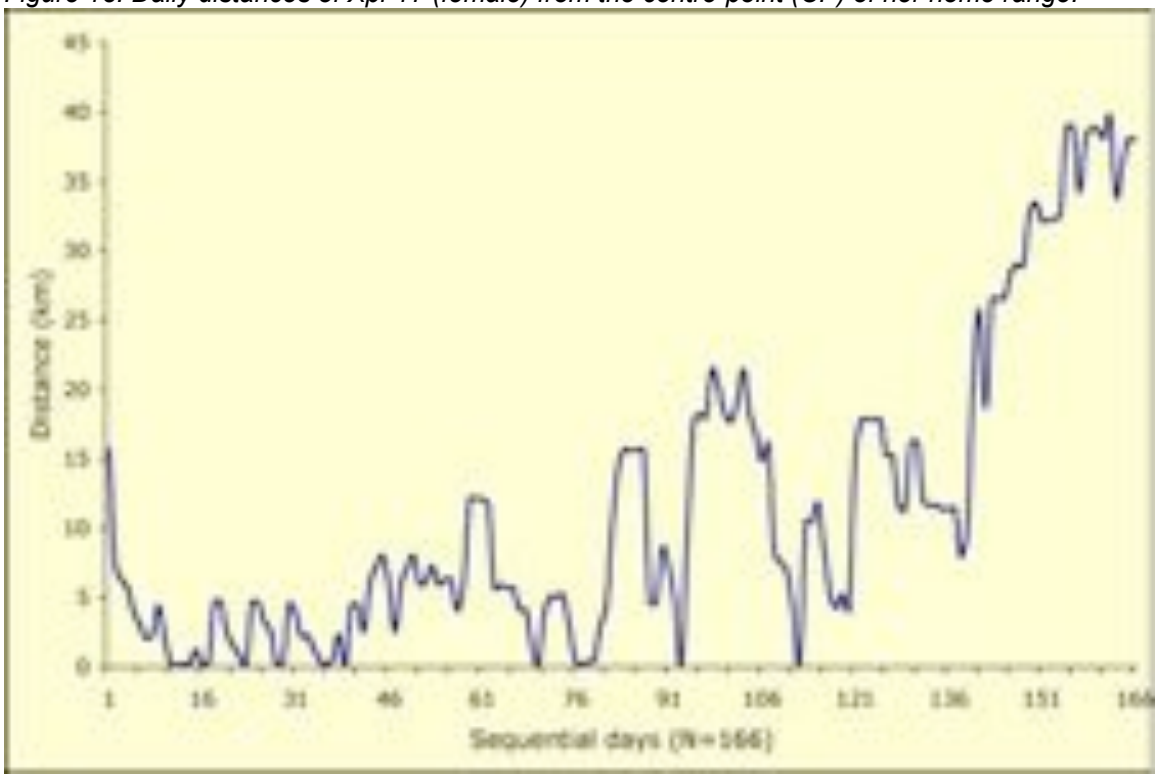


Figure 19. Daily distances of Xpl-18 (female) from the centre-point (CP) of her home range.

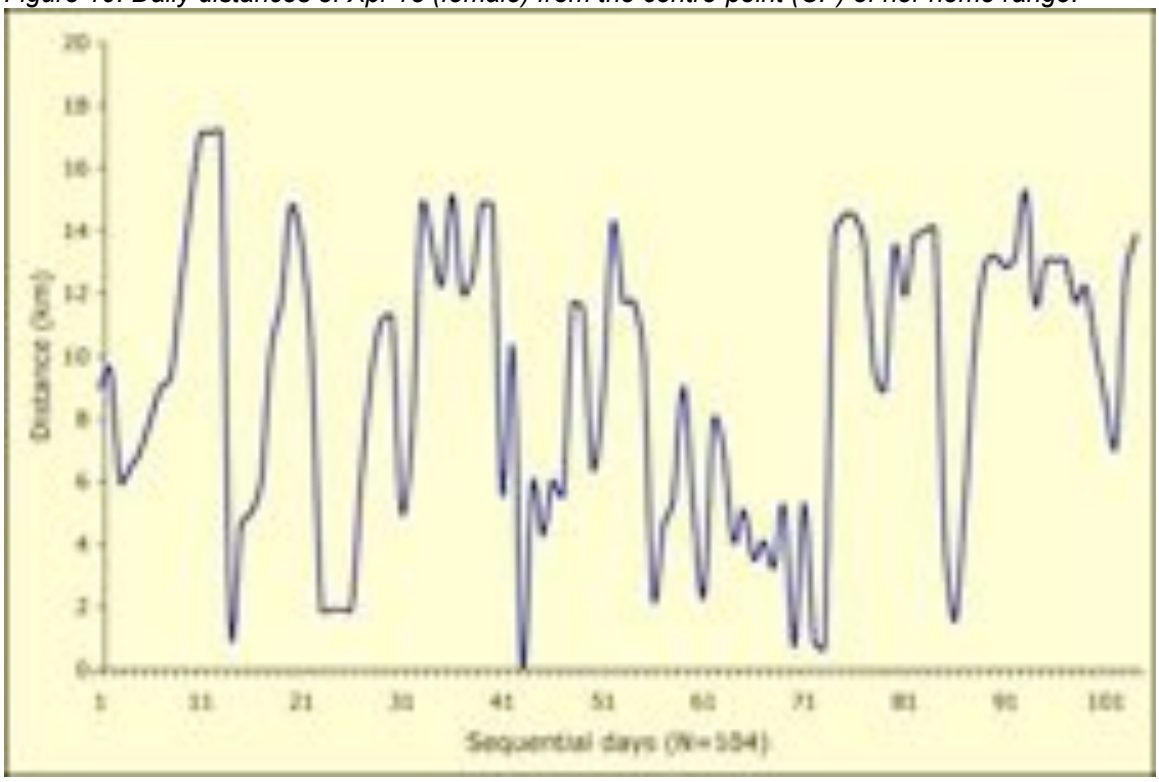


Figure 20. Daily distances of Xpl-47 (female) from the centre-point (CP) of her home range.

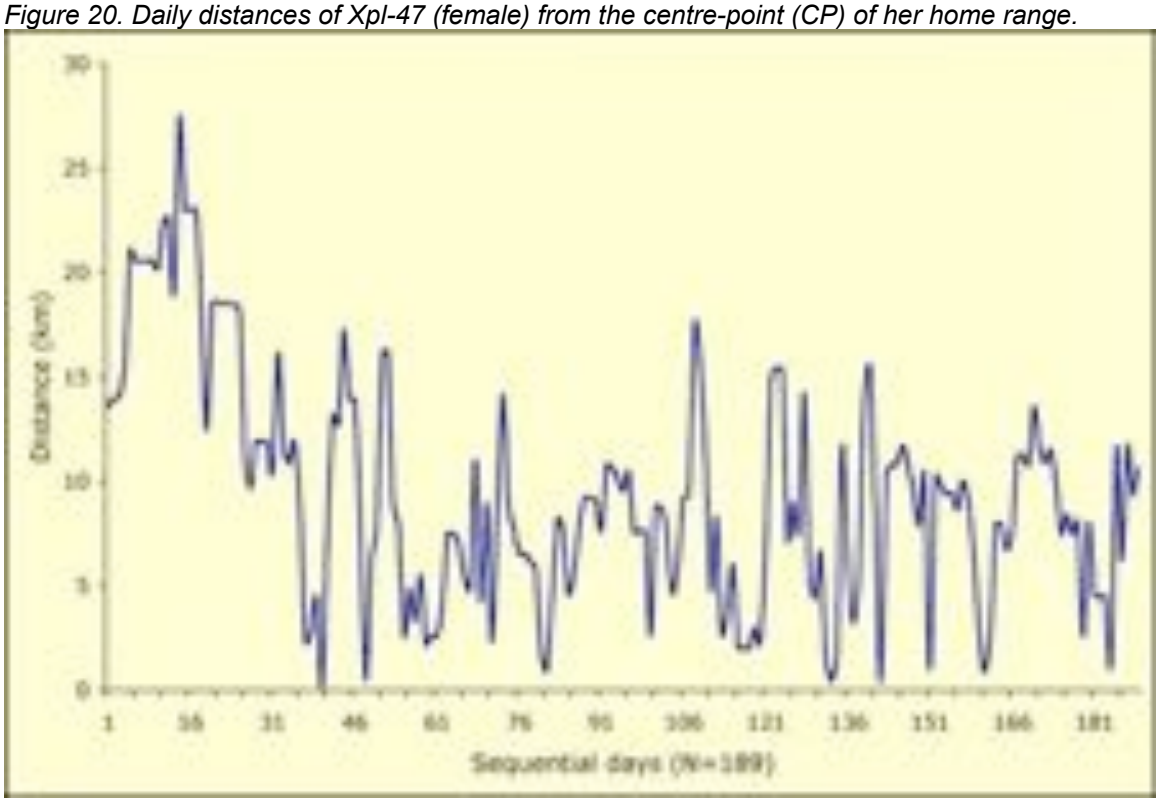
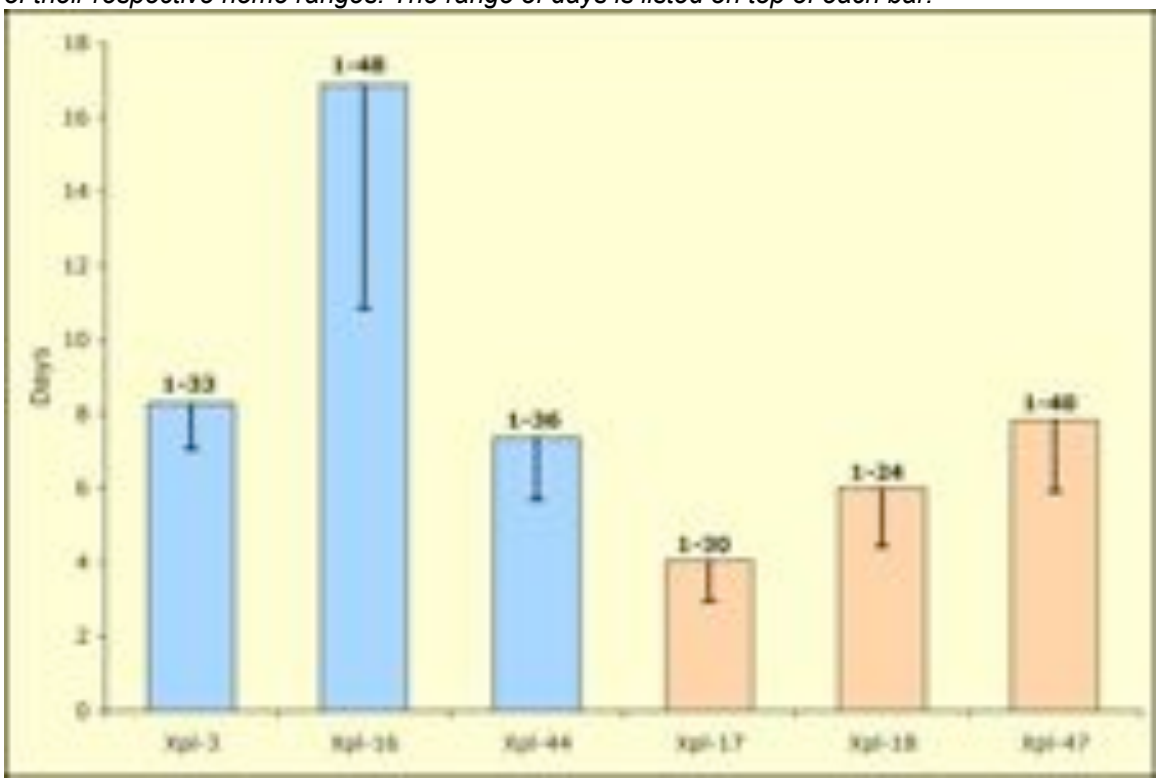


Figure 21. Average frequency (days) and standard error of lions returning to the centre-point (CP) of their respective home ranges. The range of days is listed on top of each bar.



The frequency and extent at which lions utilised different parts of their home range was not uniform. This is displayed for each of the six lions using Spider Distance analyses of the distance and bearing of movements from the centre-point (CP) of the home range (Figures 22 – 26, and Figure 8 for Xpl-16).

Further analyses were done, using circular statistics, to demonstrate the bearing (360^{o}) and the proportion of time that each of the six lions spent from the CP of their home range (Figures 27 – 32). These results reflect the data displayed by the Spider Analyses, but are more sensitive to the proportional amount of time the lions spent in the different areas. This can also be observed in the Kernel contours (Figures 7, 8, 10-12, 14).

Figure 22. Spider Distances analysis of Xpl-3 (male).

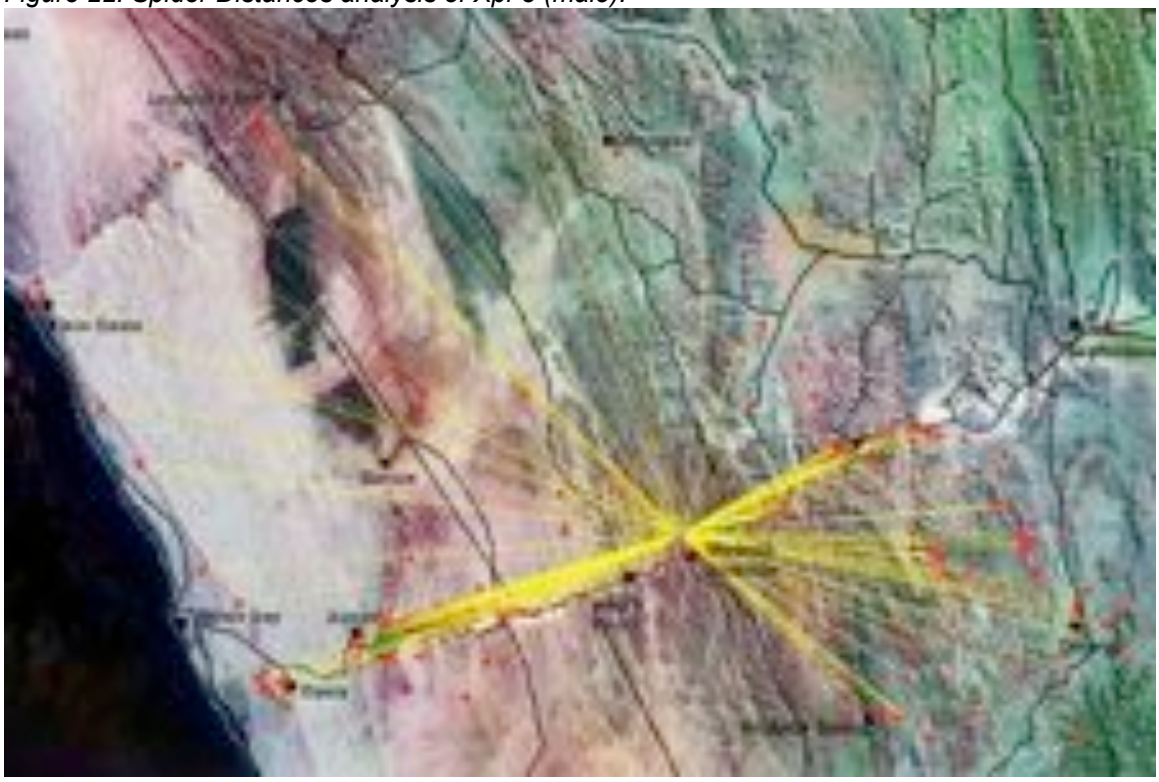


Figure 23. Spider Distances analysis of Xpl-44 (male).

Figure 24. Spider Distances analysis of Xpl-17 (female).

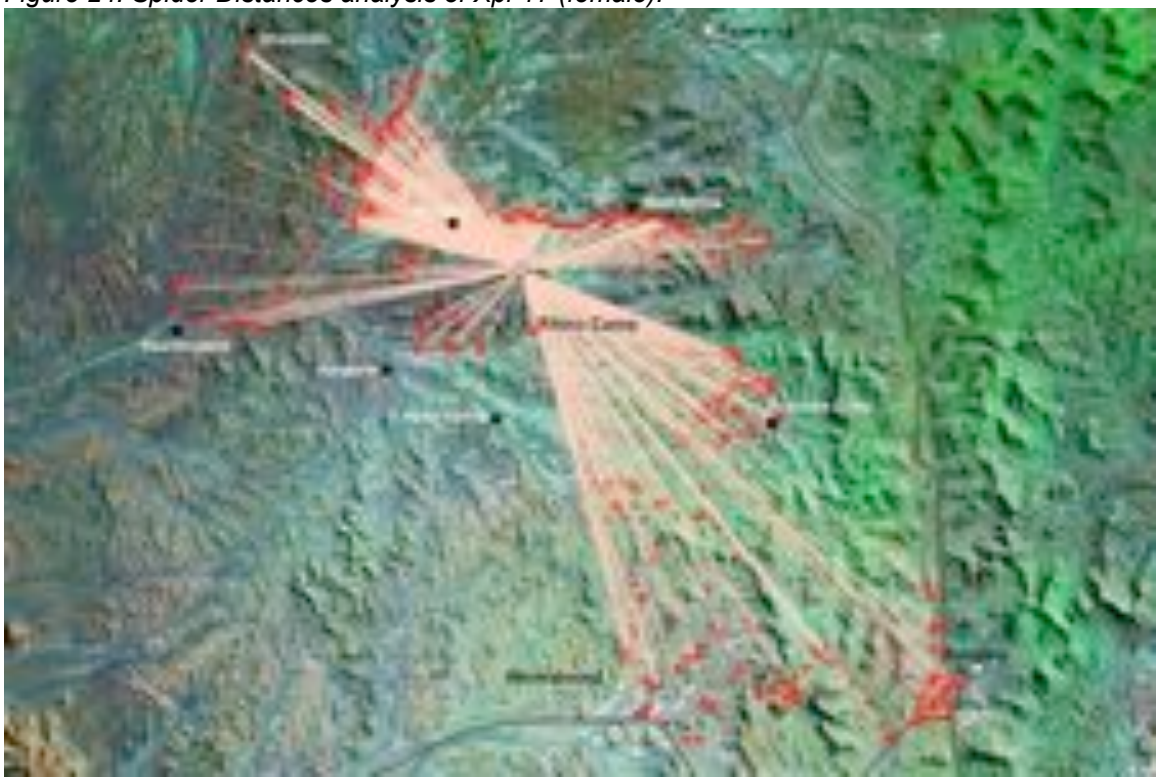


Figure 25. Spider Distances analysis of Xpl-18 (female).

Figure 26. Spider Distances analysis of Xpl-47 (female).

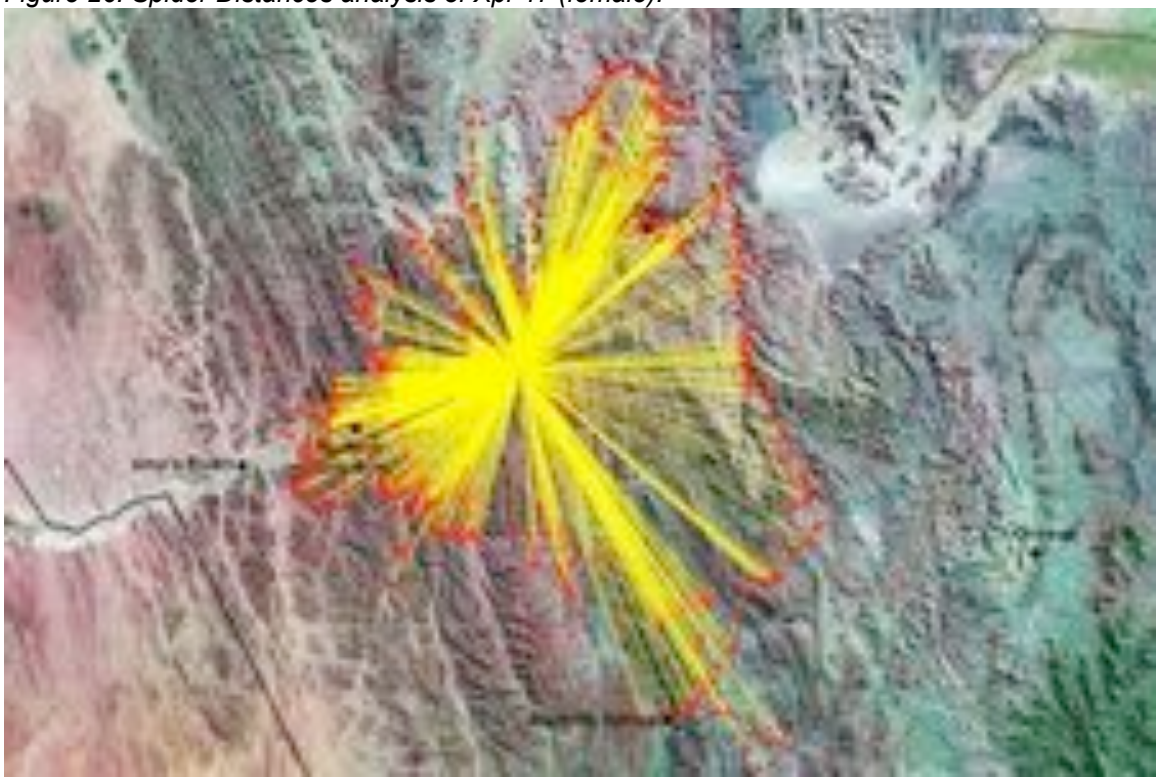


Figure 27. Proportion of time and bearing from CP of home range, for Xpl-3 (male).

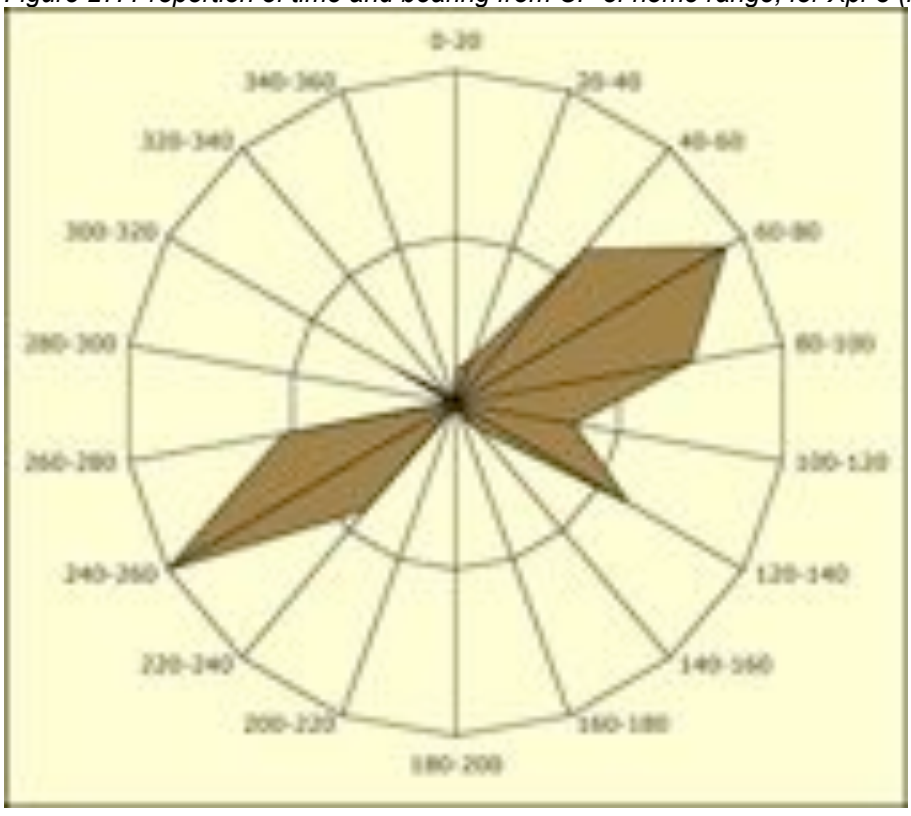


Figure 28. Proportion of time and bearing from CP of home range, for Xpl-16 (male).

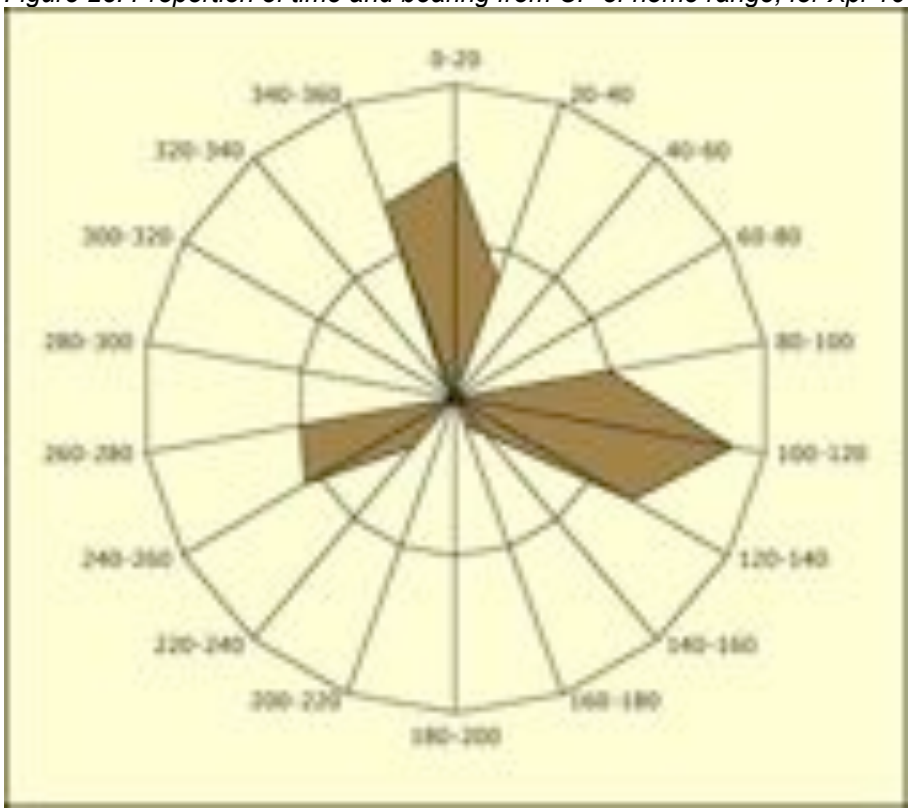


Figure 29. Proportion of time and bearing from CP of home range, for Xpl-44 (male).

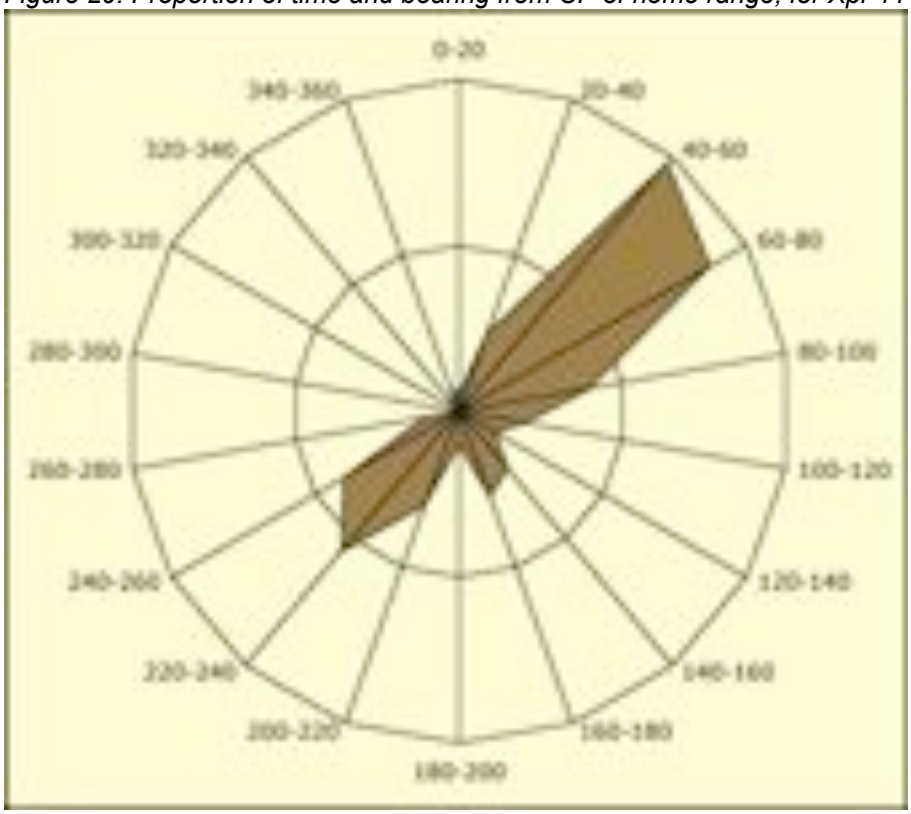


Figure 30. Proportion of time and bearing from CP of home range, for Xpl-17 (female).

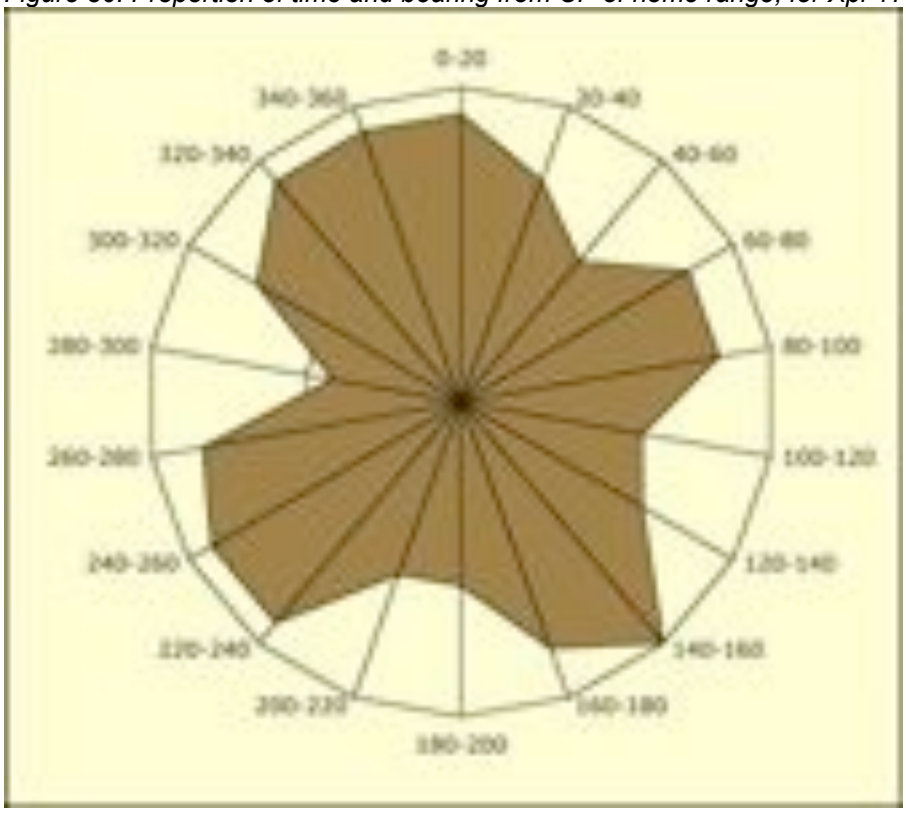


Figure 31. Proportion of time and bearing from CP of home range, for Xpl-18 (female).

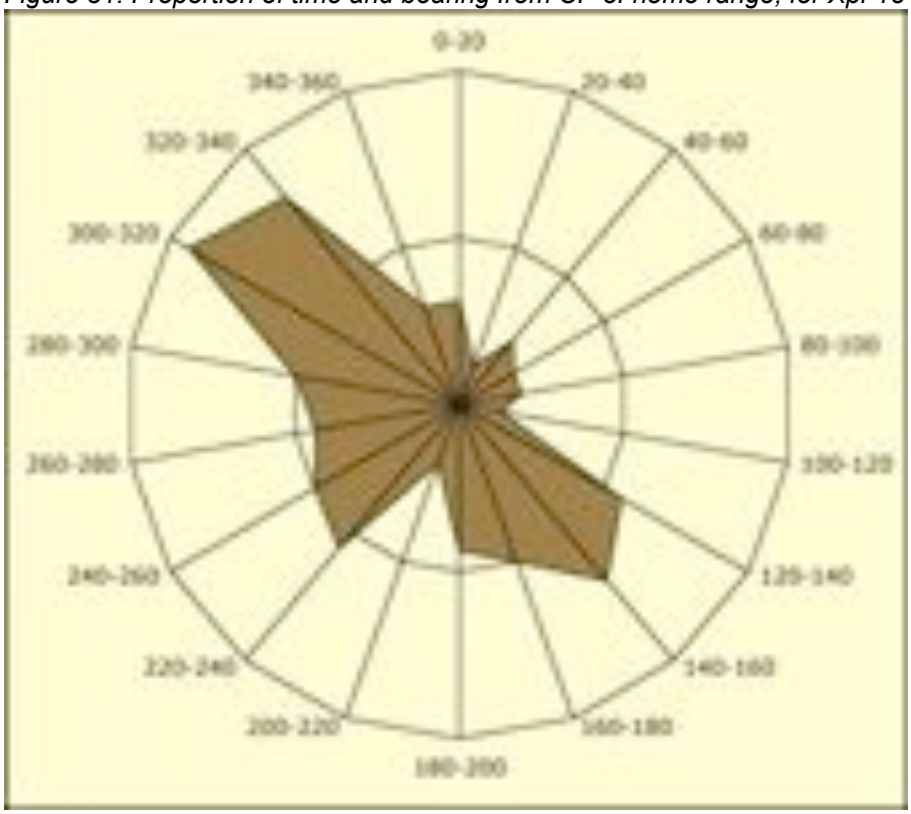
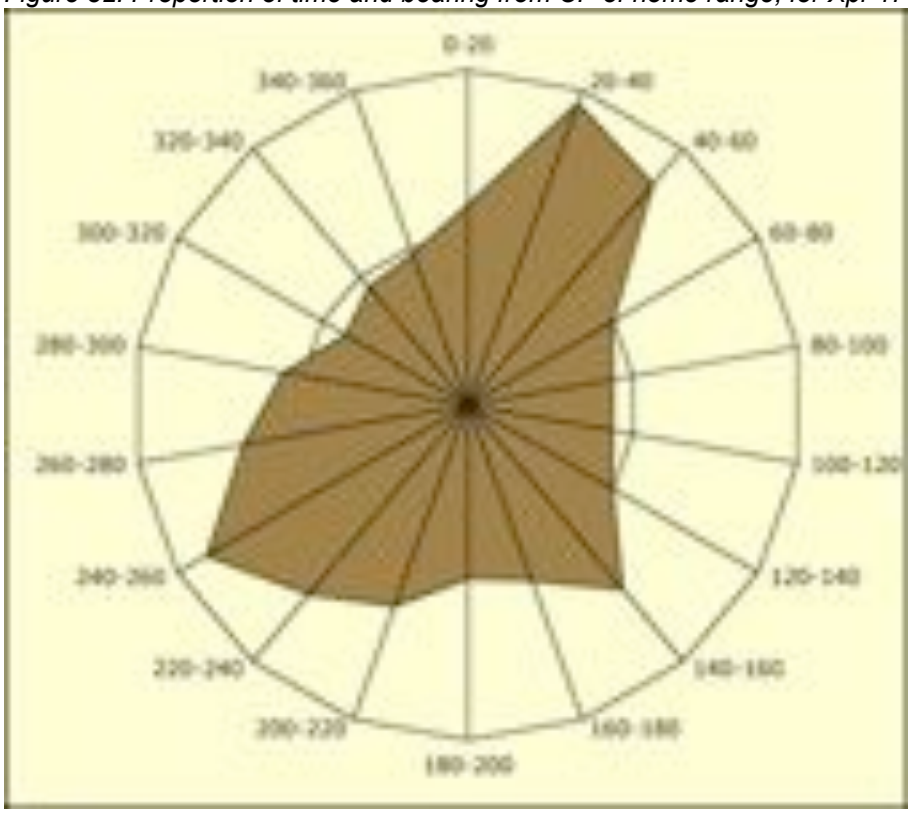


Figure 32. Proportion of time and bearing from CP of home range, for Xpl-47 (female).



The distances that lions moved away from the CP of their respective home ranges were grouped into four quarters, based on the bearing (Figure 33). The average distances that the six lions moved from the CP varied according to the direction (Figures 34 – 39). These findings contribute to the statistical process of evaluating and demonstrating the heterogeneous movement patterns. When the results from the “Spider Analysis”, “Circular Statistics”, Kernel home range estimates, and daily distances from the CP, are combined, an understanding of the movements of lions emerge, that have not previously been possible for this study.

These results are particularly valuable for the process of developing lion eco-tourism in the region. A sound understanding of the movement patterns will serve to increase the probability and likelihood of tour operators finding and viewing lions. In addition, this information will also aid the management and prevention of conflicts between lions and people over livestock.

Figure 33. Bearing from CP of home range as grouped into four quarters: North-East (0-90°), South-East (91-180°), South-West (181-270°), North-West (270-360°).

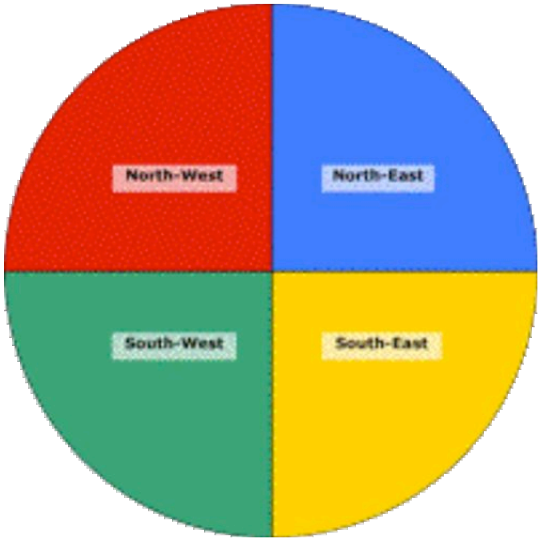


Figure 34. Average distance (SD) from CP of home range, for Xpl-3 (male). See Fig. 33.

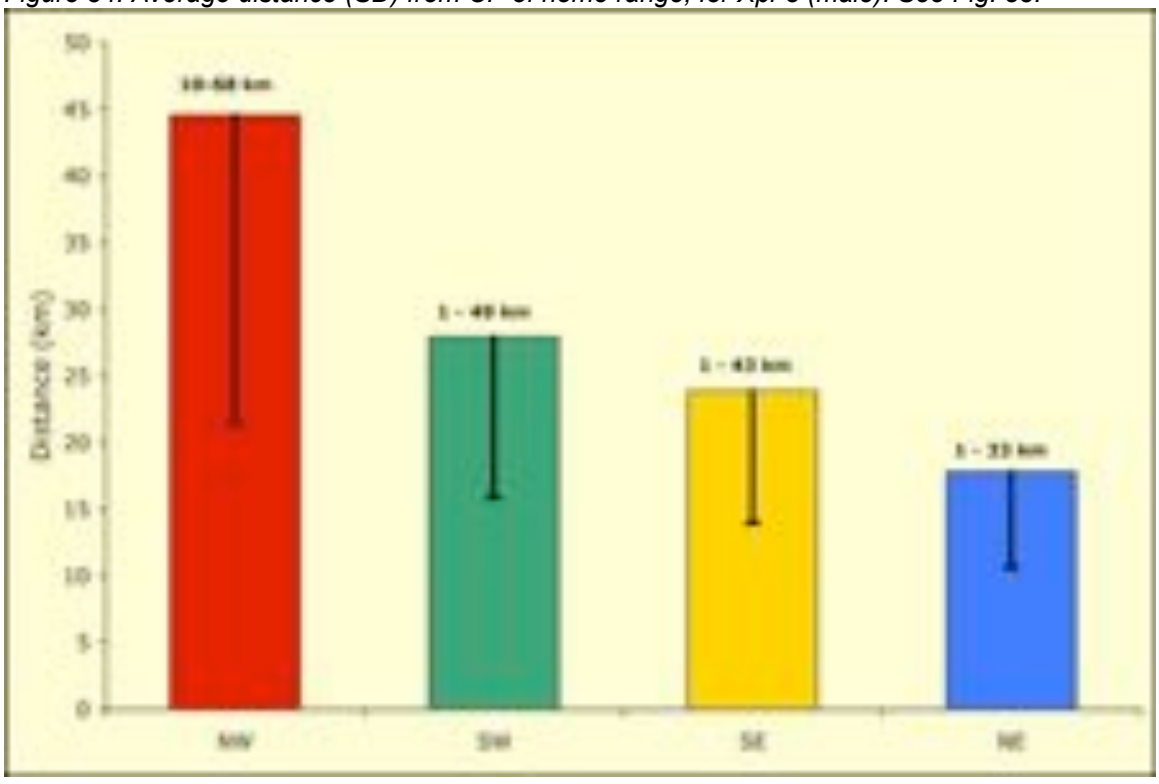


Figure 35. Average distance (SD) from CP of home range, for Xpl-16 (male). See Fig. 33.

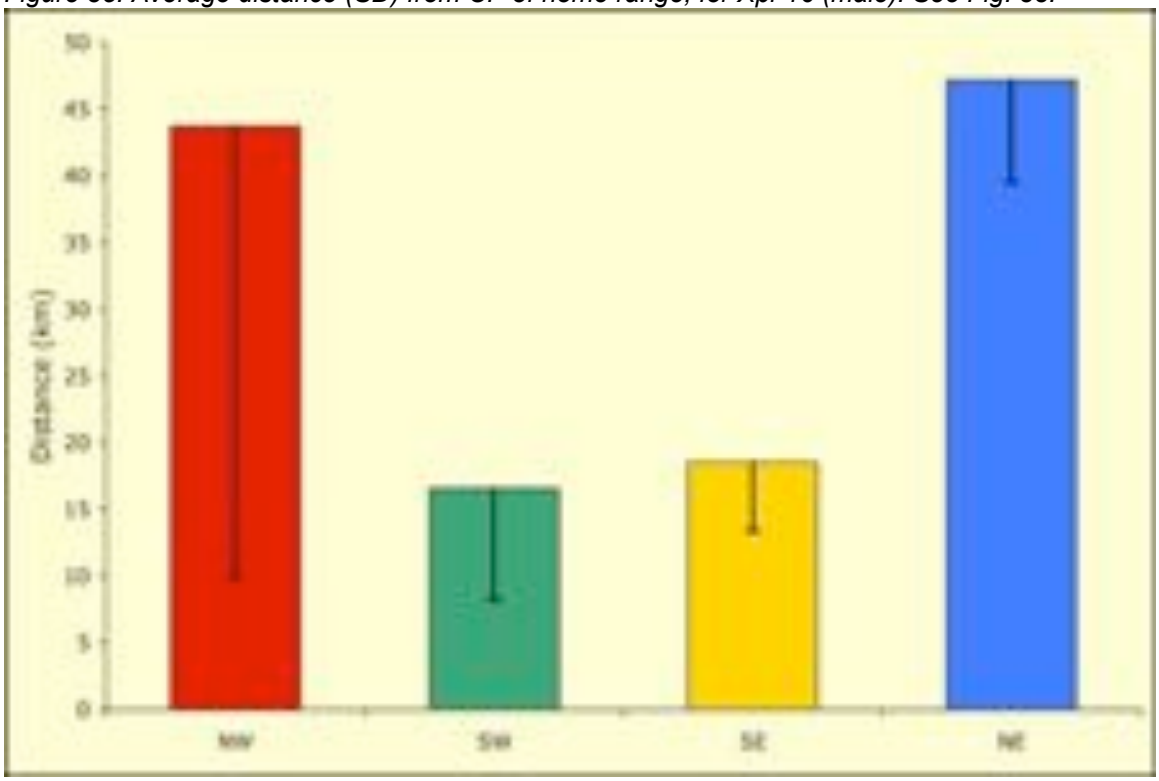


Figure 36. Average distance (SD) from CP of home range, for Xpl-44 (male). See Fig. 33.

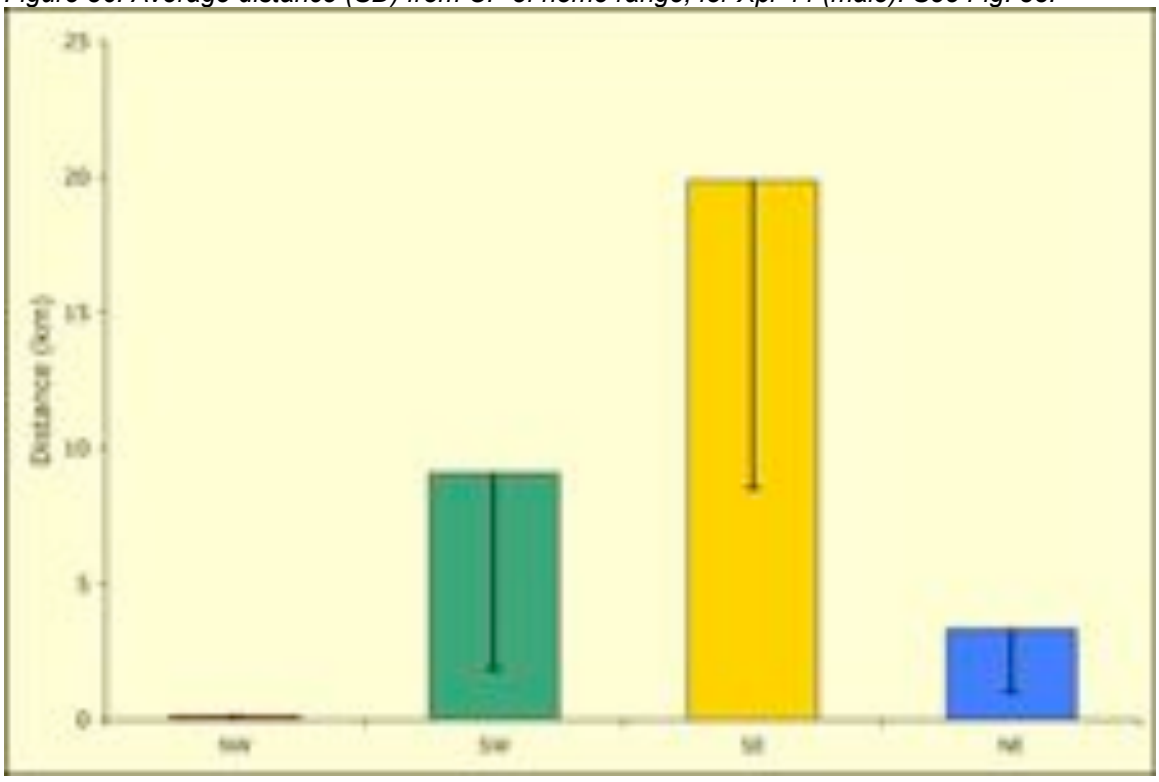


Figure 37. Average distance (SD) from CP of home range, for Xpl-17 (female). See Fig. 33.

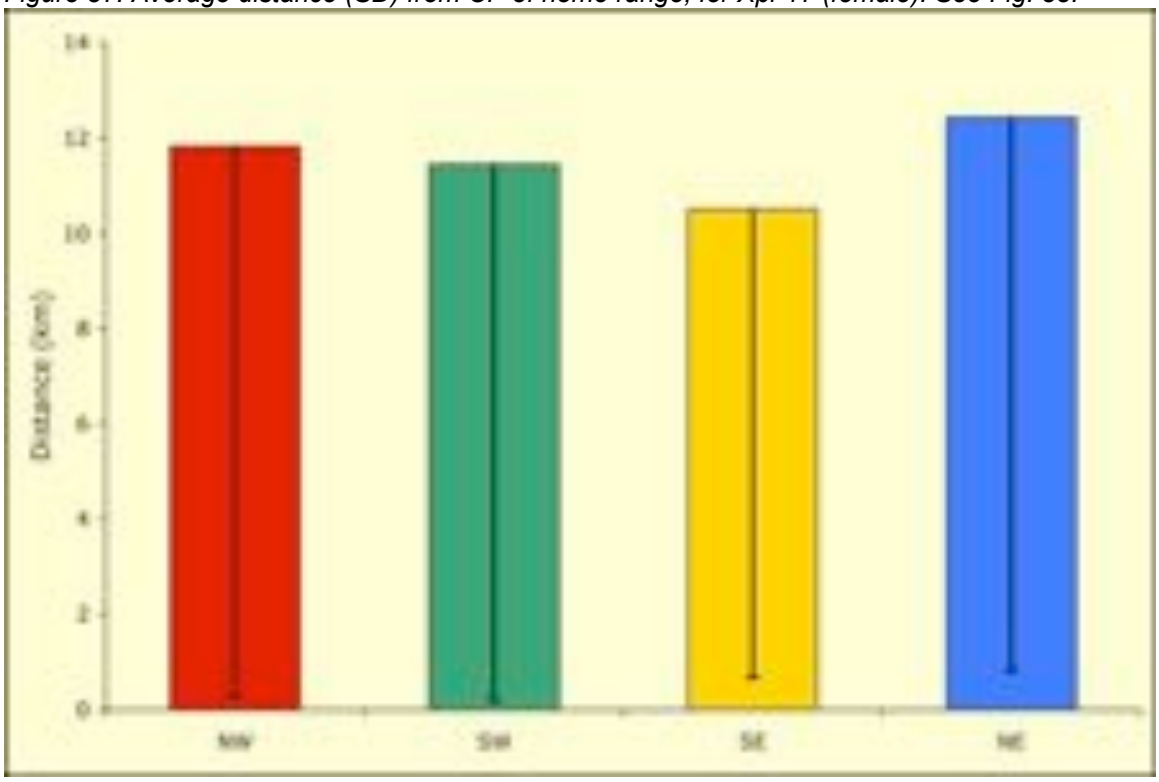


Figure 38. Average distance (SD) from CP of home range, for Xpl-18 (female). See Fig. 33.

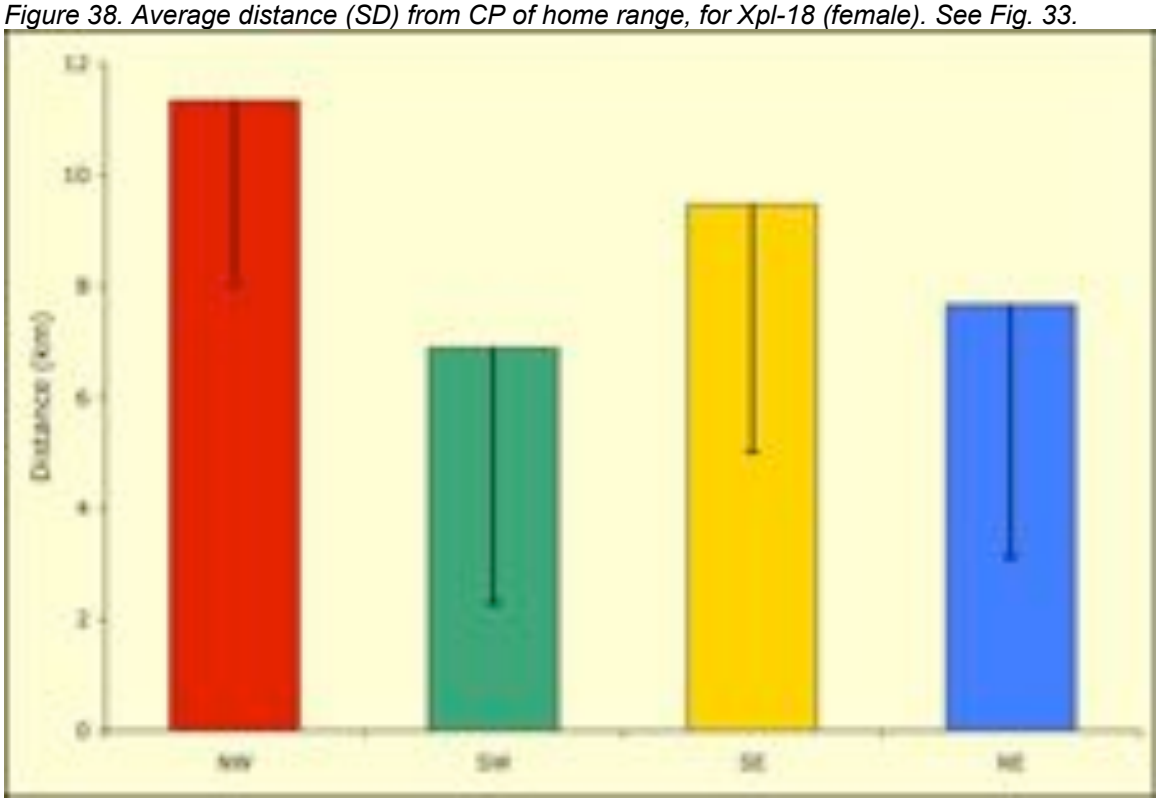


Figure 39. Average distance (SD) from CP of home range, for Xpl-47 (female). See Fig. 33.