

The status of snow leopards *Panthera uncia*, and high altitude use by common leopards *P. pardus*, in north-west Yunnan, China

PAUL J. BUZZARD, XUEYOU LI and WILLIAM V. BLEISCH

Abstract The Endangered snow leopard *Panthera uncia* is a flagship species of mountainous Asia and a conservation priority. China is the most important country for the species' conservation because it has the most potential habitat and the largest population of snow leopards. North-west Yunnan province in south-west China is at the edge of the snow leopard's range, and a biodiversity hotspot, where three major Asian rivers, the Yangtze, Mekong and Salween, flow off the Tibetan plateau and cut deep valleys through the Hengduan Mountains. The snow leopard's status in north-west Yunnan is uncertain. We conducted interviews and camera-trapping surveys to assess the species' status at multiple sites: two east of the Yangtze River and two between the Yangtze and Mekong Rivers. Thirty-eight herders/nature reserve officials interviewed claimed that snow leopards were present, but in 6,300 camera-trap days we did not obtain any photographs of snow leopards, so if the species is present, it is rare. However, we obtained many photographs of potential prey, such as blue sheep *Pseudois nayaur*, as well as photographs of common leopards *Panthera pardus*, at high elevations (3,000–4,500 m). More study is necessary in Yunnan and other areas of south-west China to investigate the status and resource overlap of snow leopards and common leopards, especially as climate change is resulting in increases in common leopard habitat and decreases in snow leopard habitat.

Keywords Climate change, common leopard, *Panthera pardus*, *Panthera uncia*, resource overlap, snow leopard, Three Parallel Rivers World Heritage Site

The snow leopard *Panthera uncia* is categorized as Endangered on the IUCN Red List (Jackson et al., 2008), and China is the most important country for conservation of the species because it has the most potential habitat and the largest population of snow leopards (Snow

Leopard Network, 2014; Alexander et al., 2016a). The north-west of Yunnan province in south-west China is a biodiversity hotspot at the edge of the snow leopard's range (Mittermeier et al., 2004; McCarthy et al., 2016). There is much uncertainty regarding the status of snow leopards in this area, and Riordan et al. (2016) expressed the need for more snow leopard surveys there to assess the validity of distribution maps. During 1950–1999, snow leopards were detected at three locations in north-west Yunnan (Alexander et al., 2016a). However, the IUCN Red List records the species as regionally extinct in Yunnan (Jackson et al., 2008), although Smith & Xie (2008) note that snow leopards are present there. Here we present data from several areas in north-west Yunnan to help clarify the status of snow leopards in this province. Three major rivers, the Yangtze, Mekong and Salween, flow down from the Tibetan plateau into north-west Yunnan, and then run approximately parallel for > 300 km, within a span of c. 100 km, separated by the Hengduan–Shan mountain ranges, with peaks up to 6,740 m. The rivers have created a complex topography, with diverse habitats, and consequently this area is a biodiversity hotspot (Mittermeier et al., 2004) and is designated the Three Parallel Rivers UNESCO World Heritage site (UNESCO, 2010; Fig. 1).

Interviews and camera trapping have been useful in determining the status of snow leopards and other wildlife (e.g. Taubmann et al., 2016; Chen et al., 2017). We conducted semi-structured interviews, using pictures to distinguish between similar species. In autumn 2012 we conducted interviews with herders and nature reserve officials at two study sites between the Yangtze and Mekong Rivers: 23 herders and two officials in the northern area of Baimaxueshan Nature Reserve near Yeri village, and four herders in Guji valley adjacent to Baimaxueshan (Fig. 1). In spring 2013 we conducted interviews with local herders at two study sites east of the Yangtze River: five herders near Langdu village and four herders near Balagezong Nature Reserve (Fig. 1). We also deployed heat/motion-sensing camera traps (Bushnell) near Langdu, Yeri and Guji. We set cameras along wildlife trails or areas snow leopards might use, such as along ridges and mountain passes, and we set cameras singly to maximize the area covered. Near Langdu we set six cameras during June–December 2013 at 4,600–4,800 m altitude. At Baimaxueshan near Yeri we set 15 cameras during December 2012–September 2014 in 41 unique locations at 2,700–5,100 m altitude, and at Guji we set three

PAUL J. BUZZARD* (Corresponding author) and WILLIAM V. BLEISCH China Exploration & Research Society, Southmark Tower B 2707, 11 Yip Hing Street, Wong Chuk Hang, Hong Kong, China
E-mail pbuzzard@dzs.org

XUEYOU LI State Key Laboratory of Genetic Resources and Evolution, Kunming Institute of Zoology, Chinese Academy of Sciences, Kunming, Yunnan, China

*Current address: Detroit Zoological Society, 8450 West 10 Mile Road, Royal Oak, MI 48067, USA

Received 22 December 2016. Revision requested 9 March 2017.

Accepted 8 May 2017. First published online 27 July 2017.

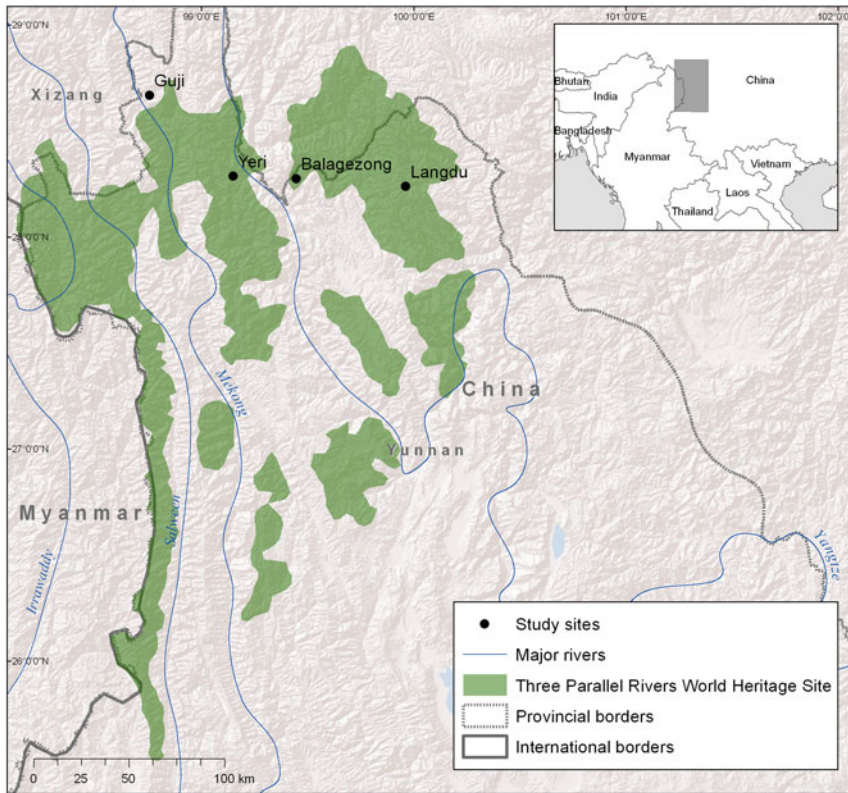


FIG. 1 Location of the Three Parallel Rivers World Heritage Site and the four study sites in north-west Yunnan, China, where interviews and camera-trap surveys were conducted to investigate the status of the snow leopard *Panthera uncia*.

cameras during September 2013–April 2014 at 4,750–4,929 m altitude. Near Yeri we set cameras in four locations 10–19 km apart. Within each of these locations the mean distance between neighbouring cameras was 420 m. At Langdu the mean distance between cameras was 920 m, and at Guji the mean distance between cameras was 440 m.

At all sites the herders and officials interviewed indicated that snow leopards were present but that there was no predation of livestock by snow leopards and no evidence of poaching of snow leopards. The cameras were deployed for 879 camera-days at Langdu, 4,824 camera-days at Baimaxueshan, and 597 camera-days in the Guji valley. We did not record any photographs of snow leopards so it is likely that if snow leopards are present they are rare. However, we did record many images of potential snow leopard prey. We recorded at least 496 blue sheep *Pseudois nayaur* in nine groups of 15–126 individuals, 264 images of the Chinese goral *Naemorhedus griseus*, 16 images of alpine musk deer *Moschus chrysogaster*, three of Chinese serow *Capricornis milneedwardsii*, five of tufted deer *Elaphodus cephalophus* and one wild boar *Sus scrofa*. We considered consecutive photographs of the same species to be independent when there was at least a 1-hour interval between the photographs (Rovero & Marshall, 2009).

At Baimaxueshan three herders and the two officials claimed common leopards *Panthera pardus* were also present, and we recorded 17 images of common leopards at 3,000–4,500 m altitude. It was not possible to determine

how many individuals were photographed because the images were not of sufficient quality to confidently distinguish individuals. Common leopards were poached > 20 years ago, according to herders, who showed several common leopard skins, but there were no reports of recent poaching, and several purported common leopard skins for sale in local tourist shops transpired to be fake. Common leopards are considered to be potential predators of Yunnan snub-nosed monkeys *Rhinopithecus bieti*, which occur at 3,900–4,300 m at Baimaxueshan, but there are no records of predation (Kirkpatrick et al., 1998).

Conservation efforts for snow leopards may benefit other carnivores (Alexander et al., 2016b). Laguardia et al. (2017) reported no records of common leopards in western China at > 4,000 m altitude, but our study shows the need to survey adequately at high altitudes to obtain robust data for both common and snow leopards, especially as common leopards may be rarer than previously thought in China (Laguardia et al., 2017). The abundance of potential prey at our study sites suggests that there is much potential habitat available for both leopard species. In the central Himalaya both species eat similar prey items, and common leopards have shown wide adaptability to diverse habitats at elevations up to 5,000 m (Lovari et al., 2013a,b). Climate change has led to the upward movement of forests and the increase of common leopard habitat at the expense of snow leopard habitat (Lovari et al., 2013b), and snow leopards may adjust their ranging to avoid competition with

common leopards (Ferretti & Lovari, 2016). In several areas of China (Eastern Tibet, Mount Gonggashan, Sichuan and Sanjiangyuan Reserve, Qinghai) camera traps have recorded both snow leopards and common leopards at the same location (Wen, 2016; Yang, 2016; JiaWu Xiong & Tong Zhang, pers. comm.). The Baimaxueshan Management Office is planning long-term camera trapping in alpine and remote areas in the reserve to monitor snow leopards and common leopards and their prey. The data presented here will be valuable for comparison with the findings of this work. More study is also needed in other parts of Yunnan and south-west China to elucidate resource overlap and the potential for competition between the leopard species. This work should include camera trapping and/or genetic analyses (Janečka et al., 2008). Our findings confirm that caution is justified when interpreting interview data on the presence of species (Caruso et al., 2017).

Acknowledgements

We thank Howman Wong, Founder and President of the China Exploration & Research Society, for help with logistics and site access, and local field assistants who helped with field work. We also thank Prof. Jiang Xuelong for guidance, and Kim Williams-Guillén for help with Fig. 1. Funding came from Symrise Inc., Eu Yan Sang International Limited, and a 2013 conservation grant from the Snow Leopard Network. This research was conducted with the necessary approvals and permits from the appropriate institutions in China.

Author contributions

PJB and XL contributed to the study design, conducted fieldwork, and co-wrote the article. WVB contributed to the study design and co-wrote the article.

References

- ALEXANDER, J.S., ZHANG, C., SHI, K. & RIORDAN, P. (2016a) A spotlight on snow leopard conservation in China. *Integrative Zoology*, 11, 308–321.
- ALEXANDER, J.S., CUSACK, J.J., CHEN, P., SHI, K. & RIORDAN, P. (2016b) Conservation of snow leopards: spill-over benefits for other carnivores? *Oryx*, 50, 239–243.
- CARUSO, N., VIDAL, E.L., GUERISOLI, M. & LUCHERINI, M. (2017) Carnivore occurrence: do interview-based surveys produce unreliable results? *Oryx*, 51, 240–245.
- CHEN, P., GAO, Y., WANG, J., PU, Q., LHABA, C., HU, H. et al. (2017) Status and conservation of the Endangered snow leopard *Panthera uncia* in Qomolangma National Nature Reserve, Tibet. *Oryx*, <https://doi.org/10.1017/S0030605316000284>.
- FERRETTI, F. & LOVARI, S. (2016) Predation may counteract climatic change as a driving force for movements of mountain ungulates. *Behavioural Processes*, 129, 101–104.
- JACKSON, R., MALLON, D., MCCARTHY, T., CHUNDAWAT, R.A. & HABIB, B. (2008) *Panthera uncia*. In *The IUCN Red List of*

- Threatened Species 2008*: e.T22732A9381126. <http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T22732A9381126.en> [accessed 25 May 2017].
- JANEČKA, J.E., JACKSON, R., YUQUANG, Z., DIQIANG, L., MUNKHTSOG, B., BUCKLEY-BEASON, V. & MURPHY, W.J. (2008) Population monitoring of snow leopards using noninvasive collection of scat samples: a pilot study. *Animal Conservation*, 11, 401–411.
- KIRKPATRICK, R.C., LONG, Y.C., ZHONG, T. & XIAO, L. (1998) Social organization and range use in the Yunnan snub-nosed monkey *Rhinopithecus bieti*. *International Journal of Primatology*, 19, 13–51.
- LAGUARDIA, A., KAMLER, J.F., LI, S., ZHANG, C., ZHOU, Z. & SHI, K. (2017) The current distribution and status of leopards *Panthera pardus* in China. *Oryx*, 51, 153–159.
- LOVARI, S., MINDER, I., FERRETTI, F., MUCCI, N., RANDI, E. & PELLIZZI, B. (2013a) Common and snow leopards share prey, but not habitats: competition avoidance by large predators? *Journal of Zoology*, 291, 127–135.
- LOVARI, S., VENTIMIGLIA, M. & MINDER, I. (2013b) Food habits of two leopard species, competition, climate change and upper treeline: a way to the decrease of an endangered species? *Ethology, Ecology & Evolution*, 25, 305–318.
- MCCARTHY, T., MALLON, D., SANDERSON, E.W., ZAHLER, P. & FISHER, K. (2016) What is a snow leopard? Biogeography and status overview. In *Snow Leopards* (eds T. McCarthy & D. Mallon), pp. 23–41. Academic Press, London, UK.
- MITTERMEIER, R.A., GIL, P.R., HOFFMANN, M., PILGRIM, J., BROOKS, C.G.M., LAMOREUX, J. & DA FONSECA, G.A.B. (2004) *Hotspots Revisted: Earth's Biologically Wealthiest and Most Threatened Ecosystems*. Conservation International, CEMEX, Mexico.
- RIORDAN, P., CUSHMAN, S.A., MALLON, D., SHI, K. & HUGHES, J. (2016) Predicting global population connectivity and targeting conservation actions for snow leopard across its range. *Ecography*, 39, 419–426.
- ROVERO, F. & MARSHALL, A.R. (2009) Camera trapping photographic rate as an index of density in forest ungulates. *Journal of Applied Ecology*, 46, 1011–1017.
- SMITH, A.T. & XIE, Y. (eds) (2008) *A Guide to the Mammals of China*. Princeton University Press, Princeton, USA.
- SNOW LEOPARD NETWORK (2014) *Snow Leopard Survival Strategy. Revised 2014 Version*. Snow Leopard Network, Seattle, USA.
- TAUBMANN, J., SHARMA, K., UULU, K.Z., HINES, J.E. & MISHRA, C. (2016) Status assessment of the Endangered snow leopard *Panthera uncia* and other large mammals in the Kyrgyz Alay, using community knowledge corrected for imperfect detection. *Oryx*, 50, 220–230.
- UNESCO (2010) Three Parallel Rivers of Yunnan Protected Areas. <http://whc.unesco.org/en/list/1083> [accessed 24 May 2017].
- WEN, C. (2016) *Formulating Principles for Snow Leopard Baseline Survey and Research Technique Regulations*. Presentation at Tianshan Snow Leopard Forum August 24–26, 2016. Shan Shui Nature Conservation Centre, Beijing, China.
- YANG, C.M. (2016) *Research on and Conservation of Snow Leopard in Gong Ga Shan*. Presentation at Tianshan Snow Leopard Forum August 24–26, 2016. Gong Ga Shan National Nature Reserve Management.

Biographical sketches

PAUL BUZZARD's work focuses on protected area management and wildlife monitoring with remote sensing technology. XUEYOU LI works on the behavioural ecology and status of ungulates and carnivores in south-west China. BILL BLEISCH focuses on protected area management and the sustainable engagement of local communities.