Habitat selection by elephants in Bwindi Impenetrable National Park, south-western Uganda

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Abstract

Elephants' preference for certain habitats of Bwindi Impenetrable National Park is discussed in relation to seasonality in plant production. Bamboo forest is favoured during the wet seasons because of the presence of young bamboo shoots. *Chrysophyllum* dominant mixed forest around Mubwindi Swamp is the best available habitat, especially during the dry periods and the only one upon which the elephants can depend for their long-term survival. Other habitat types are generally avoided. Protection of these habitats is critical if the Bwindi elephant population is to survive.

Key words: bamboo, elephant, food preference, habitat selection

Résumé

On discute ici de la préférence que marquent les éléphants pour certains habitats du Parc National de la Forêt Impénétrable de Bwindi, en relation avec la présence saisonnière des plantes. La forêt de bambou est appréciée pendant les saisons des pluies en raison de la présence de jeunes pousses de bambou. La forêt mixte où domine *Chrysophyllum*, autour du marais de Mubwindi, est le meilleur habitat disponible, spécialement pendant les périodes sèches et c'est la seule dont les éléphants peuvent dépendre pour leur survie à long terme. Ils évitent généralement les autres types d'habitat. Si l'on veut que la population d'éléphants de Bwindi survive, la protection de ces habitats est cruciale.

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Introduction

Differential use of habitat types and seasonal changes in the distribution of elephants (*Loxodonta africana* Blumenbach 1797) has been well documented elsewhere in Africa (Caughley & Goddard, 1975; Laws, Parker & Johnstone, 1975; Western, 1975; Eltringham, 1977; Short, 1983; Merz, 1986; Tchamba, 1993). Habitat selection appears to coincide with seasonal changes and corresponding food availability. Seasonal use of habitat is probably an important mechanism for survival by reducing impact on dry season habitats and allowing for food plant regeneration (Viljoen, 1989; Kabigumila, 1993). Because habitat destruction due to overgrazing can reduce the fertility and growth rates of animals (Laws & Parker, 1968), information on elephant habitat use is of crucial importance in population control and habitat management (Afolayan & Afayi, 1980). Little is known about elephant movements and patterns of habitat utilization in Bwindi or the factors influencing them. Once widespread in the Park, elephants are now represented by a relict population estimated at 22; all, except one male, moving in one group (Babaasa, 1994).

The study was conducted to determine the factors that influence habitat selection by Bwindi elephants across time and space.

Methods

The study area

The study was conducted in Bwindi Impenetrable National Park (331 km^2), which lies in south-western Uganda (0°53′ to 1°8′ south; 29°35′ to 29°50′ east). The Park is situated on the eastern edge of the Western

Rift Valley and occupies the highest part of the Rukiga Highlands. The climate is tropical with two rainfall peaks from March to May and September to November. The dry periods are December to January and June to August, the latter being more severe and longer (T. M. Butynski, unpublished report to the Uganda government). The topography of the Park consists of narrow, very steep sided valleys that run in all directions and are bounded by hill crests lying between 1400 m in the 'North Sector' and 2600 m in the 'South Sector'.

Ten vegetation types are currently described and mapped (Howard, 1991). They consist of mature mixed, *Parinari* dominant mixed, *Chrysopyllum* dominant mixed, *Newtonia* dominant mixed, colonizing, poor, hill and bamboo forests, marsh and grassland. Elephants range mainly in mature mixed, *Chrysophyllum* dominant mixed, *Newtonia* dominant mixed and bamboo forest types, an area of approximately 186 km^2 (Babaasa, 1994); this is where this study was conducted.

Field observations

Observations on habitat and food plant seasonal use and preferences were recorded from October 1992 to June 1993, a period covering the two dry and two wet seasons in the area.

Fresh elephant trails (0–5 days old) were followed for over 3600 man hours throughout the survey period. In order to get the approximate number of days elephants spent in each major habitat type, a survey was conducted for at least 4 days every fortnight. To confirm that the elephants were not utilizing any other habitat type at the same time, all four vegetation types were surveyed simultaneously for fresh elephant tracks by walking along the established trail system. Age of the elephant tracks was estimated from the appearance of dung and broken vegetation on elephant trails, however age of dung and broken vegetation was not quantified. I recorded the date of observation, location, vegetation cover/type, direction of travel and altitude. Elephant sightings or fresh trails were entered on a 1 : 50,000 topographical map of the area overlaid by a grid of 1 km^2 squares.

Samples of plants utilized as food by elephants were collected within 549 (20 × 10 m) quadrats established along the elephant trails at 200 m intervals. Elephant trails surveyed covered a total distance of approximately 120.8 km. Signs of elephant feeding were conspicuous and could be determined either indirectly by plants broken, climbers pulled down, leaves stripped from branches or by association with footprints and dung as circumstantial evidence of elephant presence. In each quadrat, I kept a record on plant species and part(s) eaten and frequency of consumption. A food plant was scored as having been eaten but the amount consumed was not assessed. For woody species, diameter at breast height (d.b.h.) was measured and recorded.

In order to assess the occurrence and abundance of the food plants, a vegetation survey was carried out independently of elephant tracks. Four representative transects, each 4 km long, were established in different areas varying in type of vegetation and preferential elephant use (bamboo, *Chrysophyllum* dominant mixed, mature mixed forest and in *Newtonia* dominant mixed forest types). A nested sampling design was employed for sampling the different life forms (woody species 20 × 10 m quadrats, shrubs 10 × 5 m quadrats and herbs 5 × 2.5 m quadrats). Quadrats were placed alternately on either side of the transect at intervals of 200 m.

Habitat selection analysis

Viljoen (1989) defines the best available elephant habitat as the one in which elephants are observed more frequently and show the highest preference relative to their overall distribution and size of the various habitats.

To evaluate the habitat preferences, the time elephants spent in each vegetation type was calculated on a monthly basis. A Preference Index (P.I.) was calculated for each habitat type with an equation adopted with some slight modification from Hillman (1975), Pepin (1986) and Viljoen (1989) where the value obtained ranges from −1.0 to +1.0, indicating the least and most preferred areas, respectively. A value of zero indicates that the animals were indifferent to the habitat and a value of −1.0 indicates that the area was not utilized at all. Four variables were used in the calculations:

n_x = the total number of days elephants spent in habitat 'x' per month estimated by appearance of dung and broken vegetation;

N_t = the total number of days in the month sampled;

a_x = the area (km^2) covered by elephant utilized habitat 'x' based on the vegetation map of the Park;

A_t = the total area (km^2) of elephant range;

n_x/N_t = the proportion of time in a month elephants spent in habitat 'x';

a_x/A_t = the proportion of the total area of elephant range covered by habitat 'x'.

If $n_x/N_t > a_x/A_t$, then P.I. $(x) = (n_x/N_t - a_x/A_t)/(1 - a_x/A_t)$

If $n_x/N_t < a_x/A_t$ then P.I. $(x) = (n_x/N_t - a_x/A_t)/a_x/A_t$

Note that there was a slight modification in the first two variables used in the above calculations. Instead of n_x being equal to the number of elephants in habitat 'x' and N_t being equal to the total number of elephants, as used by Viljoen (1989), I substituted numbers of elephants with total time elephants spent in habitat 'x' per month and total number of days per month, respectively. This was because Bwindi has only one herd of elephants (Babaasa, 1994) so that 'number of elephants' was not appropriate. Any vegetation type where fresh elephant trails, dung or feeding signs were encountered was considered to have been wholly utilized by the animals.

Results

Habitat preferences

Table 1 indicates that elephants did not utilize the habitat types in proportion to their area (Spearman rank correlation: $r_s = 0.4$, $P < 0.05$). For example, although the elephants spent much of their time (46%) in the mature mixed forest, calculations indicate a low, negative preference for it. This implies that the mature mixed forest was utilized by elephants because of its being extensive rather than a preferred habitat.

Fig. 1 shows the changes in elephant habitat monthly/seasonal use and preferences for the period October 1992 to June 1993. Elephants used the bamboo forest only during the rainy seasons. Utilization of the bamboo forest is dependent on the availability of young bamboo (*Arundinaria alpina*) shoots, which in turn depend on rainfall. During the study period, shoots were abundant during the seasons of heavy rainfall and absent during the dry periods. The only habitat that showed consistent positive preferences, little influenced by rain save for two months at the peak of the wet seasons, was *Chrysophyllum* dominant mixed forest. The reason could be its close proximity to a permanent source of water for drinking and wallowing, the Mubwindi Swamp. *Newtonia* dominant mixed forest had the lowest P.I. throughout the study period, indicating that the habitat was largely shunned by the elephants.

Seasonal use of food plants

In order to relate elephant movements to feeding strategy, an analysis of the seasonal use of the principal food plants was made. Elephants fed on a variety of food plants (78 species) incidentally. A few species of the principal food plants were utilized seasonally (Table 2). Results of a vegetation inventory in the elephant range indicated restricted availability of the food plants utilized seasonally. *Alangium chinense* and *Triumfetta macrophylla* were found only in the dry season elephant range. *Polyscias fulva* and *A. alpina* were restricted to the bamboo zone

Table 1 Habitat utilization by elephants in Bwindi showing percentage time spent by elephants in each habitat, area of habitat and preference indices of the elephants for the four major habitat types (October 92 to June 93)

Habitat[1]	Area (km^2)	% total area of elephant distribution covered by each habitat	% time spent by elephants in each habitat*	Preference index for each habitat
Bamboo zone	4	2.2	25.0 (68)	0.23
Mature mixed	126	67.7	46.1 (126)	−0.32
Chrysophyllum dominant	25	13.3	26.3 (72)	0.15
Newtonia dominant	31	16.7	2.6 (7)	−0.83
Total	186	100.0	100.0 (273)	

[1] Habitat types and their areas are after Howard (1991).

* Figures in parenthesis are the estimated total number of days elephants spent in each habitat.

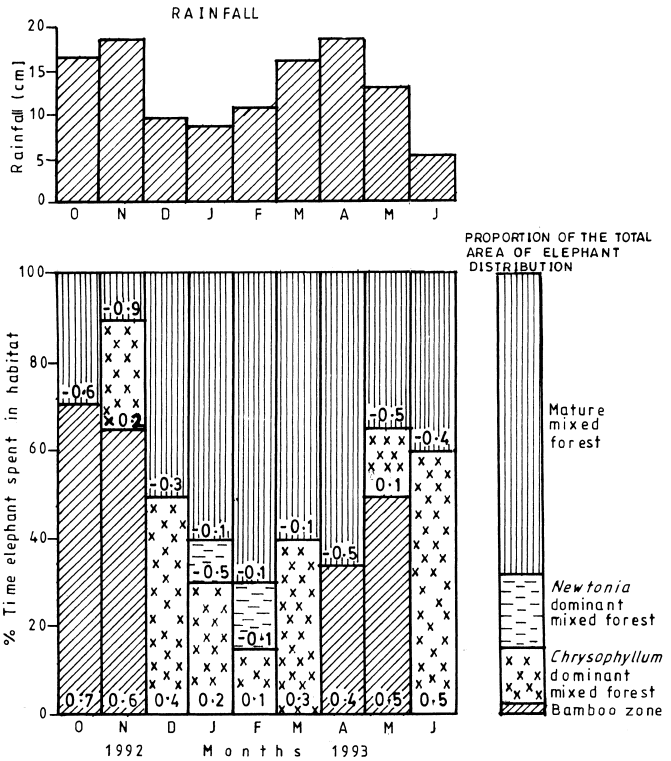

Fig 1 Percentage time spent by elephants each month in the four main habitats in the study area and availability of each habitat. The monthly preference indices for each habitat and the average rainfall are also given.

Table 2 Values of the *G*-test statistic for the seasonal variation of the most frequently utilized food plants of elephants in Bwindi (df = 5)

Food plant	Values of G	Level of significance	Season utilized
Arundinaria alpina	28.64	****	Wet
Triumfetta macrophylla	17.38	***	Dry
Alangium chinense	14.70	**	Dry
Polyscias fulva	9.89	*	Wet
Galiniera coffeoides	7.88	NS	–
Maesa lanceolata	7.78	NS	–
Newtonia buchananii	7.53	NS	–
Rubus apetalae	6.68	NS	–
Macaranga latifolia	4.82	NS	–
Strombosia scheffleri	4.76	NS	–

NS = not significant
*$P < 0.1$, **$P < 0.05$, ***$P < 0.01$, ****$P < 0.001$.

and the surrounding forest, the wet season elephant range.

Relative dietary diversity

Variation in food plant use can be viewed when the evenness index (J), alternatively referred to as homogeneity or relative diversity index, is calculated using the formula (Zar 1984):

$$J = \frac{-\Sigma P_i \log P_i}{\log k}$$

where P_i is the proportion of each particular food species

in the sample and k is the total number of species eaten during the observation period. A high value of J indicates an even distribution, i.e. the target animal spent approximately the same amount of time feeding on each species. Fig. 2 indicates that when the elephants were present in the bamboo zone, the evenness index fell. When the elephants fed on young bamboo shoots, less time was spent on other food plants.

Food plant preferences

Food preference is the extent to which a food item is consumed in relation to its availability in the environment (Petrides 1975; Viljoen 1989). Preference ratios were calculated for the ten principal food plants of the elephants (Table 3). In the absence of an accurate measure of the amount of food consumed by the elephants, stem numbers were used to approximate food plant abundance. According to Petrides (1975), the preference rating values centre around 1.00 as a reference point. Species with preference values above 1.00 are sought out as preferred food. Ratings below 1.00 represent forage species that are less preferred. Examination of the forage species in Table 3 revealed no significant correlation between the percentage availability and the preference ratio values (Spearman rank correlation: $r_s = -0.13$, $P > 0.01$) indicating that food plants were not utilized in accordance with their abundance in the environment.

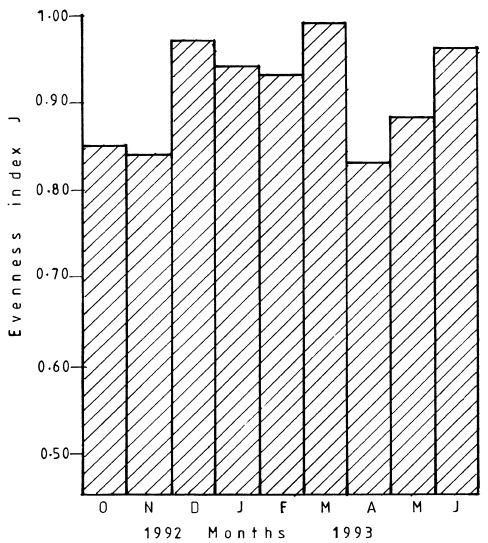

Fig 2 The evenness index J. The higher the value of J the more even the diet.

Discussion

Elephants' ranging patterns are linked to their feeding ecology. Sikes (1971), Short (1983) and White (1992) provide evidence that seasonal movements of rain forest elephants are largely a result of the distribution and fruiting patterns of food tree species. Merz (1986) and Tchamba & Seme (1993) attribute the differential use of habitat types by elephants to the distribution and variety of food resources, their abundance and permanence throughout the year, and/or the proximity of water sources. Field (1971) and Barnes (1982) suggest that elephants browse more during the dry season because crude protein content of browse is higher than that of grass. Furthermore, grass tends to accumulate tannins and rapidly become fibrous thereby reducing its palatability during the dry season. This lends support to the argument that the influx of elephants into the bamboo forest at the height of each of the two wet periods of the year is specifically to feed on high quality young bamboo shoots. Observations of the elephants and their feeding trails in the bamboo forest showed that daily ranging patterns were related to the location of dense young bamboo shoots. Data presented here suggest that this is the case because of an unusual situation where:

1 bamboo is a dominant species in a localized area but is absent elsewhere;

2 bamboo produces shoots greatly favoured and sought out by elephants in the wet seasons during the two equinoctial rains;

3 bamboo has a short growth season during which large quantities of vegetative shoots are available throughout the bamboo forest;

4 elephants respond *en masse* to sprouting bamboo shoots, and leave the bamboo forest almost immediately as the bamboo shoots mature and harden, so that the movement pattern is easily detected;

5 based on subjective assessment, no other plant species in the bamboo forest produced new flushes during the same period.

The elephants' response to young bamboo shoots probably illustrates a general feature of their biology; the opportunistic nature of their diet dictates that their movements are geared towards maximizing availability of attractive food resources. On the other hand, during the

Table 3 Preference ratios for the ten principal food plants of elephants in Bwindi. Data are from all the four habitat types

Principal food species	% available (a)	% diet (d)	Preference rating (p)
Rubus apetalae	7.2	15.7	2.18
Arundinaria alpina	6.4	13.4	2.09
Galiniera coffeoides	6.0	11.2	1.87
Alangium chinense	4.8	7.5	1.56
Polycias fulva	9.0	8.2	0.91
Macaranga lancifolia	14.4	12.7	0.88
Triumfetta macrophylla	14.7	10.4	0.71
Strombosia scheffleri	9.6	6.0	0.63
Maesa lanceolata	16.2	8.9	0.88
Newtonia buchananii	11.7	6.0	0.51

Percentage available (a) is the number of stems for each species available as related to the total number of stems available for all the species.
Percentage in diet (d) is the number of stems utilized for a given species as related to all stems utilized of all species.
Preference rating (p) is the ratio of percentage utilization (diet) to percentage availability i.e. d/a.

dry months, distribution of principal and preferred food plants seems to determine local movements.

Elephants in Bwindi stay near permanent water sources during dry periods. This could explain why, *Chrysopyllum* dominant mixed forest around Mubwindi Swamp is the most preferred habitat type for most of the dry months. It is the 'best' available habitat for elephants in Bwindi because it is critical for their long-term survival. *Newtonia* dominant mixed forest lies in a region that is essentially undisturbed by human activities (Howard, 1991). Because elephants are attracted to secondary growth (Olivier, 1978; Merz, 1981; Barnes *et al.*, 1991; White, 1992) that is lacking in such undisturbed areas, this might explain the elephants' low preference for *Newtonia* dominant mixed forest.

During this study, the bamboo forest and *Chrysopyllum* dominant mixed forest in the vicinity of Mubwindi Swamp were the core areas for Bwindi elephants, based on ranging and preference. These two habitats represent key refugia for the elephants and are critical if this small elephant population is to survive.

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