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First photographic evidence and new distribution records of the Himalayan musk-deer *Moschus leucogaster* (Hodgson, 1839) from Southern Central part of Tsirang district in Bhutan

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Abstract

Musk-deer belong to the order Artiodactyla and family Moschidae. There are seven species of musk-deer, two of which--*Moschus chrysogaster* and *Moschus leucogaster*--have been reported from Bhutan. However, the absence of comprehensive, countrywide distribution studies and species-specific research has hindered a clear understanding of the ecology, distribution and population status of these endangered musk-deer in the Bhutan Himalayas. Recent records of *Moschus leucogaster* from the south-central parts of Tsirang district represent new distribution records for the country. Notably, its occurrence at 2,200 m.a.s.l in Tsirang extends the species' lower elevational limit, providing new insights into its distributional range. These findings highlight the urgent need for extensive camera-trap surveys and detailed habitat ecological studies to reassess the species elevational ranges and habitat requirements within Tsirang District. In addition, future identification of musk-deer in Bhutan should incorporate genetic analyses to resolve taxonomic uncertainties and provide robust, quantitative evidence for refining their distributional ranges.

Key words: Conservation threats, distribution, habitat, Himalayan musk-deer, *Moschus leucogaster*

Musk-deer belong to the order Artiodactyla and family Moschidae. There are seven species of musk-deer, including the Forest musk-deer (*Moschus berezovskii*), Anhui musk-deer (*M. anhuiensis*), Alpine musk-deer (*M. chrysogaster*), Black musk-deer (*M. fuscus*), Himalayan musk-deer (*M. leucogaster*), Kashmir musk-deer (*M. cupreus*) and Siberian musk-deer (*M. moschiferus*) (Yang et al., 2003; Yi et al., 2020; Feng et al., 2023). All these species were considered Endangered on the IUCN Red List of Threatened Species except for *Moschus moschiferus* Linnaeus 1758) which is Vulnerable in the IUCN Red List (Nyambayar, 2013; Haris, 2016; Dhendup et al., 2017).

Globally, musk-deer are distributed from the Arctic Circle in Russia to Afghanistan, Bhutan, China, India, Korean Peninsula, Mongolia, Myanmar, Nepal, Pakistan and Vietnam (Grubb, 2005; Dhendup et al., 2017). In Bhutan, two species of musk-deer i.e. Alpine musk-deer (*Moschus chrysogaster* Hodgson 1839) and Himalayan musk-deer (*Moschus leucogaster* Hodgson 1839) have been recorded (Dhendup et al., 2017). *Moschus chrysogaster* is distributed across six protected areas including Jigme Dorji National Park (JDNP), Phrumsengla National Park (PNP), Jigme Singye Wangchuck National Park(JSWNP), Sakteng Wildlife Sanctuary (SWS) and Bumdeling Wildlife Sanctuary (BWS) (Wangchuk et al., 2004). Later, Dorji et al. (2018) and Wangyal et al. (2020) have also reported it from Wangchuck Centennial National Park (WCNP) and Jigme Khesar Strict Nature Reserve (JKSNR). But

M. leucogaster has been recorded in Bhutan only from JDNP, JSWNP and Zhemgang Division (Dhendup et al., 2017; JKSNR, 2020; JSWNP, 2021; Dorji and Raika, 2022). However, Black musk-deer (*M. fuscus*) are expected to occur in Bhutan as per the studies of Wang and Harris (2015). Both *M. chrysogaster* and *M. leucogaster* are categorized as Endangered in IUCN Red List of Threatened Species (Gub, 2004; Haris 2016; Dhendup et al., 2017; Mainali et al., 2023) due to surging habitat degradation, poaching and climate change impacts within the range countries (Feng et al., 2023; Mainali et al., 2023). Both species of musk-deer species are categorised under Schedule I of Forest and Nature Conservation Act of 2023, which provides legal protection in Bhutan. Beyond occurrences, there is a paucity of in-depth ecological studies about the two species of musk-deer in Bhutan.

Typically, musk-deer are shy and solitary by nature, inhabiting mountainous regions stretching from Siberia to the Himalayas (Feng et al., 2023). These deer have a stocky body type with significantly longer and more muscular hind legs than their shorter, gracile forelimbs. The fawns of *M. leucogaster* have white spots to help with camouflage, but as they mature these spots disappear (Feng et al., 2023). Unlike females, males possess prominently developed upper canine teeth and a musk-producing gland located on their abdomen (Britannica, 2020; Feng et al., 2023). Upon reaching sexual maturity, males secrete musk to attract females and establish territorial boundaries. However, detailed and comprehensive distribution records of both musk-deer species in Bhutan are scarce, with existing information limited to a few parks and wildlife sanctuaries. Records are still lacking from Territorial Divisions outside protected area networks, largely due to the absence of a comprehensive mammal inventory checklist and structured conservation plan for each Territorial Division.

Tsirang district encompasses a total geographical area of 639 km² in the southern central part of Bhutan, spanning an elevation range of 160 m to 4,144 m.a.s.l (Mongar et al., 2024) (see Fig. 1). The district is mostly covered with broadleaved forest (76.48%), followed by chir pine (4.20%), mixed conifers (6.71%) and shrubs (3.30%) that contributes to 81.75% forest covers (FMID, 2022). Total, 15.52% (6329 Ha) of the district landscape is covered by Biological Corridor No. 03, which is further connected with other ecologically-diverse protected areas such as Jigme Singye Wangchuck National Park (JSWNP) to the north, Royal Manas National Park (RMNP) to the east, and Phibsoo Wildlife Sanctuary (PWS) to the south. Climatically, Tsirang experiences warm summers and cool dry winters and receives 1399.7 mm annual precipitation, with a maximum temperature of 21.25 °C and minimum of 13 °C (NCHM, 2024). Due to this suitable ecological profile, the district is home to more than 140 species of vascular plants that provide shelter and food to 259 species of birds, 289 butterflies, 133 orchids, 28 fish and 31 mammals, including critically endangered, endangered, and vulnerable species, as well as near threatened and species of least concern (Choidup et al., 2025).

There are 42 National Biodiversity Monitoring Grid (BMG) grid cells (4 x 4 km) inside Tsirang Division (639 km²). Of these, 12 with a high potential for wildlife sightings were selected for camera traps. One camera trap was stationed per grid cell for a period of 90 days (14th April-14th June 2025). This protocol was suggested by Thinley et al. (2015) for limited budgets and camera traps (Fig. 2).

Meanwhile, rechargeable batteries (Duracell) were used for all camera traps (Panthera). Camera traps were set to 24-hour time with a capture rate of 3 images/capture over an interval of 3–5 seconds. Camera traps were placed 45–50 cm above the ground and no bait/lures were used. Captured mammal species were identified using guides to the mammals of Bhutan (Wangchuk et al., 2004) and the Indian subcontinent (Menon, 2014). In addition, we also consulted with Dr. Paras B. Singh, renowned Wildlife Ecologist at Biodiversity Conservation Society, Nepal, who confirmed the species.

Photographic evidence of *M. leucogaster* was obtained from Harkatey (27.107° N, 90.230° E) and Thrulu Lisey Thumki (27.128° N, 90.242°E) in Phuentenchhu, Tsirang district, during the second nationwide tiger survey (2021–2022) as well as in our recent camera trap survey (2024–2025). Among two camera station, Thrulu Lisey Thumki has captured highest (n = 154) images, followed by Harkatey (n = 44) during second nationwide tiger survey in 2021–2022 and same camera trap location in recent camera traps surveyed in June 2025 has captured *M. leucogaster* from Thrulu Lisey Thumki under Tsirangtoe Range. Sambar (*Cervus unicolor*), Barking deer (*Muntiacus muntjak*), Serow (*Capricornis sumatraensis*), Guar (*Bos gaurus*) and Wild pig (*Sus scrofa*) were recorded as the main sympatric species of *M. leucogaster*, which is consistent with the finding of the Neupane et al. (2021). Simultaneously, Asiatic golden cat (*Catopuma temmincki*), Marbled cat (*Pardofelis marmorata*) and Dhole (*Cuon alpinus*) were probably the main predators as it was recorded in same camera station during past as well as recent camera trap survey (Table 1).

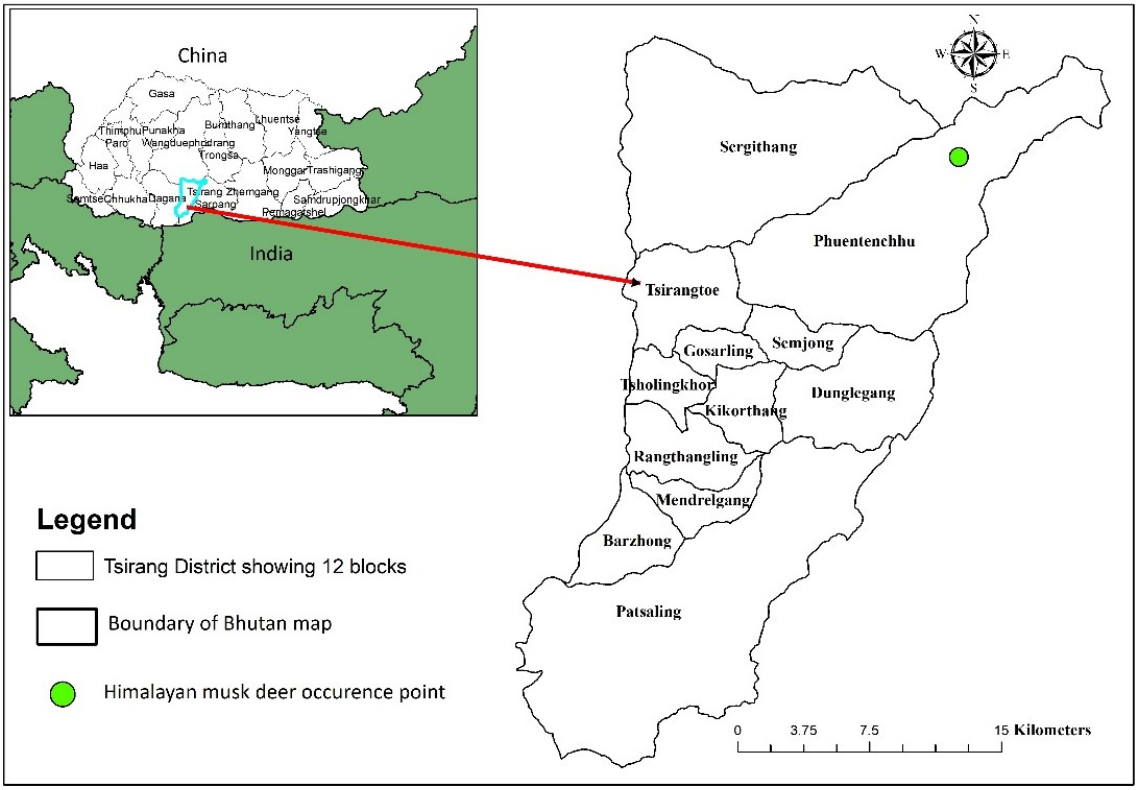

Figure 1: Bhutan map showing the occurrence of the Himalayan Musk-deer (*Moschus leucogaster*) from the Tsirang District.

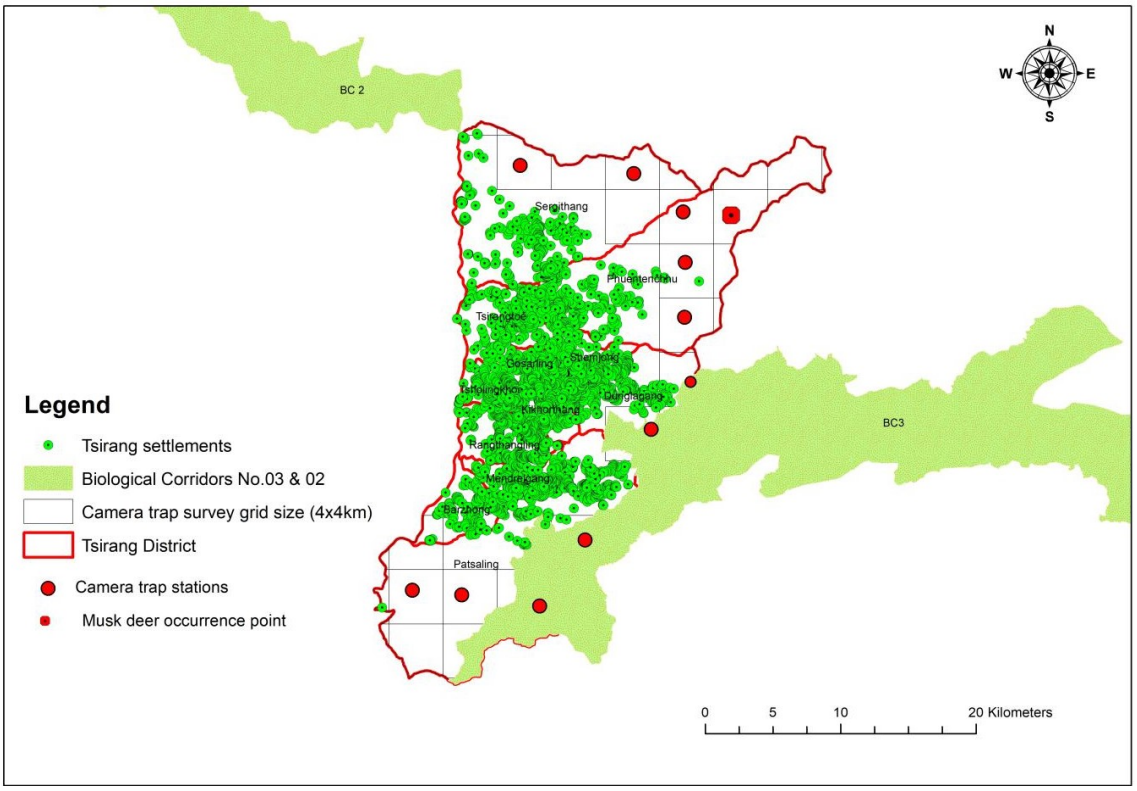

Figure 2: The map illustrates the Tsirang District landscape, interconnected with Biological Corridors No. 03 and 02, along with the survey grids established and camera trap stations for *Moschus leucogaster* (red dots) distributed across the district.

Table 1: Photographic capture history of *M. leucogaster* from southern central part of Tsirang district Bhutan.

Sl. No.	Species name	Total image captured during Second Nationwide Tiger survey (2022)		Total image captured in 2025 from Thrulu Lisey Thumki	Remarks
		Harkatey	Thrulu Lisey Thumki		
1	*Moschus leucogaster*	44	154	2	Photographic images from past and current camera traps
2	Sympatric species	Sambar, Barking deer, Serow	Sambar, Barking deer, Serow	Goral, Serow, Gaur, Sambar, barking deer, wild pig	Images from two surveys
3	Potential predator species	Asiatic golden cat, Marbled cat		Asiatic golden cat, Marbled cat, Dhole	Images from two surveys

In terms of habitat composition, *Acer campbellii*, *Betula utilis*, *Lyonia ovalifolia*, *Magnolia campbellii*, *Rhododendron arboreum*, *Rhododendron hodgsonii*, *Yushania* sp. and *Sorbus cuspidata* were the dominant plant types recorded in Thrulu Lisey Thumki in higher elevated area and *Castronopsis hystrix*, *Lyonia ovalifolia* and *Chimonobambusa callosa* thickets in Harkatey area in lower elevation area under Tsirang district in Bhutan. However, Green (1986) and Kattel and Alldredge (1991) stated that *M. leucogaster* in Nepal commonly preferred habitats dominated by oak (*Quercus* spp.), rhododendron (*Rhododendron* spp., blue pine (*Pinus wallichiana*), juniper forests (*Juniperus* spp.) and grasslands.

With regards to elevation, *M. leucogaster* is now recorded from two locations in Tsirang district: Thrulu Lisey Thumki and Harkatey which is located at an elevation of 3020 m.a.s.l and 2200 m.a.s.l., respectively. This contrasts with the findings of Srivastava and Kumar (2018) and Neupane et al. (2021) from Sikkim Himalayas where *M. leucogaster* typically occupies elevations between 3,600 m and 3,900 m.a.s.l. Possibly our findings could represent one of the lowest records of *M. leucogaster* from the Himalayas. However, the studies of Elith and Leathwick (2009) also stated that elevation alone doesn't determine species distribution; rather, it interacts with other climatic factors such as precipitation, temperature, and solar radiation.

With reference to slope, *M. leucogaster* was recorded on slopes ranging from 25–40% which is consistent with the studies of ANCA (2018) which found slopes between 21–40° are preferred. This indicates that gentle slopes (< 20%) are generally avoided due to cattle grazing and fuelwood collection, while slopes steeper beyond 41° are usually avoided, as rugged terrain limits the species' ability to escape from the predators (Shrestha, 2012; Neupane et al., 2021). In terms of crown density and ground covers, current sighted locations have dense crown covers with high diversity of shrubs, concomitantly with 25–50% ground covers along the Sergithang-Black Mountain ridges. This finding is consistent with the studies of Ilyas (2015), ANCA (2018) and Singh et al. (2018), indicating that dense ground covers are avoided, possibly because it restricts rapid movement, thereby hindering escape from predators.

Moschus leucogaster is classified as Endangered on the IUCN Red List of Threatened Species, primarily due to intense poaching driven by the high value of musk pods, which has led to a declining population worldwide (Homes, 1999; Rajchal, 2006; Harris, 2016). These deer also favor undisturbed forests and scrublands for shelter and foraging, making them highly susceptible to habitat fragmentation caused by forest clearing and livestock grazing, even within the protected areas (Green, 1986; Yang et al., 2003). Conservation efforts are further challenged by competition with other species, habitat degradation, and the risk of disease transmission (Sathyakumar, 2005; Aryal et al., 2010; Wangchuk, 2012; Shresth et al., 2014). In Bhutan, JSWNP alone recorded 39 musk-deer traps from the Black Mountain region by patrolling teams (JSWNP, 2021). Likewise, Dorji et al. (2018) has recorded 74 cases of poaching from the Wangchuck Centennial National Park (WCNP) and four hundred snares along with the apprehension of 2 poachers from the Jigme Dorji National Park (Dhendup et al., 2017).

In the eastern part of Bhutan, intensive grazing by free-ranging livestock owned by the Brokpa, semi-nomadic pastoralists of the region, and former hunting pressures extirpated Musk-deer from what is now Sakteng Wildlife Sanctuary (SWS) (Sathyakumar, 2005; Tobgay et al., 2022). In fact, continued presence of scattered grazing grounds throughout the sanctuary and associated habitat disturbance caused by seasonal livestock migrations further contributes to habitat fragmentation, posing a significant risk to the musk-deer's survival as per Tobgay et al. (2022). However, in case of Tsirang landscape, the team has recorded little evidence of poacher camps, traps and snares beneath the occurrence sites which requires in-depth ecological studies within the prime habitats as well as periodic monitoring by the concern Field Division to safeguard those threatened species within the Tsirang landscape in Bhutan.

Figure 3: Photographic evidence of *Moschus leucogaster* from Thrulu Lisey Thumki ridge. Tsirang district, Bhutan (left and right). © Divisional Forest Office, Tsirang 2025.

Conclusions

In Bhutan, occurrences of *M. chrysogaster* and *M. leucogaster* have been documented. However, a recent record of *M. leucogaster* from the south-central part of Tsirang district adds a new distribution record for the country. Notably, Timmins and Duckworth (2015) reported 2,500 m.a.s.l as the lower elevational limit for *M. leucogaster*. The recent finding at 2,200 m.a.s.l revises this limit, offering new insights into the species' overall distribution across its range countries. This highlights the need for intensive camera traps survey and habitat studies to revalidate its elevation ranges in the future. Furthermore, Yang et al. (2013) and Guo et al. (2018) highlighted that the identification of musk-deer species in the Himalayas has long been hindered by reliance on inaccurate methods, such as pelage coloration. However, their recent genetic studies successfully confirmed the presence and distribution of various musk-deer species across China and Nepal Himalayas. Similarly, future identification of musk-deer in Bhutan should prioritize genetic analysis to resolve these taxonomic uncertainties and provide reliable, quantitative evidence for reassessing the species' distribution ranges.

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Data availability

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

Author contributions

J.T. conceptualized and designed the research. T.D. and J.T. performed the survey. J.T analysed, interpreted the data and drafted the manuscript. J.T, P.T and S.C. reviewed the manuscript draft. J.T. played corresponding role to the journal.

Conflicts of interest

The authors declare that there are no conflicting issues related to this short communication.

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