eco.mont – Volume 16, Number 2, July 2024
ISSN 2073-106X print version – ISSN 2073-1558 online version: http://epub.oeaw.ac.at/eco.mont
https://doi.org/10.1553/eco.mont-16-2s47

Threats to, and conservation of, biodiversity in the Siling Co National Nature Reserve, Tibetan Plateau, China

Baoqiang Wang, Kang Chen & Ren Zhu

Keywords: Tibetan Plateau, biodiversity conservation, endangered species, wetlands, Siling Co

Abstract

Due to its unique climate and geographic location, Siling Co National Nature Reserve, located in the northwest of the Tibet Autonomous Region of China, is an important natural habitat, a hotspot of endemism, and sustains numerous endangered species. Climate change and warming temperatures, invasion by non-native species and human disturbance are serious threats to the Tibetan Plateau's local biodiversity and specialized ecosystems. To better protect biodiversity and ecosystem functions in the specialized endemic habitats of the Plateau, we summarize the status, threats and protective conservation measures in the Reserve. It is hoped that this study will provide useful information and strategies for biodiversity conservation for the Tibetan Plateau and other highland regions.

Profile

Protected area

Siling Co National Nature Reserve / Tibetan Plateau, China

Introduction

Mountainous regions support a high level of species richness and unique habitats. They also provide essential resources such as food, wood and medicine for human survival and sustainability (Körner 2004; Payne et al. 2020). Unfortunately, climate change, ecological disruptions caused by non-indigenous species, human disturbance and habitat fragmentation pose great threats to biodiversity, ecosystem services, and human wellbeing in many highland regions (Sala et al. 2000; McCain & Colwell 2011; Rahbek et al. 2019).

Among China's many mountainous regions with a great diversity of species (Tang et al. 2006), the Tibetan Plateau, a relatively young mountain range from a geological perspective (Zhang et al. 2002), hosts diverse habitats for endangered and endemic species. Recognized as a global biodiversity hotspot, it has become a priority area for conservation efforts (Myers et al. 2000). However, the number of endangered and/or endemic species has historically been greatly underestimated by researchers due to the challenges of accessing its remote areas and its vast size (Wang & Li 1982; Zhang & Zhang 2019). For instance, the first scientific investigation of the Tibetan Plateau in the 1970s identified nearly 1,000 new species (Zhang & Zhang 2019). Since 2017, a number of further new species have been observed and reported, during the second Tibetan Plateau Scientific Expedition and Research Program (Li et al. 2024). Nevertheless, information regarding biodiversity in many regions of the Plateau is still limited, hindering effective conservation efforts.

Siling Co is the largest lake on the Tibetan Plateau and the second largest saline lake in China (Figure 1). It sustains the largest numbers of rare and endangered species of any lake in the surrounding alpine grassland ecosystems of the Plateau. The lake is also the world's largest natural reserve of black-necked cranes (*Grus nigricollis*), a species that is protected nationally, and provides important habitats for other nationally protected animals such as the snow leopard (*Panthera uncia*), Tibetan antelope (*Pantholops hodgsonii*), argali (*Ovis ammon*), kiang (*Equus kiang*), and Tibetan snowcock (*Tetraogallus tibetanus*). To protect these species, Siling Co Nature Reserve was established in 1993 as an autonomous regional-level nature reserve; it was upgraded to Siling Co National Nature Reserve in 2003.

This study provides a comprehensive review of the current status of biodiversity, threats, and conservation efforts in the Siling Co National Nature Reserve. We hope that this study will furnish valuable information and recommendations for managers at this and other reserves in mountainous regions.

Study area

The Siling Co National Nature Reserve is situated in the northwestern part of the Tibet Autonomous Region, China, in the north of the Tibetan Plateau. It stretches from the East Gangdis Mountains in the south to the northern edge of the Siling Co catchment area, on the south side of the Heihe-Ali highway. In the west, it extends to the watershed between the Tangra Yumco salt lake and lakes Munico and Xurucuo; the eastern boundary is formed by the watershed between the Yinmenqu and Bobuqu rivers. The Reserve is located in an area administered by Naqu City and covers 18,936 km^2, with coordinates ranging from longitude 86°40' to 92°30'E and latitude 30°10' to 32°05'N (Figure 2). The Reserve's average elevation is 4,530 m a.s.l., with some peaks exceeding 6,000 m.

The Siling Co National Nature Reserve is located in a sub-alpine monsoon region with a semi-arid climate. The annual average temperature is below 0°C. There are only five months with a monthly average above

Figure 1 – Landscape of Siling Co. © Xiong Xiong

0°C. The average for the warmest month is about 9°C, and that of the coldest month is approximately −35°C. The annual average precipitation is about 300–400 mm.

Biodiversity

With the support of the National Science and Technology Basic Special Project from 2014 to 2019 and the second scientific expedition to the Tibetan Plateau initiated in 2017, we conducted a more systematic and comprehensive investigation than earlier studies into the biodiversity of Siling Co National Nature Reserve. According to our field studies and literature review, there are 472 vascular plant species belonging to 147 genera and 40 families. At the family level, Compositae are represented by the greatest number of species (171), followed by Gramineae (51), Cruciferae (33), Leguminosae (28) and Cyperaceae (21). Other families contributed fewer than 20 species each.

The Reserve also supports a very rich animal biodiversity, comprising 105 birds belonging to 27 families and 15 orders, 23 non-avian animals belonging to 10 families and five orders, 10 fish species belonging to two families and one order, three reptiles belonging to two families and one order, and one amphibian species. Among these, 12 are listed as Category I protected species (Figure 3): *Grus nigricollis*, *Aquila chrysaetos*, *Aquila heliaca*, *Gypaetus barbatus*, *Haliaceetus leucoryphus, Haliaceetus albcilla, Panthera uncia*, *Pantholops hodgsonii*, *Ovis ammon*, *Equus kiang*, *Tetragallus tebetanus* and *Bos mutus*.

Threats to Siling Co National Nature Reserve

Global warming

Global warming poses a significant threat to biodiversity in highland habitats (Yang et al. 2022). Over the past 50 years, the Tibetan Plateau has warmed at more than twice the global average rate, increasing by 0.3°C ~ 0.4°C per decade, reaching its highest temperature in the last 2,000 years (Chen et al. 2015). Environmental changes, such as rising temperatures, altered water distribution patterns, extreme climate events and landslides, have threatened biodiversity by affecting distribution areas, the physiological status of organisms, and the relationships between flora and fauna (Li et al. 2022). Rising temperatures mean that the Tibetan Plateau now receives more precipitation as rain than as snow (Ombadi et al. 2023). Extreme precipitation leads to a higher risk of flooding, landslide hazards and soil erosion. The resulting silt causes damage to fishes' gills, and high-altitude endemic fishes, amphibians and even water birds have become excluded from small wetland sites that were formerly suitable and important to their sustenance (Aziz et al. 2021).

Human disturbance

Human disturbance is one of the leading reasons for the decline of biodiversity in the highland ecosystem (Yang et al. 2022). The expanding human population, from 23.5 million in 1980 to 34.25 million in 2019 (Fu et al. 2021), has led to rapid urbanization and increased pressure on wildlife survival in cities like Lhasa, Shigatse and Chamdo (Wang et al. 2021; Zhang et al. 2022). Furthermore, the production of water for human consumption and everyday life has depleted water levels in lakes, rivers and wetlands, posing a threat to endemic species of fish such as *Schizopygopsis younghusbandi*, *Schizothorax o'connori* and *Schizothorax waltoni* (Wang et al. 2021; Xiong et al. 2023; Zhang et al. 2023). With its improved transport infrastructure, including the Qinghai-Tibet Railway, Tibet attracts increasingly high numbers of domestic and international tourists (over thirty million in 2022) (Statistic Bureau of Tibet Autonomous Region 2022), with Siling Co being an important scenic spot along the Lhasa to

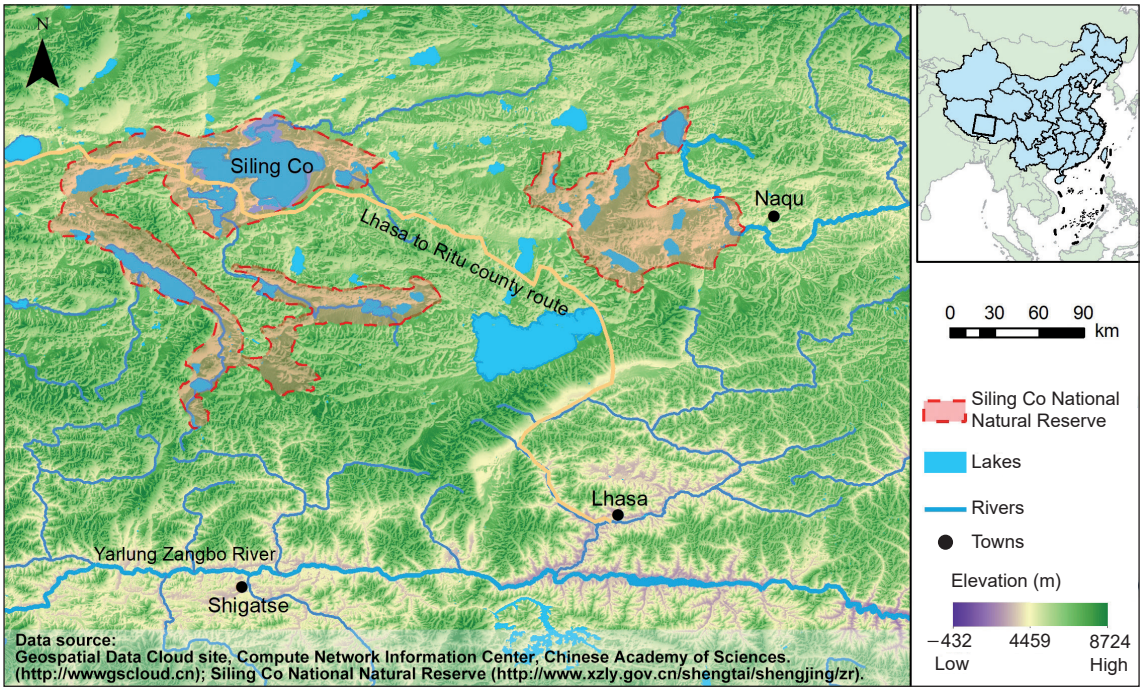

Figure 2 – Location and spatial extent of Siling Co National Nature Reserve.

Ritu county route (Figure 2). Unfortunately, tourists unintentionally introduce pests, such as the brown rat (*Rattus norvegicus*), which may carry parasites that are a threat to native biodiversity (Li et al. 2009).

Non-native species

The invasion of non-native species poses a significant threat to aquatic biodiversity (Sala et al. 2000). In recent years, China has experienced a substantial increase in introductions of non-native aquatic species (Xiong et al. 2015, 2023; Wang et al. 2016, 2021). In the first scientific survey of the Tibetan Plateau (1973–1976), there were no records of established populations of non-indigenous species. Many researchers believed that the harsh environment of the Plateau was unsuitable for invasive species to thrive. However, over the past two decades, numerous non-native aquatic species, including fishes, amphibians and plants, have been intentionally introduced to the Plateau for aquaculture, the aquarium trade, and other purposes (Deng et al. 2021; Wang et al. 2023; Zhu et al. 2023). The Plateau's diverse aquatic habitats, such as freshwater lakes, salt lakes, rivers and wetlands, provide suitable conditions for these non-native species. We have observed established populations of various species, including *Carassius auratus*, *Pseudorasbora parva*, *Paramisgurnus dabryanus* and *Cyprinus carpio*, in a variety of habitats (Feng et al. 2023; Xiong et al. 2023). These non-native species have caused a rapid decline in biodiversity and have altered the structure and functioning of the ecosystem (Xiong et al. 2023).

Protective recommendations

Ecological monitoring is crucial for the conservation of biodiversity (Martin et al. 2007). However, conducting regular monitoring on the Plateau is challenging due to the harsh environmental conditions such as low temperatures, blizzards and debris flows, and the presence of dangerous wildlife. Additionally, transport difficulties further complicate monitoring efforts in the Tibetan Plateau. To overcome these obstacles, it is essential to implement new monitoring techniques widely, such as environmental DNA, remote sensing, drone photography and automatic cameras (Nathan et al. 2015; Hill et al. 2016; Aguzzi et al. 2020); urgent action is needed to allocate more funds, equipment and resources for ecological monitoring. Furthermore, there should be a focus on providing technical training to personnel involved in monitoring, while collaboration among local government bodies, non-governmental environmental organizations, and the local community is vital to educate people and to promote biodiversity conservation.

Numerous measures have been implemented by the management of the Siling Co National Nature Reserve to protect endangered and endemic species, including the construction of fences, the creation of an ecological corridor, and the artificial propagation and release of endangered endemic species (mainly *Schizothorax* spp. and *Triplophysa* spp.). There is an urgent need to recruit highly specialized professionals for research on artificial propagation, life-history traits, and suitable habitats for these species, but the scarcity of highly qualified people is a significant constraint: in 2022, less than 0.02% of the population in the Tibet

Figure 3 – Some of the protected animals in the Siling Co National Natural Reserve. © Wang Baoqiang

Autonomous Region held a PhD, the lowest figure in China (Statistic Bureau of Tibet Autonomous Region 2022).

Acknowledgements

This research was supported by the Finance Special Fund of the Chinese Ministry of Agriculture and Rural Affairs of the People`s Republic of China (Fisheries resources and environment survey in the key water areas of Southwest China), and by the National Natural Science Foundation of China (No. 31900374, 32070436). We thank Dr. Jin Gao for processing the images in this article.

References

Aguzzi, J., N. Iveša, M. Gelli, C. Costa, A. Gavrilovic, N. Cukrov, M. Cukrov, N. Cukrov, D. Omanovic, M. Štifanić, S. Marini, M. Piria, E. Azzurro, E. Fanelli & R. Danovaro 2020. Ecological video monitoring of Marine Protected Areas by underwater cabled surveillance cameras. *Marine Policy* 119: 104052.

Aziz, M.S.B., N.A. Hasan, M.M.R. Mondol, M.M. Alam & M.M. Haque 2021. Decline in fish species diversity due to climatic and anthropogenic factors in Hakaluki Haor, an ecologically critical wetland in northeast Bangladesh. *Heliyon* 7(1): e05861.

Chen, D.L., B.Q. Xu, T.D. Yao, Z.T. Guo, P. Cui, F.H. Chen, R.H. Zhang, X.Z. Zhang, Y.L. Zhang, J. Fan, Z.Q. Hou & T.H. Zhang 2015. Assessment of past, present and future environmental changes on the Tibetan Plateau. *Chinese Science Bulletin* 60: 3025–3035.

Deng, T., Y. Li, J.Q. Zhang, W.H. Li, C.X. Xu & Y.M. Li 2021. New record of the invasive red-eared slider *Trachemys scripta elegans* (Wied, 1838) on the Qinghai-Tibetan Plateau, China. *BioInvasions Records* 10(4): 969–976.

Feng, X, B. Li, Y.F. Chen, R. Zhu, Y.T. Jia & X.Y. Sui 2023. Species-level monitoring of rare and invasive fishes using eDNA metabarcoding in the middle and upper Yarlung Zangbo River, Tibet. *Water Biology and Security* 2(1):100089.

Fu, B.J., Z.Y. Ouyang, P. Shi, X.D. Wang, H. Zheng, W.W. Zhao & F. Wu 2021. Current condition and protection strategies of Qinghai-Tibet Plateau ecological

security barrier. *Bulletin of the Chinese Academy of Sciences* 036(011): 1298–1306.

Hill, D.J., C. Tarasoff, G.E. Whitworth, J. Baron, J.L. Bradshaw & J.S. Church 2016. Utility of unmanned aerial vehicles for mapping invasive plant species: A case study on yellow flag iris (*Iris pseudacorus* L.). *International Journal of Remote Sensing* 38: 2083–2105.

Körner, C. 2004. Mountain biodiversity, its causes and function. *AMBIO* 33(sp13): 11–17.

Li, B.V., C.N. Jenkins & W.H. Xu 2022. Strategic protection of landslide vulnerable mountains for biodiversity conservation under land-cover and climate change impacts. *Proceedings of the National Academy of Sciences of the United States of America* 119(2): e2113416118.

Li, G.C., F.X. Meng, G. Zhang, Z.Y. Jiang, H.L. Lin, J.L. Liu, Y. Dun, L. Ge, Q.Y. Liu & J. Wang 2009. Investigation of Rattus norvegicus distribution along the Qinghai-Tibet railway and other areas in Tibet Autonomous Region. *Chinese Journal of Vector Biology & Control* 20(3): 213–215.

Li, X.P., Y. Niu & F.Q. Zhang 2024. Flora and species diversity of wild seed plants in Qiangtang Plateau. *Journal of Arid Land Resources and Environment* 38(4): 129–139.

Martin, J., W.M. Kitchens & J.E. Hines 2007. Importance of well-designed monitoring programs for the conservation of endangered species: Case study of the snail kite. *Conservation Biology* 21(2): 472–481.

McCain, C.M. & R.K. Colwell 2011. Assessing the threat to montane biodiversity from discordant shifts in temperature and precipitation in a changing climate. *Ecology Letters* 14(12): 1236–1245.

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.D. Fonseca & J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403(6772): 853–858.

Nathan, L.R., C.L. Jerde, M.L. Budny & A.R. Mahon 2015. The use of environmental DNA in invasive species surveillance of the Great Lakes commercial bait trade. *Conservation Biology* 29(2): 430–439.

Ombadi, M., M.D. Risser, A.M. Rhoades & C. Varadharajan 2023. A warming-induced reduction in snow fraction amplifies rainfall extremes. *Nature* 619(7969): 305–310.

Payne, D., E.M. Spehn, G.W. Prescott, J. Geschke, M.A. Snethlage & M. Fischer 2020. Mountain biodiversity is central to sustainable development in Mountains and beyond. *One Earth* 3: 530–533.

Rahbek, C., M.K. Borregaard, R.K. Colwell, B. Dalsgaard, B.G. Holt, N. Morueta-Holme, D. Nogues-Bravo, R.J. Whittaker & J. Fjeldså 2019. Humboldt's enigma: What causes global patterns of mountain biodiversity? *Science* 365(3658): 1108–1113.

Sala, O.E., F.S.I. Chapin, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kinzig, R. Leemans, D.M. Lodge, H.A. Mooney, M. Oesterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker & D.H. Wall 2000. Global biodiversity scenarios for the year 2100. *Science* 287(5459): 1770–1774.

Statistic Bureau of Tibet Autonomous Region 2022. Statistical Bulletin on National Economic and Social Development of the Tibet Autonomous Region. Available at: https://www.xizang.gov.cn/rsxz/gmjjhshfztjgb/202307/t20230714_365914.html

Tang, Z.Y., Z.H. Wang, C.Y. Zheng & J.Y. Fang 2006. Biodiversity in China's mountains. *Frontiers in Ecology and the Environment* 4(7): 347–352.

Wang, J.T. & B.S. Li 1982. Main types and characteristics of high-cold steppe in the Qiangtang Plateau of Xizang. *Acta Phytotaxonomica et Geobotanica Sinica* 6(1): 1–13.

Wang, H., Q. Wang, P.A. Bowler & W. Xiong 2016. Invasive aquatic plant species in China. *Aquatic Invasions* 11(1): 1–9.

Wang, H., D. Xie, W. Xiong, W. Tang, Z.G. Wu, K.Y. Xiao & Q. Wang 2021. Current status and future prospects of Lhalu wetland on the Tibetan Plateau. *eco.mont - Journal for protected mountain areas research and management* 13(2): 58–61.

Wang, Z.W., R. Zhu, X.X. Li, J.S. Qian & X.Y. Sui 2023. First record of the non-native western mosquitofish, *Gambusia affinis* (Baird & Girard, 1853), in the Eastern Himalayas, China. *BioInvasions Records* 12(1): 298–305.

Xiong, W., X.Y. Sui, S.H. Liang & Y.F. Chen 2015. Non-native freshwater fish species in China. *Reviews in Fish Biology and Fisheries* 25: 651–687.

Xiong, W., Z.G. Wu, H. Wang, J.J. Cai & P.A. Bowler 2023. Status, threats and the conservation of endemic species in the Yarlung Zangbo river basin. *eco.mont - Journal for protected mountain areas research and management* 15(2): 51–54.

Yang, C., H.Z. Liu, Q.Q. Li, X.Q. Wang, W. Ma, C.L. Liu, X. Fang, Y.Z. Tang, T.Z. Shi, Q.B. Wang, Y. Xu, J. Zhang, X.C. Li, G. Xu, J.Y. Chen, M. Su, S.Y. Wang, J.J. Wu, L.P. Huang, X. Li & G.F. Wu 2022. Human expansion into Asian highlands in the 21st Century and its effects. *Nature Communications* 13: 4955.

Zhang, B.P., X.D. Chen, B.L. Li & Y.H. Yao 2002. Biodiversity and conservation in the Tibetan Plateau. *Journal of Geographical Sciences* 12(2): 135–143.

Zhang, L. & D.M. Zhang 2019. Honglie Sun: the first Tibetan Plateau scientific expedition and research. *Chinese Science Bulletin* 64(27): 2763–2764.

Zhang, T.Z., F. Jiang, B. Xu, B. Li, C.B. Liang & H.F. Gu 2022 Research advances in conservation and management of endangered mammals on the Qinghai-Tibet Plateau. *Acta Theriologica Sinica* 42(5): 490–507.

Zhang, Y.H., J.Z. Yan & X. Cheng 2023. Advances in impact of climate change and human activities on wetlands on the Tibetan Plateau. *Acta Ecologica Sinica* 43(6): 2180–2193.

Zhu, R., H.H. Sun, S.H. Ji, X.X. Li, Y.T. Jia & X.Y. Sui 2023. First wild record of tench, *Tinca tinca* (Linnaeus, 1758) in Tibet, China. *BioInvasions Records* 12(1): 292–297.

Authors

Baoqiang Wang[1]

is an engineer at the Institute of Hydrobiology, Chinese Academy of Sciences. He has a PhD in Hydrobiology. His research focuses on freshwater ecology, benthic ecology and biodiversity. Email: wangbq@ihb.ac.cn

Kang Chen[2]

is a lecturer at Zaozhuang University. He has a PhD in Hydrobiology. His research focuses on fish ecology and biodiversity conservation. E-mail: chenkang992@163.com

Ren Zhu[1] – corresponding author

is a senior engineer at the Institute of Hydrobiology, Chinese Academy of Sciences. His research focuses on fish ecology, evolution and systematics. Email: zhuren@ihb.ac.cn

[1] Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan 430072, China
[2] College of Life Sciences, Zaozhuang University, Zaozhuang 277160, China