

of molecular markers in pigeon pea has become a matter of the past. In addition, a 62K genic-SNP chip was used to map and analyse the genes/QTLs for reasonable reliability and higher precision¹⁵.

In conclusion, pigeon pea breeders will be able to map complex traits, identify the gene/genomic region(s) controlling these traits, characterize them and use them for genetic improvement. The MAGIC population will also deliver desirable genotypes for future testing and possible release for cultivation under various climates.

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Camera traps reveal coat colour variation in an isolated population of golden jackals

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Long-term monitoring of golden jackals along the coastline of the southern Western Ghats, India, provided interesting results. We observed various coat colour patterns such as leucism, melanism, semi-melanism and rusty coats among jackals resembling dogs. The melanistic variation and rust colour expression may be due to the acquired genetic properties during cross-breeding with the free-ranging dogs, as the associated mutations have been previously documented in dogs and not in jackals. Genetic studies can assist us in understanding the causes and consequences of coat colour variation.

Keywords: Coat colour variation, golden jackal, hybridization, isolated populations.

GOLDEN jackals (*Canis aureus*) are a species of least concern according to the IUCN Red List. Jackals were common in reserve and non-reserve areas as well as the countryside around 30–40 years ago. The species is presently restricted to individual isolated pockets owing to changing land patterns and human population expansion. Ecological studies on jackals are less prioritized, and a comprehensive record of the meta-populations is not available. Group size of the jackals can be up to 20 and have a home range of 21.2 km² in their natural habitats and 6.6 km² in human-dominated habitats¹. When plenty of food is available in a region, the usual social organization is lacking². The population density of individual species is declining worldwide, owing to indiscriminate land-use patterns. The pace of urbanization is leading to a reduction in environmental heterogeneity and a collapse of ecological niches³. Thus, the dwindled and isolated jackal meta-populations may undergo hybridization with associated feral species. Hybridization in the wild is not always encouraging, as it can lead to endangerment and extinction through genetic swamping⁴.

The southern Western Ghats coastline extends from Mangaluru in Karnataka to Kanyakumari in Tamil Nadu, encompassing three states in India with a large stretch in Kerala. According to geologists, inward redress of the sea

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carved this landscape. The perennial rivers, coves, creeks, lagoons, backwaters, estuaries and low-lying wetlands with lush green vegetation make this region unique. Due to varied habitat cover, this landscape is the home to many rare and endemic floral and faunal species^{5,6}. The heavy urbanization rate has resulted in the wild species population declining at an alarming rate and being isolated to patches⁷. The present study examines the distribution of jackals and discusses their peculiar coat colour patterns in Kannur mangrove regions of Kerala.

We conducted surveys and camera-trap monitoring from 2012 to 2017 to monitor small mammals along the coastline tracts of the southern Western Ghats. Our questionnaire survey identified the small mammals along this coastline⁵. We also observed albinism in jackals and jungle cats from various sites along this coastline⁷. We used camera traps for jackals based on the results of a previous questionnaire survey in all the districts of Kerala. We did not use camera traps in Kanyakumari (Tamil Nadu) and Mangaluru as the questionnaire survey did not yield any reports regarding the presence of jackals. We recorded jackal presence from Thiruvananthapuram, Kollam, Kottayam, Thrissur, Kozhikkode, Malappuram and Kannur districts (Figure 1). Monitoring also helped to identify jungle cats, small Indian civets, common palm civets, and otters from this landscape. We recorded patchy distribution of jackals from plantations and forested regions of Erumeli, Kanjirapilly, Ponkunnam, Ramapuram, Uzhavoor and Manarkad in Kottayam. Wetlands in the Karyavattom region of Thiruvanthapuram, sacred grooves in the Pooyapally region of Kollam district and the coastline region of Chavakkad, Thrissur. Plantations in Kalikavu, Edakkara and Pulluni mangroves of Malappuram district, Kerala, also have jackal populations. Towards the northern side, Kadalundi in Kozhikkode district and mangrove regions in the Kannur district have jackal populations. We recorded 231 jackal captures throughout the landscape, among which 172 captures were from the mangrove regions of Kannur. Kannur mangrove regions had an isolated population of jackals surrounded by thickly populated human habitation. The camera trap records of jackals from this region showed predominant coat colour variations. We compiled photo captures, and the activity pattern was estimated by the nonparametric kernel density estimation model using the R-package *Overlap*⁸.

The camera trap records of jackals, with their wide coat colour patterns resembling those of the dog or wild dog found in the Kannur mangrove region, piqued our interest ([Supplementary Figure 1](#)). The coat colour patterns observed were rusty (dog-like), albinistic and semi-melanistic and melanistic. We directly sighted the completely melanistic jackals from the Kannur mangroves. We also recorded a semi-melanistic individual's courtship behaviour with a rusty coat colour variant ([Supplementary Figure 2](#)). In this region, the jackal activity pattern demonstrated that the animal is predominantly nocturnal

(Figure 2). However, most of the photo captures of coat colour variants were recorded during the daytime. As the population is an isolated one and no wild dogs exist in the nearby or adjoining areas, it probably could be a cross-breed. Evidence shows that the distribution of jackals is patchy, and a population with connectivity probably exists only in Kottayam district, Kerala.

David⁹ reported the presence of jackals from the Periyar Tiger Reserve and claimed it to be an unusual observation. According to him, the jackals might have migrated/foraged to the Periyar tiger reserve from an unknown location. Based on our findings, we hypothesize that the observations of Jackal in Periyar tiger reserve may be an accidental foraging activity from the nearby Erumeli as these regions have a healthy jackal population. The primary coat colour of the golden jackal varies from pale cream-yellow to dark tawny, and the pelage at the back is a mix of black, brown and white hair¹⁰. Galov *et al.*¹¹ reported jackal-dog hybrids, with individuals being sexually fertile. Studies have reported that melanism expression is due to deletion in the β -defensin *CBD103* gene, which is absent in jackals but present in dogs¹²⁻¹⁴. Kannur mangrove regions are located amidst highly urbanized areas and have substantial anthropogenic stress⁵. These mangroves are home to a small population of jackals, and the free-range dogs in this area are a major nuisance. The free-ranging dogs are a threat to poultry, cattle and human beings in this locality (as reported in the media and from our camera trap records). In a human-dominated habitat, jackals may feed on invertebrates, reptiles, birds, human food waste and garbage¹⁵. The [Supplementary Figure 1](#) provides evidence for such foraging behaviour. As dogs and jackals are phylogenetically close relatives, we cannot rule out the possibility of hybridization between them.

A previous study revealed the presence of melanistic jackals in the Dharmmadom region of Kannur¹⁶. This indicates the existence of such a trait for more than 60 years in this locality. The coat colour polymorphism is an ongoing evolutionary puzzle, and melanism is favoured in the wild by natural selection¹⁷. Jackals that live in human-dominated habitats have always been under threat. The activity seems to be predominant at night time in these regions. The observation differs from the recent reports on jackals from the Godavari mangroves in Andhra Pradesh, where the animals reported bimodal activity with an activity peak in the afternoon¹⁸. Jackals are both nocturnal and diurnal, but are fully nocturnal in areas adjoining human habitation. We suggest the coat colour variation helps camouflage the jackals as free-ranging dogs, thus possibly helping them escape from anthropogenic threats. Studies also indicate that the coat colour variants and melanistic individuals are comparatively favoured in the daytime^{17,19}. We also observed more number of such captures in the daytime than at night. Pillay²⁰ reported that the golden jackal range is decreasing at a catastrophic

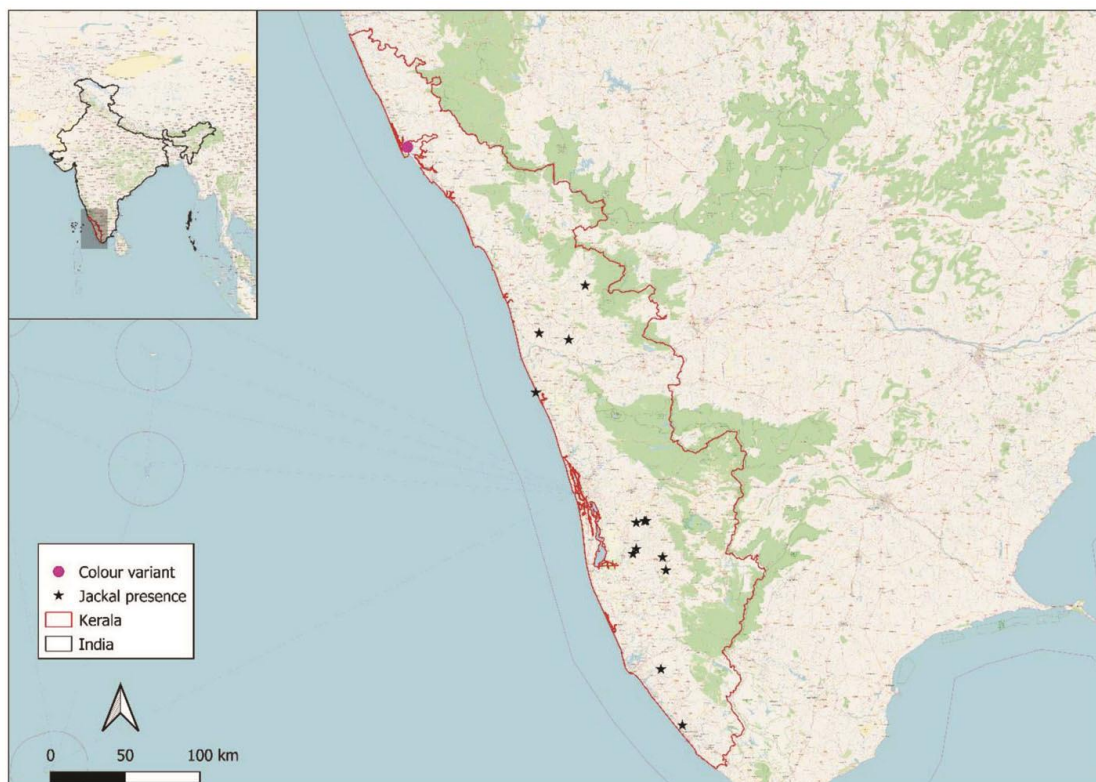


Figure 1. Distribution of jackal populations along the coastline of the Western Ghats, India.

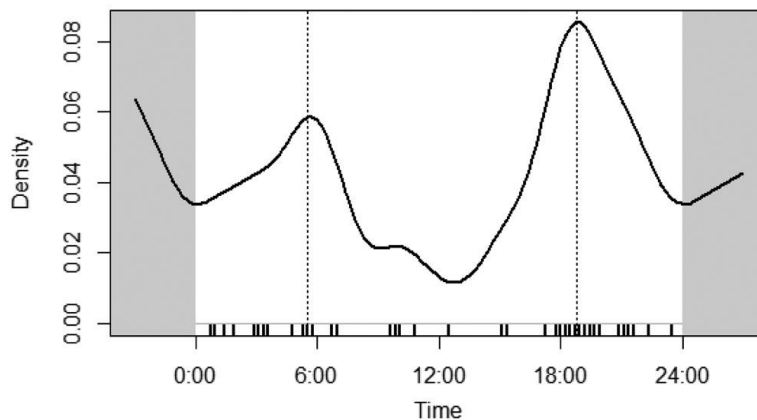


Figure 2. Activity pattern of jackals from Kannur mangrove region, Kerala.

rate and needs reassessment. The recent tiger status report shows that the golden jackals are absent in almost all the southern Western Ghats protected reserves, and the reason for this is unknown²¹. In the study locality, the jackal population is hybridized or exhibiting colour morphing as part of its struggle for existence. The introgression or the hybridization might have drastic effects on animal fitness, leading to genetic homogenization or outbreeding depression in the local population¹¹. If this scenario continues, the existing native jackal population may face severe threats due to its declining genetic stability. We propose

an in-depth molecular investigation to elucidate the genetic basis for coat colour diversity and shed light on this mystery.

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