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Diet and feeding behaviour of pygmy lorises (*Nycticebus pygmaeus*) in Vietnam

Ulrike Streicher

Wildlife Veterinarinan, Danang, Vietnam. <uli@mail.hut.edu.vn>

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Summary

Little is known about the diet and feeding behaviour of the pygmy loris. Within the Lorisidae there are faunivorous and frugivorous species represented and this study aimed to characterize where the pygmy loris (*Nycticebus pygmaeus*) ranges on this scale. Feeding behaviour was observed in adult animals which had been confiscated from the illegal wildlife trade and housed at the Endangered Primate Rescue Center at Cuc Phuong National Park for some time before they were radio collared and released into Cuc Phuong National Park.

The lorises were located in daytime by methods of radio tracking and in the evenings they were directly observed with the help of red-light torches. The observed lorises exploited a large variety of different food sources, consuming insects as well as gum and other plant exudates, thus appearing to be truly omnivorous. Seasonal variations in food preferences were observed.

Omnivory can be an adaptive strategy, helping to overcome difficulties in times of food shortage. The pygmy loris' feeding behaviour enables it to rely on other food sources like gum in times when other feeding resource become rare. Gum as an alternative food sources has the advantage of being readily available all year round. However it does not permit the same energetic benefits and consequently the same lifestyle as other food sources. But it is an important part of the pygmy loris' multifaceted strategy to survive times of hostile environmental conditions.

Thức ăn và tập tính kiếm ăn của Cu li nhỏ (*Nycticebus pygmaeus*) ở Việt Nam

Tóm tắt

Những hiểu biết về thức ăn và tập tính kiếm ăn của cu li nhỏ còn rất hạn chế. Trong họ cu li có một số loài ăn quả và một số loài ăn động vật và nghiên cứu này nhằm xác định thức ăn của loài cu li nhỏ nằm ở đâu trong phạm vi này. Tập tính kiếm ăn được quan sát trên các cá thể đực trưởng thành, đây là những cá thể được thu giữ từ các vụ buôn bán động vật hoang dã trái phép và nuôi dưỡng tại Trạm Cứu hộ Linh trưởng Nguy cấp tại Vườn Quốc gia Cúc Phương một thời gian trước khi chúng được gắn thiết bị radio ở cổ và thả vào Vườn Quốc gia Cúc Phương.

Vị trí của các con Cu li nhỏ ban ngày được xác định bằng phương pháp theo dõi sóng vô tuyến (radio tracking) và vào ban đêm chúng được quan sát trực tiếp bằng đèn pin ánh sáng đỏ. Những cá thể cu li được quan sát ăn rất nhiều nguồn thức ăn khác nhau, ăn côn trùng cũng như nhựa cây và mủ thực vật, vì vậy chúng dường như là loài ăn tạp. Sự biến đổi theo mùa về các loại thức ăn ưa thích cũng đã quan sát được.

Ăn tạp có thể là một chiến lược thích nghi, giúp vượt qua khó khăn trong thời gian khan hiếm thức ăn. Tập tính kiếm ăn của cu li nhỏ cho phép nó phụ thuộc vào các nguồn thức ăn khác như mủ trong những thời điểm các nguồn thức ăn khác trở nên khan hiếm. Mủ (Gum) là một nguồn thức ăn thay thế có thuận lợi là sẵn có quanh năm. Tuy nhiên, nó không cho phép cùng lợi ích về năng lượng và bởi vậy cùng phương thức sống giống như các nguồn thức ăn khác. Tuy nhiên nó là một phần quan trọng trong chiến lược nhiều mặt của cu li nhỏ để tồn tại trong những thời điểm điều kiện môi trường khắc nghiệt.

Introduction

Little is known about the diet and feeding behaviour of the pygmy loris. Within the lorises a variety of different feeding ecologies are represented. Usually the slow loris *Nycticebus coucang* is counted among the frugivorous and the slender loris *Loris tardigradus* among the insectivorous species. In a recent field study in Malaysia, the slow loris was found to feed preferably on plant exudates, gum and fruit (Wiens, 1995; 2002) and a field study in India proved that the slender loris is indeed almost exclusively faunivorous with termites and ants being an important component of the diet (Nekaris & Rasmussen, 2003). On this background it seems interesting to investigate the pygmy loris' dietary habits. Where does it range on the scale of faunivory, frugivory and gummivory?

Observations on wild pygmy lorises feeding are very rare and only two reports are available. On one occasion pygmy lorises were found in a tree (Tan, 1994), which showed typical gnaw marks ("gouges") and it was suggested that the animals had been feeding on gum there. On another occasion a pygmy loris was observed in a tree feeding on an unidentified fruit (Duckworth, 1994).

For a long time the pygmy loris was considered a subspecies of *N. coucang* (Hill, 1953; Petter & Petter-Rousseaux, 1979). Based on external similarities to the slow loris the pygmy loris was assumed to differ from the larger species only in size, but have similar dietary habits. Like *coucang pygmaeus* was assumed to be a species that inhabits the main canopy and lives on a frugivorous diet (Fleagle, 1978).

In captivity, pygmy lorises are usually maintained on a mixed diet, with the majority of the offered food items being fruit and vegetables and insects comprising the rest of the diet (Fitch-Snyder et al., 2001). At the Endangered Primate Rescue Center, Vietnam pygmy lorises are fed on a diet consisting of fruit, vegetable, boiled eggs, milk powder and seasonally varying insects.

Newly confiscated animals at the rescue centre show a strong preference for invertebrates. Insects are mostly the first food item accepted, whilst recently confiscated animals mostly reject fruit, boiled eggs or vegetables. Obviously, wild pygmy lorises are more familiar with insects than with the other food items offered in particular cultivated fruit. Another hint to potential wild feeding habits is the gouging on fresh branches, which nearly all the confiscated pygmy lorises exhibit (Fig. 1).

Fig. 1. Typical gauge hole in a piece of furnishing. Photo: U. Streicher.

Methods

Data have been collected from four reintroduced individuals. The animals had all been captured as adults and had only been in captivity for several months. Thus all of them must have had previous experiences with wild food sources. The animals were genetically identical, with individuals originating from Cuc Phuong, but the exact locality of their origin and the habitat type they originated from was unknown.

The release site comprised forested limestone hills surrounded by old plantations and scrub and was located in the Cuc Phuong National Park in northern Vietnam (Vo Quy et al., 1996). The released animals had been equipped with transmitters and were located during the daytime in their sleeping sites by radio-telemetric methods. Before dusk, an observer returned to the loris' sleeping site and observed it during the beginning of its active period. Observations lasted from a few minutes to more than two hours. Head torches with redlight filters were used for observation and the animals could be fairly well-observed from a distance between 5 and 15 meters; only when the canopy was extremely dense visibility was sometimes limited. The animals showed different degrees of habituation. Whereas three animals got used to the observer's presence within a short time, one proved extremely reluctant to accept the presence of a researcher and was continuously hiding when an observer was around, exhibiting minimal activity. If the observer lost direct contact with the observed loris, observations were discontinued. In addition, the animals were not followed by telemetry at night due to the treacherous character of the terrain.

Each animal was observed for four to six weeks from the date of release onward. Data was collected *ad libitum* (Altman, 1974) on prepared data sheets. Feeding trees were identified the following day by collecting a branch sample and having it identified at the scientific department of the National Park.

Results

Feeding could be observed from the first day after the release onwards. A total number of 27 feeding bouts were observed. Several different types of feeding behaviour and food items were observed. In eleven cases, the food item was identified or suspected to be an insect, in eight cases it was gum, and in eight cases it was not exactly identified plant exudates.

Animal prey

Pygmy lorises searched for animal prey by moving slowly along branches with the nose close to the substrate. On nine occasions the pygmy lorises caught insects. Insects were caught either using one or using both hands and then put in the mouth. If both hands were used, the animals clung with both legs to a branch or stood bipedal. In one case the captured insect was a moth (Hymenoptera) attracted by the head torch of the observer. The most detailed observation of insect feeding was after one animal captured a very large cricket (Hemiptera). The cricket was held with both hands and slowly eaten starting from the head. The hard skin was broken using the molars and by pushing the prey into the mouth with the hands. The skin was partly bitten off and the loris frequently got rid of access parts of skin by fiercely shaking the head. The wings of the insects were bitten off and "disposed." Towards the end of this feeding session, the animal changed the position two times, moving to another branch, whilst holding the remains of the insect in one hand. The seemingly very sticky inner contents of the insect finally covered the surrounding area of the mouth and the hands of the loris and the animal spent several minutes grooming, concentrating on the

hands by licking them intensively. On one occasion the animal was observed licking on a branch of *Dracontomelum duperreamum* (Anacardiaceae). Whereas licking on branches in most cases was associated with feeding on plant items, this case was different because the animal frequently interrupted feeding to fiercely shake its head. Similar behaviour has been found to be associated with feeding on ants (Nekaris, 2001) and therefore it was assumed that the animal was feeding on ants, which attacked the intruding loris. On another occasion the animal was observed feeding for an extended time in low scrub with climbing weeds. The food source was not identified, but later inspection of the scrub found all young shoots showed marks of an insect foraging. Feeding on insects was usually a short event. Only when the loris found a number of insects in the same location or if an insect was exceedingly large, it spent several minutes feeding. For example, the devouring of the large cricket required over twenty minutes. All feeding on insects occurred at heights less than ten meters.

Gum and other plant exudates

Feeding on gum or other plant exudates comprised the majority of observed feeding events. The common feature was intense licking on branches without locomotion. Feeding on plant substrates comprised short sessions only lasting one minute and extended sessions lasting up to twenty minutes in the same location (Fig. 2). One of the tree species where the animals showed extensive licking behaviour was *Saraca dives* trees (Fabaceae). In full blossom these trees carried large bundles of big orange flowers that were inspected intensively on at least one occasion. However, it could not be ascertained if the animal actually found something to eat in the flowers. In this tree species the animals were licking intensively on the branches but this was not accompanied by audible scratching and bark-breaking sounds. The food sources must have been rather on the surface and easily accessible. The behaviour was not observed when the trees were not flourishing. Of the few observations of wild pygmy lorises at Cuc Phuong National Park, two were made in the same tree species carrying blossoms (Roberton, pers. com.). Obviously these trees were particularly attractive, when flourishing.

Fig. 2. Pygmy loris scraping for gum on the trunk of a *Spondias axillaries* tree. Photo: U. Streicher.

Similar licking on branches was observed as well in a *Sapindus* sp. tree (Sapindaceae), a *Vernicia montana* tree (Euphorbiaceae) and at least two other non-identified tree species.

Another tree species exploited for its exudate were *Spondias axillaris* (Anacardiaceae). Here the food source could clearly be identified as gum: the tree had an old injury and was visibly shedding gum (Fig. 3). The scraping for gum was accompanied in most cases by sounds of scratching and breaking bark. The animal fed with the body orthograde, clinging with all four legs to the bark (Fig. 2). Feeding sessions on this tree were the most extended ones observed. A remarkable observation was that one animal returned to the same feeding site every time it had slept in the near vicinity.

After it became active, it always first passed the "gum bar," when it was nearby. Scratching and bark-breaking sounds were very intense.

All but one feeding event related to gum or other food exudates were observed at heights over eight metres.

Fig. 3. The same site in daytime. The shedding of gum is clearly visible. Photo: U. Streicher.

Questionable food items

A possibly but not clearly feeding-related behaviour was observed in dense scrub areas where no plants were covering the soil and where the foliage was not very dense. From tree heights below one meter, the lorises frequently visited the ground for up to thirty seconds without actually covering any distance on the ground. Before going to the ground the animals always carefully observed the area where they intended to go. They usually went to the ground along the same tree, which they climbed up again after finishing the ground visit. It seems likely that these ground trips served a feeding purpose. But because these events were not clearly identified as feeding-related behaviour, they were not counted amongst the feeding bouts.

Feeding on fruit described by Duckworth (1994) was never observed.

Solitary feeders

In our observations, pygmy lorises were never observed feeding together or even in close proximity, but the observations are too scarce to evaluate if pygmy lorises actually prefer solitary feeding. They did exploit the same food sources on the same tree but not simultaneously.

Seasonal variations in food exploitation

Animals released in spring fed preferably on different tree species than animals that were released later in the year. In spring, the animals preferred *Saraca dives* as a food tree. At that time of year the trees are in full blossom. Later on, when the tree does not have any flowers, lorises did not show any specific preference for this tree species. The animals released from September onward showed a strong feeding preference for *Spondias axillaris* trees.

Discussion

Omnivory as a strategy to overcome times of food shortage.

Feeding behaviour of the pygmy loris has previously been assumed to be largely similar to the slow loris (Fleagle, 1978). Based on the large areas of sympatric occurrence, Ratajszczak (1998) suspected different feeding preferences and suggested the pygmy loris to be the more insectivorous species. Indeed the pygmy loris shares many characteristics of feeding behaviour with the insectivorous slender loris. Details of the feeding behaviour are identical (Nekaris & Rasmussen, 2003) and both animals capture insects single-handedly or bimanually with

stereotyped movements typical for prosimians and specifically adapted to catch small rapidly moving or flying insects (Hladik, 1979). However, ants which make up a large percentage of the prey of the slender loris (Nekaris & Rasmussen, 2003), seem to play no important role for the pygmy loris' diet. The feeding on gregarious insects has been assumed to relate to the gregariousness amongst the slender lorises themselves (Nekaris & Rasmussen, 2003); slender lorises in captivity devote more time to social interactions than any other loris species (Rasmussen, 1986; Schulze & Meier, 1995). Correspondingly, the insects preferably devoured by the pygmy lorises would facilitate a solitary way of foraging not risking intraspecific competition.

The pygmy loris also shares feeding characteristics with its larger relative, the slow loris. Previously considered predominantly frugivorous (Chivers & Hladik, 1980, Barret, 1983), the slow loris was recently found to spend a large percentage of its foraging time feeding on plant exudates (Wiens, 1995; 2002). In pygmy lorises, gum and plant exudates also make up an important food source. Active stimulation of exudate flow by gouging trees has previously been documented for some callitrichids *Cebuella* and *Callithrix* (Coimbra-Filho & Mittermeier, 1978) and the fork-marked lemur *Phaner furcifer* (Petter et al., 1971) and a similar behaviour has been suggested for the pygmy loris as well (Tan & Drake, 2001). According to our observations, pygmy lorises indeed actively stimulate the exudate flow and possibly maintain a steady food source by scraping gum at the same location every night, thus inducing additional gum shedding. Licking plant exudates off the branches in flourishing trees is also a behaviour which the pygmy and the slow loris have in common, and both species show the behaviour in trees of the same family (Fabaceae). Nectarivory had been a suggested explanation (Wiens, 1995) and it is likely that the pygmy lorises were also feeding on nectar, since this behaviour was not observed when the trees were not carrying blossoms.

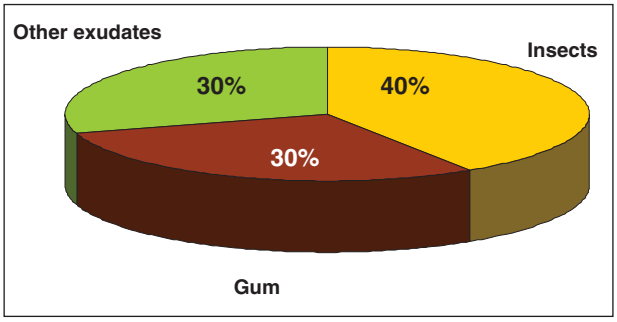

Fig. 4. Observed feeding bouts.

According to our observations, the pygmy loris is more of a generalist than the other Asian loris species and includes animal prey as well as gum and plant exudates in its diet (Fig. 4). Being a generalist could be a mere result of physiological requirements. With a body size of around 350 g, the pygmy loris is among the larger forms of prosimians. Hladik (1979) postulated that prosimians of this size have to utilize a variety of different food sources, since they are too large to be able to maintain themselves merely on insects because they simply do not find enough prey in a given habitat in one night.

But being a generalist could also be a potential advantage to overcoming difficult environmental conditions.

The winter in northern Vietnam is characterized not only by water shortage (dry season), but also by low temperatures unfavourable for many tropical plants (Nguyen Khanh Van et al., 2000). The number of insects during these winter months is much lower than during the rest of the year. There are no flourishing trees for several months and plant growth rates are at their minimum. There appears to be a seasonal variation in the majority of the loris' food sources like insects and nectar. For several months these resources are extremely rare.

During periods of low resource availability, primates may switch to alternative, poorer quality food sources and incorporate them into the diet in greater than usual quantities (Hladik, 1979; Gursky 2000). The insectivorous spectral tarsier *Tarsius spectrum* reacts to seasonal fluctuations in food availability by including higher percentages of lower quality insects in its diet (Gursky, 2000). However, the tarsier remains fully insectivorous even if this means depending on a diminished resource. But a tarsier is small, requires less insects for maintenance and can travel fast and cover a larger area in order to find sufficient food if necessary. Indeed, in times of food shortage tarsiers increase their travelling distances while foraging (Gursky, 2000). Being limited to quadrupedal locomotion without the ability to leap, the pygmy loris can't greatly increase its daily travel path length and must use a different strategy to overcome times of food shortage.

Gum has been found to be part of the pygmy loris' diet and gum is available all year round and thus a reliable food source. Consequently, gum could be an ideal food source to overcome periodical food shortage. Gum contains high concentrations of carbohydrates (Bearder & Martin, 1980) and some prosimians, such as the lesser bushbaby *Galago senegalensis* and thick-tailed bushbaby *Galago crassicaudatus* are able to persist on gum alone when other food sources are scarce (Bearder, 1987). In the bushbabies, gum is digested in the enlarged caecum through the action of symbiotic bacteria (Charles-Dominique, 1977; Hladik, 1979). In contrast, for mammals that lack microbial fermentation, gum is largely indigestible (Waterman, 1984) and the pygmy loris has no chambered site for microbial fermentation in its digestive tract (Hill, 1953). Moreover, gum has been suspected to be a self-limiting food source since detoxifying toxic components in gum might be energetically expensive and is considered responsible for a low metabolism and reduced pace of life (Wiens, 2002).

Reduced activity and extensive resting of the pygmy lorises during the winter period thus are not only measures to reduce energetic expenses but also a way to respond to the available energy sources.

The pygmy loris feeding behaviour enables it to switch to other food sources in times when its main feeding sources are rare and exploit gum as a steady reliable food source. Gum is a low quality food source and only allows living at a low energy level with a reduced metabolism. However, it is an important part of the pygmy loris multifaceted strategy to survive times of hostile environmental conditions.

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