DIET OF NILGIRI LANGUR *Semnopithecus johnii* INHABITING TROPICAL MONTANE SHOLA IN THE NILGIRI HILLS, SOUTH INDIA

T.S. Kavana[1], Joseph J. Erinjery[1] and Mewa Singh[1,2,3*]

[1] Biopsychology Laboratory and Institute of Excellence, University of Mysore, Mysore 570006, India. E-mail: kavanats@gmail.com; joerin@gmail.com

[2] Evolutionary & Organismal Biology Unit, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore 560064, India. E-mail: mewasinghltm@gmail.com

[3] National Institute of Advanced Studies, Bangalore, India.

* Corresponding author

ABSTRACT

We studied food habits of a group of 11 Nilgiri Langurs *Semnopithecus johnii* (Fischer) in the Nilgiri Hills of the Nilgiri Biosphere Reserve in south India. The study group occupied a patch of stunted montane forest surrounded by grassland, a habitat type known in south India as *shola*. Among 20 species prominent in the diet between June and December were (1) native plant species that are found principally in shola at elevations above 1,300 m (34% of feeding time), (2) pine needles, which are low-quality food items (11%), and (3) non-native plants (15%). Human activity is fragmenting shola and decimating the Nilgiri Langur habitat and food supply. Conserving the Nilgiri Langur will require protecting the shola forests of the Nilgiri Biosphere Reserve.

Keywords: conservation, diet, habitat fragmentation, low quality food, Western Ghats.

INTRODUCTION

Anthropogenic activities which lead to forest fragmentation can cause variations in the abundance and distribution of food resources, affecting the diet of a species (Johns, 1983). Animals have been found to increase their dependence on low-quality food items and fall-back food items in fragmented habitats, as shown in Collared Lemur *Eulemur collaris* (É. Geoffroy) (Donati et al., 2011) and Diademed Sifaka *Propithecus diadema* Bennett (Irwin, 2008), Tonkean Macaque *Macaca tonkeana* (Meyer) and Moustached Guenon *Cercopithecus cephus* (Linnaeus) (Tutin, 1999; Riley, 2007). Low-quality food items contain a lower amount of carbohydrates and hence provide less energy for an individual than high-quality food items (Donati et al., 2011).

Similarly, due to the absence of certain important trees in higher altitudes, populations of a species living in higher altitudes may have to depend on low-quality and fallback food items, as shown in the Yunnan Snub-nosed Monkey *Rhinopithecus bieti* Milne-Edwards (Grueter et al., 2012).

The Nilgiri Langur *Semnopithecus johnii* (Fischer) is a folivorous arboreal primate which primarily inhabits tropical evergreen forests of the Western Ghats at an altitude above 500 m (Sunderraj, 2001; Sunderraj & Johnsingh, 2001). The Nilgiri Langur is classified as Vulnerable by IUCN (Singh et al., 2008) and is listed on CITES Appendix II and Schedule I Part I of Indian Wildlife (Protection) Act, 1972 (Molur et al., 2003). The population trend of the Nilgiri Langur shows a decline (Singh et al., 2008) and large-scale habitat destruction for plantation/agriculture and poaching have affected the species (Ramachandran & Joseph, 2001). The density of the Nilgiri Langur is highest in evergreen forests between 700 and 1,500 m, but the species occurs above 1,500 m in shola, a term referring to patches of stunted montane tropical evergreen forest amid grasslands (Thomas & Palmer, 2007), which occur in the Nilgiri Hill ranges in the Western Ghats of southern India (Johnsingh & Manjrekar, 2013).

Evergreen and semi-evergreen forests in the Western Ghats are classified as low-elevation (0-800 m), medium-elevation (800-1450 m) and high-elevation forests (1,450 m and above) (source: http://www.forest.kerala.gov.in; Pascal et al., 2004). Most trees found in the medium-elevation evergreen forests (*Cullenia-Mesua-Palaquium* type) are not present in the high-altitude montane shola regions of the Nilgiris (*Litsea-Syzygium-Microtropis* type) (Pascal, 1988). Hence, we expected the Nilgiri Langur in the Nilgiri Hills to depend on a different diet than the Nilgiri Langurs in medium-elevation evergreen forests of the Western Ghats.

We also expected the Nilgiri Langur to feed on low-quality food items as fallback foods, since forests are highly fragmented in the Nilgiri Hills. Extensive commercial plantations, easy motor vehicle access and large hydroelectric impoundment in the area are the major causes for the destruction of the shola (Davidar, 1978; Rice, 1984). Hence, in the present study we compare the diet of the Nilgiri Langur from shola in the Nilgiri Hills with that in medium-elevation evergreen forests elsewhere in the Western Ghats.

METHODS

The study adhered to the ethical guidelines of the University of Mysore, and an official permit was obtained from the Chief Wildlife Warden of the Tamil Nadu State for conducting this research.

Study area

The study was conducted in Naduvattam (11°28’ N, 76°32’E) in the Nilgiri Hills district of Tamil Nadu, India. The elevation of the study site is 1,849 m. The average annual rainfall is 2,130 mm and mean annual temperature is 15.7°C (source: www.climatedata.org). The vegetation mainly consists of shola-grassland mosaic system, tea plantations and tree plantations. The present study group inhabited a shola fragment near Naduvattam Village. The size of the fragment was 5 ha. The home range of the group was 3.5 ha. The group had one adult male, seven adult females and three juveniles. The group was sympatric with a Bonnet Macaque *Macaca radiata* (É. Geoffroy Saint-Hilaire) group in the study area.

We used previous studies from other regions (medium-elevation evergreen forest) for comparison of food items with our study. These previous studies were conducted in Kakachi at ~1,000 m altitude (Oates et al., 1980), Silent Valley at ~900 m altitude (Ramachandran & Joseph, 2001), Pachcha Palmalai shola at ~ 1,200 m altitude (Sushma, 2004) and Nelliyampathy at ~1,000 m altitude (Ramachandran & Suganthashaktivel, 2010). All these study areas, except Pachcha Palmalai, were contiguous forest areas. The Pachcha Palmalai shola was surrounded by tea estates on one side and contiguous forest on the other side (Sushma, 2004).

Study period and observation methods

The study was conducted between June and December 2010 and hence we do not have full data to compare the diet between seasons. We habituated the monkeys for two months before starting observations. We observed the langurs from a distance of about 10 m from the trees on which they were present. We did not collect any data when it was misty or when visibility was low. We collected data on major activities including feeding, resting, locomotion, self-directed and social behaviour using focal animal sampling, though for the present study, we analysed only the feeding data. We continuously followed an individual langur for 5 minutes to collect the focal data. We separated the data on feeding on different food items from the above data. We collected samples (leaf, flower, fruit) from the respective trees and had them identified at the Botanical Survey of India, Coimbatore. The total amount of time spent on focal animal sampling was 110 h (n=1,320), distributed evenly across the study period. The data was collected between 08:00 h and 16:00 h.

Information on plants was obtained from the Biotik portal (www.biotik.org) and India Biodiversity Portal (www.indiabiodiversity.org), with nomenclature checked against www.theplantlist.org.

RESULTS

Nilgiri Langurs were found to feed on 34 plant species in the present study. Of these, 20 species contributed more than 1% of observations (Table 1). About 40% of the observed diet was contributed by five major species, viz. *Turpinia cochinchinensis* (Lour.) Merr. (9.6%), *Ternstroemia gymnanthera* (Wight & Arn.) Sprague (8.8%), *Magnolia nilagirica* (Zenker) Figlar (8.9%), *Rhodomyrtus tomentosa* (Aiton) Hassk. (6.3%) and *Pinus* sp. (11.4%). The langurs spent more time consuming leaves (77%) than flowers (9.3%), fruits (8.9%), petioles (3.7%) or bark (0.8%). They spent more time feeding on broad-leafed trees (73%) than on shrubs (15%), conifers (11%) or ferns (0.6%).

Of the 20 major food-plant species consumed by Nilgiri Langurs in the study, seven are endemic to the Western Ghats, four are non-native species and five are found only above 1,300 m asl. They spent 23% (n=531 mins) of the feeding time on endemic species, and 15% (n=347 mins) on non-native

Table 1. Plant species consumed by the Nilgiri Langur in the Nilgiri Hills, with percentage of observations for each, in the present study.

Family	Species	Plant part used	% of feeding time spent on each species
Pinaceae	*Pinus* sp.#	Leaves	11.4
Staphyleaceae	*Turpinia cochinchinensis* (Lour.) Merr.#	Leaves	9.6
Magnoliaceae	Magnolia nilagirica (Zenker) Figlar*#	Leaves, Flowers	8.9
Theaceae	*Ternstroemia gymnanthera* (Wight & Arn.) Sprague	Leaves, Flower, Bark	8.8
Myrtaceae	*Rhodomyrtus tomentosa* (Aiton) Hassk.	Leaves, Fruits	6.3
Sabiaceae	*Meliosma pinnata* (Roxb.) Maxim.	Leaves	5.6
Solanaceae	*Datura innoxia* Mill. **	Leaves	5.4
Rutaceae	*Melicope lunu-ankenda* (Gaertn.) T.G. Hartley	Leaves	4.4
Araliaceae	*Schefflera capitata* (Wight & Arn.) Harms*	Leaves, Petiole	4.2
Solanaceae	*Cestrum aurantiacum* Lindl. **	Leaves	4.1
Ulmaceae	*Celtis philippensis* Blanco	Leaves	3.4
Solanaceae	*Solanum erianthum* D. Don **	Leaves, Fruits	3.2
Lauraceae	*Litsea floribunda* Gamble*	Petiole, Leaves, Fruit	2.5
Sabiaceae	*Meliosma simplicifolia* (Roxb.) Walp.	Leaves, Fruit	2.5
Rosaceae	*Photinia serratifolia* (Desf.) Kalkman	Leaves, Flower	2.4
Lauraceae	*Litsea wightiana* (Nees) Hook. f.*#	Leaves, petiole	2.2
Oleaceae	*Jasminum mesnyi* Hance **	Leaves	1.9
Elaeocarpaceae	*Elaeocarpus munroii* Mast.*	Leaves	1.7
Elaeocarpaceae	*Elaeocarpus variabilis* Smarzty*	Leaves	1.6
Myrtaceae	*Syzygium densiflorum* Wall. ex Wight & Arn.*#	Leaves	1.5
	Other species (<1% in diet)		8.4

* Endemic species
** Non-native species
# Species found only over 1,300 m

species. They spent 34% (n=785 mins) of feeding time on trees that are found only above 1,300 m asl (both endemic and non-endemic species are included in this category).

Amongst the species used by the Nilgiri Langur in mid-elevation forests at other sites, only *Gomphandra coriacea* Wight, *Syzygium cumini* (L.) Skeels, *Litsea floribunda* Gamble, *Litsea wightiana* (Nees) Hook. f., *Meliosma pinnata* (Roxb.) Maxim., *Antidesma montanum* Blume and *Persea macrantha* (Nees) Kosterm. are found over 1,600 m asl (source: Biotik portal [www.biotik.org] and India Biodiversity Portal [www.indiabiodiversity.org]) in the Western Ghats (Table 2). Of these, only the two *Litsea* species (4.7% of feeding combined observations, n=109 mins), *M. pinnata* (5.6%, n=129 mins) and S. cumini (1.5%, n=35 mins) were found to be common and consumed by Nilgiri Langurs in the Nilgiri Hills. The other species were absent in the study area.

DISCUSSION

Knowledge of dietary adaptations of a species inhabiting fragmented high altitude forests is important for conservation and management of the species. In the present study we found that the diet of the Nilgiri Langur in high-altitude fragmented

Table 2. Plant species fed in percentage by the Nilgiri Langur in other studies below 1,300 m mean sea level, listed in descending order of their prominence in the diet. Nomenclature corrected according to www.theplantlist.org

Species	Family	Kakachi[1] (1,000 m)	Silent Valley[2] (900 m)	Pachcha Palmalai shola[3] (1,200 m)	Nelliyampathy[4] (1,000 m)	Average of all sites
Cullenia exarillata A. Robyns*	Bombacaceae	3.3	13.4	9.22	14.41	10.08
Gomphandra coriacea Wight**	Icacinaceae	21.4	1.2	2.08	0	6.17
Palaquium ellipticum (Dalzell) Baill.	Sapotaceae	0	7	3.09	8.47	4.64
Drypetes venusta (Wight) Pax & K.Hoffm.*	Euphorbiaceae	0	2.4	11.24	3.81	4.36
Myristica dactyloides Gaertn. **	Myristicaceae	10.8	5.2	0	0	4
Drypetes oblongifolia (Bedd.) Airy Shaw*	Euphorbiaceae	12	0	0	0	3.1
Syzygium laetum (Buch.-Ham.) Gandhi	Myrtaceae	0	4.8	0	3.39	2.05
Calophyllum polyanthum Wall. ex Planch. & Triana	Clusiaceae	0	2	0	5.51	1.88
Litsea wightiana (Nees) Hook.f. *	Lauraceae	1.1	0	0	5.93	1.76
Meliosma pinnata (Roxb.) Maxim.	Sabiaceae	0	0	6.82	0	1.76
Antidesma montanum Blume	Euphorbiaceae	5.0	1	0	0	1.5
Persea macrantha (Nees) Kosterm.	Lauraceae	1.6	0	1.33	2.12	1.46
Epiprinus mallotiformis (Müll.Arg.) Croizat*	Euphorbiaceae	1.2	0	4.36	0	1.39
Mesua ferrea L.	Clusiaceae	0	2.4	2.15	0.85	1.35
Bischofia javanica Blume	Euphorbiaceae	0	3.8	1.33	0	1.28
Dimocarpus longan Lour.	Sapindaceae	0	1.6	1.70	1.69	1.25
Ficus beddomei King*	Moraceae	0	2.4	0	2.12	1.13
Ficus exasperata Vahl	Moraceae	0	0	4.48	0	1.12
Mallotus tetracoccus (Roxb.) Kurz	Euphorbiaceae	0	0	3.6	0.85	1.11

Species	Family	Kakachi[1] (1,000 m)	Silent Valley[2] (900 m)	Pachcha Palmalai shola[3] (1,200 m)	Nelliyampathy[4] (1,000 m)	Average of all sites
Tetrastigma sulcatum (P. Lawson) Gamble	Vitaceae	4	0	0	0	1.10
Oreocnide integrifolia (Gaudich.) Miq.	Urticaceae	0	0	4.3	0	1.08
Gomphandra tetrandra (Wall.) Sleumer	Icacinaceae	0	0	0	4.24	1.06
Myristica beddomei King**	Myristicaceae	0	0	0	4.24	1.06
Diospyros sylvatica Roxb.**	Ebenaceae	0	0	4.1	0	1.03
Holigarna nigra Bourd.*	Anacardiaceae	1.1	0	0	2.54	1.01
Canarium strictum Roxb.	Burseraceae	0	1	2.15	0.85	1
Diospyros ovalifolia Wight**	Ebenaceae	0	0	4	0	1
Gordonia obtusa Wall. ex Wight*	Theaceae	0	0	4	0	1
Ficus nervosa B.Heyne ex Roth	Moraceae	0	1.60	1.33	0.85	0.95
Macaranga peltata (Roxb.) Müll.Arg.	Euphorbiaceae	0	0	1.2	2.54	0.94
Cinnamomum malabatrum (Burm.f.) J.Presl*	Lauraceae	0	2	0	1.69	0.92
Piper sp.	Piperaceae	0	0	1.9	0	0.89
Mesua thwaitesii Planch. & Triana*	Clusiaceae	0	0	0	3.39	0.85
Elaeocarpus tuberculatus Roxb.	Elaeocarpaceae	0	2.2	0	0.85	0.76
Ormosia travancorica Bedd.*	Fabaceae	2.9	0	0	0	0.73
Garcinia morella (Gaertn.) Desr.	Clusiaceae	0	2.8	0	0	0.7
Litsea oleoides Hook.f.*	Lauraceae	1.1	0	1.26	0.42	0.7
Callicarpa tomentosa (L.) L.**	Verbenaceae	0	0	2.4	0	0.65
Coffea arabica L.	Rubiaceae	0	0	0	2.54	0.64
Tectona grandis L.f.	Lamiaceae	0	0	0	2.54	0.64

Species	Family	Kakachi[1] (1,000 m)	Silent Valley[2] (900 m)	Pachcha Palmalai shola[3] (1,200 m)	Nelliyampathy[4] (1,000 m)	Average of all sites
Vernonia arborea Buch.-Ham.	Asteraceae	0	0	2.15	0	0.64
Mangifera indica L.	Anacardiaceae	0	1.2	0	1.27	0.62
Loranthus sp.	Loranthaceae	0	0	2.4	0	0.60
Viburnum punctatum Buch.-Ham. ex D. Don	Caprifoliaceae	0	0	2.34	0	0.59
Litsea floribunda Gamble*	Lauraceae	0	2.2	0	0	0.55
Artocarpus heterophyllus Lam.	Moraceae	0	0	0	2.12	0.53
Elaeocarpus serratus L.	Elaeocarpaceae	0	0	0	2.12	0.53
Garcinia gummi-gutta (L.) Roxb.**	Clusiaceae	0	0	0	2.12	0.53
Olea dioica Roxb.	Oleaceae	0	1.6	0	0.42	0.51
Cinnamomum verum J.Presl**	Lauraceae	2.	0	0	0	0.5
Macaranga indica Wight	Euphorbiaceae	0	2	0	0	0.5
Syzygium cumini (L.) Skeels	Myrtaceae	0	2	0	0	0.5
Agrostistachys indica Dalzell	Euphorbiaceae	1.9	0	0	0	0.48
Cinnamomum sulphuratum Nees*	Lauraceae	1.9	0	0	0	0.48
Xanthophyllum flavescens Roxb.	Polygalaceae	0	1.8	0	0	0.45
Melia azedarach L.	Meliaceae	0	0	1.77	0	0.44
Prunus ceylanica (Wight) Miq.	Rosaceae	1.2	0	0	0	0.4
Syzygium mundagam (Bourd.) Chithra	Myrtaceae	0	1.6	0	0	0.4
Symplocos cochinchinensis (Lour.) S. Moore	Symplocaceae	0	1.6	0	0	0.4
Turpinia malabarica Gamble	Staphyleaceae	0	1.6	0	0	0.4
Aglaia bourdillonii Gamble*	Meliaceae	1.5	0	0	0	0.38

Species	Family	Kakachi[1] (1,000 m)	Silent Valley[2] (900 m)	Pachcha Palmalai shola[3] (1,200 m)	Nelliyampathy[4] (1,000 m)	Average of all sites
Mallotus paniculatus (Lam.) Müll.Arg.	Euphorbiaceae	1.5	0	0	0	0.38
Calophyllum walkeri Wight	Calophyllaceae	1.3	0	0	0	0.33
Clerodendrum infortunatum L.	Lamiaceae	1.3	0	0	0	0.33
Grewia tiliifolia Vahl	Malvaceae	0	0	0	1.27	0.32
Holigarna grahamii (Wight) Kurz*	Anacardiaceae	0	0	0	1.27	0.32
Apodytes dimidiata E.Mey. ex Arn.	Icacinaceae	0	1.2	0	0	0.3
Vepris bilocularis Engl.	Rutaceae	1.2	0	0	0	0.3
Toddalia asiatica (L.) Lam.	Rutaceae	0	0	1.14	0	0.29
Cyathea spinulosa Wall. ex Hook.	Cyatheaceae	1.1	0	0	0	0.28
Ficus hispida L.f.	Moraceae	0	0	1.07	0	0.27
Ficus microcarpa L.f.	Moraceae	0	1	0	0	0.25
Mallotus philippensis (Lam.) Müll.Arg.	Euphorbiaceae	0	0	1.01	0	0.25
Ochlandra sp.*	Poaceae	0	1	0	0	0.25
Other species (<1% in diet)		19.6	20.8	10.08	12.3	15.7

* Endemic to Western Ghats
** Endemic to South India and Sri Lanka
[1] Oates et al. (1980)
[2] Ramachandran and Joseph (2001)
[3] Sushma (2004)
[4] Ramachandran and Suganthashaktivel (2010)
[5] As *D. elata*

areas constituted mainly of broad-leafed trees and conifers. Also, the Nilgiri Langurs fed on several non-native species.

Altitude is a strong predictor of the diet of the colobines (Tsuji et al., 2013). Colobines inhabiting alpine temperate forests fed more on lichens than on fruits and flowers than those living at lower altitudes (Ruhiyat, 1983; Kirkpatrick & Grueter, 2010), due to shortage of their preferred foods (fruit and foliage) in high-altitude habitats (Tsuji et al., 2013). In the Nilgiri Hills, the Nilgiri Langurs depend on many plants that are present only above 1,300 m altitude. Many favoured tree species that are found in medium-elevation forests are absent in high-altitude forests, and hence, do not figure in the diet of Nilgiri Langurs.

The Nilgiri Langurs were not found to feed on non-native species to a large extent (>1% of the diet) in medium-elevation evergreen forests of the Western Ghats. However, in the Nilgiri Hills, they were found to feed on non-native food species. The decreased availability of native species due to fragmentation may have led them to feed on non-native species even where these are suboptimal foods. In particular, *Datura* spp. have high levels of toxicity due to presence of tropane alkaloids and the langurs might need to spend a higher amount of time resting to digest these (Preissel & Preissel, 2002). Similarly, pine needles are not generally a preferred food among primates. Japanese Macaques *Macaca fuscata* (Blyth) avoided conifer leaves, which had high tannin content (Hanya et al., 2011). However, Barbary Macaques *Macaca sylvanus* (Linnaeus) included conifer leaves in their diet even though the tannin content was higher than the leaves consumed by the Japanese Macaques. Barbary Macaques consumed conifer needles only when there was a dietary stress in a lean winter season (Taub, 1977), and is possible that the high consumption of conifer needles in the present study might likewise be an indication of dietary stress.

The major habitat of the Nilgiri Langurs in the Nilgiri Hills is small fragments of shola. The absence of mid-elevation evergreen trees restricts the dietary breadth, and destruction of remaining shola will further narrow this. Collection of firewood, human disturbance and poaching are major threats in the remaining small fragments. Hence, a large-scale effort has to be put into conservation and management of the remaining shola fragments in the Nilgiri Hills.

ACKNOWLEDGEMENTS

We thank the Chief Wildlife Warden and the officials of the Tamil Nadu Forest Department for permission to conduct this study and for their field assistance; BSI, Coimbatore and Arundhati Das of ATREE for assistance in tree identification; and the anonymous reviewers. This study was supported by a Science and Engineering Research Board, India Ramanna Fellowship to MS.

REFERENCES

Davidar, E.R.C. 1978. Distribution and status of the Nilgiri Tahr (*Hemitragus hylocrius*) 1975-78. *Journal of Bombay Natural History Society* **75**: 815-844.

Donati, G., Kesch, K., Ndremifidy, K., Schmidt, S.L., Ramanamanjato, J.-B., Borgognini-Tarli, S.M. and Ganzhorn, J.U. 2011. Better few than hungry: Flexible feeding ecology of collared lemurs *Eulemur collaris* in littoral forest fragments. *PLoS One* **6**: e19807.

Grueter, C.C., Li, D., Ren, B., Xiang, Z. and Li, M. 2012. Food abundance is the main determinant of high-altitude range use in snub-nosed monkeys. *International Journal of Zoology* 2012: 739419. doi:10.1155/2012/739419.

Hanya, G., Ménard, N., Qarro, M., Tattou, M.I., Fuse, M., Vallet, D., Yamada, A., Go, M., Takafumi, H., Tsujino, R., Agetsuma, N. and Wada, K. 2011. Dietary adaptations of temperate primates: comparisons of Japanese and Barbary macaques. *Primates* **52**: 187-198.

Irwin, M.T. 2008. Feeding ecology of *Propithecus diadema* in forest fragments and continuous forest. *International Journal of Primatology* **29**: 95-115.

IUCN. 2015. The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>. Downloaded on 13 April 2015.

Johns, A.D. 1983. *Ecological Effects of Selective Logging in a West Malaysian Rain-forest.* PhD dissertation, University of Cambridge, UK.

Johnsingh, A. and Manjrekar, N. 2013. *Mammals of South Asia.* Universities Press, Hyderabad, India.

Kirkpatrick, R.C. and Grueter, C.C. 2010. Snub-nosed monkeys: multilevel societies across varied environment. *Evolutionary Anthropology* **19**: 98–113.

Molur, S., Brandon-Jones, D., Dittus, W., Eudey, A., Kumar, A., Singh, M., Feeroz, M.M., Chalise, M., Priya, P. and Walker, S. 2003. *Status of South Asian Primates: Conservation Assessment and Manage-*

ment Plan (CAMP). Zoo Outreach Organization/ CBSG-South Asia, Coimbatore, India.

Oates, J.F., Waterman, P.G. and Choo, G.M. 1980. Food selection by the south Indian leaf-monkey, Presbytis johnii in relation to leaf chemistry. *Oecologia* **45**: 45-56.

Pascal, J.P. 1988. Wet Evergreen Forests of the *Western Ghats of India.* French Institute of Pondicherry, Pondicherry.

Pascal, J.P., Ramesh, B.R. and Franceschi, D.D. 2004. Wet evergreen forest types of the southern Western Ghats, India. *Tropical Ecology* **45**: 281-292.

Preissel, U and Preissel, H.G. 2002. *Brugmansia and Datura: Angel's Trumpets and Thorn Apples*. Firefly Books, Buffalo, New York, USA.

Ramachandran, K.K. and Joseph, G.K. 2001. Feeding ecology of Nilgiri Langur (*Trachypithecus johnii*) in Silent Valley National Park, Kerala, India. *Indian Forester* **127**: 1155-1164.

Ramachandran, K.K and Suganthasakthivel, R. 2010. *Ecology and Behaviour of the Arboreal Mammals of the Nelliyampathy Forests*. KFRI research report No. 382, KFRI, Peechi, India.

Rice, C. 1984. *Behavior and Ecology of Nilgiri Tahr* (*Hemitragus hylocrius*). PhD dissertation, Texas A & M University, USA.

Riley, E.P. 2007. Flexibility in diet and activity patterns of Macaca tonkeana in response to anthropogenic habitat alteration. *International Journal of Primatology* **28**: 107-133.

Ruhiyat, Y. 1983. Socio-ecological study of *Presbytis aygula* in west Java. *Primates* **24**: 344-359.

Singh, M., Kumar, A. & Molur, S. 2008. *Trachypithecus johnii*. The IUCN Red List of Threatened Species 2008: e.T44694A10927987. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T44694A10927987.en. Downloaded on 29 October 2015.

Sunderraj, S.W. 2001. Ecology and conservation of Nilgiri langur (*Trachypithecus johnii*). *Envis Bulletin: Wildlife and Protected Areas* **1**: 49-59.

Sunderraj, S.W. and Johnsingh, A. 2001. Impact of biotic disturbances on Nilgiri langur habitat, demography and group dynamics. *Current Science* **80**: 428-436.

Sushma, H. 2004. *Resource Utilization and Niche Separation in Sympatric Rain Forest Arboreal Mammals.* PhD dissertation, University of Mysore, India.

Taub, D.M. 1977. Geographic distribution and habitat diversity of the Barbary macaque *Macaca sylvanus* L. *Folia Primatologica* **27**: 108-133.

Thomas, S. and Palmer, M. 2007. The montane grasslands of the Western Ghats, India: community ecology and conservation. *Community Ecology* **8**: 67-73.

Tsuji, Y., Hanya, G. and Grueter, C.C. 2013. Feeding strategies of primates in temperate and alpine forests: comparison of Asian macaques and colobines. *Primates* **54**: 201-215.

Tutin, C.E.G. 1999. Fragmented living: behavioral ecology of primates in a forest fragment in the Lopé reserve, Gabon. *Primates* **40**: 249-265.