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A New Color Morph of the Southern Purple-faced Langur (*Semnopithecus vetulus vetulus*) from the Rainforests of Southwestern Sri Lanka

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Abstract: The southern purple-faced langur (*Semnopithecus vetulus vetulus*) is endemic to Sri Lanka and is listed as Endangered on the IUCN Red List. Following several decades of widespread deforestation in the country, viable habitat has been severely reduced for these arboreal, folivorous primates. Living close to densely populated human settlements has led to further conservation difficulties. They have adapted to exploiting cultivated fruits in home gardens resulting in human-primate conflict, besides confronting electrocution hazards when crossing roads using power lines. The opening of the Colombo-Matara Expressway has also posed a threat, with the possibility of troops from either side becoming genetically isolated. Twenty-six troops were studied from 2007 to 2011 in the southwestern districts of Galle and Matara; of these, 14 contained one or more individuals with an atypical pelage coloration, which we call here a white color morph. Two white alpha males were documented, along with adults, juveniles, and young of both sexes, totaling 30 individuals. The troops around Deniyaya and Getabaruwa villages contained members that showed a distinct pelage, and all of the members of these troops had dissimilar cranial features and body size compared to other *S. v. vetulus*. Molecular analysis is now required to discover the genetic basis for this variation and any possible competitive advantages associated with its spread, with the possibility that this may originate a new subspecies. The discovery of a new color morph may provide an additional opportunity to promote primate conservation; greater national support is urgently needed considering the perilous future facing *S. vetulus*. Further research prospects and conservation recommendations are discussed in this paper.

Key words: Purple-faced langur, *Semnopithecus vetulus*, Sri Lanka, endemic species, endangered species, color morph, conservation

Introduction

The purple-faced langur, *Semnopithecus vetulus* (Erxleben, 1777), was previously classified in the genus *Trachypithecus* Reichenbach, 1862. *Trachypithecus*, however, is currently considered to encompass solely the Southeast Asian langurs (Molur 2003; Brandon-Jones 2004; Dela 2007). Recent molecular analysis of several colobine species by Karanth *et al.* (2008) has determined the Nilgiri and Sri Lankan langurs to phylogenetically cluster with the Hanuman langur (*Semnopithecus*) at three sequenced markers, whereas the langurs of Southeast Asia (*Trachypithecus*) form a distinct clade (see also Osterholz 2008). Despite this evidence, several studies classify the species in the genus *Trachypithecus* (Groves 2001, 2005; Rudran 2007; Parker 2008). This paper should provide ample opportunity for

further genetic research into the species, aside from the current classification debate.

The purple-faced langur is endemic to the island of Sri Lanka and is represented by four allopatric subspecies, each from different geographical zones (taxonomy following Groves 2001). The focal subspecies of this paper—the southern purple-faced langur, *Semnopithecus vetulus vetulus*—is found in the Wet Zone and classified as Endangered on the IUCN Red List (2011). Agricultural development and irrigation, along with spreading human settlements, have been destroying the Sri Lankan rainforest for decades (Erdelen 1988). Today, much of the rainforest is fragmented, and troops that inhabit home ranges bordering suburban areas inevitably exploit agricultural land for food. Conflict in southern areas may alter perceptions of the purple-faced langur, currently considered to be a pest in the more populated

Western province, where it is the most common primate (Dela 2007; Rudran 2007). However, people sharing their gardens are generally tolerant owing to religious and cultural beliefs, which prohibit harming animals, leaving habitat loss as the most important threat (Nahallage 2008).

Sri Lanka's industrial growth requires a corresponding infrastructure; the first phase of the Colombo-Matara Expressway, linking the capital city to as far south as Galle, was scheduled to open September 2011. All of the troops in this study are to the northeast of the expressway, and the troops 15–20 km from the coast in both the Southern and Western provinces will now have little to no contact with the main island population. The occurrence of fatal electrocutions is linked to their strong preference to remain above ground during even minor road crossings, to avoid both vehicles and dogs (Moore 2010). It is predicted that the expressway will completely isolate numerous troops from the genetic pool of the rest of the island.

The majority of *S. vetulus* research is focused on the Critically Endangered western purple-faced langur (IUCN 2011), *S. v. nestor* Bennett, 1833. Therefore, it was decided by the team at the Wildlife Conservation Society Galle to undertake research on the southern subspecies, in the face of escalating conservation issues. Investigations of this scale had not been attempted in Sri Lanka previously; the specific aim was to assess group composition and behavioral changes when the langur is in an anthropogenic landscape. The unexpected discovery of a striking new color morph shows the limitations of our knowledge, and how much more scope remains for research and conservation of purple-faced langurs.

Methods

The study was conducted in the southwestern districts of Galle and Matara, in the wet zone of Sri Lanka. Data on langur group composition were collected between May 2007 and January 2011 by members of the Wildlife Conservation Society Galle (WCSG), based at Hiyare Rainforest Reserve. Troops were approached on foot, and habitat was categorized as tea plantation, home garden, or rainforest. Recordings of the latitude and longitude were taken using a Garmin Etrex Vista H when the troop was first encountered. Exact location was recorded only once as the home range of the purple-faced langur is exceptionally small, averaging 2–3 ha (Rudran 1973a). Troops were allocated a troop identification number, and individual group members were numbered; for example, T18-I5 was a white alpha male in group T18 situated near Wathugala (Fig. 1a). The initial sighting of a troop was followed by an intensive period of study (from 15 to 25 days), until each individual was identified. Identification cards for each individual combined the unique identification number with an annotated sketch with identifiable markings.

In the typical dark color morph individuals, the pelage characters allowed sex determination of the adults (Rudran 1973a). Sub-adult and infant females do not have the identifiable white pubic patch, and sexing of younger individuals

was only possible if the gonads were visible. The white color morph adults were also sexed using this method, or occasionally sex could be determined when they were seen mating. Age (adult, sub-adult, infant) was estimated based on body size (Rudran 1973a).

The initial study phase allowed the troops to habituate to the researchers and photographers, allowing visual contact to be maintained almost entirely throughout the study. During the initial research period, troops were studied from 06:00 to 10:00 and 16:30 to 18:30 each day. Talking with the local people allowed us to locate the troops quickly whenever we returned for further observation. Behavioral recordings were made only after habituation using Nikon Monarch 8 × 32 binoculars. Photographs were taken using a Canon 7D body with Canon 500 mm F4 lens.

Results

External morphological traits of the new color morph

The southern subspecies is primarily distinguishable by a defined silver-white rump patch; a detailed description of the standard pelage characters has been documented by Phillips (1935; Fig. 1b). The newly discovered color morph has a white body and limbs, sometimes with ashy patches, and a white tail (Fig. 1a, Fig. 2). The underparts have pink and yellow skin tones visible through white hair, and the hands and feet are similarly pink-and-yellow toned with black patches. The head has white or off-white whiskers, the throat patch and hairs around the mouth are also white and the crown is of beige to ashy brown hair. Naked parts of the face and ears are black and the eyes have a golden brown iris, as with the standard color morph.

There is no evidence to suggest albinism for the following reasons: all white individuals have a black face, none of the white individuals have red eyes, and all of the white individuals have an ashy brown crown of hair. Among the Colombo National Museum primate collection a pale-colored specimen was collected by Phillips from the Matara District as early as 1923 (catalog number 4G 20.11.1923), evidencing that a slight degree of color diversity among the Southern purple-faced langur is not uncharacteristic (Fig. 3).

External morphological traits of the Deniyaya and Getabaruwa troops

Distinct morphological features are shown by both standard and white color morph members of troops in the vicinity of Deniyaya and the southwestern village of Getabaruwa (Deniyaya: 6°20'42"N, 80°33'37"E, Getabaruwa: 6°19'09"N, 80°33'04"E), which are 7.25 km apart. The body size of all troop members is smaller in comparison to normal *S. v. vetulus*. Cranial differences in all troop members include a more flattened brow profile, longer and more curved whiskers, and a darker brown crown of hair (Fig. 4). The standard color morph is darker and the pubic patch appears brighter and more prominent.

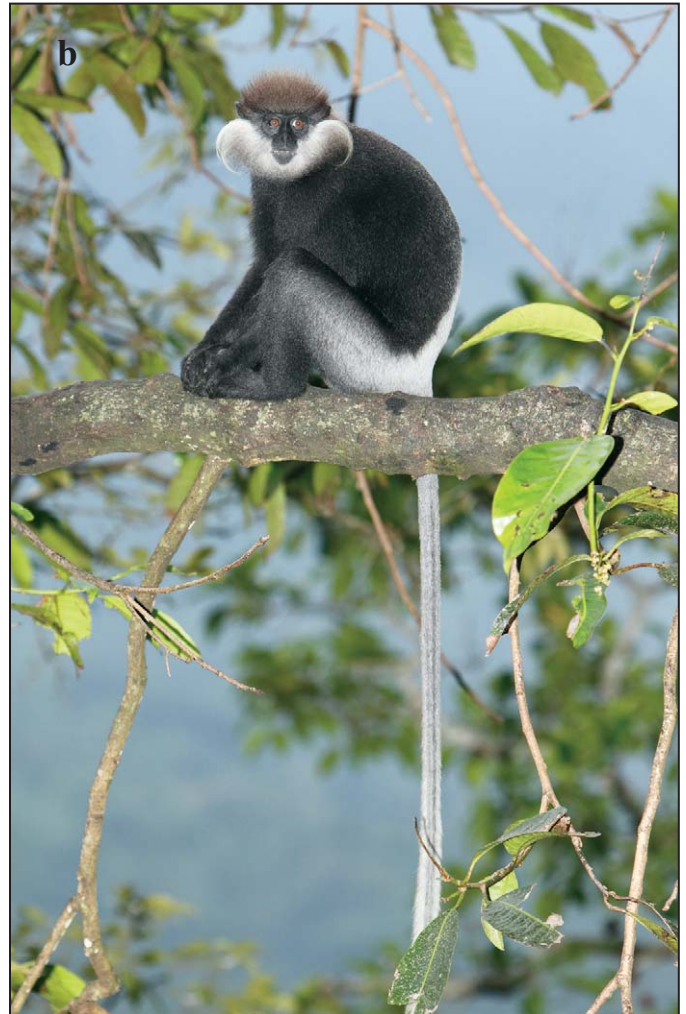


Figure 1. A comparison of the newly discovered color morph to the standard pelage; a) a white colored alpha male from troop 18; b) a troop 14 member with the standard color morph of *S. v. vetulus*. Photographs by Nadika Hapuarachchi.



Figure 2. An individual showing ashy patches on the body and limbs during locomotion. Photograph by Nadika Hapuarachchi.



Figure 3. Museum specimens collected by Phillips from the Matara district in 1923. A degree of color diversity can be seen between the lower standard color specimen (4F, 02/12/1923) and the lighter individual above (4G, 20/11/1923).

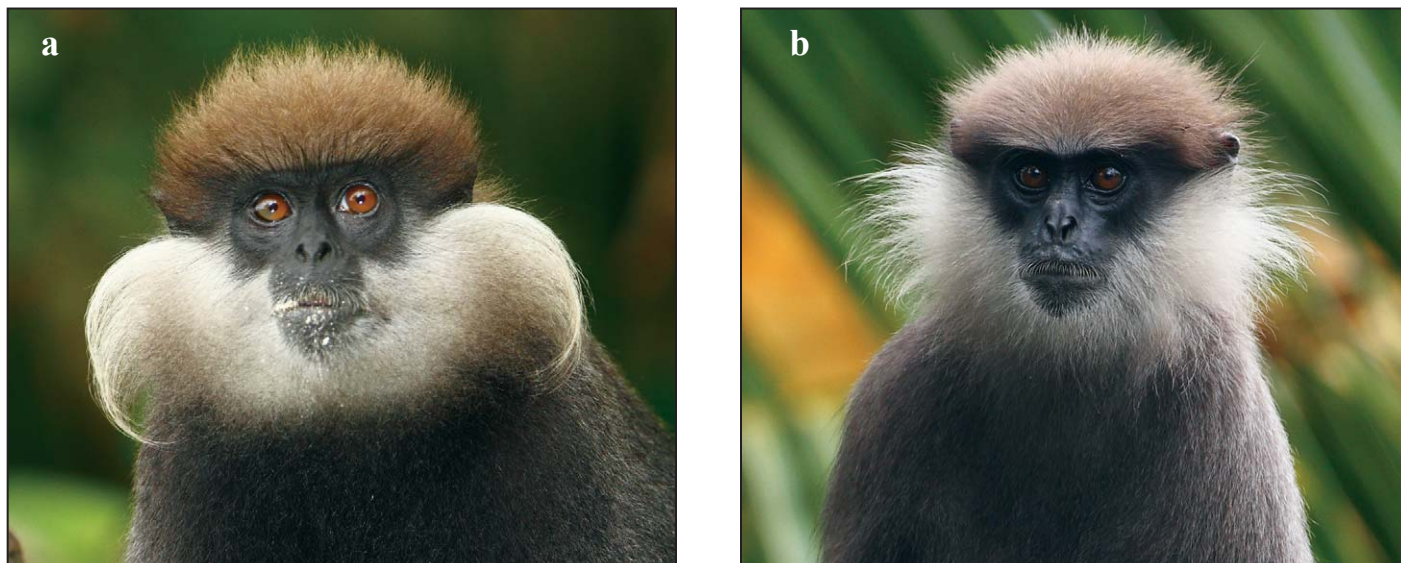


Figure 4. Exemplars of cranial features of the Deniyaya and Getabaruwa troops compared with individuals elsewhere in the southwest study area: a) Getabaruwa troop member showing the characteristic flattened brow line, long and curved whiskers, and darker brown hair crown; and b) a standard specimen of *S. v. vetulus*. Photographs by Nadika Hapuarachchi.

Distributions of the study troops

Although 10 troops were found around the protected area of the Sinharaja Rainforest Reserve (T6, T7, T8, T12, T13, T16, T17, T18, T19, T22), the majority were outside of protected areas. Of the 14 troops containing white color morph individuals, 12 were found in the rainforest, four of them bordering tea plantations; one troop was also found occupying home garden habitat and another was in a mixed habitat home range. Troops containing the white color morph were maximally 18.5 km apart (T16 and T26), very close proximity was found between four troops to the West of Deniyaya (<2 km; T17, T18, T19, T22). One white infant was documented in troop 14, which has a more southerly location compared to other white individuals (Fig. 5). It is possible that this individual was albino as the initial sighting was brief and it has not been seen since 27 September 2011, indicating an early death.

Group composition

Minimum and maximum troop sizes recorded were five to 11 members, with an average troop size of 7.5 ($n=26$). In total, 30 individuals were recorded displaying the newly documented white color morph: two alpha males, 14 adults of which 13 were females, eight sub-adults, and five infants (Table 1). A single white adult individual could not be sexed and two sub-adults were determined male; all other minors were of unknown sex. The maximum ratio of standard pelage to white was 3:2, the alpha male of troop T18 was of the white color morph (Table 1). Combinations of white mother and white infant (T8 and T19) and white mother with standard-colored infant (T15) were recorded (Figs. 6 and 7). Changes in troop composition (births and deaths) are not analyzed in this paper, although it should be noted that 49 injuries and 33 deaths were caused by electrocution during the study.

Discussion

Limited information is available on the endangered *S. v. vetulus*; our study aimed to augment previous findings, focusing on troop composition and behavioral adaptations within the varied and changing habitat of the southern subspecies. The importance of long-term research has been demonstrated by the extraordinary and unexpected discovery of this new distinct color morph (Fig. 1a). The striking color morph should stir interest beyond the scientific community, across the Biodiversity Hotspot of Sri Lanka (Myers 2000) as a source of national pride in relation to the abundance of endemics the island supports (Crusz 1973; Erdelen 1988). The authorities must begin to cross-reference issues consistently across ministries, for the preservation and protection of known, unknown, and newly discovered flora and fauna.

Different morphological characters, compared to other *S. v. vetulus*, are found in the Deniyaya and Getabaruwa troops, situated predominantly in the rainforest. Smaller body size, a flattened brow shape and longer, more curved whiskers are exhibited by all members of the 13 study troops that contain white individuals (Fig. 4a), excluding the southerly troop 14 with a dead white infant presumed to be albino (Fig. 5). The pelage is different within these troops, not only in the white color morph individuals but also in the standard color morph; the hair is darker on the body and the head crown, and the white pubic patch is also more prominent.

A general darkening of pelage in the Hanuman langur, *Semnopithecus entellus* (Dufresne 1797), is noted in the southern wet zone of India (Pocock 1939; Nag 2011). Coat color is a plastic morphological character in langurs, although other data follow a cline unlike our observed difference in a small group. The two color morphs interbreed freely, producing offspring of either color (Figs. 6 and 7), and a varying degree of

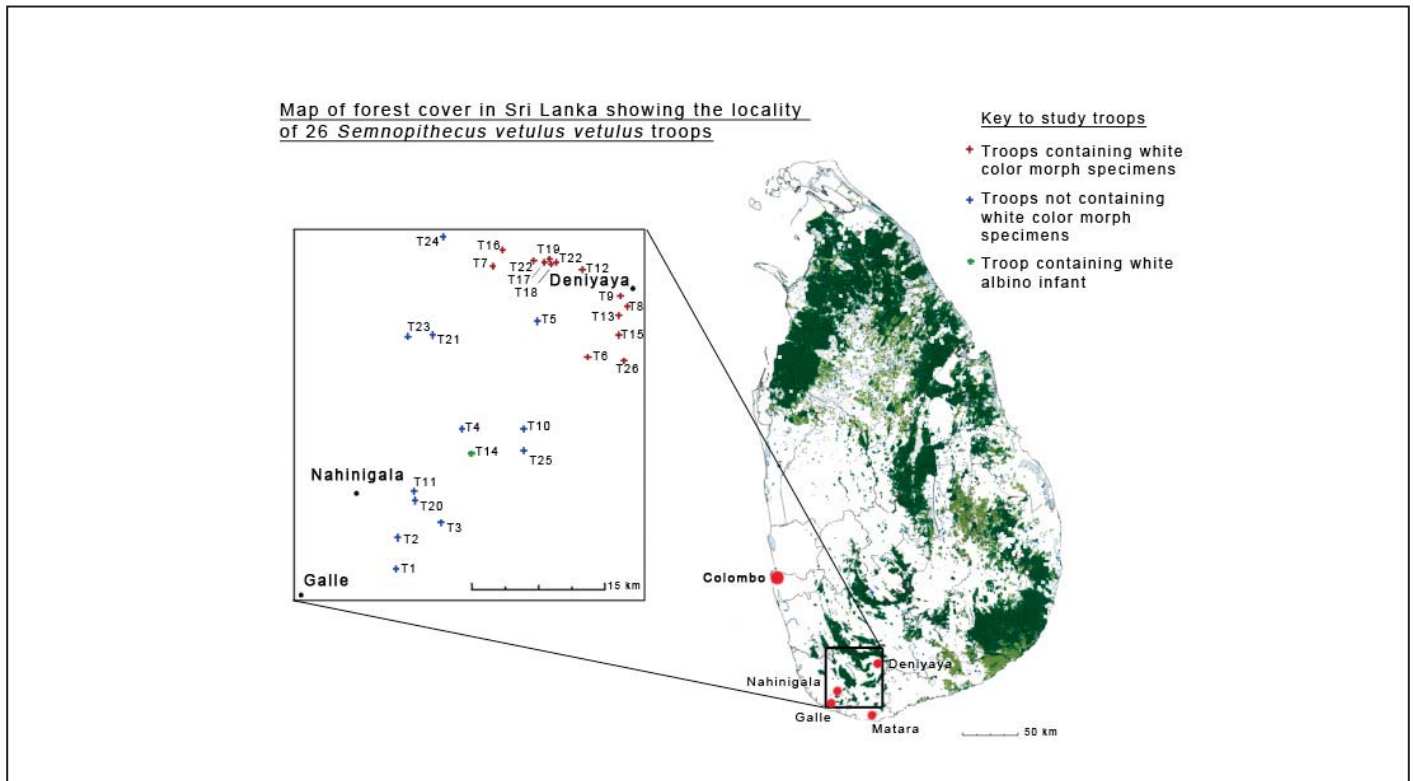


Figure 5. Map of Sri Lanka's forest cover, with an enlargement (inset) of the Galle and Matara districts surveyed by the Wildlife Conservation Society Galle. Red crosses show where troops containing the white color morph are located and blue crosses show the location of troops studied that do not contain the white color morph. The single green cross indicates the troop containing an albino infant. Source of the forest cover data: *Assessment of Tree Resources in the Home Gardens of Sri Lanka* by Ariyadasa (2002).

ashy patches can be seen on the body of the 30 individuals exhibiting the white color morph (Fig. 2). Further investigation and monitoring is required to determine whether genes are dominant-recessive, possible regulatory gene changes, and the possibility of a sexual preference arising.

During a survey conducted by Rudran (2007), interviewees informed of the shooting of six western albinos in 2003, presumably killed for their pelts. The white color morph is still a rarity and requires immediate government protection from poaching. A standard pelage specimen was found shot near the rural villages of Kotapala and Deniyaya in April 2011, which highlights the plea of Dela (2004): culturally related tolerance may not be ubiquitous and should not be relied upon in long-term conservation strategies. A range of fatalities were also found to be induced indirectly by human co-habitation, in congruence with western studies (Dela 2004; Rudran 2007). Mortification from dog attacks or speeding vehicles occurs due to the langur being ill-adapted for ground locomotion (Hladik and Hladik 1972; Moore 2007). A consequential preference to remain above ground results in the use of power lines when crossing roads, which caused 49 injuries and 33 deaths from electrocution recorded by the team during the study. As human population pressures continue to deplete the natural habitat of the langur, fragmentation of the landscape will only exemplify these fatal dangers further.

Only 2% of undisturbed forest remains in Sri Lanka's wet zone, and forest cover declines continuously as just 21% of the remnants are under protection (Kumar 1999). Lowland tea plantations in the south often border rainforest and encroachment may cause further habitat loss for *S. v. vetulus*; plantation agriculture has left the hill country almost devoid of forest except for isolated patches above 1,524 m (Wickramagamage 1998). The resourcefulness of the langur, shown in their exploitation of home gardens (Dela 2007), can also be seen by those bordering tea plantations that are often recorded feeding on *Albizia* (Fabaceae), a non-commercial, imported genus used for tea shade. It is vital that the Southern Province authorities recognize the sheer economic value of high biodiversity in terms of sustained tourism, and implement strict borders and surveillance on forest reserves such as Sinharaja.

Part of the Colombo-Matara Expressway, between Colombo and Galle, was due to open in September 2011. The road will isolate all troops 15–20 km from the coast. The formation of a permanent barrier to gene flow exemplifies the problems of a fragmented habitat to an acute extreme (Parker 2008). The viability of the populations to the west and south of the road is now highly questionable. Troops that inhabit areas already widely affected by the strains of prolific human settlements, radiating from the coastal road, will become genetically isolated from inland troops.

The coastal corridor formed by the Expressway will be separated from the remaining rainforest reserves in the south-west, and a tendency towards home garden and plantation frugivory may also increase as more troops become habituated to humans. The physiological effect of a low diversity diet still requires further investigation (Dela 2007; Moore 2008). The perceptions of the people in the south must now be monitored, as in the west, where langurs are often classified as pests when coexisting in an anthropogenic landscape (Dela 2007; Rudran 2007, Parker 2008). A commensal existence with humans may currently be possible but it is implausible that the tolerance of the Sri Lankan people forms a sustainable plan for conservation (Dela 2004; Nahallage et al. 2008; Parker 2008).

Guidance for future conservation and research opportunities

The conservation of primates in Sri Lanka does not currently hold a priority status; the departments of forestry, wildlife, environment, agriculture, and urban planning all fall into different ministries that rarely cross-reference issues. Although the law in Sri Lanka protects primates, *S. vetulus* faces a perilous future if national policies are not implemented to ensure the species is protected. Guidance for new conservation strategies in the south should be deduced from those for the Critically Endangered western purple-faced langur (IUCN Red List 2011), *S. v. nestor* Bennett, 1833. The status of the western subspecies as one of the 25 most endangered primates in the world (Dela and Rowe 2007) has led to the majority of *S. vetulus* research focusing on this subspecies. Conservation advice that tackles human perceptions of primates in the vicinity of Colombo, the capital city of Sri

Table 1. The 26 troops recorded with the date of first recording, localities, habitat type, total number of individuals, and details of white color morph members.

Troop ID	Date of first recording	Coordinates		Nearest village	Habitat type	No. of members	White color morph individuals
		Latitude	Longitude				
T1	01 May 2007	6°03'38"N	80°19'00"E	Hiyare	HG	5	
T2	29 January 2008	6°05'53"N	80°19'04"E	Kottawa	RF	10	
T3	05 November 2008	6°06'25"N	80°21'38"E	Yakkalamulla	HG	5	
T4	04 May 2009	6°12'14"N	80°23'01"E	Udugama	RF	11	
T5	30 July 2009	6°18'42"N	80°27'35"E	Millawa, Morawaka	RF	10	
T6	02 August 2009	6°16'35"N	80°30'43"E	Getabaruwa, Morawaka	RF	9	1 sub-adult, sex unknown
T7	25 August 2009	6°22'06"N	80°24'54"E	Menikavita, Neluwa	RF	7	1 sub-adult, sex unknown; 1 infant
T8	02 January 2010	6°19'06"N	80°32'38"E	Diyadawa, Deniyaya	HG/RF	6	1 adult female; 1 infant
T9	21 January 2010	6°20'17"N	80°32'41"E	Deniyaya	RF	6	1 alpha male; 1 adult female; 1 sub-adult, sex unknown
T10	19 February 2010	6°12'12"N	80°26'48"E	Pitabeddara	HG	8	
T11	01 March 2010	6°08'21"N	80°19'60"E	Nakiyadeniya	RF/TP	9	
T12	15 April 2010	6°21'52"N	80°30'23"E	Mederipitiya	RF	8	1 sub-adult, sex unknown
T13	07 May 2010	6°19'37"N	80°33'06"E	Diyadawa, Deniyaya	RF	8	1 sub-adult, male
T14	15 May 2010	6°10'42"N	80°23'36"E	Dediyagala	RF	6	1 infant
T15	22 May 2010	6°17'54"N	80°32'39"E	Kotapala	RF/TP	7	2 adult females; 1 adult, sex unknown
T16	15 June 2010	6°23'03"N	80°25'26"E	Warukadeniya	RF	7	1 adult female; 1 sub-adult, male
T17	05 August 2010	6°22'26"N	80°27'23"E	Lankagama	RF	6	2 adult females
T18	18 September 2010	6°22'17"N	80°28'43"E	Wathugala	RF/TP	6	1 alpha male; 3 adult females
T19	19 September 2010	6°22'13"N	80°28'31"E	Lankagama	RF/TP	10	3 adult females; 1 infant
T20	24 September 2010	6°07'49"N	80°20'09"E	Nakiyadeniya	HG	7	
T21	02 October 2010	6°17'56"N	80°21'15"E	Malgalla, Hiniduma	HG/RF	6	
T22	14 October 2010	6°22'18"N	80°27'59"E	Pitadeniya, Lankagama	RF/TP	9	1 adult female; 1 infant
T23	20 October 2010	6°17'46"N	80°19'39"E	Hiniduma	RF	5	
T24	10 December 2010	6°23'53"N	80°21'50"E	Batuwangala, Neluwa	RF	8	
T25	11 January 2011	6°10'52"N	80°26'47"E	Kaduruwana	RF	6	
T26	19 January 2011	6°16'20"N	80°32'55"E	Kotapala	HG	10	2 sub-adults, sex unknown

Lanka, can be used as a case study for other provinces as they encounter similar population pressures (Dela 2007; Rudran 2007; Nahallage 2008; Parker 2008).

Rudran (2007) recently surveyed *S. v. nestor* in the densely populated areas of the west, where 81% of its habitat had been lost due to deforestation. The 21 km² of rainforests around Kalatuwawa and Labugama reservoirs that were identified as the last major strongholds of the western subspecies will now be permanently divided from the population on the other side of the Colombo-Matara Expressway. The initial road route has been altered in congruence with the

environmental impact assessment review in order to preserve important wetland systems close to Colombo (RDA 2007). Road construction was also briefly suspended in September, in order for the UN to receive a full report on the impact of the expressway on the Sinharaja Rainforest. Global attention is now on the Sri Lankan government to protect the reserve, although, the international recommendations to expand the protected area are unlikely with the road less than 100 m from the current border. The Southern Transport Development Project has made essential improvements to infrastructure and produced biannual environmental monitoring reports during construction, but the government must now strictly implement the National Wildlife Policy, which was updated in 2000.

The conflict that may arise from primate crop damage, especially in the narrow coastal corridor formed by the road, can be subdued by a systematic quantitative report of agricultural loss due to primates, often perceived to be of a greater extent than in reality (Siex and Struhsaker 1999; Riley 2007; Nahallage 2008). Reports should clearly inform farmers and the general public of the importance of biodiversity in

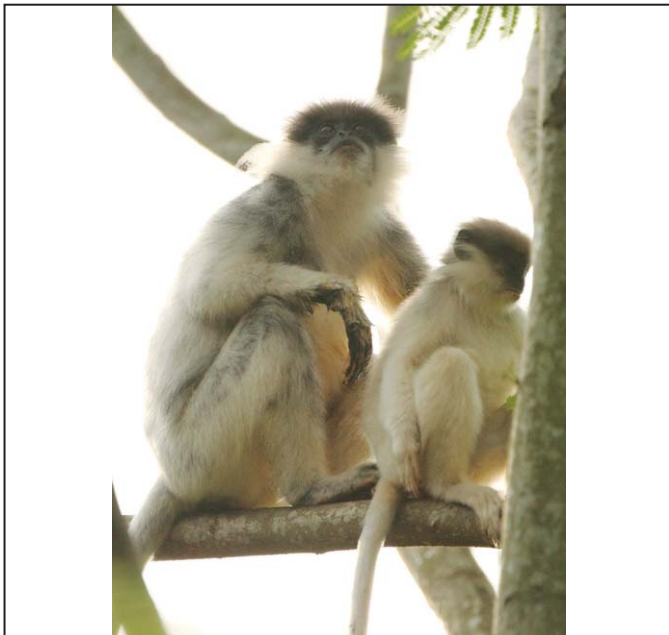


Figure 6. Offspring from a white mother can be of either color morph: a) white color morph mother with white infant. Photograph by Nadika Hapuarachchi.

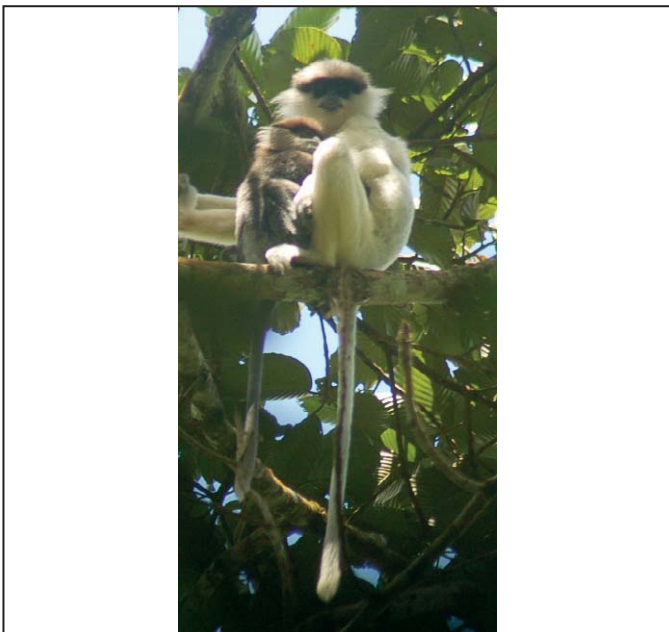


Figure 7. White color morph mother with black infant. Photograph by P.A. Rohan Krishantha.



Figure 8. An individual crossing the road using plastic coated wires. Photograph by Nadika Hapuarachchi.



Figure 9. An electrocution fatality due to road-crossing using live wires. Photograph courtesy of Karen Conniff.

terms of how it could benefit themselves and their families in the future. The Sri Lankan culture is focused strongly on religion and family; therefore, a religious overtone should be included in workshops and talks, with the preservation of wildlife directly linked to the prosperity and wealth of future generations.

Semnopithecus v. vetulus is likely to habituate further to humans, becoming an easy target for rifles and catapults (Eschmann 2008), but occurrences such as the shooting we recorded and that of Dela (2004) should stop if the whole community is aware of the consequences. Education of the younger generation is possible through schemes such as ‘Trees for monkeys’ by the Wildlife Conservation Society Galle, which allows children to plant, for example, an endemic *Artocarpus nobilis* tree (Moraceae). The scheme highlights the importance of conserving non-commercial trees for primate consumption to avoid human-primate conflict in relation to crop damage.

Habitat loss is to some extent preventable and repairable, and forest regeneration programs will be essential to the survival of the endemic langur. The Sinharaja Rainforest Reserve is one of the strongholds for the southwest. With good management, troops that include the white color morph members should proliferate in the vicinity of protected areas. The forestry sector master plan (1995) must be strictly followed if the remaining wet zone forest of Sri Lanka is to be protected. The surveillance of strict borders on reserves and co-operation with the urban planning department are necessary as the Southern province continues to develop. Fines should also be implemented as a deterrent for commercial plantations encroaching on valuable habitat.

Connective corridor strategies would appear to suit *S. v. vetulus* as a predominantly arboreal primate (Rudran 2007), although strategies should be thoroughly investigated in terms of optimal width and effect on other non-target species (Soulé and Gilpin 1991). On a smaller scale, where NGOs and volunteers could contribute relatively inexpensively, rope bridges and lines for crossing to nearby fragments and over roads could reduce genetic flow barriers and mortality by electrocution. Fragmentation outside of protected areas will undoubtedly continue; the viability of small pockets of isolated troops is uncertain (Parker 2008), therefore increasing connectivity can only help in avoiding local extinctions.

Further genetic analysis is required in respect of the 13 troops around Deniyaya and Getabaruwa villages; the morphological differences observed in the field indicate the possibility of a new subspecies. DNA samples retrieved from these troops and other *S. v. vetulus* troops will require meticulous comparison of ample nuclear and mitochondrial markers, as divergence may not be particularly old. In order to implement effective conservation measures the potential sub-specific status of these troops must be determined (Brandon-Jones 2004).

The genetic mutations required for color change have been studied in several mammals, a classic example being rock pocket mice (*Chaetodipus intermedius*; Merriam, 1889); the mc1r gene and regulatory gene Agouti have been

pinpointed as color determinants (Hoekstra 2003). Changes in coat color—a plastic morphological character in langurs (Hill 1939; Pocock 1939; Nag 2011)—do not indicate speciation (Fig. 3), although the observed cranial and size differences require further investigation. The present discovery of an unusual new color morph provides research opportunities for population and evolutionary geneticists into a recent and major color alteration, along with the prospect of promoting, protecting, and conserving Sri Lanka’s endemic and endangered primate species. The striking white primate will hopefully provide an iconic image for the reinforcement of the current conservation strategies employed, heightening awareness of the vast number of endemics on the island and instilling much needed pride in the Sri Lankan populace regarding the biodiversity of their island.

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