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Taxonomic Implications of a Field Study of Morphotypes of Hanuman Langurs (*Semnopithecus entellus*) in Peninsular India

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Abstract The Hanuman langur is one of the most widely distributed and morphologically variable non-human primates in South Asia. Even though it has been extensively studied, the taxonomic status of this species remains unresolved due to incongruence between various classification schemes. This incongruence, we believe, is largely due to the use of plastic morphological characters such as coat color in classification. Additionally these classification schemes were largely based on reanalysis of the same set of museum specimens. To bring greater resolution in Hanuman langur taxonomy we undertook a field survey to study variation in external morphological characters among Hanuman langurs. The primary objective of this study is to ascertain the number of morphologically recognizable units (morphotypes) of Hanuman langur in peninsular India and to compare our field observations with published classification schemes. We typed five color-independent characters for multiple adults from various populations in South India. We used the presence-absence matrix of these characters to derive the pair-wise distance between individuals and used this to construct a neighbor-joining (NJ) tree. The resulting NJ tree retrieved six distinct clusters, which we assigned to different morphotypes. These morphotypes can be identified in the field by using a combination of five diagnostic characters. We determined the approximate distributions of these morphotypes by plotting the sampling locations of each morphotype on a map using GIS software. Our field observations are largely concordant with some of the earliest classification schemes, but are incongruent with recent classification schemes. Based on these results we recommend Hill (Ceylon Journal of Science,

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Colombo 21:277-305, 1939) and Pocock (Primates and carnivora (in part) (pp. 97–163). London: Taylor and Francis, 1939) classification schemes for future studies on Hanuman langurs.

Keywords Classification schemes · Colobines · Morphological characters · Subspecies

Introduction

Hanuman or common langurs (family Cercopithecidae, subfamily Colobinae) are the most widely distributed nonhuman primates in South Asia (Choudhury 2007; Napier and Napier 1967). They are dispersed throughout most of India and Sri Lanka (Ellerman and Morrison-Scott 1966; Oates *et al*. 1994), and are also established in parts of Pakistan, Nepal (Oates *et al*. 1994; Roonwal 1984), Bhutan, and Bangladesh (Choudhury 2007). They occur in a wide range of habitats from arid regions on the edge of the desert in Rajasthan to the rain forests of Western Ghats and at altitudes of 100–4270 m above mean sea level (msl) in the Himalayas (Bishop 1978; Hrdy 1977). Although Hanuman langurs are one of the most well known, revered, and extensively studied nonhuman primates in India, the taxonomic status of this species has remained unresolved.

Hanuman langurs exhibit much morphological variation throughout their range, which is reflected in the multitude of classification schemes proposed to resolve its taxonomic status. Pocock (1928, 1939) conducted one of the earliest systematic reviews of Hanuman langur classification. He considered Hanuman langur as a single species, *Semnopithecus entellus*, with 14 subspecies including *S. e. schistaceus*, *S. e. entellus*, *S. e. ajax*, *S. e. achilles*, *S. e. hypoleucos*, *S. e. priam*, *S. e. dussumieri*, *S. e. thersites*, *S. e. achates*, *S. e. iulus*, *S. e. aeneas*, *S. e. priamellus*, *S. e. elissa*, and *S. e. anchises* (Pocock 1939 and Table I). He also provided a detailed description of all subspecies and their approximate distributions.

Hill (1939), however, split the Hanuman langur into 4 species (*Semnopithecus schistaceus*, *S. entellus*, *S. hypoleucos*, and *S. priam*). He elevated Pocock's *Semnopithecus entellus entellus* to species level with no subspecies and placed the remaining subspecies in the other 3 species. Accordingly he placed the Himalayan subspecies *hector*, *schistaceus*, *achilles*, *ajax*, and *lanius* under *Semnopithecus schistaceus*. Similarly, he placed the subspecies from South India and Sri Lanka, *priam*, *thersites*, and *anchises* under *Semnopithecus priam*, and *hypoleucos*, *aeneas*, *elissa*, *iulus*, *dussumieri* and *achates* under *S. hypoleucos*.

Ellerman and Morrison-Scott (1966), Napier and Napier (1967), Roonwal and Mohnot (1977), and Roonwal (1984) followed these early classifications, all of which mirror Pocock (1928, 1939) with some changes (Table I). *Semnopithecus* was subsumed into *Presbytis* and Hill's (1939) subspecies *lanius* was retained, but renamed *lania*. Thus, these classification schemes again considered the Hanuman langur as a single species but with 14–16 subspecies (Table I). Roonwal (1979, 1984) classified the various subspecies of Hanuman langur into 2 broad groups: the Northern and Southern types based on tail carriage. The Northern type (NT) has a tail that loops forward toward the head and is distributed north of the Tapti-Godavari

Table I Overview of the different classification schemes of Hanuman langurs proposed by various authors

Pocock (1928)	Pocock (1939)	Hill (1939)	Roonwal and Mohnot (1977)	Roonwal (1984)[a]	Groves (2001)	Brandon-Jones (2004)
Northern type						
Pi. e. schistaceus	*S. e. schistaceus*	*S.schistaceus*	*P. e. schistaceus*	*P. e. schistaceus*	*S. schistaceus*	*S. e. schistaceus*
Pi. e. entellus	*S. e. entellus*	*S.entellus*	*P. e. entellus*	*P. e. entellus*	*S. entellus*	*S. e. entellus*
Pi. e. ajax	*S. e. ajax*	*S. s. ajax*	*P. e. ajax*	*P. e. ajax*	*S. ajax*	*S. e. ajax*
Pi. e. achilles	*S. e. achilles*	*S. s. achilles*	*P. e. achilles*	*P. e. achilles*	—	—
Pi. e. lanius	—	*S. s. lanius*	*P. e. lania*	*P. e. lania*	—	—
Pi. e. hector	—	*S. s. hector*	—	—	*S. hector*	*S. e. hector*
—	—	—	*P. e. anchises*	*P. e. anchises*	—	*S.e. anchises*
—	—	—	*P. e. shanicus*	—	—	—
—	—	—	—	—	—	*S. e. achates*[b]
Southern type						
Pi. e. achates	*S. e. achates*	*S. h. achates*	*P. e. achates*	*P. e. achates*	—	—
Pi. e. iulus	*S. e. iulus*	*S. h. iulus*	*P. e. iulus*	*P. e. iulus*	—	—
Pi. e. hypoleucos	*S. e. hypoleucos*	*S. h. hypoleucos*	*P. e. hypoleucos*	*P. e. hypoleucos*	*S. hypoleucos*	*S. e. hypoleucos*
Pi. e. aeneas	*S. e. aeneas*	*S. h. aeneas*	*P. e. aeneas*	*P. e. aeneas*	—	—
Pi. e. dussumieri	*S. e. dussumieri*	*S .h .dussumieri*	*P. e. dussumieri*	*P. e. dussumieri*	*S. dussumieri*	—
Pi. e. pallipes	*S. e. priam*	*S. p .priam*	*P. e. priam*	*P. e. priam*	*S. priam*	*S. p. priam*
—	*S. e. thersites*	*S. p thersites*	*P. e. thersites*	*P. e. thersites*	—	*S .p. thersites*
—	*S. e. anchises*	*S. p .anchises*	—	—	—	—
Pi. e. priamellus	*S. e. priamellus*	—	*P. e. priamellus*	*P. e. priamellus*	—	—
Pi. e. elissa	*S. e. elissa*	*S.h.elissa*	*P. e. elissa*	*P. e. elissa*	—	—

[a] Also includes Ellerman and Morrison-Scott (1966); Napier and Napier (1967).

[b] According to the Brandon-Jones (2004) distribution map, these subspecies have both Northern and Southern tail carriage.

Pi = *Pithecus*, *S* = *Semnopithecus*, *P* = *Presbytis*, *e* = *entellus*, *h* = *hypoleucos*, *p* = *priam*.

rivers. The Southern type (ST) has a tail that loops backward away from the head and is distributed south of these rivers in peninsular India and Sri Lanka (Roonwal, 1979, 1984 and Fig. 1). Hill (1938) was the first to report tail carriage variation among Hanuman langurs, reporting that *Semnopithecus entellus* exhibits NT tail carriage whereas *S. priam* has ST tail carriage.

Groves (2001) retained the genus name *Semnopithecus* and split the Hanuman langur into 7 species (*S. schistaceus*, *S. entellus*, *S. ajax*, *S. hector*, *S. hypoleucos*, *S. priam*, *S. dussumieri*), elevating 7 subspecies from earlier classification schemes to species level. He subsumed the remaining subspecies into these 7 species, with the exception of *lania*, which is no longer listed. IUCN follows this classification scheme.

Finally, Brandon-Jones (2004) split the Hanuman langur into 2 species, *Semnopithecus entellus* and *S. priam*, with 9 subspecies. Here, *Semnopithecus entellus* has 7 subspecies: *S. e. schistaceus*, *S. e. entellus*, *S. e. ajax*, *S. e. hector*, *S. e. achates*, *S. e. hypoleucos*, and *S. e. anchises* whereas *S. priam* has 2 subspecies: *S. p. priam* and *S. p. thersites*.

Thus most authors considered the Hanuman langur to be a single species, *Semnopithecus entellus* (or *Presbytis entellus*), but split this species into as many as 14 (Pocock 1928, 1939), 15 (Ellerman and Morrison-Scott 1966; Napier and Napier

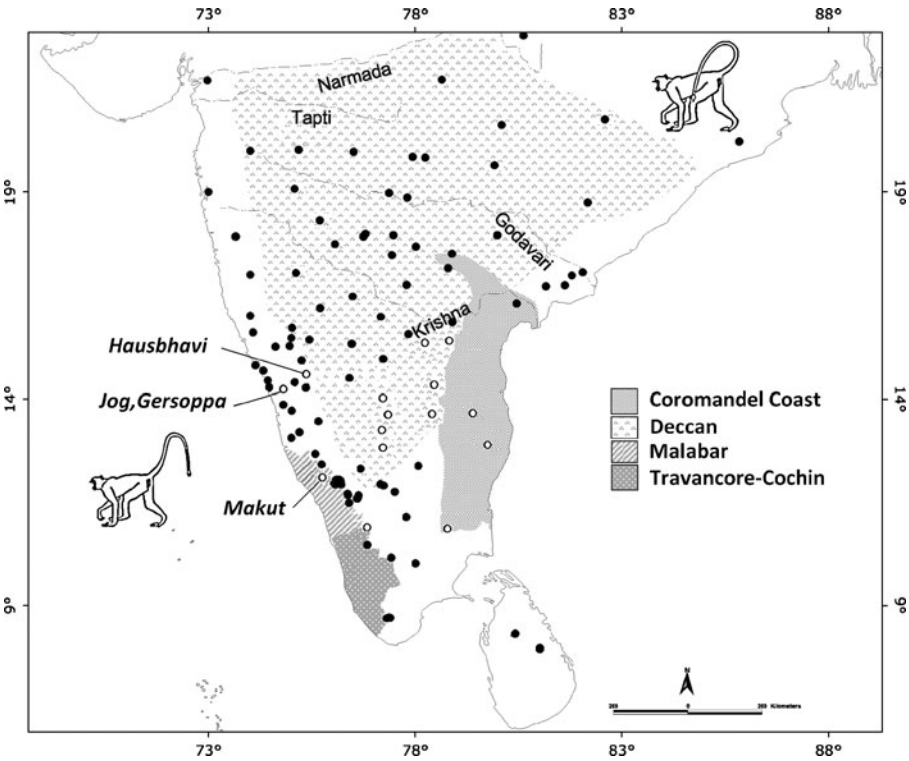

Fig. 1 Sampling locations of Hanuman langurs in peninsular India. Open circles represent sampling locations that were also type localities for various subspecies described by Pocock (1939). These include *Semnopithecus entellus achates* (Hausbhavi), *S. e. iulus* (Gersoppa), *S. e. aeneas* (Makut), *S. e. priamellus* (Travancore-Cochin), *S. e. anchises* (Deccan), and *S. e. priam* (Coromandel). Also shown are the 2 broad groups among Hanuman langurs based on tail loop. The Northern type (NT) has a tail that loops forward toward the head and the Southern type (ST) has a tail that loops backward away from the head. The NT and ST are distributed north and south of the Tapti-Godavari rivers, respectively.

1967; Roonwal 1984), and 16 (Roonwal and Mohnot 1977) subspecies. Other classification schemes have assigned the various populations of the Hanuman langur into 2 (Brandon-Jones 2004), 4 (Hill 1939), and 7 (Groves 2001) distinct species, each in turn consisting of multiple subspecies (Table I). This multitude of classification schemes clearly indicates that the taxonomy of Hanuman langurs is in a flux.

In this context, recent molecular studies of the langurs of the Indian subcontinent are important. These molecular phylogenetic studies based on nuclear and mitochondrial markers suggested that Hanuman langurs are closely related to Nilgiri (*Semnopithecus johnii*) and purple-faced langurs (*S. vetulus*: Karanth *et al*. 2008; Osterholz *et al*. 2008; Zhang and Ryder 1998), which are distributed in peninsular India and Sri Lanka respectively. Thus these 3 species are now placed in the genus *Semnopithecus*, distinct from leaf monkeys in the genera *Trachypithecus* and *Presbytis*. In addition, the mitochondrial tree in conjunction with nuclear markers did not support the monophyly of Hanuman langurs (Karanth *et al*. 2008, 2010;

Osterholz *et al*. 2008). Instead Hanuman langurs were polyphyletic with respect to Nilgiri and purple-faced langurs. Accordingly, Karanth *et al*. (2010) recommended provisional splitting of Hanuman langurs into 3 species, such that the taxonomy is consistent with their evolutionary relationship. However, they did not attempt to designate species names because these studies were based on a limited sample. Nevertheless the molecular studies also suggest that Hanuman langurs consist of multiple species.

Thus there is much disagreement in the literature on the subspecies or species status of various populations of Hanuman langurs. This ambiguous taxonomic status has serious consequences for studies targeting these taxa. Hanuman langurs have been used extensively as a model system in various biomedical, ecological, behavioral, and evolutionary research (Karanth *et al*. 2010). In addition, taxonomic status often dictates conservation priorities; thus this situation will also confound conservation efforts for Hanuman langurs.

We believe that there are 3 reasons for the lack of resolution in Hanuman langur classification. 1) Classification schemes were largely based on coat color, which is often highly plastic. 2) They were informed opinions of taxonomists instead of being based on objective analysis of morphological characters using statistical tools. 3) In addition, they were inferred from reanalysis of existing museum specimens collected in the first half of the last century or reinterpretation of earlier work. Thus no new material from the field had been used in most of these studies, with the exception of Brandon-Jones (2004). This has resulted in an unfortunate dichotomy: Though there have been extensive field studies on behavioral and ecological aspects of Hanuman langurs, museum specimens have been the sole material for most taxonomic research. The validity of descriptions based merely on museum specimens over actual onsite observations has long been debated (Pennell 1934). In this regard, several authors advocate that field studies can complement the qualitative tools of descriptive taxonomy (Dunn 2003; Martin 2003; Wheeler 2004; Woodbury et al. 1956).

To this end, we undertook a field study to document variation in external morphological characters among Hanuman langurs in South India and Sri Lanka. We subjected the color-independent characters to statistical analyses to identify distinct clusters or morphotypes and to address the following questions: How many morphotypes of Hanuman langurs are present in South India and Sri Lanka? What diagnostic characters can be used to identify these morphotypes? What are the approximate distributional limits of these morphotypes? Which classification scheme best fits the observed morphotypes from the field?

Materials and Methods

We were primarily interested in ST Hanuman langurs, which are distributed south of the Tapti-Godavari rivers according to Roonwal (1979, 1984). We examined ST Hanuman langurs because they exhibit higher levels of morphological variation than NTs, as is apparent from more numbers of subspecies reported among Southern types in most classification schemes (Table I). Therefore we conducted our survey in peninsular India (8–21°N, 73–78°E), covering the states of Andhra Pradesh, Goa, Maharashtra, Karnataka, Kerala, and Tamilnadu in India, as well as northern Sri

Table II Details of locations of Hanuman langur (*Semnopithecus*) sampled along with their coordinates for the neigbor joining tree

State	Place	Code	Longitude	Latitude	Type localities as per Pocock (1939)	Morphotype
Andhra Pradesh	Nizampur	NZMPR	78.005	17.678		St1
Andhra Pradesh	East Godavari	EGOD	81.783	16.983		Nt
Andhra Pradesh	West Godavari	WGOD1	81.616	16.745		Nt
Andhra Pradesh	Warangal	WRNGL1	79.981	17.95		Nt
Andhra Pradesh	Horsley Hills (*Coromandel*)	HORSLY1	78.4	13.648	*S. e. priam*	St5
Andhra Pradesh	Kadapa (*Coromandel*)	KDP	78.466	14.366	*S. e. priam*	St5
Andhra Pradesh	Nalgonda	NLGND	78.788	17.157		Nt
Andhra Pradesh	Mahbubnagar	MHBNGR	77.783	16.75		St1
Andhra Pradesh	Tirupathi (*Coromandel*)	TRPTI	79.416	13.65	*S. e. priam*	St5
Andhra Pradesh	Kurnool (*Deccan*)	KRNL	78.220	15.31	*S. e. anchises*	St3
Chattisgarh	Gautampur	GAUTMPR	75.04	23.01		Nt
Goa	Bondla	GOA	74.066	15.605		St1
Gujrat	Bharuch	BHARUCH	72.966	21.7		Nt
Jharkhand	Palamau	PALAMAU	84.6	23.416		Nt
Karnataka	Hampi	HMP	76.457	15.318		St1
Karnataka	Ramnagar, Hampi	RHMP	76.466	15.3335		St1
Karnataka	Haveri	HVR	75.248	14.922		St1
Karnataka	Bidar	BDR	77.463	17.956		St1
Karnataka	Honnavar	HNVR	74.46	14.269		St1
Karnataka	Ankola	ANK	74.317	14.674		St1
Karnataka	Pavagada (*Deccan*)	PVGD	77.219	14.107	*S. e. anchises*	St3
Karnataka	Nagarahole	NGRH	76.083	12		St1
Karnataka	Kukke Subrahmanya	KKEF	75.574	12.667		St2
Karnataka	Agumbe	AGMB	74.998	13.064		St2
Karnataka	Karkala	KRKL	75.108	13.238		St2
Karnataka	Moodbidre	MDBD	74.993	13.069		St2
Karnataka	Kudremukha	KDMK	75.195	13.199		St2
Karnataka	Bandipur	BND	76.624	11.663		St5
Karnataka	Biligiri Ranga Temple	BRT	77.152	11.938		St5
Karnataka	Balle	BALLE	76.212	11.925		St1
Karnataka	Sunkadakatte, Nagarahole	NGRHSNK	76.194	11.976		St1
Karnataka	Makut	MAKUT	75.754	12.088	*S. e. aeneas*	St2
Karnataka	Theerthahalli	THRTLLI	75.011	13.718		St2
Karnataka	Muthodi	MUTHDI	75.656	13.459		St2
Karnataka	Jog, Gersoppa	JOGFALLS	74.808	14.224	*S. e.iulus*	St1
Karnataka	Hausbhavi	HUSBHVI	75.383	14.553	*S. e. achates*	St1
Karnataka	Halesorba	HSORBA	75.078	14.392		St1
Karnataka	Ranebennur	RNEBENNR	75.668	14.624		St1
Karnataka	Amasebail	AMSBL	74.949	13.612		St2
Karnataka	Shikaripura	SHIKAPR	75.35	14.267		St1
Karnataka	Mysorezoo	MYSZOO	76.67	12.299		St1
Kerala	Trivandrum	TRIZOO	76.595	8.51		*St2*
Kerala	Walayar (*Cochin*)	WLYR	76.83	10.835	*S. e. priamellus*	St4

Table II (continued)

State	Place	Code	Longitude	Latitude	Type localities as per Pocock (1939)	Morphotype
Kerala	Muthanga (*Malabar*)	MTHNGA	76.36	11.695		St4
Kerala	Tolpetty (*Malabar*)	TPTY	76.067	11.933		St1
Kerala	Aralam (*Malabar*)	ARLM	75.681	12.003	*S. e. aeneas*	St2
Kerala	Chinnar	CHNR	77.267	10.3		St5
Madhya Pradesh	Jabalpur	JABALPUR	85.95	23.166		Nt
Madhya Pradesh	Kanha	KANHA	85.616	22.283		Nt
Madhya Pradesh	Kangerghati	KNGHRGHT	82.166	18.75		Nt
Maharashtra	Matheran	MATHRN	73 .280	18 .999		St1
Maharashtra	Radhanagari	RADHNGRI	73 .838	16 .359		St1
Maharashtra	Mahabhaleshwar	MHBLSWR	73.655	17.921		St1
Maharashtra	Lathur	LATHUR	76.749	17.922		St1
Orissa	Bhuvaneshwar	BHUBNSWR	85.833	20.233		Nt
Orissa	Bagra	BAGRA	85.65	18.833		Nt
Tamil Nadu	Theppakad	THPKD	76.601	11.591		St5
Tamil Nadu	Kalakkad-Mundanthurai	KMTR	77.383	8.7		St5
Sri Lanka	Anuradhapura	ANRDPRA	80.396	8.334		St5
Sri Lanka	Polonnaruwa	PLNRWA	81.008	7.936		St5

Lanka. We chose the districts in these states based on past surveys (Kumara *et al*. 2010; Kumara and Singh 2004; Kurup 1981, 1984; Srinivasulu and Nagulu 2001; Baldwin *et al*. 1975) as well as forest department reports. We also included some NTs as controls from parts of Gujarat, Madhya Pradesh, Chattisgarh, and Orissa. As far as possible we included the type localities mentioned in various classification schemes in the survey (Table II).

We prepared a comprehensive list of all probable species or subspecies for South India based on published taxonomic work (Table I) and a list of all external morphological characters used to identify these species or subspecies. From this list we chose a total of 5 color-independent morphological characters for further study: presence or absence of crest, presence or absence of streak between the eye and the ear, Northern or Southern type tail carriage (Fig. 1), the extent of blackness (EOB) on the hand (Fig. 2), and forms of tail carriage among the Southern type (Fig. 3). The Southern type has 2 forms of tail carriage (Roonwal 1979; 1984): TC1 appears like a inverted letter U, wherein the distal arm of the tail loop reaches the level of the back (distal and proximal arms of approximately same lengths) with the tail tip pointing straight downward (Fig. 3b). TC2 appears like the letter S, wherein the distal arm of the tail loop is always shorter than the proximal arm with the tail tip pointing obliquely downwards (Fig. 3c). We recorded tail carriage characters when the subject was walking and not when it was standing or running (as per Roonwal 1984).

We scored characters for ≥1 adult male or female per troop from the field as well as from photographs of individuals from various populations. We made observations using 8×50 binoculars and used a digital camera for photographs (Canon EOS 30D).

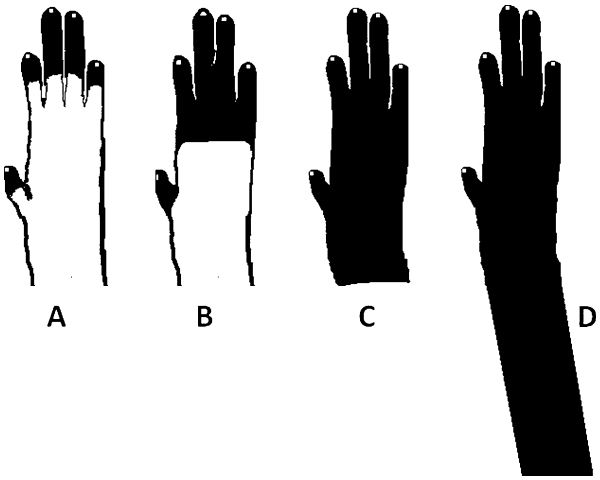

Fig. 2 Variation in the extent of blackness (EOB) of the hand among Hanuman langurs. (**a**) EOB restricted to fingertips. (**b**) EOB to knuckles. (**c**) EOB to wrist. (**d**) EOB to the elbow. (Modified from Pocock 1939).

In addition to the characters mentioned previously, we recorded pelage color for each troop studied, as well as troop size, troop count, troop range, and troop composition. For each location, we noted altitude, latitude, and longitude. We sought the assistance of volunteers to score the characters to minimize observer bias. We also keyed characters from photographs for central Indian and Sri Lankan langurs and included wild-caught individuals whose provenance could be clearly established.

Data Analyses

We coded binary characters as 1 for present and 0 for absent. For the extent of blackness and tail carriage characters we assigned a positive number (Table III). We used this character matrix in PAUP (Swofford 2001) to determine the pairwise total distance (equivalent to Hamming's distance) between individuals. We used this pairwise distance to generate an unweighted paired group method with arithmetic mean (UPGMA) and neighbor-joining (NJ) trees in PAUP. We assigned clusters generated in these trees to various morphotypes. We determined the approximate distributions of these morphotypes by plotting the sampling locations of each morphotype on a map via MapInfo Professional and DIVA-GIS (Hijmans *et al.* 2004). We compared the various characters of these morphotyes and their

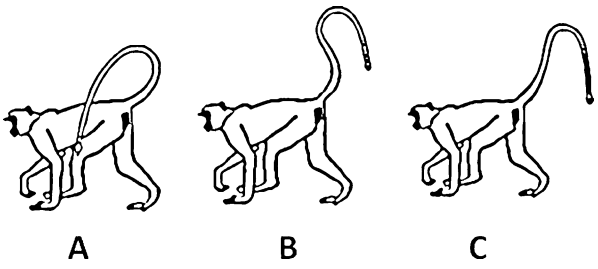

Fig. 3 Variation in tail carriage among Hanuman langurs. (**a**) Northern type. (**b**) Southern type with TC2 tail carriage. (**c**) Southern type with TC1 tail carriage (see text for details).

Table III The 6 morphotypes of Hanuman langurs (*Semnopithecus*) reported from peninsular India and Sri Lanka, and their diagnostic characters. Also shown is the fit between the morphotypes observed in field and the various classification schemes

	Streak	Crest	EOB	TL	TC	Pocock (1939)	Hill (1939)	Groves (2001)	Brandon-Jones (2004)
Nt	0	0	3	1	0	*S. e. entellus*	*S. entellus*	*S. entellus*	*S. e. entellus/achates/anchises*
St1	1	0	3	2	1	*S. e. achates*	*S. h. achates*	*S. dussumieiri*	*S. e. anchises*
						S. e. iulus	*S. h. iulus*		
St2	1	0	4	2	1	*S. e. hypoleucos*	*S. h. hypoleucos*	*S. hypoleucos*	*S. e. hypoleucos*
						S. e. aeneas	*S. h. aeneas*		
St3	0/1	0	2	2	2	*S. e. anchises*	*S. p. anchises*	*S. dussumieiri*	*S. e. achates*
St4	0	0	2	2	1[a]	*S. e. priamellus*	—	*S. dussumieiri*	—
St5	0	1	1	2	2	*S. e. priam*	*S. p. priam*	*S. priam*	*S. p. priam*
						S. e. thersites	*S. p. thersites*		*S. p. thersites*

[a] TC not known for Walayar population.

Streak and crest: present=1, absent=0.

EOB = extent of blackness on the hand, finger tips=1, to knuckles=2, to wrist=3, to the elbow=4; TL= tail loop, NT=1, ST=2; TC = tail carriage, TC1=1, TC2=2, absent=0.

distributions with published classification schemes to determine the classification scheme that best fitted the field data.

Results

Our survey included a total of 1523 individuals belonging to 107 troops observed at 102 locations in South India and Sri Lanka (Fig. 1). Troop size varied from 4 (Walayar, Muthanga, Nilambur in Kerala, and Makutta of Karnataka) to 106 (Kalamber, Nanded District of Maharashtra) individuals. We recorded Hanuman langurs from sea level in Gokarna and 2 m above msl at Honnavar in Karnataka to 1352 m above msl at Mahabaleshwar in Maharashtra. The majority (89) of the Hanuman langur troops were unimale, multifemale and the rest were multimale, multifemale (13) and all-male (2) troops. We were unable to determine troop composition for 3 troops. We also observed 7 captive individuals (1 from Saligrama, Kundapur; 3 from Trivandrum zoo; 2 from Mysore zoo; 1 from Pilikula Zoo, Mangalore).

We typed 94 adult individuals for the 5 color-independent morphological characters. We were unable to type adults for some troops because the subjects were very shy. The NJ dendrogram consisted of 6 distinct clusters (Fig. 4). These included NT Hanuman langur and 5 clusters among the ST Hanuman langurs. The clusters in the NJ tree did not change when we used other distance measures, such as average distance. We assigned these clusters to different morphotypes: Nt for NT Hanuman langur cluster and St1–5 for the 5 clusters among the ST Hanuman langurs. We found the same 6 clusters in the UPGMA tree (tree not shown). Table III summarizes the character states of the 6 morphotypes. Figure 5 shows

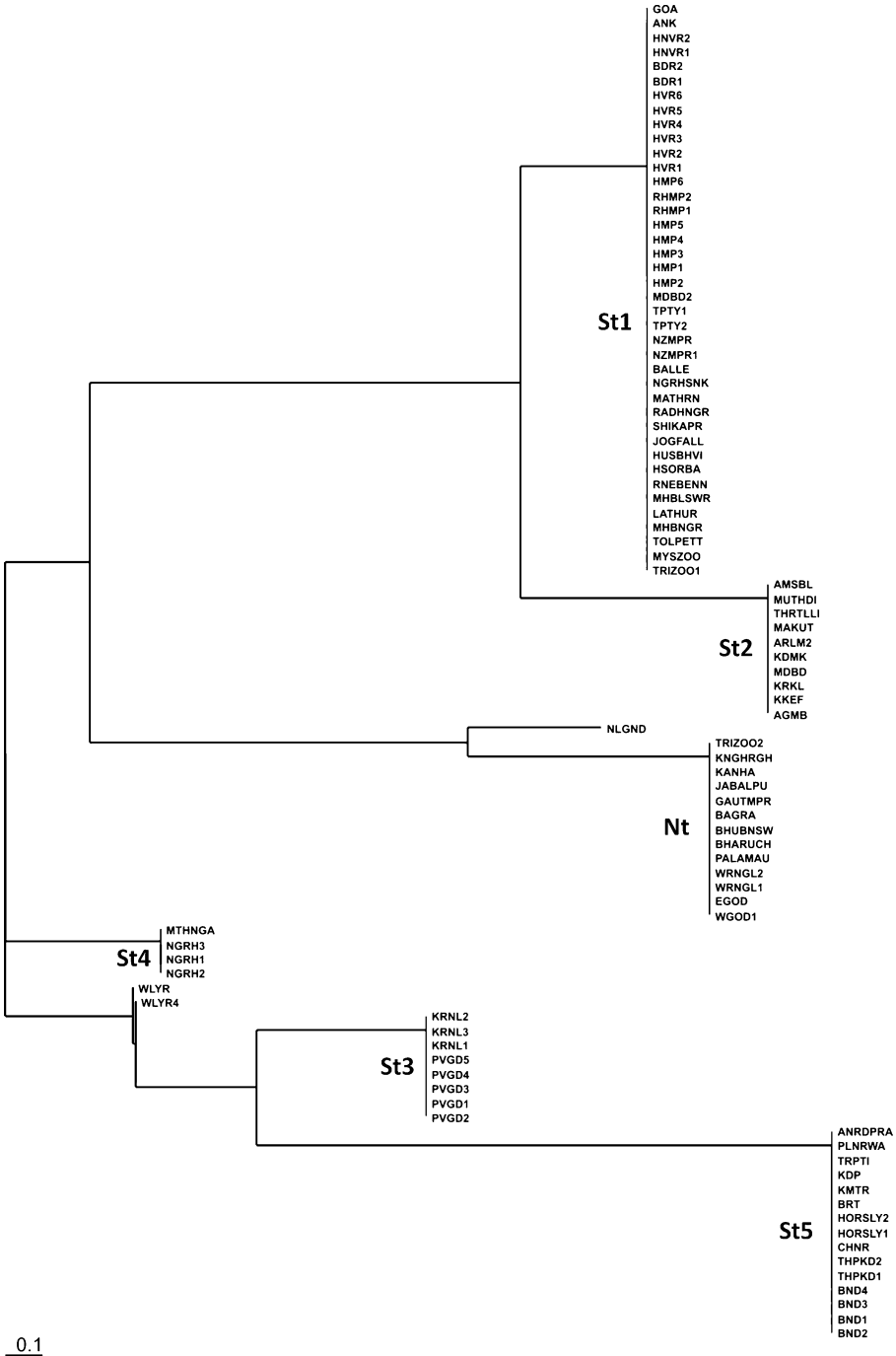

Fig. 4 Neighbour-joining tree based on 5 color-independent morphological characters typed from 94 Hanuman langurs. St1–5 represents the 5 clusters (morphotypes) among the Southern type Hanuman langurs. Nt refers to Northern type Hanuman langur. Details of abbreviations and localities are given in Table II.

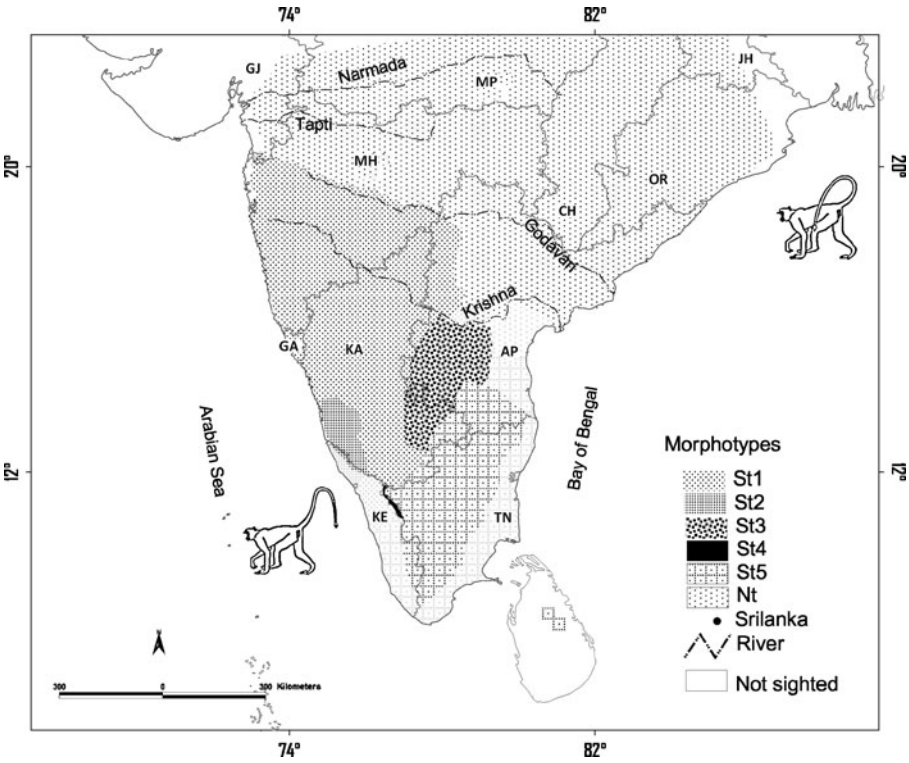

Fig. 5 Approximate distributions of Hanuman langur morphotypes in peninsular India. The state names are abbreviated as follows: GJ = Gujrat; MP = Madhya Pradesh; CH = Chattisgarh; OR = Orissa; KA = Karnataka; AP = Andhra Pradesh; KE = Kerala; TN = Tamil Nadu; GA = Goa; JH = Jharkhand. Faded areas represent locations where langurs were reported in the past but were not encountered in our survey.

their approximate distributions. Among the ST Hanuman langurs, morphotype St1 had the widest distribution and St4 was restricted to a very small area. Of the 6 morphotypes, Nt consisted exclusively of all northern tail loop individuals whereas other morphotypes (St1–5) consisted of southern tail loop individuals.

Morphotype St1 was crestless and often had a prominent streak (brownish to dark brownish band between the eye and the ear). In some populations the streak was not very prominent and in a few cases it was completely absent. The EOB was up to the wrist (Fig. 2c). The dorsal and ventral sides of the body, limbs, and tail all had a brownish gray color and the paw was black. The coat color was generally darker in the wetter and humid areas (wet zone) and slightly dull in drier areas (dry zone) of peninsular India. The intensity of orange color on the belly and chest in adults was more prominent in wetter, coastal habitats and dull and paler in the drier regions. Nevertheless, the wet and dry zone populations all showed the TC1 form of ST tail carriage. Interestingly, some populations, e.g., from Nilambur in Kerala and Nagarahole in Karnataka, had all of the aforementioned characters except that the streak was absent. St1 had a very wide distribution ranging from Nagarahole in the South to Nashik in Maharashtra all along the coastal areas. Mahbubnagar and Medak of Andhra Pradesh formed the easternmost boundaries for this morphotype.

All the populations of St2 morphotype had a prominent dark brown streak and lacked a crest. The mane was dark brown to buff. The EOB on the hand extended to the elbow and sometimes up to the shoulder (Fig. 2d). This EOB was one of the unique characters of St2 populations. The form of ST tail carriage observed was TC1, as in St1 populations. Some populations in the Brahmagiri range (Makutta, Aralam) possessed a mane suffused with orange along with dark brown hair. The coat color was much darker in all these populations vs. that in St1 populations. The coat color was dark brown to black on the dorsal and ventral parts. The limbs and tail were black with a buff-colored tail tip. St2 populations ranged all along the wet evergreen and shola grassland habitats from as far north as Theertahalli in the Shimoga district of Karnataka to the end of the Brahmagiri range near Tolpetty in Kerala. St2 populations were abundant in Aralam in Kerala and Bhadra, Someshwara, Talacauvery, Pushpagiri wildlife sanctuaries, and Kudremukh National Park in Karnataka. Populations in and around Kutta and Tolpetty in the Karnataka and Kerala border, respectively, appeared to be intermediate forms of St1 and St2 morphotypes. In these individuals the EOB ranged from that of typical St1 to St2 types.

Individuals of morphotype St3 were usually streakless, but sometimes had a faint streak, and lacked a crest. They were paler in color than individuals of St1 morphotypes. The coloration on other parts of their body was very similar to St1 except that the EOB on the hand was restricted to the knuckles (Fig. 2b). The form of ST tail carriage was TC2 (Fig. 3b). These morphotypes were abundant in the Tumkur district (Pavgada, Devarayanadurga) of Karnataka, and the Ananthpur and Kurnool districts of Andhra Pradesh. Diguvametta in Andhra Pradesh formed the easternmost boundary of this morphotype.

Morphotype St4 lacked the streak as well as the crest. This morphotype had a pale sepia brown color on the dorsal side and mane was slightly buff in color. The contrast between mane and body was quite evident. The color of the tail resembled that of the dorsal area, with the tail tip being slightly buff colored. The form of tail carriage was the same as in St1 (TC1) and the EOB on the hand was restricted to the knuckles (Fig. 2b), as in St3. We observed this morphotype in parts of Nagarahole in Karnataka and across the border in Muthanga in Kerala. Another population from Walayar in Kerala resembled St3 but we do not have data on the form of ST tail carriage for these individuals. The position of Walayar population was not resolved in the NJ tree. The sample size of St4 morphotype was very small and further studies are required to confirm the validity of this morphotype and to establish their distributional range.

St5 was very distinct, with a prominent upstanding crest on the crown. These populations had no streak and the EOB of the hand was confined to the peripheries of the fingers (Fig. 2a). Pelage color was light grayish, and the limbs and the tail also had light grayish shade. The southern populations of this morphotype from Chinnar in Kerala, Kalakkad-Mundanthurai tiger reserve (KMTR) in Tamil Nadu and northern parts of Sri Lanka had a slightly darker pelage color vs. that of the northern populations from Kadapa and Tirupathi in Andhra Pradesh, Madumalai in Tamil Nadu and Bandipur in Karnataka. All the populations of this morphotype had TC2 tail carriage (Fig. 3b). The Cuddapah and Chittore districts of Andra Pradesh form the northern limits of the morphotype. We also observed them in Southern

Karnataka along the banks of the Cauvery River, and in Biligiri Ranga temple and Bandipur tiger reserves. In Tamil Nadu they were confined to Western parts of the state along the Western Ghats. We also sighted this morphotype in Kerala south of Palakkad in Parambikulam, Thattekad, Idukki, Thekkady, Periyar tiger reserve, Achenkovil, Neyyar, and Chinnar. Kalakkad-Mundanthurai tiger reserve in Tamil Nadu formed the southern most distribution of this morphotype in peninsular India. We also observed this morphotype in Anuradhapura and Polonnaruwa in northern Sri Lanka.

Populations exhibiting the NT tail carriage constituted the sixth morphotype (Nt) in peninsular India. These morphotypes were very similar to St1 except that they lacked the streak between the eye and the ear and exhibited the NT tail loop (Fig. 3a). The Nt morphotype had the largest distribution range in peninsular India. They were distributed predominantly to the north of the Krishna River in the Nalgonda and Guntur districts of Andhra Pradesh and in northern and eastern Maharashtra. We also observed them in Gujrat, Madhya Pradesh, Chattisgarh, and Orissa.

Discussion

We describe 6 morphotypes of Hanuman langurs that could be identified in the field using a combination of 5 diagnostic characters discussed in Hill (1938), Pocock (1928, 1939), and Roonwal (1979, 1984): the presence or absence of crest, presence or absence of streak, the EOB on the hand, the tail carriage (NT and ST), and form of tail carriage (TC1 and TC2). Most classification schemes for Hanuman langurs, including Ellerman and Morrison-Scott (1966), Napier and Napier (1967), Roonwal and Mohnot (1977), and Roonwal (1984), do not provide a detailed description of each subspecies or species and their approximate distributions; thus we are unable to compare them with the 6 morphotypes we report. Nevertheless, these classification schemes, along with those of Hill (1939), were very similar to those of Pocock (1928, 1939; Table I).

The field characters of the 6 morphotypes reported here match 9 of the subspecies described by Pocock (1939). St1 closely resembled his *Semnopithecus entellus achates* and *S. e. iulus*. Interestingly, the characters of the dry zone populations of St1 were similar to those of *Semnopithecus entellus achates*, whereas those from the wet zone resembled *S. e. iulus*. Pocock's *Semnopithecus entellus hypoleucos* and the darker coat colored *S. e. aeneas* were similar to morphotype St2. Morphotype St3 resembled the description for *Semnopithecus entellus anchises*. The description of the *Semnopithecus entellus priamellus* matched our observations of morphotype St4 from Walayar in Kerala and Nagarahole in Karnataka roughly. This subspecies has been synonimized into *Semnopithecus priam thersites* (Brandon-Jones 2004; Hill 1939) or *S. dussumieri* (Groves 2001). Further work is required to confirm the validity of this morphotype and to determine its distribution. The characters described for *Semnopithecus entellus priam* and *S. e. thersites* were very similar to those we observed in morphotype St5. In morphotype St5 the southern populations from KMTR and Sri Lanka had darker coat color, as reported for *Semnopithecus entellus thersites*, whereas those from northern parts of the range had lighter coat

color, as in *S. e. priam* (Pocock 1939). The distributions of these 5 morphotypes (Fig. 5) roughly corresponded to the distributions of the subspecies they resemble. Moreover, the type localities mentioned by Pocock for the aforementioned subspecies fall within the range of the various morphotypes (Table II, Fig. 1). The Northern type morphotype, Nt, resembled Pocock's *Semnopithecus entellus entellus*. This was the only morphotype with NT tail carriage and was observed in the northern parts of peninsular India. Thus in our field survey we came across most of the subspecies reported by Pocock in South India. The 2 subspecies that we did not record are *Semnopithecus entellus dussumieri* and *S. e. elissa*. Given that Pocock's (1928) taxonomic review is one of the earliest and our field observations are largely concordant with his subsequent review (Pocock 1939), we use his subspecies names for the rest of the discussion.

Interestingly, in our NJ tree St1 (*iulus* and *achates*) and St2 (*aeneas* and *hypoleucos*) clustered together, corresponding to Hill's *Semnopithecus hypoleucos*. Similarly, the clustering of St3 (*anchises*) and St5 (*priam* and *thersites*) supports Hill's *Semnopithecus priam*. Hill also elevated the subspecies *Semnopithecus entellus entellus* (Nt morphotype in the NJ tree) to *S. entellus.* Recent molecular studies also support assigning species status to NT Hanuman langurs (Karanth *et al*. 2010). Thus the species assignments proposed by Hill (1939) appear to be consistent with current data.

In the NJ tree (Fig. 1), populations showing NT tail loop formed a cluster (Nt morphotype), but St morphotypes 1–5 did not fall in a separate ST cluster. Nevertheless, molecular data support the separation of NT populations of North India from ST populations of peninsular India (Karanth *et al.* 2010). The Tapti-Godavari rivers form the border between the Southern and Northern types. Our field observations suggest that NTs have extended their range south of the River Godavari up to the River Krishna in the Guntur district of Andhra Pradesh (Fig. 5). We also came across troops showing both tail carriages. In Narasimha Jharna, North Karnataka, the majority of the individuals exhibited ST tail carriage but 2 males showed NT tail carriage, whereas in Lonar, Maharashtra most individuals had NT tail carriage but 5 individuals showed ST tail carriage. We also sighted 3 individuals exhibiting both ST and NT tail carriage in Lonar and Dharmabad, Maharashtra and in Aurangabad (Ellora caves), Buldhana and Nanded in Maharashtra, and Adilabad and Nalgonda in Andhra Pradesh. These populations in the transition zone often had characters that were intermediate between Nt and St1. Taken together these observations are indicative of a possible hybrid zone between Nt and St1 morphotypes.

Groves (2001) placed *achates*, *anchises*, *elissa*, *priamellus*, and *iulus* into a single species, *Semnopithecus dussumieri*, and assigned species status to *hypoleucos* and *priam.* However, our NJ tree did not cluster *achates*, *anchises*, *elissa*, *priamellus*, and *iulus*. Instead, *iulus*, *achates*, and *hypoleucos* clustered together (St1 and St2) whereas *anchises*, *priam*, and *thersites* (St3 and St5) formed another cluster. Hill (1939) was also doubtful of the existence of the *dussumieri* form. Nevertheless, the distributions and characters of Groves' *Semnopithecus hypoleucos*, *S. priam*, and *S. entellus* were consistent with our observations.

Our field observations are largely incongruent with the distribution map in the classification scheme of Brandon-Jones (2004). For example, according to Brandon-

Jones, the distribution of *Semnopithecus entellus anchises* extend from North Karnataka and Andhra Pradesh all the way into Northeastern Gujrat, whereas our observation suggests that *anchises* type (St3) was restricted only to a few districts of Andhra Pradesh and parts of Karnataka (Fig. 5). Likewise, we observed *achates* (dry zone St1) predominantly in drier parts of peninsular India, and the northernmost limits of this morphotype were in Maharashtra and Andra Pradesh, whereas Brandon-Jones shows it in much of North India along with parts of central peninsular India. It seems that Brandon-Jones has misclassified *entellus* type (Nt) as *anchises* (St3) and *achates* (dry zone St1) types, both of which have ST tail carriage. This is not surprising given that *achates* (dry zone St1) is quite similar to *entellus* type (Nt) with the exception of tail carriage and streak presence, and tail carriage can be observed only in the field. Brandon-Jones also shows *hypoleucos* (St2) as distributed as far north as Mahabaleshwar in Maharashtra, whereas our field observations suggest that their northern limit is further south in Karnataka. The Mahabaleshwar area harbors *iulus* (wet zone St1). Thus our study disagrees with Brandon-Jones (2004) with respect to the distributional range of *anchises* (St3), *achates* (St1), *hypoleucos* (St2), and *entellus* (Nt). However, our observations for *Semnopithecus priam priam* and *S. p. thersites*, i.e., morphotype St5, are comparable to the distribution maps in Brandon-Jones, with the caveat that we did not observe this morphotype in the coastal districts of Kerala and Tamil Nadu.

Pelage color was generally darker in the wetter and humid areas and slightly dull in drier areas of peninsular India. This trend was apparent along the east–west gradient in rainfall in peninsular India, with lighter forms in low rainfall areas in the east and darker forms in the high rainfall regions of the west. We also observed a north–south gradient in pelage color along the west coast and the Western Ghats that appears to be related to rainfall, with lighter forms in the north and darker forms in the south. Pocock (1939; p. 89) noted that there was a general darkening of pelage color when *entellus* was traced from plains of north southward into the wetter zone of the Western Ghats. Groves (2001) invoked Gloger's rule to explain the dark pelage color of *Semnopithecus hypoleucos*. Many primate species, including macaque (*Macaca*), patas (*Erythrocebus patas*), and vervets (*Chlorocebus pygerythrus*), show light and dark color variations that seem to be associated with habitat (Bradley and Mundy 2008). Taken together these observations suggest that pelage color might be plastic and probably should not be used to delimit morphotypes.

Brandon-Jones (2004) suggests that the presence of characters such as dark pelage color and the streak between the eye and the ear in some Hanuman langur populations were due to hybridization with Nilgiri langur (*Semnopithecus johnii*). Our field observations do not support this hypothesis. During our surveys, we observed Hanuman and Nilgiri langur hybrids in KMTR and Top Slip (Anamalai hills), areas that formed the southwestern limits of St5 (*priam*) in peninsular India. In these areas the adjoining nonhybridizing populations of St5 lacked the streak and did not have dark pelage color. Further north in the Nilgiri and Brahmagiri hills the distributions of Hanuman and Nilgiri langur overlap once again, but we recorded no hybrids. Interestingly, these areas are inhabited by St2 (*hypoleucos*), which had dark pelage color and a streak between the eye and the ear. Thus, we did not observe characters ascribed to hybridization in populations adjacent to hybrid zones but we did observe them in populations where no hybridization has been reported.

Our field observations were largely consistent with those of Pocock (1939) and Hill (1939). The species/subspecies status of the taxa described in these classification schemes needs to be tested using multiple lines of evidence that includes genetic, behavioral, and ecological data. However, the description and distribution of the Nt morphotype in our study as well as those from Karanth *et al*. (2010) matched the *entellus* type of Pocock (1939), Hill (1939), and Groves (2001). The Nt morphotype has NT tail carriage, lacks the streak between the eye and the ear, and is distributed north of the Tapti, Godavari, and Krishna rivers. Populations of Nt morphotype from as far apart as Jaipur in the west and Calcutta in the east harbored identical nuclear alleles and belonged to the same mitochondrial haplogroup (Karanth *et al.* 2010). Given that Nt is both morphologically, based on the NJ tree, and genetically (Karanth *et al.* 2010) distinct from St morphotype we recommend species status for this morphotype (*Semnopithecus entellus*), as in Hill (1939) and Groves (2001). Its northern boundary and relationship with the Himalayan types need to be ascertained. These observations render Brandon-Jones' (2004) delimitations of *Semnopithecus entellus entellus*, *S. e. anchises*, and *S. e. achates* untenable. More data, particularly molecular data, are needed to ascertain the species status of the St morphotypes.

Karnataka state harbored all the St Morphotypes (St1–5), followed by Kerala, which possessed 4 morphotypes (St1, 2, 4, and 5). These states could be targeted for a more rigorous study of ST Hanuman langurs. We observed 3 St morphotypes in Andhra Pradesh, whereas Tamil Nadu, Maharashtra, and Goa each had one. The Nilgiri biosphere reserve in the trijunction of Karnataka, Kerala and Tamil Nadu is of great importance because it harbors 4 St morphotypes (1, 2, 4, and 5). According to Pocock (1939), the distributions of *aeneas*, *priamellus*, and *elissa* also fall in this area. More intensive surveys are required in the Nilgiri biosphere reserve to confirm the presence of these morphotypes. The area encompassed by the Nilgiri biosphere reserve exhibits a high degree of variation in topography and habitat, and also shows high levels of diversity in other taxonomic groups (Daniels 1992, 1996; Easa and Shaji 1997), suggesting that this area might also have played an important role in the diversification of Hanuman langur St morphotypes.

Current Status of Various Morphotypes

St1 were the most widely distributed and appeared to be least threatened because St1 were found predominantly in human-dominated ecosystems and were often habituated to humans. However, we noted several instances of crop-raiding by St1 populations, particularly in North Karnataka. This had led to human–langur conflict in these areas. Morphotypes St2, St3, and St4 appeared to be very shy, avoided proximity to humans, and had restricted distributions. We did not come across any populations of these morphotypes that were habituated to humans. Nevertheless, areas where these morphotypes were distributed were severely affected by various anthropogenic activities such as heavy vehicular movement, road constructions, hydroelectric projects, industries, and mining. The influence of these anthropogenic activities on morphotypes St2–4 is in urgent need of study.

The St5 morphotypes were also widely distributed but were confined predominantly to forested areas. Currently these populations did not appear to face any major threat. However, a handful of St5 populations were also habituated, mainly inside several protected areas of South India. In some cases these morphotypes were being fed junk foods such as salt biscuits, spicy chips, and bread by tourists, drivers of heavy motor vehicles, and local hotel owners. This trend of feeding langurs with junk food is worrisome because these monkeys are predominantly leaf-eaters.

We confirm previous reports of hunting (Kumara and Singh 2004; McCann 1933) of Hanuman and Nilgiri langurs for meat and therapeutic purposes by local people (tribal and nontribal) and migrant laborers. These cases were mostly restricted to the forested areas of Karnataka, Tamil Nadu, and Kerala. Habituated troops of morphotypes St1 and St5 were also more susceptible to road kills. We did not encounter morphotypes St3–5 in monoculture plantations of teak and eucalyptus within protected areas, suggesting that human modified landscapes were not suitable for these langurs.

Given increasing anthropogenic activities and their putative effect on langur survival, there is a pressing need to understand the biology, distribution, and status of the various morphotypes. Researchers should extend study of this kind to the NT Hanuman langurs of North India.

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References

Baldwin, L. A., Kavanagh, M., & Teleki, G. (1975). Field research on langur and proboscis monkeys: An historical, geographical, and bibliographical listing. *Primates, 16*, 351–363.

Bishop, N. H. (1978). Langurs living at high altitudes. *Journal of the Bombay Natural History Society, 74*, 518–520.

Bradley, B. J., & Mundy, N. I. (2008). The primate palette: The evolution of primate coloration. *Evolutionary Anthropology, 17*, 97–111.

Brandon-Jones, D. (2004). A taxonomic revision of the langurs and leaf monkeys (Primates: Colobinae) of South Asia. *Zoos' print journal, 19*, 1552–1594.

Choudhury, A. U. (2007). The eastern limit of distribution of the hanuman langur *Semnopithecus* entellus dufresene. *Journal of the Bombay Natural History Society, 104*, 199–200.

Daniels, R. J. R. (1992). The Nilgiri Biosphere Reserve and its role in conserving India's biodiversity. *Current Science, 64*, 706–708.

Daniels, R. J. R. (1996). The Nilgiri biosphere reserve: A review of conservation status with recommendations for a holistic approach to management (India). UNESCO South-South Cooperation Program.

Dunn, C. P. (2003). Keeping taxonomy based in morphology. *Trends in Ecology & Evolution, 18*, 270.

Easa, P. S., & Shaji, C. P. (1997). Freshwater fish diversity in Kerala part of the Nilgiri Biosphere Reserve. *Current Science, 73*, 180–182.

Ellerman, J. R., & Morrison-Scott, T. C. S. (1966). *Checklist of palaearctic and Indian mammals, 1758–1946* (2nd ed.). London: Trustees of the British Museum (Natural History).

Groves, C. P. (2001). *Primate taxonomy*. Washington, DC: Smithsonian Institution Press.

Hijmans, R. J., Guarino, L., Bussink, C., Mathur, P., Cruz, M., Barrentes, I., *et al.* (2004). *DIVA-GIS. Vsn. 5.0*. A geographic information system for the analysis of species distribution data (Manual available at: http://www.diva-gis.org).

Hill, W. C. (1938). The mode of carrying the tail in leaf-monkeys. *Ceylon Journal of Science (B), 21*, 66–67.

Hill, W. C. (1939). An annotated systematic list of the leaf-monkeys. *Ceylon Journal of Science, Colombo, 21*, 277–305.

Hrdy, S. B. (1977). *The langurs of Abu-female and male strategies of reproduction*. Cambridge: Harvard University Press.

Karanth, P. K., Singh, L., Collura, R., & Stewart, C.-B. (2008). Molecular phylogeny and biogeography of langurs and leaf monkeys of South Asia (Primates: Colobinae). *Molecular Phylogenetics and Evolution, 46*, 683–694.

Karanth, P. K., Singh, L., & Stewart, C.-B. (2010). Mitochondrial and nuclear markers suggest Hanuman langur (Primates: Colobinae) polyphyly: Implications for their species status. *Molecular Phylogenetics and Evolution, 54*, 627–633.

Kumara, H. N., & Singh, M. (2004). Distribution and abundance of primates in rain forests of the Western Ghats, Karnataka, India and the conservation of *Macaca silenus*. *International Journal of Primatology, 25*(5), 1001–1018.

Kumara, H. N., Kumar, S., & Singh, M. (2010). Of how much concern are the 'least concern' species? Distribution and conservation status of bonnet macaques, rhesus macaques and Hanuman langurs in Karnataka, India. *Primates, 51*, 37–42.

Kurup, G. U. (1981). *Report on the census surveys of rural and urban populations of non-human primates of South India*. Calicut: Zoological Survey of India.

Kurup, G. U. (1984). Census survey and population ecology of Hanuman langur, *Presbytis entellus* (Dufresne 1797) in south India. *Proceedings of the Indian National Science Academy, 50*, 245–256.

Martin, R. D. (2003). In: *Field and laboratory methods in primatology: A practical guide* (pp. xv– xxv). Cambridge: Cambridge University Press.

McCann, C. (1933). Observations on some of the Indian langurs. *Journal of the Bombay Natural History Society, 36*, 618–628.

Napier, J. R., & Napier, P. H. (1967). *A handbook of living primates*. London: Academic Press.

Oates, J. F., Davies, A. G., & Delson, E. (1994). The diversity of living colobines. In A. G. Davies & J. F. Oates (Eds.), *Colobine monkeys: Their ecology, behaviour and evolution* (pp. 45–73). Cambridge: Cambridge University Press.

Osterholz, M., Walter, L., & Roos, C. (2008). Phylogenetic position of the langur genera *Semnopithecus* and *Trachypithecus* among Asian colobines, and genus affiliations of their species groups. *BMC Evolutionary Biology, 8*, 58.

Pennell, F. W. (1934). How field study can modify older taxonomic concepts. *Bulletin of the Torrey Botanical Club, 61*, 85–88.

Pocock, R. I. (1928). The langurs or leaf monkeys of British India. *Journal of the Bombay Natural History Society, 32*(472–504), 660–672.

Pocock, R. I. (1939). *Primates and carnivora (in part)* (pp. 97–163). London: Taylor and Francis.

Roonwal, M. L. (1979). Field study of geographical, sub specific and clinal variations in tail carriage in the Hanuman langur, *Presbytis entellus* (primates) in *South Asia*. *Zoologischer Anzeiger, Jena, 202*, 235–255.

Roonwal, M. L. (1984). Tail form and carriage in Asian and other primates, and their behavioral and evolutionary significance. In M. L. Roonwal, S. M. Mohnot, & N. S. Rathore (Eds.), *Current primate research* (pp. 93–151). Jodhpur, India: Jodhpur University Press.

Roonwal, M. L., & Mohnot, S. M. (1977). *Primates of South Asia: Ecology, sociobiology, and behavior*. Cambridge, MA: Harvard University Press.

Srinivasulu, C., & Nagulu, V. (2001). Status of primates in Andhra Pradesh. *Envis Bulletin: Wildlife and Protected Areas, 1*(1), 109–112.

Swofford, D. (2001). *PAUP*– Phylogenetic analysis using parsimony and other methods, Version 4*. Sunderland, MA: Sinauer Associates.

Wheeler, Q. D. (2004). Taxonomic triage and the poverty of phylogeny. *Philosophical Transactions of the Royal Society, B, 359*, 571–583.

Woodbury, A. M., Ricker, W. E., Cottam, C., Taber, R. D., & Pendleton, R. C. (1956). Uses of marking animals in ecological studies. *Ecology, 37*, 665–685.

Zhang, Y. P., & Ryder, O. A. (1998). Mitochondrial cytochrome b gene sequences of Old World monkeys: With special reference on evolution of Asian colobines. *Primates, 39*, 39–49.