Int J Primatol (2012) 33:743–748
DOI 10.1007/s10764-012-9609-0

Purple-faced Langurs in Human-Modified Environments Feeding on Cultivated Fruits: A Comment to Dela (2007, 2012)

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Received: 26 November 2011 / Accepted: 13 January 2012 / Published online: 16 June 2012

Abstract Recently Dela (*International Journal of Primatology*, *28* (2007): 607–626; *International Journal of Primatology*, *33* (2012): 40–72) published her study from the mid-1980s on the diet of purple-faced langurs *Trachypithecus* (*Semnopithecus*) *vetulus* in village gardens and rubber plantations. Unlike studies from the 1970s that reported the species, like other colobines, to be largely folivorous with few ripe fruits eaten, Dela found them to be largely frugivorous. The frequent feeding on ripe fruits challenges the paradigm that colobine digestive adaptations restrict the use of ripe fleshy fruits. No reference was made to any other post-1970s study on the species. Here I provide a concise overview of more than a dozen studies conducted in the 1990s and 2000s that show that 1) other populations live in similar human-modified environments showing feeding adaptations as reported by Dela, 2) these populations rely largely on cultivated crops and feed heavily on fruits, 3) living in these situations introduces them to additional threats. Especially in western Sri Lanka little natural habitat remains and deforestation has led the langurs to exchange the forest jungle for the urban jungle, with power lines, fences, walls, and roofs being used instead of trees. The main fruits that provide a staple for langurs in these areas are jackfruit (*Artocarpus heterophyllus*), banana (*Musa* spp.), and mango (*Mangifera indica*); studies in undisturbed habitats and indeed Dela's own study suggest the heavy use of human-edible fruits by langurs may not necessarily indicate preferential selection of these food sources. Living in human-modified environments makes the langurs more prone to infection with gastrointestinal parasites, and may lead to death by electrocution or being killed by guard dogs. The large degree of agreement between studies suggest that feeding on ripe fruits from cultivars is not unique to Dela's two study groups and shows that some langur groups are able to survive for extended periods on uncolobine-like diets when they cannot access their preferred foods.

Editor's Note: The author of the original article has declined to submit a response to the commentary that conforms to the space and format constraints of the journal.

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Keywords Colobine · Conservation · Digestive flexibility · Feeding strategies · *Semnopithecus vetulus*

Introduction

Recently Dela (2007, 2012) published the results of her 2-year study conducted in the mid-1980s on the feeding ecology of purple-faced langurs *Trachypithecus vetulus* (equally known as *Semnopithecus vetulus* or *Presbytis senex*). In the early 1970s it was shown that this species, like many other colobines, was largely folivorous (Hladik 1977; Hladik and Hladik 1972). In relatively undisturbed forest, and in the presence of other primates —one other colobine (*Semnopithecus priam*) and one other cercopithecoid (*Macaca sinica*)— on average 28 % of the feeding records were on fruit and in only 2/13 mo >50 % of feeding records fruit were consumed (up to 65 %).

Dela studied two groups of (western) purple-faced langurs in village gardens (Pandura) and rubber plantations (Piliyandala), in the absence of any other primates and without access to natural forest. She showed that on average 53–59 % of the feeding records were on fruit (often from domesticated plants) and in only 4 of the 32 mo <40 % of the feeding records were on fruit. This makes these groups among the most frugivorous of all colobines. In addition, the frequent feeding on ripe fruits challenges the paradigm that colobine digestive adaptations restricts the use of ripe fleshy fruits (Bennett 1983; Cork 2006; Davies 1991; Kay and Davies 1994). Dela's research demonstrated the behavioral plasticity of the purple-faced langurs allowing them to survive in human-modified environments. It also illustrated the extreme situation the purple-faced langurs face, especially in western Sri Lanka, with hardly any forest left and purple-faced langurs living almost exclusively commensally with humans (Parker *et al*. 2008); indeed in the years after Dela's study, her study groups lost large proportions of the trees in their home ranges because of clear-felling (Dela 2012).

Reading Dela's (2012) paper, it may appear that no ecological research has been conducted on purple-faced langurs for decades, suggesting a uniqueness to Dela's study. Other than her own 2007 paper and her doctoral dissertation from 1998, none of the 49 post-1970s references cited refers to research on purple-faced langurs or other Sri Lankan primates. In fact, in recent years a relatively large number of papers have been published on the ecology of purple-faced langurs, and although perhaps not as long-term as Dela's, combined the studies give a more comprehensive overview of the feeding ecology and behavioral plasticity of the species. These papers also illustrate that Dela's findings are not unique to the situation in which her focal groups were living. I hereby give a concise overview of research conducted on the ecology of purple-faced langurs, especially where it pertains to feeding ecology or adaptations to living in human-modified environments.

Feeding Ecology

Rudran (2008) and Moore *et al*. (2010) reported on the diet of purple-faced langurs in western Sri Lanka. Like Dela's their focal groups were living largely on village

grounds or in urbanized areas. They identified 15 and 43 food plants, respectively, for a total of 50 species, the majority of which being cultivars. They noted that for 10/15 and 13/13 of the most commonly eaten food plants the fruits were consumed. There was a high degree of agreement between these studies and Dela's (Fig. 1). For instance, the three most commonly consumed food plants in Rudran's study, jackfruit (*Artocarpus heterophyllus*), banana (*Musa* spp.), and mango (*Mangifera indica*), comprising 50 % of the diet, made up 68 % of the diet in the study of Moore *et al*., and 41 % in Dela's. Fifteen of the 50 species identified by Rudran and Moore *et al*. were included in the 45 most frequently used food plants by Dela (2012).

We recently analyzed interviews with farmers in southern Sri Lanka to establish what crops were commonly eaten by purple-faced langurs (Nijman and Nekaris 2010a). Farms were situated up to 5 km from the nearest forest, and 142 out of 273 farmers indicated that purple-faced langurs frequented their farms. Fourteen crops were identified as being eaten by the langurs and as with the previous studies jackfruit and banana topped the list. Overall these studies confirm the findings of Dela that purple-faced langurs living in human-dominated landscapes have moved from a folivorous diet to one of cultivated fruits. Jackfruit, with its very large fruits, and other fruit-bearing trees play a pivotal role in the persistence of purple-faced langurs in these areas.

A team from Sri Lanka's National Botanical Gardens and the University of Tokyo studied the selection of wild fruits by animals in Sinharaja, a protected rain forest, using camera traps and feeding platforms (Jayasekara *et al*. 2007). Of the 23 animal species that were photographed on the feeding platforms, the purple-faced langur was the third most common in terms of number of visits. The langurs selected 6 of the 15

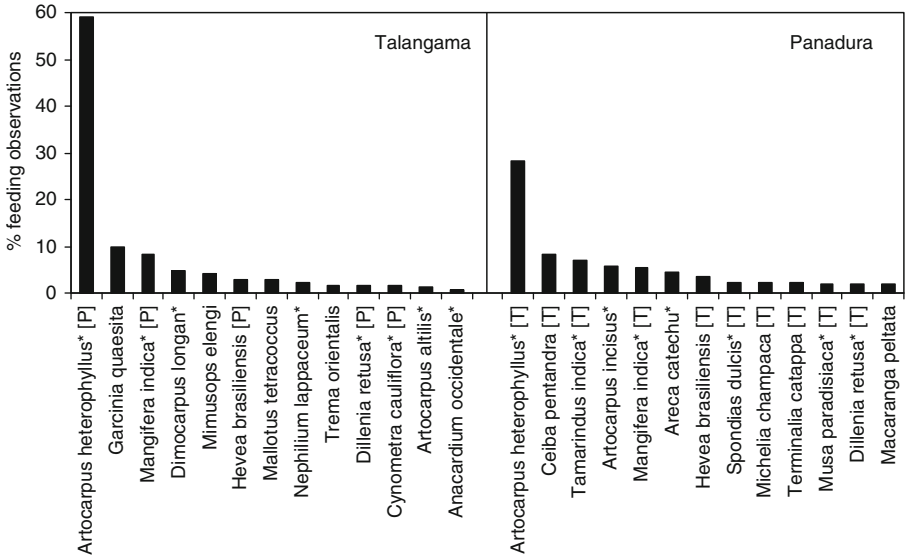

Fig. 1 Diet of purple-faced langurs (*Trachypithecus vetulus*) in village gardens without access to natural forest in the towns of Talangama and Panadura, western Sri Lanka, showing a high degree of concordance between sites. Depicted are the 13 most frequently used tree species at both sites. (Data from Talangama from Moore *et al*. 2010 and R. Moore, *in litt*., data from Panadura from Dela 2012). * = species producing human-edible fruits; P = plant species eaten in Talangama included in the 30 most frequently eaten plant species in Panadura; T = plant species eaten in Panadura included in the 30 most frequently eaten plant species in Talangama.

fruits offered but, intriguingly, did not eat 3 of the fruits of genera that feature prominently in the feeding studies of Dela, Rudran, and Moore *et al*., i.e., *Artocarpus*, *Mangifera*, and *Garcinia*. Dela (2012) showed heavy use of human-edible fruits by langurs but some of the plant species with the highest selection ratios (*Terminalia catappa*, *Macaranga peltata*, *Ceiba pentandra*, *Trema orientalis*, *Michelia champaca*) were used primarily for their leaves. There is no statistically significant relationship between the proportion fruit eaten from any given food plant and its selection ratio (Fig. 2). Thus, food plants that were used for food more, or less, than expected on the basis of availability were equally likely to be used mainly for fruits or leaves. These data support the notion of Rudran (2008) that the langur's heavy use of cultivated plants in certain areas (hereby also referring to Dela's 2007 study) is likely due to deforestation reducing wild plant diversity instead of to an actual preference for cultivated foods.

Adaptations to Human-Modified Environments

In the 2000s researchers conducted a number of surveys to assess the distribution and status of purple-faced langurs (Bernede 2003; De Silva *et al*. 2011; Nahallage *et al*. 2008; Parker *et al*. 2008; Peiman 2001; Rudran 2008), especially in the western part of their range, leading to the species being considered globally Endangered according to IUCN threat criteria (Dittus *et al*. 2008). Between 81 % and 90 % of the natural habitat in the range of the western purple-faced langur has been replaced by residential areas, home gardens, plantations, and other human-dominated areas (Rudran 2008; Rudran *et al*. 2009). Within this region it appears to be absent from approximately half of the sites where it was known historically, and remaining populations are isolated by kilometers of unsuitable habitat (Parker *et al*. 2008). Rudran *et al*. (2009: p. 53) concluded that "deforestation has fragmented and drastically depleted the preferred habitat and principal food sources of the highly arboreal and folivorous *T. v. nestor*." The gardening traditions of local people, mimicking the layers of the rain forest, and the general high levels of tolerance of the Sri Lankans toward the

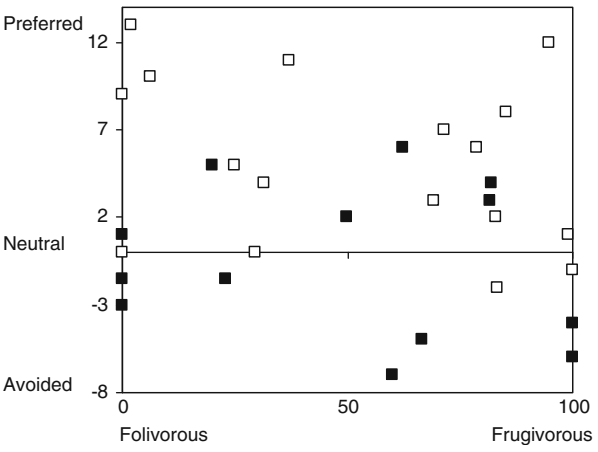

Fig. 2 Relationship between ranked selection ratios (SR*i* = % feeding records on plant species *i*/relative basal area of plant species *i*: data from Dela 2012: Table V) and diet (with 0 representing all feeding observations comprising leaves and 100 representing all feeding observations comprising fruits: data from Dela 2012: Tables III and IV) for two groups of purple-faced langurs (*Trachypithecus vetulus*). *Open symbols* represent Panadura and *filled symbols* represent Piliyandala). Neither relationship is statistically significant.

langurs (Nijman and Nekaris 2010b; Rudran 2008), may give a clue to how these populations have lingered on. Essentially, deforestation has led the langurs to exchange the forest jungle for the urban jungle, with power and telephone lines, fences, walls, and roofs being used instead of trees (Moore *et al*. 2010).

Another line of research also highlighted the ecological effects of purple-faced langurs living side by side with humans. Researchers at the Polonnaruwa Archeological Sanctuary investigated the gastrointestinal parasites in a population of purple-faced langurs (Dewit *et al*. 1991; Ekanayake *et al*. 2006, 2007). Parts of the sanctuary are subject to a continuous flow of local pilgrims and tourists, who, along with local residents, use areas near water as open toilets, for picnicking, and for disposal of food waste. Further, local farmers graze their cattle in the sanctuary. The researchers showed that infection with the apicomplexan protozoan *Cryptosporidium* (causing the diarrheal illness cryptosporidiosis in humans) was higher in purple-faced langur groups using areas and water that had been heavily soiled by human feces and livestock (Ekanayake *et al*. 2006). Work in the more urbanized parts of the purple-faced langur's range highlighted some of the other dangers of living too close to humans, with langurs being killed by electrocution and guard dogs, or by traffic while crossing roads (De Silva *et al*. 2011; Parker *et al*. 2008).

Although some aspects of the behavior and ecology of purple-faced langurs have led to marked changes in human-modified environments, others remain essentially unchanged. The calling patterns of purple-faced langurs did not differ between urbanized areas and natural habitats, and in urban areas the langurs did not respond vocally to the villagers (Eschmann *et al*. 2008). They concluded that as a consequence of living in highly urbanized environments the langurs were desensitized to the effects of most human activity.

In conclusion, in the years after her research Dela's (2007, 2012) findings have been solidified by research on other populations of purple-faced langurs living in similar human-modified environments. In several populations fruits of cultivars (primarily jackfruit, banana, and mango) dominate the diet but there are clear indications that these fruits are not preferred in all situations. Not only has extreme deforestation and fragmentation led to the local extinction of populations of purple-faced langurs, but it has also brought langurs and humans in closer contact than ever before. Although some aspects of the ecology of the langurs are plastic enough to allow survival in human-dominated landscapes, others may carry as yet unforeseen repercussions.

Acknowledgments I thank Anna Nekaris, Richard Moore, Lilia Bernede, and Gehan da Silva Wijeyratne for sharing their experiences with Sri Lanka's primates; Giuseppe Donati for help with interpreting nutritional data; and two reviewers for constructive feedback.

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