

Summary

Douc langurs are specialised folivorous primates with a pregastric fermentation system. The present study dealt with food and nutrient intake in captive and semi-free Douc langurs. The focus of the study was on leaf-intake. Its intents were the quantitative investigation of food and nutrient intake, identification of food intake patterns, and assessment of the digestibility of leaves.

Though the feeding ecology of a species should ideally be studied in the wild, a quantitative examination of food intake of free-ranging animals is hardly possible. Therefore, the approach of this study consisted in the examination of food intake under captive and semi-free conditions. Three samples of Douc langurs kept under different keeping and feeding conditions were included in this study. The different feeding conditions varied concerning the proportion of leaves in the diet and the degree to which food selection was possible. The feeding conditions were defined as natural diet (semi-free condition), semi-natural diet, and artificial diet (captive conditions, respectively). The study was conducted in Vietnam (Endangered Primate Rescue Center, Cuc Phuong National Park) and at Cologne Zoo.

The spectrum of food plant species in Vietnam (natural diet, semi-natural diet) was composed of 87 species (including many Leguminosae) from 36 families. At Cologne Zoo (artificial diet), the spectrum of food plant species consisted of 28 species (including many Salicaceae) from eleven families.

Only a fraction (about 40 %) of the leaves available was actually consumed, and the animals fed selectively on leaves. Leaves constituted a proportion of about 95 % of consumed folivorous foodstuffs, while other folivorous foodstuffs available in the captive Douc langurs' diet constituted only small amounts of the quantity consumed, indicating a rather high degree of folivory.

Another result of this study supporting the consideration of Douc langurs being highly folivorous Colobines consists in extremely high digestibility values (dry matter: 86 %, crude protein: 87 %, organic matter: 86 %, NDF: 84 %, ADF: 81 %, ADL: 71 %, cellulose: 89 %, hemicellulose: 88 %) of the semi-natural diet, which consisted almost exclusively of fresh leaves.

Plant species, the leaves of which contained much crude protein and little fibre were preferred to other species. Preference was indicated by the consumption of large quantities and by high values of preference, using the Crawley preference index (1983). Young leaves, which contain more crude protein and less fibre than mature leaves of the same species, were preferred to them.

Alkaloids, tannins, cyanogenic, and antimicrobial compounds were avoided. This is consistent with results on feeding patterns, indicating a tendency to consume larger quantities of leaves with increasing quantity of food offered, as well as with increasing number of plant species offered.

These patterns might be related to the species' high degree of folivory. Although the species' natural habitat (i.e., evergreen or semi-deciduous forest) provides leaves in large quantities, during certain times of the year, few plant parts are available other than mature leaves. Mature leaves may contain secondary plant compounds that function as repellents against herbivores, and that might be toxic to Douc langurs. The species apparently is faced with a large number of different secondary plant compounds occurring in the food plant species. By consuming a diet composed of many different species, the animals are indeed confronted with a multitude of different secondary compounds, but only in respective small amounts, which can more easily be degraded and detoxified.

Daily dry matter intake of the animals under conditions of semi-natural diet amounted to 477 g (5.02 % body weight) and was smaller under conditions of artificial diet. The protein/fibre ratio of leaves consumed in the artificial diet at Cologne Zoo was higher than in leaves consumed in the natural and semi-natural diets in Vietnam, though seasonal variance in the

nutrient composition of the leaves in Cologne existed. Mature leaves (collected during summer) had a lower protein/fibre ratio than young leaves (collected during spring). When compared to the feeding recommendations by the National Research Council (1978) for Old World monkeys, the protein requirements of the Douc langurs were met in the semi-natural diet, but not in the artificial diet. It is, however, not known if the National Research Council's recommendations apply for Douc langurs, as they are based mainly on studies on Rhesus macaques, which may have different nutrient requirements than Colobines.

The results of the present study indicate that feeding of captive Douc langurs and other closely related species could be optimised by (1) providing ideally more than the double amount of leaves that is actually consumed (to allow for food selection), especially late in the day (to allow for night-time feeding), (2) offering a broad spectrum of different plant species, (3) varying the spectrum of plant species offered per leaf meal, (4) presenting leaves as bundled twigs, as opposed to loose leaves (to allow for appropriate foraging behaviour and to allow the consumption of other folivorous foodstuffs than leaves), (5) providing supplemental leafeater-pellets *ad libitum* and, with regard to temperate climates where fresh leaves are not available throughout the whole year, (6) by collecting and deepfreezing leaves early in the vegetation period, as leaf quality decreases with leaf age.

Although the endangered status of the Douc langur did not allow experimental food selection trials, and though sample size was small due to the animals' rarity, several patterns of food intake were revealed in the present study. These patterns were displayed by the Douc langurs studied in Vietnam (natural diet, semi-natural diet) and confirmed by the Douc langurs studied at Cologne Zoo (artificial diet), and included selectivity when feeding on leaves, preference of leaves with high content of protein and low content of fibre, and avoidance of leaves containing alkaloids, tannins, cyanogenic, and antimicrobial compounds. By selecting leaves with a high protein/fibre ratio and by consuming only small amounts of individual (digestibility-reducing) secondary compounds, the animals might be able to include large proportions of leaves in their diet, and maximise their protein intake without consuming large amounts of fibre.

The patterns of food intake displayed by the Douc langurs in the present study are similar to those observed in other Colobines. These patterns, which are compatible with the expectations derived from the optimal foraging theory (e.g., Schoener 1971), might represent typical Colobine food intake patterns, or even general principles on folivory in primates.

This study is one of the very few quantitative studies on folivory in primates. For the first time, it provides quantitative data on food intake in a highly specialised folivorous primate, the Douc langur, under conditions approximating the feeding situation of free-ranging animals. The scope of this study has been broadened by relating quantitative data on food intake to nutritional data. Besides providing reference values on food and nutrient intake in Douc langurs, the results of this study present a unique database, which can help lead to a better understanding of nutrient and energy maximising in folivores.

Considering *in situ* conservation of this endangered primate species, the list of food plant species and the information on the "typical" nutrient composition of leaves consumed by the animals, which were provided by this study, can help to evaluate the quality and suitability of conservation areas as possible habitats for Douc langurs.

Further studies should focus on the food intake behaviour of Douc langurs in the wild, including phenological studies of the habitat to evaluate availability of the different food items. When examining food intake patterns in relation to plant chemistry, secondary plant compounds, as well as nutrients that could not be analysed in this study (e.g. crude fat, nonfibrous carbohydrates) should be considered.