

Spontaneous foraging behavior of primates in outdoor enclosures

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In 1995 there was media attention in the Netherlands for the spontaneous use of medicinal plants by woolly monkeys (*Lagothrix lagotricha*). These plants were planted by the keepers in their outdoor enclosure in the zoo Apenheul. The Dutch Institute for Ethnobotany and Zoopharmacognosy instigated field studies in this Zoo during 1996 and 1997. In both years a group of about 20 woolly monkeys (females, infants and juveniles) had free range during the day (and mixed with visitors) within the enclosure (Van Asseldonk and De Haas 1997).

During the years 1998-2002 we observed the foraging behavior of Bolivian squirrel monkeys (*Saimiri boliviensis*), both in Apenheul and in the French Vallée des Singes.

Study group and methods

Preliminary studies included an inventory of the vegetation and an estimate of the bite size for woolly monkeys (*Lagothrix lagotricha*) and several observational ad libitum and scan sampling studies (Altman 1974). The woolly monkeys we studied in Apenheul Primate Park were part of a group of 18 females with two babies that was free ranging between visitors. In the spring of 1996 we observed 8 adult females for ten days by focal animal sampling (8x10 observer days). We observed 4 individuals in a 20x4 days spread through the opening season in 1997. An inventory of the vegetation was made and compared to the consumption.

The Bolivian squirrel monkey (*Saimiri boliviensis*) groups in Apenheul primate park (NL) consisted of about 100 and the group in Vallée des Singes (France) of about 50 free ranging individuals.

The enclosures that we studied are each about 10,000 m², several vegetation plots divided by asphalt walking roads.

To study the foraging behavior for *Lagothrix lagotricha* focal (continuous) sampling was used (Altman 1974). For *Saimiri boliviensis* we applied ad libitum (continuous and location fixed) sampling. The statistics we used were summarizing and descriptive.

Results

In the woolly monkeys (*Lagothrix lagotricha*) area, we found 123 different plant species (some could not be specified beyond genus level), belonging to 53 plant families. To make this quantitative, and comparable to the consumption, we estimated of all plants present the amount of bites that were available for eating. To estimate the size of a bite three observers imitated the monkeys foraging behavior, carrying out 10x10 samples for each item.

Adult:	Grass (and alike)	3.9 (st dev 1.8) g
	Herbs	2.3 (st dev 0.8) g
	Tree/shrub (leaf)	1.6 (st dev 0.5) g
Juvenile:	all kinds	0.9 (st dev 0.4) g

The total amount of available bites present for *Lagothrix lagotricha* we estimated to be a total of 25,215,468 bites (6090 kg).

The squirrel monkey (*Saimiri boliviensis*) enclosures were not quantified for the vegetation. They were rather new plots and the list of plants present was available in Apenheul. There were over 97 different species planted, and in the area's used for observation we noted the presence of 46 species.



Fig. 1 Woolly monkey family foraging on nettle (*Urtica dioica*) plants in Apenheul zoo.



Fig. 2 Female woolly monkey foraging on mugwort (*Artemisia vulgaris*) flowers.

For the woolly monkeys (*Lagothrix lagothricha*) in 1996 the consumption of 43 (and in 1997 of 44) plant species from the wild was reported (Fig.1 and 2). There were large differences in plant choice between individuals and between specific days. About 25% of the plant consumption in both years we found to be of the Fagaceae family. Equally available were *Quercus rubra* and *Fagus sylvatica*. Yet consumption of *Quercus* was 3 fold (in 1997) to 10 fold (in 1996) that of *Fagus*. There was also a substantial consumption of *Berberis* spp. (10-15%). The preference in the consumption of trees, shrubs and grass appeared to be rather consistent amongst the group members. There was more animal specificity in the choice of dicotyledone herbs. Summarizing we noticed specific herb preference for plants of the Asteraceae, Caryophyllaceae, Boraginaceae and Urticaceae families. These are plant families with relatively many medicinal herbs in the Netherlands (Van Asseldonk 2001). The dosage of the incidental bites is proportional to the human dosage when using these herbs as a food supplement or a home remedy. Herbs we noticed to be consumed included amongst others: *Taraxacum officinale*, *Matricaria chamomilla*, *Urtica* spp., *Plantago* spp., *Impatiens parviflora*, *Rumex* spp., *Aegopodium podagraria*, *Glechoma hederacea*, *Trifolium* spp., *Fragaria vesca*, *Myosotis arvensis* and *Polygonum* spp. The average plant consumption in both years was about 7 g/animal/hour (22 bites/hour); additional 4-6 insects/hour and 2 bites of sand, pebbles or clay were consumed every hour.

With Bolivian squirrel monkeys (*Saimiri boliviensis*) consumption was seen of 17 (2000); 19 (2001) and 16 (2002) different plant species. A great deal of the foraging behavior concerned catching of insects: about 8 % (2000); 10 % (2001); 12 % (2002) of the total amount of bites. These monkeys have a preference for grass, flowers and flower- and leaf buds (*Rosa* spp., *Silene dioica*) and nuts and other parts of *Fagus sylvatica*. We noted about 10 bites an hour.

Discussion

Specific cases of sick animals that use bitter herbs as reported by Huffman (2005) we did not find because for obvious reasons sick animals were not allowed to mix with visitors. The woolly monkeys (*Lagothrix lagothricha*) seem to make a selection from the available plant species within the outdoor enclosure. Certain plant species like barberries, oak and grasses are frequently eaten by all the individuals, probably as a food item. Other plant species are consumed incidentally by some individuals. It is possible (however it will be difficult to establish) that a health benefit is gained from this. The dietary supplement achieved through spontaneous foraging included an unexpected large amount of animal prey. This has given rise to an increase of protein (eggs, insects) supplied in the woolly monkeys zoo diet. Additional to the consumption of plants and insects both monkey species under study frequently ate inorganic material like sand, earth and pebbles.

Table 1. Summary of items consumed by *Lagothrix lagothricha* (observed during 3 hours a day).
1 bite (adult) is about 0,23 g (herb) or 0,16 g tree-leaf or 0,39 g grass

Summary of foraging by <i>L. lagothricha</i>	1996: june	1997: jun-oct
Items only mentioned if eaten by > 1 individual or eaten >9 bites	8 individ x 10 days	4 individ x 20 days
Items consumed	nr of bites	nr of bites
Animal	1347	1107
Anorganic (in 1996 data of 1 individual missing)	501	896
PLANTS		
<i>Quercus rubra</i>	1212	844
<i>Fagus sylvatica</i>	113	413
<i>Berberis</i> spp.	563	880
<i>Mahonia aquifolium</i>	102	3
<i>Poa</i> spp.	291	412
<i>Rubus</i> spp.	30	268
<i>Urtica urens/dioica</i>	48	103
<i>Acer campestre/ pseudoplatanus</i>	77	106
<i>Impatiens parviflora</i>	4	55
<i>Taraxacum officinale</i>	228	64
<i>Trifolium</i> spp.	10	20
<i>Rumex</i> spp.	0	54
<i>Aegopodium podagraria</i>	10	9
<i>Glechoma hederacea</i>	8	6
<i>Fragaria vesca</i>	8	53
moss species	7	0
<i>Myosotis arvensis</i>	32	0
<i>Ilex aquifolium</i>	10	0
<i>Juncus effuses</i>	4	0
<i>Matricaria recutita</i> (chamomilla)	5	5
<i>Picea abies</i>	26	0
<i>Pinus sylvestris</i>	11	0
<i>Plantago major</i>	8	0
<i>Polygonum aviculare</i>	23	19
<i>Persicaria</i> (<i>Polygonum persicaria</i>)	2	33
<i>Pulmonaria</i> off	21	0
<i>Quercus robur</i>	40	0
<i>Stellaria media</i>	82	18
<i>Artemisia vulgaris</i>	2	3
<i>Arundinaria japonica</i>	0	6
<i>Betula pendula</i>	0	7
<i>Cardamine</i> spp.	0	7
<i>Cirsium arvense</i>	0	34
<i>Eupatorium cannabinum</i>	0	3
<i>Helianthus annuus</i> (intr 97)	0	13
<i>Phragmites australis</i>	0	22

<i>Senecio vulgaris</i>	0	8
<i>Symphoricarpos albus</i>	0	3
	4825	5474
including incidental bites		
total of bites	4924	5611
nr of plantspecies	43	44
average of bites/indiv/day	64,8	71,0

The spontaneous foraging in the zoo is an interesting supplementary diet factor, that could be health promoting, both by offering additional micro nutrients (for example minerals or antioxidants, that are present in 'wild vegetables', compare Pieroni et al. 2002), and by allowing the animals to make adaptive individual-specific corrections to the supplied zoo diet.

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