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Status of the saker falcon in China

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In line with the "ecosystem approach" of the Convention on Biological Diversity (CBD) (Secretariat of the Convention on Biological Diversity, 2004) toward recognizing the service value in maintaining the essential balance of biodiversity, there has been a conceptual shift toward conservation frameworks that integrate a wider range of dedicated conservationists (Pearson, 2016). In this paper, we explore the saker falcon *Falco cherrug* (hereafter saker) to illustrate how intrinsic service and cultural values within this conceptual paradigm enhance its conservation.

BirdLife International (2020) estimates a global population of 10,500 breeding pairs (bp) of sakers distributed across the Palearctic, but the species is classified as globally endangered on the International Union for Conservation of Nature (IUCN) Red List due to a rapid population decline in Central Asia. Mongolian Plateau and Qinghai-Tibetan Plateau (QTP) support the majority of global breeding sakers (Kovács et al., 2014), with 25%–50% of the global population residing on the QTP in winter (Dixon et al., 2015). However, accurate population estimates are not available for Mongolia and China, which are the two countries that hold the largest national breeding population of sakers.

We searched scientific literature on Google Scholar (https://scholar.google.com/) using the keywords "saker falcon", "*Falco cherrug*", and its Chinese name, we also searched the China National Knowledge Infrastructure database (https://www.cnki.net/) using its Chinese name to obtain relevant publications dating from 1989 to 2019. There were only five Chinese saker studies dating from 1989 to 1999. In contrast, since 2000, the search returned 188 publications, of which 38 focused on China, spanning ecology, conservation, health, genetics, behavior, and culture (Figure 1). The continuous attention of researchers has contributed to the discovery of the importance of China to saker conservation.

Conservation and ecology studies, which have elucidated important data on saker populations and threats to the species, account for more than half of the publications on sakers in China (60%). The abundance of sakers in China is attributed to large areas of semi-desert, steppe, and plateau, which provide suitable habitats for breeding and wintering sakers (Sutton and Puschendorf, 2020). Based on observations from Xinjiang and Qinghai, Dixon (2009) suggested that the overall Chinese breeding population of sakers was likely to be 3,000–5,000 bp, although this estimate was drawn from limited field surveys and an absence of quantitative data. An estimate of 1,000–2,000 bp for the Chinese saker breeding population was used for an IUCN Red List review in 2012, which was calculated based on a retrospective estimate of 3,000–7,000 bp in 1990 (Moshkin, 2010) and the assumption that the Chinese population had declined by 3.0–3.5 times. Overlooking the circularity of this approach, BirdLife International (2020) concluded that the

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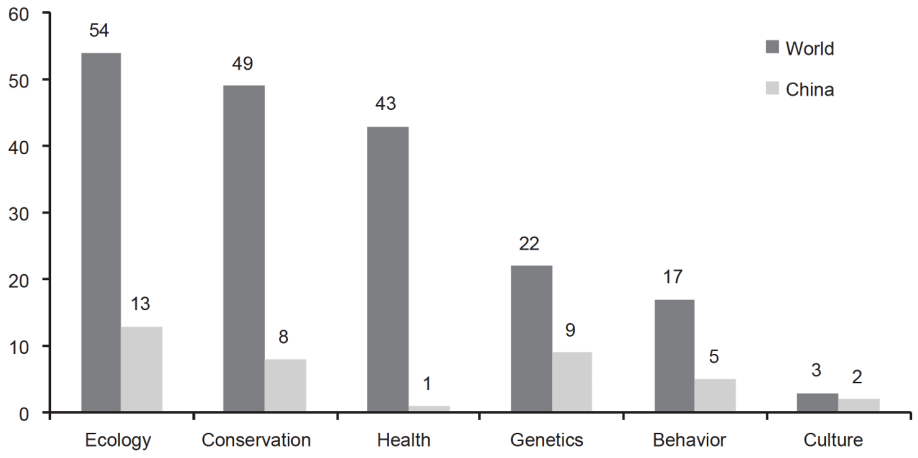

Figure 1 Saker-related publications since 2000, categorized by subject. Studies produced by Chinese researchers or including a significant reference to sakers in China are represented separately.

Chinese population declined by 39% (median over three generations). The decline rate of Chinese population is considered similar to the average rate in Russia and Kazakhstan. In addition, given the uncertainty of population estimates used, BirdLife International (2020) precautionarily estimated that the global population declined by at least 50% over three generations. In summary, population size estimates for sakers in China (Table S1 in Supporting Information) are few and limited in scale and reliability.

Nevertheless, recent evidence confirmed that the QTP was the most important area for sakers in China. Based on previous qualitative descriptions of species abundance on the QTP, Baumgart (1978) postulated that 15,000–20,000 bp in this region was not an unreasonable estimate. Potapov and Ma (2004) estimated a density of 2.3 bp per 1,000 km^2 across a survey area of 1,811 km^2, while Dixon (2009) noted that a conservative breeding density of 1 bp per 1,000 km^2 would equate to approximately 2,500 bp on the QTP. However, breeding surveys in eastern Qinghai in 2007 revealed a higher mean breeding density of (5.2±2.2) bp per 1,000 km^2, which indicated that the plateau population exceeded the maximum of 5,000 bp estimated for China as a whole (Dixon et al., 2015).

There were nearly twice as many genetic studies of sakers in China (21%) compared with international studies (12%). International publications by Chinese researchers pertained to establishing genetic markers, genetic population structuring, and the application of genomic data to evolutionary studies (e.g., Zhan et al., 2013), which heralded the era of conservation genomics for sakers. More recently, the effective population size (*Ne*) was estimated for the QTP population based on the transcribed saker genome (Pan et al., 2017). Using two different modeling approaches, the range of *Ne* was calculated as 8,177 to 52,868, which was equivalent to an estimated breeding density of 1.6–10.6 bp per 1,000 km^2. These modeled estimates were congruent with observed breeding densities in the QTP survey areas. Despite its global importance, knowledge of saker population distribution, size, and trends is poorly understood in China, with little information reported for several provinces within the saker distribution range (e.g., Gansu, Shanxi). Therefore, targeted surveys in these provinces and systematic long-term monitoring in key areas of the saker distribution are urgently needed.

We used a classification of direct threats (Salafsky et al., 2008) to define threats to sakers in China. This classification utilizes standardized nomenclature to describe threats in a hierarchical system. Main threats to sakers in China include trapping sakers for falconry and pest control of prey species, along with electrocution by power lines (Table S2 in Supporting Information).

Illegal poaching and smuggling of sakers in Xinjiang have been traced to the early 1990s, with a rapid increase in these activities during the next decade based on the data of illegally captured sakers confiscated by the forestry administration and customs offices (Li et al., 2000). Liu et al. (2019) reported that more than 2,000 sakers were involved in 76 criminal cases from 1993 to 2016, while the mean number of sakers per case reduced from 77 (3.3 cases per annum) to just 10 (3.0 cases per annum) after international air and border security regulations were tightened in 2001. We searched the UNEP-WCMC CITES trade database to obtain records of legal exports of saker from 1981 to 2019 (Table S3 in Supporting Information). From 1993 to 2016, 40 export shipments involving 622 sakers from China were recorded. Since there are no captive breeding facilities in China, the exported sakers were assumed to be wild-caught birds. Most were exported to Gulf States, predominately in Saudi Arabia and UAE.

The use of rodenticides as “pest” control of small mammalian herbivores in the steppes of northern China and QTP threatens an important food resource for sakers inhabiting

grassland and desert ecosystems. The use of rodenticides may reduce the carrying capacity of habitats at local scales for predatory species and harm non-target predators through secondary poisoning.

Biological resource use, including harvesting of sakers for falconry and control of their prey species, presents the greatest threat to saker conservation in China. Chinese authorities are enforcing legislation that prohibits the illegal trade of sakers, which has progressively reduced the scale of trafficking, indicating success in prohibiting organized criminal networks (Table S4 in Supporting Information). The use of rodenticides to control small mammal pests in rangeland ecosystems affects sakers directly and indirectly through poisoning and reduction in prey availability. Alternative ecological pest management options adopted in China include artificial nests and perches in open grasslands to attract raptors that prey on small mammals. Artificial nests increase saker breeding populations in nest-site limited habitats with abundant prey, facilitate nest monitoring, and improve nesting success. It is a promising measure of stewardship in saker conservation in China.

Electrocution risk for raptors is particularly high at power lines in open landscapes with abundant prey, and saker electrocution has been recorded at power lines in western China (Dixon et al., 2013). Though targeted remediation can mitigate the risk of electrocution at dangerous poles, such measures have not been implemented in China. In view of the global significance of saker populations in China, necessary retroactive actions should be taken to mitigate electrocution risk at existing lines and to ensure that new lines are constructed for bird safety.

Table S2 (Supporting Information) lists secondary threats to sakers in China, which include energy production and mining, agriculture, and anthropogenic disturbance that result in the loss of habitat, negative impacts on habitat use, and effects on prey species. China is also seriously affected by desertification, mostly in the steppe and grassland ecosystems of northern and western provinces, which may reduce the quality and extent of saker habitats. Moreover, climate change (e.g., temperature, Zhang et al., 2019) could impact sakers. Recent saker studies in China coordinated by the Institute of Zoology, Chinese Academy of Sciences, including conservation agencies in Abu Dhabi, UAE, Mongolia, Russia, Slovakia, Moldova, Kazakhstan and the UK, etc., provide an example of an international collaborative approach to preserve the cultural value of falcons. Falconers in UAE have placed significant cultural value on the saker, which has underpinned funding and co-ordination of saker surveys and research in Xinjiang and Qinghai (e.g., Dixon et al., 2015), which are integrated with genetic research on sakers in China (e.g., Zhan et al., 2013). Chinese researchers have paved the way for using a genomics approach for saker conservation, which can be applied to future studies of saker population size, trends, and genetic structures within China and globally. Genomics approaches have been widely applied to studies on fishes (He et al., 2019), plants (Bai, 2019), and viruses (Zhang and Gui, 2018), which have contributed to the conservation and management of wildlife (Wei et al., 2019). With adequate sampling and appropriate analysis, it is possible to use genomic data to elucidate current and historical effective population sizes of a species (Pan et al., 2017).

Saker conservation in China can draw upon intrinsic, service, and cultural values of the species to adopt management strategies within the framework of the CBD's "ecosystem approach" under the China National Biodiversity Conservation Strategy and Action Plan (NBSAP). Mainstream biodiversity conservation in decision making and management at all levels of the government is a critical component of the NBSAP strategy. As a signatory party to the Convention on the Conservation of Migratory Species of Wild Animals, China has an important role in the implementation of the Saker Falcon Global Action Plan (Kovács et al., 2014), particularly through concentrated efforts to integrate research, establish conservation policies, implement ecologically based pest control in rangeland management, and engage in coordinated conservation activities with a wider range of international parties.

Compliance and ethics *The author(s) declare that they have no conflict of interest.*

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SUPPORTING INFORMATION

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