Habitat selection by bull elephants in central Zimbabwe

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Abstract

A sample of bull elephants was monitored over two years and the habitats in which they were found are presented. No seasonal preferences were identified but a significant selection was noted for three out of the eight woodland types used in the analysis. A method, somewhat dated already, of determining habitat preference for elephants is presented. This technique may prove useful for examining habitat preference with regard to making management decisions.

Résumé

Nous avons suivi pendant deux ans un échantillon d'éléphants m,les et nous présentons les habitats où nous les avons trouvés. Nous n'avons pas identifié de préférences saisonnières mais nous avons noté une sélection significative pour trois des huit sites forestiers utilisés pour cette analyse. Nous présentons une méthode, déjà ancienne, pour déterminer la préférence des éléphants en matière d'habitat. Cette technique peut se révéler utile pour examiner ces préférences au moment de prendre des décisions de gestion.

Introduction

Elephants (*Loxodonta africana africana*) rely on a wide range of seasonally varying vegetation to sustain themselves. If resources are exploited disproportionately to their availability, use is described as 'selective' (Johnson 1980). It is often assumed that an animal will select resources that are best able to satisfy its nutritional requirements (Manly et al. 1993). Since resources are usually not distributed evenly in the environment, it is reasonable to assume that elephants, for example, will prefer some habitats to others. Petrides (1975) defined a preferred habitat as the one in which an animal is found proportionally more frequently out of all available.

An animal's preference or avoidance of different habitats has been assessed using a variety of well-developed techniques. The simplest and most common method is the forage ratio that is attained by dividing the percentage of observations in a specific habitat by the percentage of that habitat in the study area. The forage ratio equation was modified by Ivlev (1961) to be 'bounded' or scaled. The limitations of this method were pointed out by Jacobs (1974) when he noted that the forage ratios depend on the relative abundance of food types in the environment. Unless the habitat areas are equal the potential will be to overestimate the preference shown for small habitats and underestimate for larger habitats. He suggested a modification of Ivlev's index based on relative habitat availability. While this modification gives relatively accurate indices of selection, they lose biological relevance at the extremes of their respective scales. The issue of overestimating selectivity of small habitats by small amounts of use and underestimating large-habitat selection unless the habitat is heavily used is not completely solved by the above methods. Also, this form of analysis is limited because it provides only a ratio of habitat use to the availability and does not test the results statistically (Alldredge and Ratti 1986). Many studies have used a chi-squared goodness-of-fit approach for testing if the observed habitat use is equal to the expected use (Neu et al. 1974). However, a danger with this approach is that with many habitat types and few observations, assumptions of chi-square may be violated. An additional problem is that if the observed values are high there is a greater likelihood of the second type of errors.

The selection index technique described by Manly et al. (1993) was used in this analysis because it is a technique based on the concept of a resource selection function. This is a function of characteristics measured on resource units such that the value for a unit is proportional to the probability of that unit being used. Manly et al. (1993) argue that this concept leads to a unified theory for analysing and interpreting data on resource selection and can replace many ad hoc statistical methods that have been used in the past. The major advantage of this method for determining habitat selection is that it uses confidence interval procedures that consider multiple resources to assess selectivity.

Study area

The study area is situated in the Sebungwe region of Zimbabwe, in the Sengwa Wildlife Research Area (SWRA). The vegetation is generally deciduous and dry deciduous savanna woodland. The main vegetation associations are *Brachystegia–Julbernardia* woodland, *Colophospermum mopane* woodland, *Acacia* spp. riparian woodland, riverine grasslands and *Combretum* spp. thickets. A single rainy season usually occurs from November to April but is highly variable in timing and quantity, and the mean annual rainfall is 668 mm.

Materials and methods

Locations of the 16 bull elephants used in the habitat preference analysis were determined through radio-telemetry over two years. The UTM grid reference was entered into a spreadsheet then imported into the software programme MapInfo (Troy, NY ver. 2.1). Grid fixes, which had been overlaid onto a vegetation map of the research area, were then queried. The results were re-imported into the spreadsheet, and the determination of habitat preference was calculated as described in box 1. For this analysis, eight vegetation types were used.

Box 1. Measuring habitat selection (adapted from Manly et al. 1993)

The selection ratio is O_u/E_u

where: O_u = observed use of a habitat by all elephants
E_u = expected use of a habitat by all elephants

This ratio is defined by the equation:

$$\hat{w}_i = u_{i+}/(h_i\, u_{++})$$

where:

- $\hat{w}_i$ = the selection ratio using totals for all elephants during season *x* for habitat type *i*
- u_{i+} = the count of type *i* habitat used by all elephants by season
- h_i = the proportion of availability of habitat *i*
- u_{++} = the total count of fixes for all elephants in all habitats during season *x*

The variance of $\hat{w}_i$ ($\mathrm{var}(\hat{w}_i)$)can be calculated and used to find the Bonferroni confidence intervals for population selection ratios to establish resource selection.

$$\mathrm{var}(\hat{w}_i) = \left\{ \sum_{j=1}^{n} \left(u_{ij}/h_i - \hat{w}_i u_{+j}{}^2 \right) \Big/ (n-1) \right\}\left\{ n/u_{++}{}^2 \right\}$$

where:
n = the number of collared elephants
Confidence intervals with an overall confidence level of approximately 100(1 – α)% are calculated using:

$$\hat{w}_i \pm z_{\alpha/(2I)}\mathrm{se}(\hat{w}_i)$$

where:
$z_{\alpha/(2I)}$ = the percentage point of the standard normal distribution corresponding to an upper tail probability of $\alpha/(2I)$, and I is the number of habitat types. Using $z_{\alpha/(2I)}$ is taking into account the fact that multiple comparisons were made. $\alpha = 0.05$ (95% confidence limits) in calculating *z* (critical *z* value table; Siegel & Castellan 1988, p.320). These confidence intervals are based on the assumption that $\hat{w}_i$ is normally distributed. Comparison of the data from this study with similar data tested for normality in Manly et al. (1993) suggest that this is a reasonable assumption, provided there are more than 6 observations within each habitat type. Significance was determined if the confidence interval (ci) around was below 1 for negative selection (e.g. $\hat{w}_i$ = 0.5: lower ci = 0.2, upper ci = 0.8) or above 1 for positive selection (e.g. $\hat{w}_i$ = 2: lower ci = 1.5, upper ci = 5).

If $O_u = E_u$ (no selection) then $\hat{w}_i = 1$
If $O_u > E_u$ (+ selection) then $1 < \hat{w}_i < \infty$
If $O_u < E_u$ (– selection) then $0 < \hat{w}_i < 1$

Results

Table 1 shows the eight different vegetation types on which the analysis was performed. The first column indicates the habitat; the second the total number of locations used in the calculation of preference. The third and fourth columns show the percentage of habitat and the percentage of the total number of fixes used in determining the selectivity index (column five). The sixth and seventh columns show the upper and lower confidence limits, and the eighth column indicates whether a habitat is selected for, against or neither selected nor avoided NS.

The habitat selection analysis indicated that bulls appear to use the research area relatively equally with availability (fig. 1). The selection for *Julbernardia–Vellozia* woodlands and grasslands, *Brachystegia-Combretum* bush and *Colo. mopane* mixed woodland may be due to the diverse nature of the vegetation available in these habitats. The negative selection for the thickets may be due in part to the lack of surface water available to elephants because of the sandy soils and the deciduous nature of the woody vegetation. Overall, there was no significant selection for the four major vegetation types in the research area. There was, however, selection for *Julbernardia–Vellozia* woodlands and grasslands, *Brachystegia–Combretum* bush, and *Colo. mopane* mixed woodland.

Large variation among elephants in their occupation of different habitats resulted in wide confidence intervals. The habitat selection analysis indicated that bulls appear to use the research area relatively equally with availability.

Discussion

These results indicate that the accepted pattern of seasonal habitat use by elephants in miombo woodlands was supported by these findings. Soils impede access to *Colo. mopane* woodlands in the wet season when the thickets are preferred.

The overall pattern of an animal's diet is a product of the time it spends feeding in different vegetation communities and on the various food types within those communities (Lindsay 1994). The Manly et al. (1993) method of habitat selection is a relatively simple way to accurately estimate elephant preferences for

Table 1. Summary of results showing the selection ratio (w_i) and the direction of habitat selection for bull elephants between January 1994 and June 1996. If $O_u = E_u$ (no selection) then $\hat{w}_i = 1$. If $O_u > E_u$ (+ selection) then $1 < \hat{w}_i < \infty$. If $O_u < E_u$ (– selection) then $0 < \hat{w}_i < 1$

Habitat	Fixes (total no.)	Total habitat (%)	Total fixes (%)	Selectivity index (w_i)	Lower 95% confidence limit	Upper 95% confidence limit	Selection ($p < 0.05$)
Combretum–Terminalia woodland	319	6	6	1.03	0.48	1.57	NS
Colophospermum mopane woodland	1582	43	30	0.70	0.59	0.82	positive
Miombo	1207	23	23	1.02	0.59	1.45	NS
Riverine wood and grassland	706	12	14	1.15	0.57	1.73	NS
Julbernardia–Vellozia wood and grassland	552	5	11	2.29	1.56	3.03	positive
Brachystegia–Combretum bush	301	1	6	4.43	1.82	7.03	positive
Colo. mopane mixture	423	4	8	2.13	1.58	2.67	positive
Thicket	134	7	3	0.35	0.21	0.48	negative
Total	5225						

NS = not significant. For a full explanation of this technique see box 1.

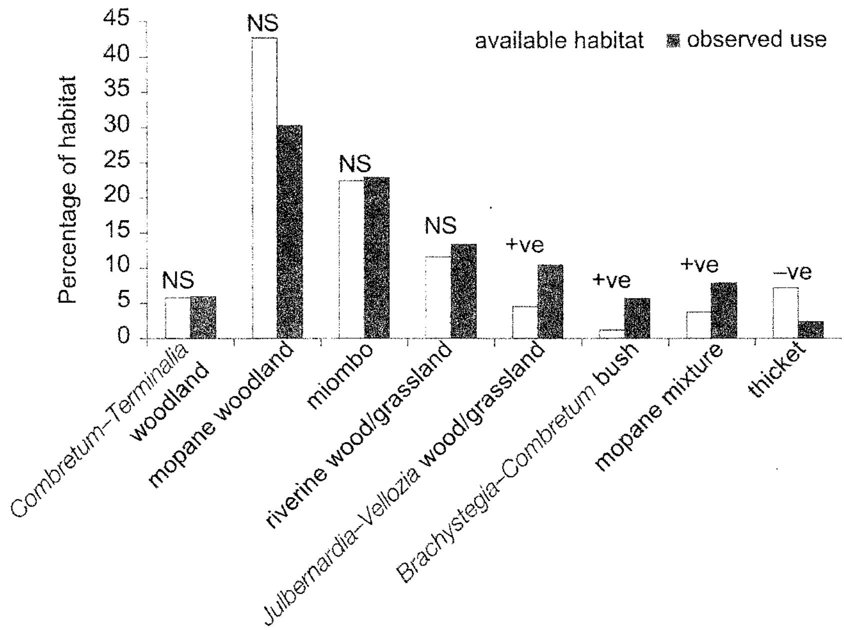

Figure 1. Differences in the availability and use of habitats by elephants. NS = not significant, +ve = positive selection, -ve = negative selection

different vegetation types. This method has been improved upon, and a more recent reference is Manly et al. (2002).

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