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REVIEW ON THE GENUS *TRACHYPITHECUS*: DISCOVERY OF A NEW SPECIES AND A DECLINE IN THE POPULATION.

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ABSTRACT The current work is a research article that aims to review the genus *Trachypithecus*: the discovery of the new species Popa Langur (*Trachypithecus popa*) and the current conservation status of the genus. The present study is based on the research work of Dr. Christian Roos who with his team conducted a study to clarify the phylogeny of *Trachypithecus*, a genus in the family *Cercopithecidae* which led to the discovery of a new species Popa Langur. The review is an attempt to summarize the reason for the species to have remained unidentified for many years. Based on the research work available on the genus *Trachypithecus* and further on Popa langur, the possible reason for speciation is contested. The population of the animal is declining; the present study looks into the reasons for a decrease in its numbers. It can be considered that loss of habitat, restrictive diet along with foraging behavior, human activity, and intrusion might be the reason for the species to be less in numbers and remain unobtrusive. The current research article emphasizes the possible outcomes and difficulties faced by the genus.

KEYWORDS : Popa Langur, Trachypithecus, phylogeny, DNA, mitochondrial.

INTRODUCTION

The current researchers have made an attempt to review the discovery of the new species Popa Langur of the genus *Trachypithecus*. The present study also determines the reasons for a decline in the population of the genus *Trachypithecus*. The review article takes into account the research study carried out by Dr. Christian Roos that led to the discovery of the new species Popa Langur (*Trachypithecus popa)* along with other published research available. Views from eminent environmentalists have also been considered.

Cercopithecidae is a family of twenty-four genera and 138 recognized species, making it the largest family in the order Primates.

Trachypithecus is a genus in the subfamily Colobine dominating in the geographic region of Myanmar, East of Bangladesh, some regions of Tripura in India, South-East Asia, Bhutan, Thailand, Southern China, and also some parts of the Sundaland region. The Southeast Asian islands are among the richest islands in the world in terms of biodiversity (Nijman & Meijaard, 2008). The genus contains 20 species divided into four groups. The four groups are classified based on differences and similarities in genetics, phenotype, ecology, and behavior (Ross et al., 2021). *Trachypithecus* is phylogenetically instilled with the Family *Cercopithecidae* and is closely related to *Semnopithecus*(He et al., 2012).

Image 1. Popa Langur

Image source**: Roos, Christian et al. "Mitogenomic phylogeny of the Asian colobine genus *Trachypithecus* with special focus on *Trachypithecus phayrei* (Blyth, 1847) and description of a new species." Zoological research vol. 41,6 (2020): 656-669.**

Phayre's Langur (*Trachypithecus phayrei*) is a member of the widespread genus, and to elucidate the taxonomy, distribution, and evolutionary history, 41 mitochondrial genomes from georeferenced fecal samples and museum specimens, including two holotypes were sequenced. They are prominently found in Myanmar, east of Bangladesh, and some regions of Tripura and Assam in India. The species belongs to one of the four groups namely *Trachypithecus obscurus* which consists of (*T. obscurus, T. barbei, T. crepusculus, and T. phayre*i). The species *T. phayrei* consists of two subspecies, *T. phayrei. phayrei* and *T. phayrei. shanicus*.(Ross et al., 2021). The geographic locations of the two subspecies were confounding and hence DNA data of these species were sequenced. The results of mitochondrial DNA revealed the data obtained from species of central Myanmar was of neither of the two subspecies (*T. phayrei phayrei and T. phayrei shanicus*) but was suggesting a third potential lineage of *T. phayrei.*

The present report mainly took into account the work of researcher Dr. Christian Roos and his team along with some local wildlife researchers and enthusiasts.

DISCUSSION

Phylogeny

According to (Roos et al., 2021; Perelman et al., 2011),the genus was segregated for understanding phylogenetic relations; the 20 species of *Trachypithecus* were identified into four groups as follows; The *T. pileatus* group contains three species (*T. pileatus, T. geei,* and *T. shortridgei*), the *T. francoisi* group contains seven species *(T. francoisi, T. delacouri, T. ebenus, T. hatinhensis, T. laotum, T. leucocephalus,* and *T. poliocephalus)*, the T. cristatus group contains six species (*T. cristatus, T. auratus, T. germaini, T. margarita, T. mauritius, and T. selangorensis*), and the *T. obscurus* group contains four species (*T. obscurus, T. barbei, T. crepusculus, and T. phayrei*). Previously most of the studies on the taxonomy of colobines have used morphological and behavioral characters and have been futile to resolve their evolutionary relationship or establish a stable phylogeny-based taxonomy (Karanth et al., 2008). The collected data was in the form of fecal matter and dried tissues and craniodental measurements. A total number of 14 fecal samples were collected from wild animals, captive animals and from zoos, 25 dried tissue samples and craniodental measurements were obtained from 4 museums and from 2 holotypes and 1 paratype. The 2 holotypes were of *T. phayrei phayrei* and *T. phayrei shanicus* and paratype was of *T. geei*. Mitogenomic data was produced by DNA extraction leading to PCR (Polymerase Chain Reaction) followed by Sanger sequencing. For phylogenetic reconstruction, extra mitogenome sequences were added from the GenBank. For morphometric analyses, external measurements (head-body length, tail length, hindfoot length, and ear length) were taken

from original museum specimen labels (15 adult males, 11 adult females, 14 young subadults, or adults of unknown sex).

Mitogenomic Tree

From the earlier records and previously done research by He et al.(2012), Karanth et al. (2008) and Perelman et al. (2011) (as cited in Roos et al., 2021) on the genus and species, 2 mitogenomic trees were constructed showing phylogenetic relationship. The first tree was about the separation in the *Trachypithecus* genus and radiation of all the species from one another, the *T. pileatus* group branched first, ca. 4.49 million years ago (Ma).The remaining taxa diverged 3.87 (3.35–4.38) Ma into a clade containing the *T. obscurus* and *T. cristatus* groups, and a clade subsuming the *T. francoisi* group and *T. crepusculus*. The *T. obscurus* and *T. cristatus* groups split 3.24 (2.78–3.70) Ma, and the *T. francoisi* group separated from *T. crepusculus* 3.06 (2.60–3.51) Ma(Roos et al., 2021).

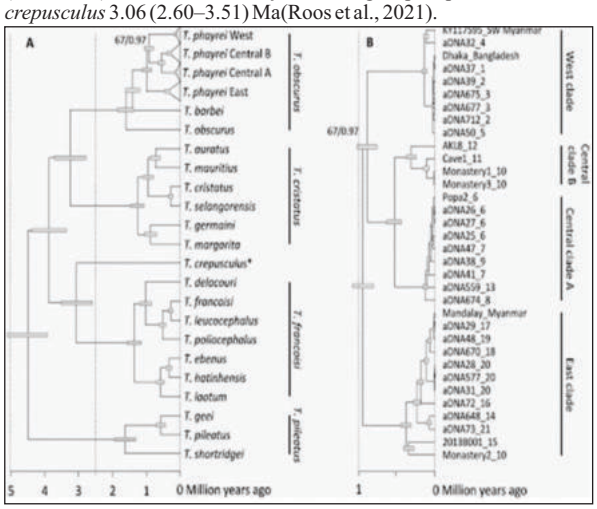

Figure 1 Phylogenetic results, mitogenomic tree Image source: Roos, Christian et al. "Mitogenomic phylogeny of the Asian colobine genus Trachypithecus with special focus on Trachypithecus phayrei (Blyth, 1847) and description of a new species." Zoological research vol. 41,6 (2020): 656-669.

The second tree was of *T. phayrei* and the obtained data was divided into three clades based on their mitochondrial DNA and the geographic location of their source. The three clades are the West clade, Central clade, and East clade. Samples collected from Bangladesh and west of the Ayeyarwaddy and west of Chindwin rivers from Myanmar (locations 1-5; Figure 2), grouped in the West clade and the samples from the central dry zone of Myanmar and neighboring Kayah-Karen Mountains, east of the Ayeyarwaddy River and west of the Thanlwin River (locations 6–13), formed the Central clade, and those from the Shan Plateau and neighboring China clustered in the East clade. In the Central clade, there were two subclades, with one containing samples from the central dry zone (Central clade A) and the other containing samples from the western foothills of the Kayah-Karen Mountains (Central clade B)(Roos et al., 2021).

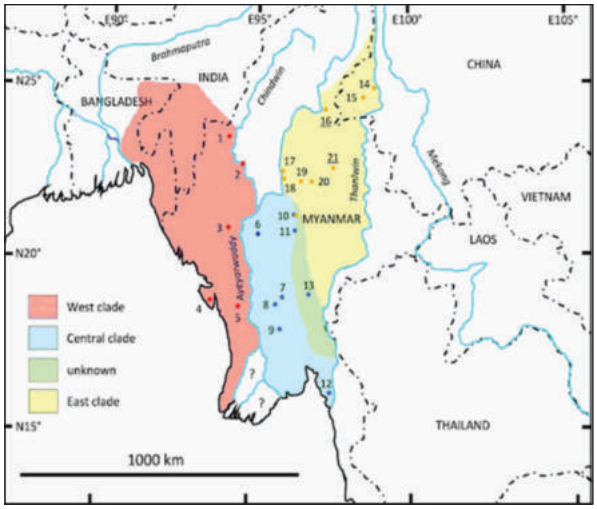

Image 2: Geographic Distribution

As per earlier research (Roos et al., 2021;Evans et al., 2020;Varma et al., 2008), it is observed that the west clade is dominated by *T. p. phayrei*, while the east clade is dominated by *T. p. shanicus* who is synonymous with *T. p. melamera*. The *P. shanicus* and *P. melamera* are two different subspecies was an error that occurred due to the holotype collected of the two subspecies was of individuals of different age groups. The holotype of *T. phayrei* was collected in 1913 from the central clade region. Studies suggest that the speciation of *Trachypithecus* in South-East Asia has been largely influenced by extrinsic factors such as changes in forest cover and/or sea level (Roos et al., 2021).The description of new species has been seen to affect the species-area relationships in many ways, depending on their nature and their area of occurrence (Nijman and Meijaard, 2008).

Image source : Roos, Christian et al. "Mitogenomic phylogeny of the Asian colobine genus *Trachypithecus* with special focus on *Trachypithecus phayrei* (Blyth, 1847) and description of a new species." Zoological research vol. 41,6 (2020): 656-669.

Taxonomy and Description

To expound the details, views from relevant researchers and competent professionals from the field were taken. Researcher Dr. Christian Roos, (in an interview) stated that the fecal samples that had been obtained 10 years ago neither belonged to *T. p. phayrei* nor *T.p.shanicus/ melamera*. This evidence led to a journey to find out the phylogeny of that organism. The holotype in the museum, collected in 1913 was labeled as *T. phayrei* but mitogenomic data revealed that it was not of *T. phayrei*. The samples collected from the central clade did not match any sequence and hence it was termed as unknown or new species. External morphometric data displayed the diagnosable difference in the members of three clades, which proved that the members from the central clade are unnamed and therefore, they elevated the members of *Trachypithecus phayrei phayrei* and *Trachypithecus phayrei melamera* from subspecies level to species level and described the members from unnamed taxon as new species.

The new species is named *Trachypithecus popa* sp. *nov.* , common name Popa Langur. The name Popa is based on the landmark Mt. Popa, the place where the designated holotype was originally collected and the place where the number of individuals from the species is highest. The species is dark brown or gray-brown on the dorsum, with a sharply contrasting gray or whitish center, their hands and feet are black, from above the elbow, the arms on the dorsal side gradually darken to black hands. The pale underside extends onto the chin and down to the inner side of the arms and thighs. The tail is paler than the back, notably at the base and underside. The face is black with a wide fleshy white muzzle and broad white rings fully encircling the eyes. The hairs on the head are raised to a crest or are at least long and irregularly structured, but with no parting or whorl behind the brows present. This crest of hair and the forward-facing whiskers give the head a rhomb-like shape(Roos et al., 2021).

There are some visible differences between the three species and they are as follows.

Table 1 Morphological Table

Morphological Characteristics	*T. phayrei*	*T. popa*	*T. melamera*
Arms	Arms darken from the elbow and below.	Arms darken from the elbow and above.	The arm above the elbow is darker than the lower arm.
Crest Hair	Crest hair with irregular length and size.	Crest hair with irregular length and size.	Whorl or parting hair behind the brows
Whiskers	Whiskers are laterally directed.	Whiskers are directed in the forward direction.	Whiskers are directed in the forward direction.
Head shape	Head shape appears triangular	Head shape appears rhomboidal	Head shape appears round in shape.
Eye Orbit	White fleshy muzzle encircles the eyes fully.	Eyes are fully encircled with white rings	The white rings are restricted to the inner side.

Tail	Males have a shorter tail than the males of the other two species.	Average tail length is observed.	Average tail length is observed
Palate	The bony palate appears like a square shape	The bony palate appears rectangular.	The bony palate appears like a square shape
Teeth Size	Have average teeth size.	Larger teeth than the other two and the third molar appear larger overall.	Have average teeth size.

Conservation

The genus inhabits one of the many biodiversity hotspots in the continent, the Indo-Burma region, and the Southwestern area around the Du long river of China. The genus being metastasized in a large region still faces many life-threatening issues of which habitat loss and illegal hunting accounts to be a major contributing factor for declining in the population of the species of the genus *Trachypithecus.* Many species of the genus are arboreal and their diet contains 90% leaves and around 9% fruits(Harding, 2010). Deforestation and logging activities expose the animal out of its habitat and make it vulnerable to predation. Although predation of Asian arboreal colobines is rare, the formation of antipredator strategies was seen against raptors, small felids, snakes, and other small terrestrial animals like domestic dogs and binturong which happen to prey on young infants of *T.cristatus* species(Harding, 2010). In the genus, infants are orange colored that begin to change after three months of age(Srivastava, 1999).This might increase the chances of being more visible and less camouflaged in the surroundings.

It has been recorded, *T.cristatus* along with other nonhuman primates is threatened throughout its range by logging, hunting for meat and medicinal uses, and capture for the pet trade in the Malay Peninsula (Harding, 2010). The major region where the genus inhabits is dominated by communities that hunt the animal primarily for food (Srivastava, 2006). The construction of reserve forests around the habitat has allowed the primates to maintain their room but to a limited extent. The instances of illegal hunting, poaching are frequent and presented with records. During a survey in the Lao PDR on *T.phayrei* the researchers came across a fresh headless skin and skull of a gray leaf monkey, called Khang (Kang) in the area of Nam Sang several kilometers upstream of Ban So, and also suggested Khang to remain locally common in the area (Timmins et al., 2013). Consuming wild animal meat in the Malayan Peninsula and Southwest China has had a long millennial tradition (Biller-Sandalj et al., 2016). In the Arunachal Pradesh region of India, hunting of Capped langur has been associated with, source of food, medicinal purpose, and as artifacts for socio-cultural practices and religious and cult ceremonies(Kumar & Solanki, 2008).

Large infrastructural projects of the government also have a significant impact on local communities, their management of natural resources, and also on their interactions with wildlife (Cui et al., 2016). Depletion of food plants important to the langurs due to the collection of non-timber forest produce was found to be the most serious threat in Pakke wildlife sanctuary(Kumar & Solanki, 2008). Logging, forest fragmentation, loss of canopy, natural barriers like rivers, infrastructural development, human intervention, construction of trails, and pathways through the forests have left the arboreal primate concentrated and accentuated. The range of *T. shortridgei* is presumed to be from northern Kachin state, Myanmar, and the valley of the Dulong and Nu rivers. This region has a low human population but is beleaguered by an increasing number of environmental and socio-economic problems which are associated with poverty, social disobedience, illegal activities such as logging, smuggling of wildlife, and drug trafficking(Cui et al., 2016). The range of Phayre's leaf monkey in Laos is in the hilly landscape but of all, it is converted to agriculture and the remaining forest patches are so small that hunting sensitive species have been eradicated from the southern states of the nation(Timmins et al., 2013).

Protecting the primate should be a collaborative effect taken by the government, the local communities, and the NGO. The local communities are a major factor that controls the density of an animal in the region. Their participation in conservation by making them aware of the endemicity of the species. Many people have a parochial view of forest species and fail to understand that a species that is common locally might not be present anywhere else(Cui et al., 2016).

Strict restrictions on the movement of humans in forests, community awareness, public participation, grants, more encouragement of youth in conservation activities will have promising effects in reverting a species from evanescence. Education can play an important role in species protection. We suggest that local knowledge of the forest, agriculture, and culture needs to be maintained and integrated with current ecological knowledge(Cui et al., 2016).

CONCLUSIONS

The present work reviewed the genus *Trachypithecus* to understand the reasons behind the discovery of the species Popa Langur and the reasons for the decline in the population of the genus. The research work of several environmentalists was reviewed with special emphasis on the work of Dr. Christian Roos who discovered the new species of the genus *Trachypithecus*. Dr. Parvish Pandya, an environmentalist from India, also contributed his views regarding the discovery of the new genus. He stated that variation and genetic isolation can be one of the reasons that caused the animal to isolate and prevent interbreeding with the other individual under the same genus, which could have led to its separation from the other species and development of accentuated characters. Masanaru Takai. (Ph.D. scholar) expressed that Mount Popa is an isolated peak and the surrounding area is occupied by rice fields and villages, this might be the reason for speciation.

Unavailability of molecular technologies that could arrange the animals based on their genomic data and morphological misidentification caused the animal to be overlooked. Considering the range of the animal, it is endemic to Myanmar and the region in which it is found (other than Mt. Popa) has a high human activity which has caused its number to be decreasing and is appropriate to consider it Endangered.

All colonies apparently possess a sacculated stomach gut with forestomach in which cellulolytic microbes aid in the digestion of fibrous and sometimes toxin-rich foliage. The digestive apparatus that enables colobines to digest leaves requires that food spend a relatively long period in transit. These dietary constraints have major implications for activity patterns, ranging and feeding ecology(Stanford,1991). The lack of research and advanced technologies in 1913 cannot be ignored, which led to the taxonomic error and made the individuals labeled as the *T.phayrei* species.

The sole motor ultimately driving evolutionary changes seems to be the environment(Vrba, 1980).The loss of habitat, restrictive diet, foraging behavior, human activity, and intrusion just might be the reason for the species to be less in numbers and remain unobtrusive. The current work was an attempt to reach out about the discovery of Popa langur to a large audience of non-specialist, amateurs, citizen scientists, beginners in animal science and young age groups having inclination towards life science and conservation**.**

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