Adaptation of migratory Tibetan antelope to infrastructure development

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ABSTRACT
Background: The Tibetan antelope (Pantholops hodgsonii) is a migratory ungulate species that inhabits the Qinghai–Tibet Plateau. In recent years, the population of Tibetan antelope has steadily increased owing to rigorous protection measures to safeguard the species from commercial poaching. Currently, infrastructure development, competition with domestic livestock, and predation are the principal factors threatening the survival of Tibetan antelope. 

Result: Our study found that migratory Tibetan antelope can adapt to the development of infrastructure over time, decreasing the potential negative impacts of such developments. 

Conclusion: We, therefore, urge infrastructure development companies to incorporate wildlife corridors that enable free movement of wildlife populations, particularly for migratory species.

Introduction
The development of infrastructure can lead to an increase in animal–traffic conflicts and synurbization of many ungulates (Forman and Alexander 1998; Apollonio, Andersen, and Putman 2010; Wyckoff et al. 2018). The Tibetan antelope (Pantholops hodgsonii) is a migratory ungulate that is also endemic to the Qinghai–Tibet Plateau (Schaller 1998). The species declined from over one million individuals in the mid-1980s to fewer than 70,000 a decade later owing to severe commercial poaching for their underfur. As a result of rigorous protection, the population has steadily increased from the year 2000 onwards (Schaller 2012). Consequently, the species’ conservation status was changed from “Endangered” to “Near Threatened” in 2016 on the IUCN red list of threatened species (IUCN SSC Antelope Specialist Group 2016), showing considerable improvement.

Migratory populations of Tibetan antelope on the Qinghai–Tibet Plateau
Tibetan antelope exhibits sexual dimorphism (Figure 1.1), which allows for individuals to be separated into same-sex groups (Figure 1.2) outside of the rutting season (Schaller et al. 2006). Only the female Tibetan antelope migrate. On the Qinghai–Tibet Plateau, at least four migratory populations of Tibetan antelope occur, as well as several sedentary populations (Schaller 1998). According to their distribution, the four migratory populations could be divided by region: the western Chang Tang, the middle Chang Tang, the eastern Chang Tang, and the Qinghai populations. During the migratory season, thousands of female Tibetan antelope congregate from early May to give birth (Figure 1.3) and then return to wintering grounds with their offspring in late August, about four months later (Schaller 1998; Buho et al. 2011). The return journey of female Tibetan antelope back to their wintering grounds after calving takes substantially longer owing to the slow pace of newborn calves (Manayeva et al. 2017).

Primary threats to the survival of Tibetan antelope on the Qinghai–Tibet Plateau
In the absence of poaching, the Tibetan antelope is primarily threatened by the expansion of human infrastructure (Figure 2.1), resource competition with domestic livestock (Figure 2.2), and predation (Figure 2.3) (Leslie and Schaller 2008). Infrastructure development that can encroach on this species’ habitat includes the construction of roads, high-voltage power lines, oil pipelines, and other similar types of infrastructure. Besides habitat destruction and fragmentation (Figure 2.1), roads can increase the likelihood of Tibetan antelope being killed in vehicle collisions and can also affect their behavioral responses, such as their vigilance levels, flight response, and overall movement patterns (Forman and Alexander 1998; Lian et al. 2012, 2011; Xu et al. 2019).
Figure 1.1. Male and female Tibetan antelope exhibiting sexual dimorphism. Besides their different coat color and body size, males can be distinguished by their long upright horns. The photograph was taken in the Kekexili National Nature Reserve in December 2019.

Figure 1.2. Subadult male Tibetan antelope (third and fourth individuals on the right) are in a bachelor herd. In same-sex groups, the young learn survival skills from adults. The photograph was taken in the Kekexili National Nature Reserve in March 2020.

Figure 1.3. Migratory populations of Tibetan antelope include adult females, yearling females born in the previous year, and newborn calves. The photograph was taken near Lake Selin Co, the largest lake in the Tibetan Autonomous Region, in July 2017.
Tibetan antelope adaptation to infrastructure development

Of the four migratory populations of Tibetan antelope, only the Qinghai population is threatened by the potential negative impacts of infrastructure development (Schaller et al. 2006; Manayeva et al. 2017). The Qinghai population of Tibetan antelope migrates between the Kekexili National Nature Reserve and the Sanjiangyuan National Nature Reserve. This population receives more conservation attention owing to the development of the Qinghai–Tibet Highway (QTH) and the Qinghai–Tibet Railway (QTR), which traverses their migratory routes. During their annual migration, migrating Tibetan antelope are required to cross both the QTH and the QTR twice. The impacts of roads on wildlife are more severe than other forms of infrastructure owing to the additional urban development and increased human disturbance that accompanies such developments. The QTR has 26 wildlife corridors that are included in its design. Subsequently, Tibetan antelope have adapted their migratory movements to include the use of these corridors (Yang and Xia 2008; Figure 3.1). Additionally, during hours of low volume road traffic, migratory antelope cross the QTH (Figure 3.1). Individual antelope have also been observed foraging or resting under the bridges of the QTR (Figure 3.2) and under high-voltage power lines (Figure 3.3), suggesting that they have become accustomed to the presence of the infrastructure. Similar behavioral responses have been observed in mule deer.
Figure 2.3. A wolf eating a Tibetan antelope. Wolves are the main predators of Tibetan antelope. The photograph was taken in the Kekexili National Nature Reserve in April 2020.

Figure 3.1 The migratory route of the Qinghai population of Tibetan antelope from the calving ground in the Kekexili National Nature Reserve, shown on the west side of the Qinghai-Tibet Highway (QTH), which is 150 km away from the wintering ground in the Sanjiangyuan National Nature Reserve, the area on the east side of the Qinghai-Tibet Railway (QTR). Figure 3.1A shows that migrating Tibetan antelope are required to cross both the QTH and the QTR twice each year. Figure 3.1B shows the Wubei Bridge of the QTR, which was used by more than 90% of migratory antelope in our study. Figure 3.1C shows the migratory Tibetan antelope crossing the QTH, putting them at risk of vehicle collisions. The photographs were taken at milestone No. K2997 of the QTH in May 2019 (Figure 3.1C) and December 2020 (Figure 3.1A&B) respectively.

Figure 3.2. Male Tibetan antelope foraging under a bridge of the Qinghai-Tibet Railway, appearing undisturbed by passing trains. The photograph was taken at the Chumaer Bridge of the Qinghai-Tibet Railway in July 2018.
(Odocoileus hemionus) in North America (Sawyer, Chad, and Thomas 2012).

Conclusion

Substantial infrastructural development on the Qinghai–Tibet Plateau has threatened the disruption of critical migratory routes for Tibetan antelope. This study included 18 years of population monitoring, which shows that Tibetan antelope have adjusted their behavior to cope with the presence of the QTR and QTH. Additionally, they have learned how to utilize wildlife corridors incorporated into the infrastructure during their migration. Construction of major infrastructure can have considerable negative impact on wildlife species; however, our study suggests that some of these impacts may decrease over time as species develop adaptive responses. Furthermore, environmental considerations such as the incorporation of wildlife corridors into infrastructure, are essential for allowing species to display normal movement behaviors, particularly for migratory species. Ensuring the sustainability of the free-flowing movement of wildlife populations is also vitally important for sustaining genetic diversity within populations.

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Disclosure statement

The authors declare that all of the photographs used in this article are original and that they have no conflict of interest.

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References

Apollonio, M., R. Andersen, and R. Putman. 2010. European Ungulates and Their Management in the 21st Century. Cambridge: Cambridge University Press.

Buho, H., Z. Jiang, C. Liu, T. Yoshida, H. Mahamut, M. Kaneko, M. Asakawa, et al. 2011. “Preliminary Study on Migration Pattern of the Tibetan Antelope (Pantholops Hodgsonii) Based on Satellite Tracking.” Advances in Space Research 48 (1): 43–48. doi:10.1016/j.asr.2011.02.015.

Forman, R. T. T., and L. E. Alexander. 1998. “Roads and Their Major Ecological Effects.” Annual Review of Ecology and Systematics 29 (1): 207–231. doi:10.2307/221707.

IUCN SSC Antelope Specialist Group. 2016. “Pantholops Hodgsonii. The IUCN Red List of Threatened Species 2016: E.T15967A50192544.” doi:10.2305/IUCN.UK.2016-2.RLTS.T15967A50192544.en.

Leslie, D. M. J., and G. B. Schaller. 2008. “Pantholops Hodgsonii (Artiodactyla: Bovidae).” Mammalian Species 40 (817): 1–13. doi:10.1644/817.1.

Lian, X., X. Li, D. Zhou, and P. Yan. 2012. “Avoidance Distance from Qinghai-Tibet Highway in Sympatric Tibetan Antelope and Gazelle.” Transportation Research Part D: Transport and Environment 17 (8): 585–587. doi:10.1016/j.trd.2012.06.009.

Lian, X., T. Zhang, Y. Cao, J. Su, and S. Thirgood. 2011. “Road Proximity and Traffic Flow Perceived as Potential Predation Risks: Evidence from the Tibetan Antelope in the Kekexili National Natural Reserve, China.” Wildlife Research 38 (2): 141–146. doi:10.1071/WR10158.
Manayeva, K., B. Hoshino, H. Igota, T. Nakazawa, and G. Sumiya. 2017. “Seasonal Migration and Home Ranges of Tibetan Antelopes (Pantholops hodgsonii) Based on Satellite Tracking.” *International Journal of Zoological Research* 13 (1): 26–37. doi:10.3923/ijzr.2017.26.37.

Sawyer, H., L. Chad, and H. Thomas. 2012. “Mitigating Roadway Impacts to Migratory Mule Deer—A Case Study with Underpasses and Continuous Fencing.” *Wildlife Society Bulletin* 36 (3): 492–498. doi:10.1002/wsb.166.

Schaller, G. B. 1998. *Wildlife of the Tibetan Steppe*. Chicago: University Chicago Press.

Schaller, G. B. 2012. *Tibet Wild: A Naturalist’s Journeys on the Roof of the World*. Washington D. C.: Island Press.

Schaller, G. B., A. Kang, X. Cai, and Y. Liu. 2006. “Migratory and Calving Behavior of Tibetan Antelope Population.” *Acta Theriologica Sinica* 26 (2): 105–113. doi:10.1016/S0379-4172(06)60069-3.

Wyckoff, T. B., H. Sawyer, S. E. Albeke, S. L. Garman, and M. J. Kauffman. 2018. “Evaluating the Influence of Energy and Residential Development on the Migratory Behavior of Mule Deer.” *Ecosphere* 9 (2): e02113. doi:10.1002/ecs2.2113.

Xu, W., Q. Huang, J. Stabach, B. Hoshino, and P. Leimgruber. 2019. “Railway Underpass Location Affects Migration Distance in Tibetan Antelope (Pantholops hodgsonii).” *Plos One* 14 (2): e0211798. doi:10.1371/journal.pone.0211798.

Yang, Q., and L. Xia. 2008. “Tibetan Wildlife Is Getting Used to the Railway.” *Nature* 452 (7189): 810–811. doi:10.1038/452810c.