Lion Hunting Strategies and Remotely-Sensed Vegetation Structure in an African Savanna

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Question:

Are there patterns in how lions use vegetation structure (behavioral and sexual differences)?
Backdrop (1):
How do male lions achieve high hunting success?

Photo: G. Asner
Backdrop (2):
Quantifying the role that landscape heterogeneity (specifically vegetation structure) plays in shaping predator–prey dynamics.

Photo: G. Asner
Combining two unique datasets:

GPS telemetry data on 8 lions from the Satara region.

LiDAR vegetation structure data
Likelihood of lines-of-sight lengths from a single site

\[ p(\mathbf{y}_i|\lambda_i) = \prod_{j=1}^{m} \text{Exp}(y_{i,j}|\lambda_i) \]
Likelihood of lines-of-sight lengths from a single site

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Each site is a separate draw from a gamma distribution

\[ \text{Gam}(\lambda_i|\alpha, \beta) \]
Likelihood of lines-of-sight lengths from a single site

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Likelihood of lines-of-sight lengths from all sites

\[ p(y|\lambda) = \prod_{i=1}^{n} \left( \prod_{j=1}^{m} \text{Exp}(y_{i,j}|\lambda_i) \right) \]
Likelihood of lines-of-sight lengths from a single site

\[ p(y_i | \lambda_i) = \prod_{j=1}^{m} \text{Exp}(y_{i,j} | \lambda_i) \]

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Likelihood of lines-of-sight lengths from all sites

\[ p(y | \lambda) = \prod_{i=1}^{n} \left( \prod_{j=1}^{m} \text{Exp}(y_{i,j} | \lambda_i) \right) \]

Uncertainty in \( y \) (dragging)

\[ p(y_i | z_i) = \frac{1}{100} \]
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Baye’s rule:

\[ p(y | x) \propto p(x | y)p(y) \]
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Priors

\[ p(\alpha) = \text{Exp}(\alpha | e) \]
\[ p(\beta) = \text{Gam}(\beta | c, d) \]
What is the probability of the parameters conditioned on the data?

\[ p(\lambda, \alpha, \beta, y|[z]) \propto \prod_{i=1}^{n} \left( p(y_i|[z_i]) \prod_{j=1}^{m} \text{Exp}(y_{i,j}|\lambda_i) \right) \prod_{i=1}^{n} \text{Gam}(\lambda_i|\alpha, \beta) \text{Gam}(\beta|c, d)\text{Exp}(\alpha|e) \]
What is the probability of the parameters conditioned on the data?

$p(\lambda, \alpha, \beta, y|z) \propto \prod_{i=1}^{n} \left( p(y_i|z_i) \prod_{j=1}^{m} \text{Exp}(y_{i,j}|\lambda_{i,j}) \right) \prod_{i=1}^{n} \text{Gam}(\lambda_{i,j}|\alpha, \beta) \text{Gam}(\beta|c, d) \text{Exp}(\alpha|e)$

Likelihood Ratio test for whether groups are different

$L R = \frac{p([z]|y, \lambda, \alpha, \beta)}{p([z]|y_{\eta}, \lambda_{\eta}, \alpha_{\eta}, \beta_{\eta}, y_{\nu}, \lambda_{\nu}, \alpha_{\nu}, \beta_{\nu})}$
During the day (solid line) lines-of-sight (m) are shorter than at night (dashed line).
### Table: Time-of-day Analysis

<table>
<thead>
<tr>
<th>ID</th>
<th>Time-of-day</th>
<th>n</th>
<th>$\alpha$</th>
<th>CI</th>
<th>$\theta$</th>
<th>CI</th>
<th>$\theta/\alpha$ (m)</th>
<th>lnL</th>
<th>LR</th>
<th>dev</th>
<th>P-value</th>
<th>sig</th>
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<td>0.42</td>
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<td>8E-21</td>
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<td>0.31-</td>
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<td>Night</td>
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<td>0.31-</td>
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</table>

During the day (solid line) lines-of-sight (m) are shorter than at night (dashed line).

This is supported by the Likelihood Ratio Test
There are no sexual differences in the lines-of-site of lion night locations
Male lions kill in locations with shorter lines-of-site than they rest. There are no resting/killing differences for females.
These male lion resting/killing differences were consistent for both small and large prey.
Conclusions:

Male lions in Satara, unlike females, hunt in densely vegetated landscapes and rest in open areas (robust to ‘dragging’ and small sample sizes). These results are consistent for small and large prey.
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