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Movement analysis for monitoring predation by large carnivores: lions in Kruger National Park

by

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Summary

In this study I investigated how movement data acquired from Global Positioning System (GPS) data could be used to assist in the estimation of the diet and prey selection of a large African carnivore, the African lion (*Panthera leo*), in the central region of the Kruger National Park (KNP), South Africa. I show that Generalized Linear Models (GLMs) can be used to increase the probability of locating lion kills at GPS clusters, where a cluster is defined as two or more consecutive GPS locations within 100 m of each other. In addition, considering the social structure of lion prides, I show that using a metric of distance between individuals in a pride at the beginning of clusters associated with kills can further increase the predictive ability of models employed to locate kills from GPS data. However, similar to other GPS cluster based approaches there is an underestimate of smaller prey items in the prey profile. I collected scats at GPS clusters and used this additional dataset to show that the GPS cluster approach employed in the KNP underestimated the presence of smaller ungulates, namely impala (*Aepyceros melampus*) and warthog (*Phacochoerus africanus*) in the diet by at least 50%. I found that a negative relationship existed between prey items missed at GPS clusters and the size of the species, with more prey items missed as the size of the species declined. Therefore, investigating carcass remains at GPS clusters underestimated the numerical importance of the smaller prey species. However, this underestimation of small prey was not important when the biomass of prey consumed by lions was assessed, as the larger prey item not missed form the bulk of the consumed mass. In the central region of the KNP zebra (*Equus quagga*) were the most consumed prey item, followed by wildebeest (*Connochaetes taurinus*), impala and buffalo

(*Syncerus caffer*). I assessed two measures of prey selection for the lions in the study area, with each considering a different approach to prey availability. Prey selection varied considerably when availability was assessed as prey individuals or prey groups. In addition, generalisation of prey selection based on a broad assessment of prey availability in the region differed to prey selection patterns assessed on a fine scale in the pride range for each pride. Finally, I found that buffalo showed fine scale vulnerability to predation by lions based on climate and vegetation structure. Six months of below average rainfall appeared to be sufficient to reduce buffalo body condition and increase vulnerability to predation. Buffalo were more vulnerable to predation by lions in areas with longer grass and denser bush. Ultimately the use of GPS cluster data combined with scat corrections gives a good representation of the diet of a large African carnivore, and approaches the accuracy that is obtained through continuous observation data. Good quality diet estimates are needed for the accurate assessment of prey selection by carnivores as well as the fine scale investigation of habitat and climate mediated predation risk for ungulates.

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I, Craig Tambling declare that the thesis/dissertation, which I hereby submit for the degree Doctor of Philosophy at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

SIGNATURE:

DATE: 20 July 2010

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Abstract

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Doctor of Philosophy in

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Methods used to estimate the prey consumption by large carnivores include direct continuous observation, stomach content analysis, carcass observations and scat analysis. Continual observations are widely considered the best approach to estimate large carnivore diets, with lions (*Panthera leo*) being no exception. Continual observation allows the recording of all prey encounters and biases inherent in the other approaches are minimised. However, continuous observations are not always feasible, and in situations where animals cannot be observed at all times, diets are often estimated from observed carcasses. This often leads to an over-estimation of large kills in the estimated diet. Alternative methods that are free of the constraints placed on continuous observations are needed to provide data of a similar quality to that obtained using these continuous observation bouts. I employed a cluster follow up technique to locate lion kills from remotely accessed Global Positioning System (GPS) data from lions in the Kruger National Park (KNP). I develop Generalized Linear Models (GLMs) that increase the probability of locating kills at GPS cluster events. By increasing the predictive ability of detecting kills I show that this technique can be used to locate kills in a more efficient manner than random searching of GPS clusters, with further advantages in that multiple groups of lions can be monitored simultaneously. By incorporating this technique into an adaptive research framework, the diet of lions (and that of other large carnivores) can be estimated. In addition, I show that the spatial association between lions at kill sites, while feeding on carcasses, provides a further increase in the predictive ability of kill site models. Lionesses were found to be considerably closer together at the start of clusters associated with kills in comparison to clusters where no kill was found. This pattern remained consistent for both small and large kills. This proximity approach could therefore be incorporated into the GLMs that are developed to predict kill sites of large social carnivores. To further reduce the bias (where small kills are often missed) inherent in carcass observations, I combined scats and carcasses collected from known times, locations and lion groups to construct a temporal kill record for each group of lions. By combining scats and carcasses I estimate that at least 50% of the small prey items, namely impala (*Aepyceros melampus*) and warthog (*Phacochoerus africanus*) were missed when GPS clusters were investigated for carcasses. Ultimately, I show that a combination of GPS cluster investigations based on models developed using GPS movement data in combination with lion proximity data, augmented with scats collected at GPS clusters, could provide estimates of large carnivore diets that begin to approach estimated diets obtained through continuous monitoring.

The resulting diet, estimated from the GPS cluster approach in combination with scat collection, indicated that the dominant prey item in the region was zebra (*Equus quagga*) followed by

wildebeest (*Connochaetes taurinus*), impala and buffalo (*Syncerus caffer*). Selection indices for the eight dominant prey items were calculated using prey availability measures obtained from the aerial census data and ground counts of groups. It has been suggested that group level selection is a better approach to calculating predator-prey interactions, and that stability in predator-prey systems is improved if group metrics of prey are used as apposed to individual measures of availability. I show that there is a considerable shift in selection indices, as well as in the order that prey is selected, when using different measures of prey availability. In selection studies, more effort needs to be paid to the assessment and definition of prey availability to ensure results accurately reflect selection patterns in the field, especially when data are used for the development of management practices. Combining buffalo predation data collected from GPS cluster investigations with buffalo mortality data collected over five years prior to the commencement of the GPS cluster investigations, allowed an investigation into patterns of lion predation on buffalo between 2000 and 2007. Buffalo of both sexes were more vulnerable to predation in habitats that gave lions an ambush advantage (i.e. increased grass height and tree density). Despite this similarity in landscape risk, different processes lead to similar fates in dangerous habitats for buffalo of both sexes. Predation pressure by lions on buffalo increased following periods of reduced rainfall; with more buffalo predated on following drier six month periods. Predation on males constituted a significant proportion of all predation and was focused predominantly into the late dry season.

The resulting method of locating kills by using GPS clusters and correcting carcass data with scats collected along the movement path represents a robust technique to estimate large carnivore diets. In the concluding chapter I present avenues where future research can build on the current thesis and present a framework that can be employed when attempting to estimate large carnivore diets.

Note on the text

Each chapter is set out in the style of the journal to which it has or will be submitted. Consequently there is some repetition and stylistic differences in each of the chapters. In addition, other authors are included in the paper reference. However, for each chapter, my input was greatest. I planned the research, undertook the field work, analyzed the data and wrote the manuscripts. I was helped by my co-authors. Wayne Getz, Johan du Toit and Elissa Cameron were my supervisors and Lydia Belton, Samuel Laurence, Steve Bellan and Paul Cross were fellow students.

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