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FOOD PLANTS OF CAPTIVE ELEPHANTS IN THE OKKAN RESERVED FOREST, MYANMAR (BURMA), SOUTHEAST ASIA

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Abstract. Intensive use of natural resources by humans causes the loss of elephant habitats and increases competition for critical resources. As a consequence, fatal conflicts between wild elephants and the human population in rural areas occur more frequently. Traditionally, captive elephants forage in the forests surrounding the camp of the owner. So far, detailed knowledge on the food plants used by these elephants has hardly been available from Myanmar. This is surprising since working elephants are still indispensable for timber extraction in that country, as well as in view of the fact that the animals require good quality food, considering the high-energy loss due to the extreme physical exertion. In order to contribute to the sustainable management of their natural feeding grounds, we conducted a study on the plant species eaten by working elephants. Ten working elephants studied in their natural habitats fed on more than 124 different plant species, exceeding the numbers previously recorded in the literature. We also found that feeding activity was significantly different between male and female elephants. Bull elephants fed more frequently than cow elephants, while diet was more diverse in female animals. *Accepted 30 January 2006*.

Key words: *Asian elephant* (Elephas maximus), *forest type*, *grazing grounds*, *habitat*, *Myanmar (Burma)*, *natural diet*, *Southeast Asia*, *working elephants*.

INTRODUCTION

Myanmar or Burma has a long tradition of domesticating wild Asian elephants (*Elephas maximus*). In former times the world's largest land animal was used in war and cultural pageants by ancient kings, and elephants represented the strength and wealth of their owners in many South Asian countries. Myanmar has today between 5500 and 6800 (Kempf & Santiapillai 2001, Baker & Kashio 2002) captive elephants, and therefore holds the largest population of captive elephants among 11 South Asian countries. Captive elephants are still used primarily for heavy work in forestry, transportation, and agriculture, especially in areas where heavy machinery cannot be used (Baker & Kashio 2002).

For feeding, working elephants in Myanmar are traditionally released after work in a nearby forest, while no additional food is provided. By feeding on wild plants these captive elephants potentially compete with wild elephant herds and with other herbivorous animals. At the same time, the excessive use of natural resources by humans results in the shrinking of suitable elephant habitats (Lair 1999, Khyne U Mar 2002) and competition for the remaining resources potentially increases (Lair 1999). Hence natural elephant food is becoming scarce and fatal conflicts between elephants and the human population

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in rural areas occur more frequently (Lair 1999, Ye Myint pers. comm). Considering that a group of wild elephants has an annual home range of 610 km^2 (Smithsonian NZP 2005) these animals need large forested areas.

So far no detailed knowledge about the components of the natural diet of Asian elephants exists. Although some work on this aspect has been done in other countries, like India, Nepal and Sri Lanka, such data are not readily available from Myanmar (Abeyratne 1986). Due to the increasing conflicts with the human population in rural areas, Myanmar scientists, particularly veterinarians and foresters, approach these problems through protection or even cultivation of the plant species elephants feed on in the forest, or, if necessary, the development of artificial elephant food.

The foraging situation for elephants becomes even more critical when captive animals are employed for hard work. Working elephants need substantial quantities of food to recover their strength after extreme physical work. Adequate nutrition is an essential factor for the surviral of the animals, since a poor diet may lead to infertility, poor growth and elephants showing symptoms of deficiency of specific nutritive elements (Abeyratne 1986, Khyne U Mar 2002). Therefore more detailed information about the habitat requirements and food preferences of captive elephants is desirable for the maintenance of a healthy elephant population in domestication and in the wild, as well as for habitat management (Dhakal & Ojha 1995, Karunaratne & Ranawana 1998).

Elephants are generalist or intermediate feeders that feed on grasses and browse, consuming a large number of plant species (Sukumar *et al.* 1987, Sukumar 1989, Karunaratne & Ranawana 1998). In general, the food consumption of elephants can vary according to the season, region, and individual requirements or taste (Sukumar *et al.* 1987, Kalemera 1989, Sukumar 1989, Viljoen 1989, Karunaratne & Ranawana 1998). The main object of our study was to gain knowledge about the plant species included in the natural diet of Asian elephants and to investigate the feeding activity of captive elephants in their foraging habitat. These objectives can be expressed in the following questions:

FIG. 1: Site A: Forest surrounding the temporary elephant training camp "Kant Law", Insein District, Yangon Province.

FIG. 2: Site B: Environment of the elephant research camp "Myaing Hay Wun", Insein District, Yangon Province.

- What plant species are included in the natural elephant diet? – Are there preferences?
- What does the feeding activity of Asian elephants look like?
- Do feeding habits differ between elephants of different sexes, or between old (≥ 25 years) and young (≤ 24 years) animals?

METHODS

The study was carried out in the Okkan Reserved Forest, southwest of the Yoma Hills in the Insein District, Yangon Province in Myanmar during the dry season from January until April 2002. During this season, the captive elephants are not working and allowed to feed also during daytime. Hence this period was optimal for studying the feeding habits of Burmese working elephants.

Study area. The common forest types in the region were "Mixed Deciduous Forests" or "Tropical Moist Deciduous Forests". Dominant and economically interesting species include *Tectona grandis*, *Xylia dolabriformis*, *Homalium tomentosum*, *Salmalia insignis*, *Gmelina arborea*, *Lannea grandis*, *Pterocarpus macrocarpus*, *Millettia pendula*, *Berrya ammonilla*, *Mitragyna rotundifolia* and trees of the genus *Termalia* and *Vitex*, as well as bamboos and other grasses like *Bambus polymorpha*, *Cephalostachyum pergracile*, *Dendrocalamus membronaceaus*, and *Pennisetum pedicellatum* belonging to the family of Gramineae (Edwards 1950, Kermode 1964, Oo Maung 1980).

Within the Okkan Reserved Forest, feeding behavior of the elephants was studied at two different sites:

A the surrounding area of the temporary Elephant Training Camp "Kant Law", where closed but degraded forests characterize the scenery (Fig. 1), 9 elephants.

B the surroundings of the Elephant Research Camp "Myaing Hay Wun", about 20 km southwest of site A, where degraded bushland characterizes the scenery and only a few trees above 5 m height have remained (Fig. 2), 1 elephant.

Elephants studied. The elephants studied belonged to the Myanmar Timber Enterprise (MTE, governmental enterprise) and were chosen based on age, sex,

TABLE 1. Characteristics of the ten test elephants, the corresponding observation time, number of scientifically identified plant species fed on by each individual, and individual feeding activity (*N = no tusks*, *S = small tusks*, *T = tusker*, *OT = observation time*, *ScSp = scientifically identified species*, *NM = number of mouthfuls*, *FA = feeding activity*).

elephant	sex	mark	age	MTE-No	OT (h.min)	No of ScSp	NM	FA (% of OT)
AMT35	M	T	35	3414	25.83	22	982	73
AMT25	M	T	25	5252	25.21	24	1421	69
AMS24	M	S	24	4893	23.54	20	1156	67
AMT19	M	T	19	5269	25.85	22	1717	76
AMN11	M	N	11	6413	26.03	22	1390	83
AFN50	F	N	50	6329	26.58	22	478	52
AFS40	F	S	40	2529	26.11	26	750	57
BFN35	F	N	35	3825	19.60	35	1520	76
AFS23	F	S	23	5260	24.40	27	1041	53
AFS09	F	S	09	6347	19.24	26	841	73
average/sum						25	11296	68

and special characteristics. Five male and five female elephants, between 9 and 50 years old, were observed (Tab. 1). Samples of blood and feces were taken from each test elephant and analyzed in a laboratory to make sure the elephants were healthy and in a good physical condition.

Data collection. Each elephant was studied over four days, with two exceptions that were only observed over three days, resulting in a total of 38 observation days. For recording the daily feeding rhythm we noted the time at the beginning and the end of observation as well as time and duration of feeding breaks. Two types of feeding breaks were defined:

- long breaks of more than 15 min. (if an elephant was eating less than 10 mouthfuls per hour, this was also considered to be a feeding-free period)
- short breaks of five to 15 min. without any ingestion of food.

Data on the plant species consumed by the elephants and the number of mouthfuls of each species were obtained by permanently following the feeding animal. In order to avoid disturbance, the animals were normally observed from a distance of 10 m to 20 m. This method was also employed in a slightly modified way by Chandra *et al.* (1990). The local names of the ingested plants were whenever possible supplied in the field by local helpers. Samples of each plant species were collected for scientific identification at the Forest Research Institute in Yezin.

Data analysis. For detecting possible differences in the elephants' diet at the two sites A and B, we used a diversity index based on plant species eaten by the elephants. The fewer species two samples share, the higher the β diversity will be (Magurran 1988). The additionally used Similarity Measure of Jaccard (C_J) equals 1 in the case of complete similarity, and 0 if the sites have no species in common (Magurran 1988). Two different indices were used: Routledge's measure β_R, which takes overall species richness and the degree of species overlap into account (Routledge 1977, Magurran 1988) and Jaccard's similarity measure, which is widely adopted for estimating β diversity (Magurran 1988).

For the statistical analysis, the Wilcoxon Mann-Whitney test was applied using a 5% level of significance (Dalgaard 2002, Dolić 2004). The feeding activity at different hours per day was compared with the Kruskall-Wallis test (Dolić 2004).

RESULTS

Number of plant species used. Elephants used 124 food plants, and we were able to identify 73 (59%) to species level. For 23 (19%) plant species only the genus or family could be classified. Furthermore, 25 (20%) could be named only with local terms; three (2%) plant samples could not be identified at all.

Rutledge's β diversity (β_R) was 62.76, indicating that only a few species were consumed in both areas

(A and B). The Jaccard similarity index of C_J = 0,13 confirms that only a few species, namely 15, were eaten at both sites. Hence sites A and B differ in their plant composition and will be considered as different habitats in the following analysis.

Out of 96 botanically identified species, only 86 could be properly assigned to the elephants studied, and will therefore be considered in the further analysis. At site A, nine elephants were observed feeding on a total of 66 different plant species from 27 families. In comparison, the elephant BFN35 observed at site B fed on 35 different plant species from 20 families. However, BFN35 fed on more plant species (35) than any other elephant observed. The others fed on only 20 to 27 different plant species. The numbers of plant species used by each elephant are summarized in Tab. 1. Considering only the nine elephants observed at site A, the number of plant species exploited did not differ significantly between young and old elephants. However, we found a difference in the diet of elephants of different sexes: cow elephants fed on significantly more plant species than bulls did (Fig. 3), although the significance is small (Wilcoxon Mann-Whitney; W = 18.5; p = 0,047). We found no significant differences in the number of plant species fed on by the individual elephants.

Plant species and preferences. At site A, seven plant taxa were identified as important food sources that provided about 97% of the elephants' diet. Of these, the bamboos (Gramineae) with three species, *Bambusa polymorpha*, *Dinochloa macclellandii*, and *Cephalostachyum pergracile*, were clearly the most important and accounted for 57% of all observed mouthfuls (100% = 9741) (see appendix). Second were the Zingiberaceae, which with seven species provided 15% of the diet, followed by other Gramineae (12%), the Arecaceae (5%), then the Combretaceae, Musaceae and Convolvulaceae, with 8% combined. The remaining 20 families with 35 species provided only 3% of the total diet (see appendix).

All nine elephants studied at site A fed on *Calamus* spp. (Arecaceae), *Bambusa polymorpha* (Gramineae, Bambusoideae), and *Thysanolaena maxima* (Gramineae). At least eight elephants fed on *Acorus calamus* and *Licuala peltata* (Arecaceae), *Amomum sericeum* and *Costus speciosus* (Zingiberaceae), *Argyreia tiliaefolia* (Convolvulaceae), and *Musa bakeri* (Musaceae). Preference of plant taxa, measured by the

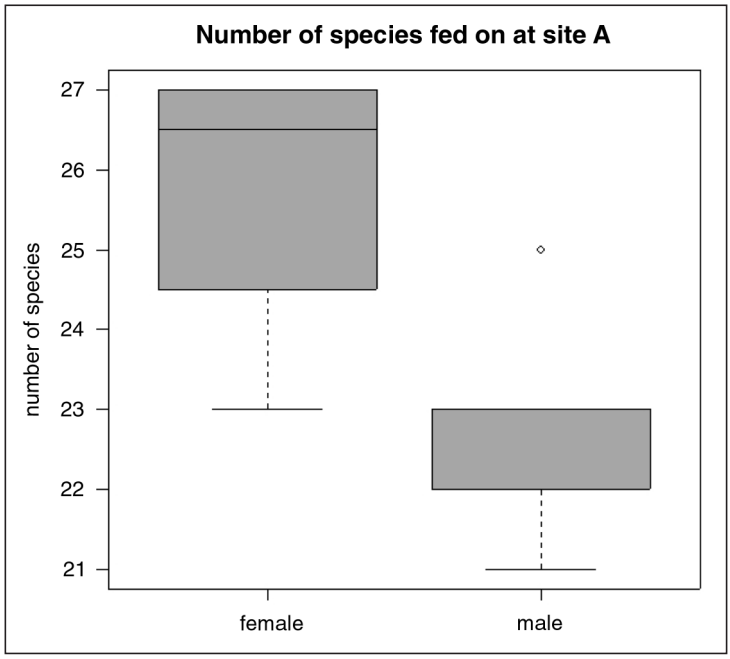

FIG. 3: Comparison of the number of scientifically identified plant species fed on by male and female elephants at site A.

number of elephants feeding on the respective group, showed the following ranking: Arecaceae, Bambusoideae (Gramineae), Zingiberaceae, other Gramineae, Convolvulaceae, and Musaceae, just to mention the most important.

The elephant BFN35, observed at site B, fed mainly on species from four taxonomic groups that accounted for 94% of its entire foraging activity. The most important food plants were also the Bambusoideae (Gramineae), which with 85% represented the main part of the diet. *Dendrocalamus membronaceaus* (39%), *Cephalostachyum pergracile* (33%), and *Bambusa polymorpha* (13%) were the most frequently exploited species at site B. The other three important food sources were other Gramineae (4%), the Convolvulaceae (3%), and the Caesalpiniaceae (1%). The remaining 16 families provided, with 22 species, only 6% of the complete diet.

Feeding behavior. The elephants were observed for 242 h 23 min., 165 h 35 min. or 68% of which was spent foraging. During this time, we counted a total of 11 296 feeding actions. We did not find significant differences in feeding activity between different hours of the day. Nevertheless, almost all the animals followed a general tendency of being more active in the morning, then declining activity between 12:00 h and 14:00 h, the hot daytime, followed by increasing activity in the late afternoon (Fig. 4). There were no differences between young and old elephants in the frequency of food ingestion (Wilcoxon Mann-Whitney; $W = 15$; $p = 0.29$). However, the frequency of mouthfuls taken differed significant between male and female animals (Wilcoxon Mann-Whitney; $W = 1$; $p = 0.03$). Bulls fed more frequently than cow elephants did (Fig. 5). A comparison of the percentage of time spent feeding did not show statistically significant differences, neither in the comparison of young and old elephants nor between the sexes (Wilcoxon Mann-Whitney; young-old: $W = 16$; $p = 0.53$ and sex: $W = 6$; $p = 0.21$).

DISCUSSION

Discussion of methods. We found the collection and conservation of food plant samples a successful method for recording the plant species included in Asian elephant diet. As a drawback, it is quite difficult and dangerous to observe elephants at close quarters in habitats with poor visibility (Sukumar *et al*. 1987),

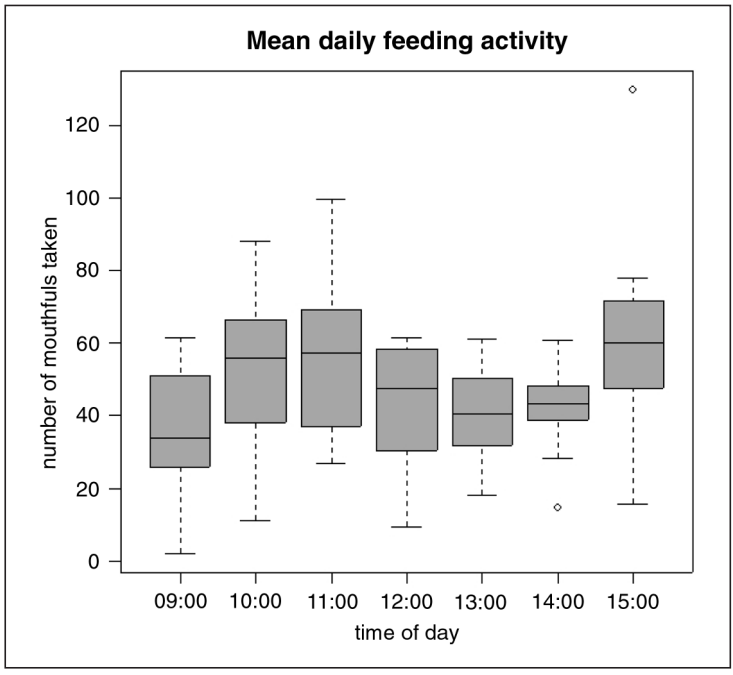

FIG. 4: Mean daily feeding activity of elephants at sites A and B.

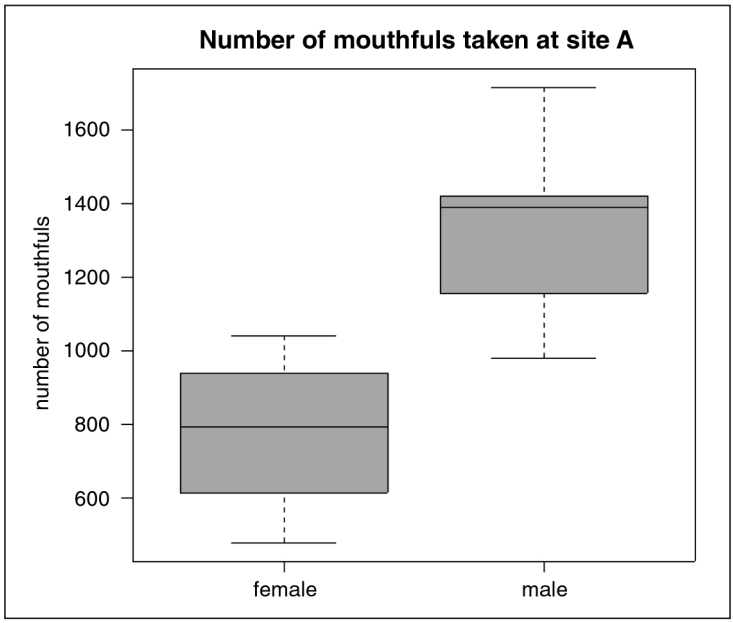

FIG. 5: Comparison of the number of mouthfuls taken by male and female elephants at site A.

especially in areas where wild elephants still share the feeding grounds. Our results were obtained with locally available equipment and relatively little financial effort. As we observed only a few elephants over a relatively short time, a larger generalization may not be appropriate. To obtain more complete information, more elephants should be observed for longer periods, and in different seasons and locations, which would result in a highly time consuming process (Sukumar *et al*. 1987).

Feeding patterns of Asian elephants have been previously studied on the basis of stable carbon isotopes, investigating the portion of grass and browse included in elephant diet. A great advantage of this method is that average results and general conclusions about the population as a whole can be achieved (Sukumar *et al*. 1987). However, our classical observation techniques allowed the recording of additional data on feeding behavior, especially detailed information on the plant species the elephants fed on, information that is extremely relevant regarding habitat management and protection. In comparison, carbon isotopic analysis does not provide this kind of fine-grained information.

Discussion of results. Our total number of 124 plant species consumed by the elephants in the Okkan Reserved Forest exceeds the numbers mentioned in the literature, e.g., 22 plant species in the Royal Chitwan in Nepal (Dhakal & Ojha 1995) and 112 plant species eaten by Asian elephants in the deciduous forest of southern India (Sukumar 1989, Karunaratne & Ranawana 1999), with most of these species belonging to very few families, such as Arecaceae, Leguminoseae, Malvaceae, and Gramineae (Sukumar *et al*. 1987, Karunaratne & Ranawana 1999). In another study from southern India, only 25 plant species accounted for 85% of the elephants' total uptake (Sukumar 1989, Ullrey *et al*. 1997). Such a restriction to a few species for the main part of the diet is confirmed by the present study. For example, the observed elephants fed at site A on 18 species that accounted for 93% of the total diet, while 66% of the total diet was even formed by only three species. This tendency was also confirmed by the data noted at site B. Plants fed on frequently were not necessarily the most preferred or the most important ones, as even rarely used plants may have important roles within the elephant food spectrum, and more detailed research, e.g., a comparison of food availability and food choice, is required.

Our comparison of the number of plant species eaten by male and female elephants has produced an

important result: plant choice in cow elephants was significantly more diverse than in bulls, though bulls fed more frequently than females did. Hence female elephants could be described as "gourmets" while male animals seem to be "gourmands". This observation could indicate different nutrient requirements of male and female elephants. Additionally, there may also be age-specific differences in feeding patterns. Other studies found that the proportion of grass, for instance, varied according to the age of the elephant (Sukumar *et al.* 1987, Dhakal & Ojha 1995). However our study did not confirm significant differences between young and old elephants.

Daily dry matter intake for adult Asian elephants has been estimated to be 1.5–1.9% of body weight (Sukumar 1989) and for young growing elephants even more (Abeyratne 1986). Toke Gale (1974) found a daily intake of about 136–680 kg of fresh vegetation for adult animals. Under conditions of poor food quality, the required amount of food may be even higher (Abeyratne 1986). Consequently, a long foraging duration or a supply of quickly consumable food is essential, as an elephant will not be able to consume a large quantity of low quality food in just a few hours (Abeyratne 1986).

Compared with, e.g., climbing plants or tree bark, bamboo can be eaten more quickly. Hence elephants may satisfy their hunger with a filling food like bamboo or other grasses, and meet critical requirements for other nutrients by feeding on time-consuming browse (Sukumar 1989, Karunaratne & Ranawana 1999). This could explain the high proportion of bamboo in the natural elephant diet described in the present paper.

Most studies on natural elephant diet distinguished only between grass and browse. A detailed record of the plant species included in natural elephant food is less common. Due to its growth characteristics and its δ^{13} C-value of C_3, bamboo is classified as a browse, even if it is botanically a grass (Sukumar *et al.* 1987). So since the observed elephants were mainly feeding on bamboos, browse species dominated their feeding pattern in the present study. However, bamboos also represent an important resource for the human population and therefore are often scarce (Oo Maung 1980). In particular the bamboo species most consumed by the elephants, *Bambusa polymorpha*, is intensively used by the rural population, which contributes to the increasing conflicts of interest between people and elephants.

In comparison with grasses, browse supports the immune system (Sukumar 1989). The consumption of bark for example helps to cover the calcium needs of elephants, and may consequently serve more than just for satisfying hunger (Sukumar 1989). The climber *Tinospora nudiflora* (Menispermaceae) that was consumed by five elephants in our study is known as a very efficient medicine in Myanmar. Even when the proportion of grass in the diet is higher than browse, elephants spend much more time on browse (Karunaratne & Ranawana 1999).

Elephants are selective feeders with differing feeding habits depending on their physiology, the season, and individual taste (Sukumar *et al.* 1987, Sukumar 1989, Dhakal & Ojha 1995). Feeding elephants may optimize nutrient intake by choosing an optimal combination of the seasonally available grass and browse (Sukumar *et al.* 1987, Dhakal & Ojha 1995). The animals' diet is therefore proportional to the availability of plant species within their feeding grounds (Sukumar *et al.* 1987). During the monsoon season, grasses have a much higher protein content and are preferred by the elephants (Sukumar 1987, Dhakal & Ojha 1995). In comparison, woody vegetation becomes a more important element of their diet during the dry season (Field & Ross 1976). This could be a further explanation for the high proportion of browse in the elephant diet recorded in the present study. Seasonal changes in elephant diet preferences are also confirmed by studies carried out in other Asian countries and in Africa (Field & Ross 1976, Sukumar 1987, Kalemera 1989, Viljoen 1989).

Working five to eight hours per day and five days a week over a period of eight months yearly, working elephants have a high loss of energy (Khyne U Mar 2002). For an average of 68% of the observation time our elephants spent most of their time feeding. This corresponds with the feeding activity (70–80%) of wild elephants in Sri Lanka (Vancuylenberg 1977) and Asian elephants in general, 70–90% (Seidensticker 1984). Furthermore, the feeding grounds surrounding the camps are often degraded and provide only poor quality food (Lair 1999, Khyne U Mar 2002). Thus working elephants could have serious problems in satisfying their nutritive requirements: a high loss of energy versus less time for the consumption of food.

If the habitats continue shrinking, forests continue degrading, and good quality food is getting scarce, conflicts between wild elephants and the human population in rural areas might become even more serious. Indeed the issue of conservation entails conflicts

embedded in people's attitudes and in inequalities of resource allocation. At present, the magnitude of the problem has exceeded the anticipations of a few decades ago (Nepal & Weber 1995).

With regard to the maintenance and restoration of natural elephant habitats, knowledge of the feeding preferences and habits of elephants is an essential element (Dhakal & Ojha 1995). Since a healthy population of elephants indicates an adequate food availability, and indirectly also the abundance of smaller herbivores, the conservation or restoration of natural elephant habitats would not only serve the whole elephant population but also other wildlife (Chandra *et al*. 1990).

CONCLUSIONS

The present study may be understood as an initial step towards a detailed identification of the Asian elephant's natural diet and habitat requirements and as a contribution to sustainable management strategies for elephant feeding grounds. The home range size of an elephant group depends on the availability of food and can be measured using modern techniques like telemetry. For a qualitative and quantitative assessment of the habitat characteristics, techniques and data from many different disciplines must be combined.

Today there is a growing recognition that nature conservation issues must be dealt by considering also the needs of humans, since the existence of a native human population in any place involves complex interactions of ethnic, social, economic, political, historical and biological aspects that exceed a strictly ecological approach (Lusigi 1984, Mares 1986, McNaughton 1989, Western 1989, Shafer 1990). Conservation concepts based on strictly intellectual or aesthetic values understandably may have little meaning to local villagers who have to struggle for their existence (Nepal & Weber 1995, Ye Myint, pers. comm.). In order to defuse the conflicts between wild elephants and the human population in rural areas, multi-criteria approaches, taking into account the requirements of both elephants and humans will be crucial, together with sustainable forest management strategies.

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APPENDIX. Scientifically identified plant families and species fed on at site A, including the number of mouthfuls of each species (*S/F = number of species fed on per family*, *PF = preference for a plant family*, *NM = number of mouthfuls*, *PS = preference for one species*, *NE = number of elephants feeding on a certain species*).

Plant family	S/F	PF (%)	Scientific name	NM	PS (%)	NE
Acanthaceae	1	0.02	*Thunbergia* spp. 1	2	0.02	1
Araliaceae	3	0.12	*Hedera helix*	9	0.09	2
			Trevesia spp. 1	2	0.02	2
			Schefflera venulosa	1	0.01	1
Arecaceae	7	5.06	*Calamaus* spp.	186	1.91	9
			Acorus calamus	141	1.45	8
			Licuala peltata	111	1.14	8
			Wallichia disticha	42	0.43	5
			Caryota urens	8	0.08	3
			Plectocomia macrostachya	3	0.03	1
			Lasia aculeata	2	0.02	1
Burseraceae	1	0.02	*Garuga pinnata*	2	0.02	1
Caesalpiniaceae	1	0.02	*Bauhinia ornata*	2	0.02	1
Combretaceae	3	2.83	*Combretum acuminatum*	248	2.55	7
			Calycopteris floribunda	27	0.28	1
			Combretum spp.	1	0.01	1
Convolvulaceae	3	2.46	*Argyreia tiliaefolia*	129	1.32	8
			Ipomea purpurea	57	0.59	4
			Calonyction aculeatum	54	0.55	2
Cyperaceae	1	0.11	*Carex stramentitia*	11	0.11	1
Dilleniaceae	1	0.24	*Dillenia indica*	23	0.24	3
Dioscoreaceae	2	0.07	*Dioscorea wallichii*	6	0.06	2
			Dioscorea cylindrica	1	0.01	1
Dracaenaceae	2	0.15	*Dracaena* spp. 1	13	0.13	3
			Dracaena spp. 2	2	0.02	1
Euphorbiaceae	2	0.02	*Antidesma diandum*	1	0.01	1
			Mallotus spp.	1	0.01	1
Bambusoideae (Gramineae)	3	57.01	*Bambusa polymorpha*	3815	39.16	9
			Dinochloa macclellandii	1632	16.75	7
			Cephalostachyum pergracile	106	1.09	6
other Gramineae	7	11.97	*Neohouzeaus helferi*	493	5.06	3
			Chloris inflata	190	1.95	5
			Thysanolaena maxima	165	1.69	9
			Eragrostis zeylanica	153	1.57	3
			Rottboellia spp.	111	1.14	3
			Panicum astro-asiaticum	47	0.48	4
			Dichanthium spp.	7	0.07	1
Malvaceae	2	0.35	*Kydia calycina*	33	0.34	1
			Gossypium spp.	1	0.01	1
Menispermaceae	2	0.13	*Tinospora nudiflora*	12	0.12	5
			–	1	0.01	1
Mimosaceae	1	0.02	*Mimosa pudica*	2	0.02	1
Musaceae	1	2.55	*Musa bakeri*	248	2.55	8
Moraceae	4	1.43	*Ficus* spp.	71	0.73	5
			Ficus glomerata	43	0.44	6
			Artocarpus chaplasha	16	0.16	4
			Streblus asper	9	0.09	2

Appendix continued

Plant family	S/F	PF (%)	Scientific name	NM	PS (%)	NE
Orchidaceae	3	0.28	*Phaius* spp. 1	21	0.22	4
			Phaius spp. 2	4	0.04	1
			Paphiopedilum parishii	2	0.02	1
Pandanaceae	1	0.17	*Pandanus odoratissima*	17	0.17	1
Papilionaceae	4	0.16	*Desmodium* spp.	10	0.10	2
			Dalbergia volubilis	2	0.02	1
			Derris sinuata	2	0.02	2
			Desmodium gangeticum	2	0.02	1
Semiliaceae	1	0.01	–	1	0.01	1
Urticaceae	1	0.06	*Sarcochlamys* spp.	6	0.06	1
Verbenaceae	1	0.03	*Congea velutina*	3	0.03	2
Vitaceae	1	0.06	*Vitis trifoliata*	6	0.06	1
Zingiberaceae	7	14.63	*Amomum sericeum*	969	9.95	8
			Curcuma roscoeana	147	1.51	3
			Phrynium cadellianum	130	1.33	7
			Phrynium spicatum	122	1.25	6
			Costus speciosus	42	0.43	8
			Globba bulbifera	12	0.12	2
			Elettaria cardamomum	3	0.03	1
families: 27	species: 66	100	total	9741	100	9