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The Black-necked Cranes of the Longbao National Nature Reserve, Qinghai, China

Current Status and Conservation Issues

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*This study is the first to have surveyed the population of black-necked cranes (*Grus nigricollis*) at the Longbao National Nature Reserve, Qinghai, China, throughout most of the 7.5 month annual crane residence period, with 17 crane counts having been made on the reserve's main wetland between 6 April and 16 November 2011. In 2011, the first cranes are believed to have arrived at Longbao at the end of March, and the last are believed to have departed between 7 and 11 November. The peak adult black-necked crane count was 216 on 25 April, while the low count was 81 on 23 October, which increased to 153 during migration staging on 6 November. This represents a 9-fold increase in the peak annual adult crane count since the earliest known count from 1984. Twenty-nine nests were observed in the survey area in May and June, and on 12 September 2011, 21 of 29 nesting pairs had surviving chicks, with 9 crane pairs having a pair of surviving chicks, while 12 crane pairs had a single surviving chick. Threats to cranes at Longbao include untied dogs, which harass breeding cranes, eat eggs, and kill chicks; recently erected power lines along the wetland, which may prove hard for cranes to see and avoid; and disturbance of nesting cranes from humans and their livestock. Other threats include climate change, which is drying up shallow wetlands in the Longbao region and elsewhere on the Tibetan Plateau, and severe degradation of hillslope pastures, which is forcing local herders to keep their yaks on the main wetland pastures for longer periods each year and will inevitably cause increased disturbance to cranes and further degradation of the wetland. The Longbao Wetland presently qualifies for Ramsar designation based on its black-necked crane population under Ramsar Criteria 2 and 6.*

Keywords: *Black-necked crane; Longbao Wetland; Qinghai; Tibetan Plateau; nomadic herding; overgrazing; climate change; Ramsar.*

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Introduction

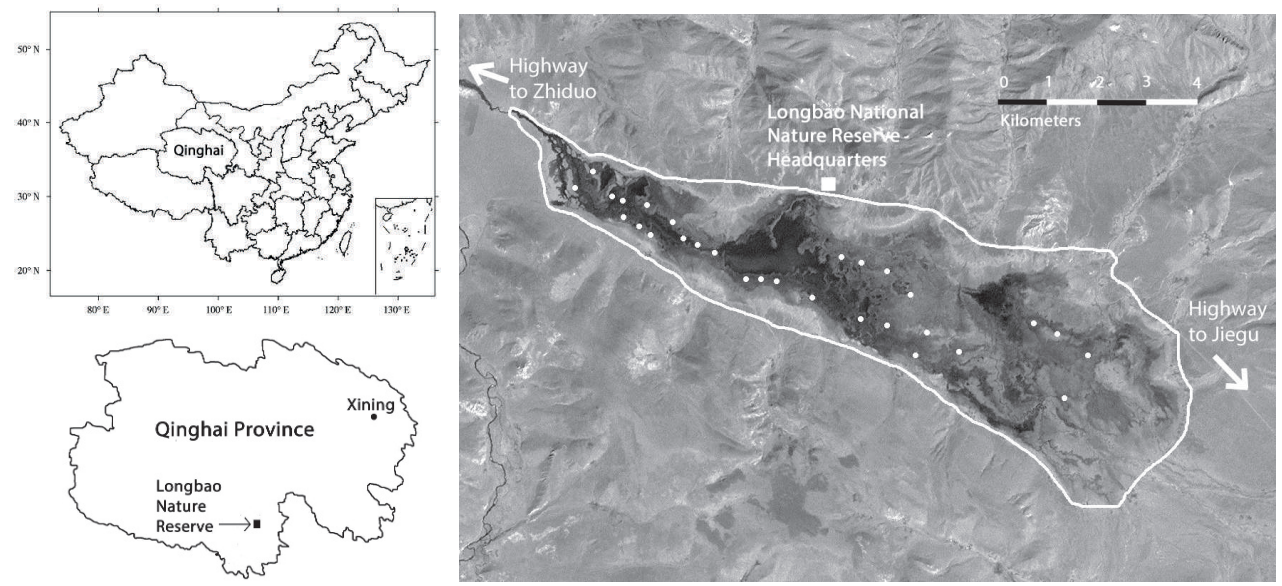
The black-necked crane (*Grus nigricollis*) is the only species of crane that breeds exclusively on the high-altitude wetlands of the northern, central, and western Tibetan Plateau, while spending winters amongst wetlands and agricultural fields in China's southern Tibet Autonomous Region (TAR), northwest Yunnan Province, and western Guizhou Province, as well as in Bhutan (Bishop 1996; BLI 2001). The most recent estimate of the total population of black-necked cranes was placed at 11,000, with 6940 black-necked cranes having been counted in January 2007 in the Yarlung Tsangpo (Brahmaputra) basin in the southern TAR, 3562 in total counted in January 2004 in northwest Yunnan and western Guizhou Provinces, and 462 counted from 2006–2007 in Bhutan (Bishop and Drolma 2007). The species is classified as vulnerable by the International Union for Conservation of Nature (IUCN) due to its single small population, the widespread loss of wetlands throughout its range, and changing agricultural practices on its wintering grounds that have reduced the supply of waste grain, for example, immediate autumn plowing of fields and conversion of barley fields to greenhouse agriculture (Bishop et al 2000; BLI 2012).

While observed in groups as large as 330 in winter, in summer black-necked cranes are widely dispersed on their northern breeding grounds (Bishop 1996; Bishop and Drolma 2007). However, several black-necked crane breeding sites do have relatively high concentrations of cranes in summer, the three most important known breeding sites being: (1) the Ruoergai (Tibetan: *Zoige*) Marshes of northern Sichuan Province, with an estimated black-necked crane population: 2500; (2) the TAR's Shenzha (Tibetan: *Shainza*) County and the Seling Lake Black-necked Crane National Nature Reserve (no accurate population estimate available); and (3) the Longbao (Tibetan: *Rongpo*) National Nature Reserve, with an estimated population of about 114 (see following) (Bishop 1996; BLI 2001; Liu et al 2009).

In 2011, 25 years after the establishment of the Longbao National Nature Reserve, we undertook a study

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FIGURE 1 National Aeronautics and Space Administration (NASA) Landsat image of the Longbao Wetland, Yushu County, Qinghai. White line: black-necked crane survey route. White rectangle: Longbao Nature Reserve Headquarters. White dots: location of 29 known black-necked crane nests on the main Longbao Wetland in the spring of 2011. (Image source: Landsat.org)



to assess the current status of and habitat use by black-necked cranes at Longbao over the species' roughly 7.5 month annual residence period at the wetland, the findings of which are discussed herein. In addition, in order to identify potential threats to cranes and crane habitat, the study also undertook a preliminary examination of human land-use practices on the Longbao Wetland, which at present are largely limited to grazing yaks and other livestock. Major goals of the study were to systematically collect baseline data for use in developing an effective management plan for the reserve and to see if the site qualified for designation as a Ramsar Wetland of International Importance.

Study site

The Longbao National Nature Reserve (33°11′N; 96°35′E) was established in 1986 and has an area of about 100 km^2 covering valley bottom wetlands and meadows. The reserve is located about 50 km northwest of Jiegu (Tibetan: *Jyekundo*), the Yushu County seat, lying just south of the highway connecting Yushu and Zhiduo (Tibetan: *Zhidoi*) Counties. The reserve's primary area of ecological importance is a wetland that is approximately 14 km long with a maximum width of about 3.5 km (Figure 1). The maximum depth of the wetland is reported to be about 4 m, but most of the wetland is generally much shallower. This wetland lies at an elevation of about 4200 m in a broad mountain valley flanked by ridges that typically rise up to 750 m above the wetland. The wetland is fed by groundwater, streams, precipitation, and snowmelt, and it drains into the Yi Chu River to the northwest, a short tributary of the nearby Tongtian (Yangtze) River.

Ecosystems in the reserve are primarily a mix of wet and dry *Kobresia*/*Carex* sedge grass meadows, but they also include aquatic ecosystems such as lakes, ponds, marsh, and riparian corridors (Li and Zhou 1985; Li and Li 2005). Some limited willow (*Salix* sp) shrublands occur on hillslopes along the southwest side of the wetland. In addition to one of the densest populations of breeding black-necked cranes known to exist, the wetland is also an important stopover and breeding site for a variety of other migratory waterfowl, the most numerous of which are the bar-headed goose (*Anser indicus*), ruddy shelduck (*Tadorna ferruginea*), and ferruginous pochard (*Aythya nyroca*). Frequently seen mammals at the wetland include the Tibetan sand fox (*Canis ferrilata*), red fox (*Canis vulpes*), Himalayan marmot (*Marmota himalayana*), wooly hare (*Lepus oiostolus*), and black-lipped pika (*Ochotona curzoniae*).

In addition, the entire Longbao Nature Reserve is grazed by livestock. There are presently about 150 yak-herding households residing on or within 1 km of the perimeter of the main Longbao Wetland, which are all heavily reliant on the wetland's pasture resources for grazing much of the year. Large tracts of the main wetland have been divided into individual household pasture allotments, and since 1997, these single-family allotments have been fenced off. The remainder of the wetland consists of larger, partially fenced pastures that are used collectively by groups of families.

Black-necked cranes arrive at the Longbao Wetland each year in late March or early April and depart in late October or early November, with arrival and departure dates believed to vary according to such factors as weather, availability of food, and readiness of chicks to

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TABLE 1 Summary of known black-necked crane counts at the Longbao Wetland.

Source	Date	Adults[a)]	Chicks	Combined total
Li and Zhou (1985)	July 1984	24	5	29
Li and Ma (1989)	7 May 1988	28	0	28
Wong (2002)	Spring 1994[b)]	≥40	0	≥40
Wong (2002)	May 1996	75–80	0	75–80
Li (2004)	July 1998	?	?	108
Ma (2003)	15–16 May 2003[c)]	8–10	0	8–10
Longbao Reserve	2006[d)]	?	?	≥150
This study	28 October 2010[e)]	≤112	≥6	118
This study	25 April 2011[f)]	216	0	216
This study	20 April 2012[g)]	178	0	178

[a)]The "Adult" category includes both mature breeding cranes and returning nonbreeding juveniles.

[b)]This figure is based on a count of 20 crane nests, not a complete wetland crane count.

[c)]This count was made along the Yushu-Zhiduo Highway on the north side of the wetland only. At the time, the highway was undergoing a period of heavy road construction.

[d)]This figure is not a piece of recorded data but based on the collective memory of the reserve staff.

[e)]This count was made without a spotting scope; thus, the chicks were probably undercounted.

[f)]High count for 2011 only; also see Table 2.

[g)]High count for 2012 only; also see Table 2.

undertake migration. Some of these cranes use shallow areas of the wetland as a breeding ground, while others simply stopover en route to other sites during both the spring and autumn migrations. The only previous detailed studies on black-necked cranes conducted at the Longbao Wetland were done by Li and Zhou in 1984 (Li and Zhou 1985) and by Li and Ma in 1988 (Li and Ma 1989), with both of these studies focusing on the crane's breeding behavior. Peak counts of black-necked cranes made at Longbao during the course of these studies were (1) 24 adults and 5 chicks in 4 families in July 1984, and (2) 16 returning nonbreeding juveniles and 6 breeding pairs in May 1988 (Li and Zhou 1985; Li and Ma 1989). Wong reported 20 black-necked crane nests at Longbao in 1994 and 75 to 80 adult black-necked cranes at Longbao in late May 1996, including 25 nesting pairs (Wong 2002). An additional count from the records of the Longbao Nature Reserve found 108 black-necked cranes at the reserve in July 1998 (Li 2004). Unfortunately, as a result of the 14 April 2010 Yushu earthquake, which devastated the city of Jiegu and surrounding region, there do not appear to be any surviving black-necked crane count data for the first decade of the 21st century at Longbao. However, in 2003, in the midst of heavy road construction work on the new Yushu-Zhiduo Highway, only "4 or 5 pairs" were sighted, while the staff of the reserve are in general agreement that there were at least 150 cranes at Longbao during the 2006 crane residence period (Table 1) (Ma 2003).

Far less is known about black-necked crane migration routes to, from, and stopping over at Longbao, which at present is limited to a single repeat sighting of a black-necked crane banded at Longbao. This bird, 1 of 8 black-necked cranes banded at Longbao between 1987 and 1988, was banded on 25 June 1988 and sighted again on 14 November 1988 at the Napahai Wetland in Zhongdian County, Yunnan Province (Wu et al 1993; Li and Li 2005). However, 5 black-necked cranes mounted with satellite tracking transmitters at Napahai in 2009 all proceeded to summer in western Sichuan (Liu et al 2012).

Material and methods

In preparation for the present survey, on 28 October 2010 a cursory, "binoculars-only," practice count of cranes at Longbao was conducted by circling the main wetland by car, in the course of which 118 black-necked cranes were counted, including 55 cranes in a single group and at least 6 chicks (Table 1). This practice count established the basic survey methodology for the 2011 survey, which consisted of driving clockwise the entire way around the perimeter of the main Longbao Wetland, a driving distance of about 35 km. This survey circuit started from the Longbao Nature Reserve headquarters and generally involved counting the adult black-necked cranes, their nests, and chicks born in 2011 at each of 22 set survey points that were established at

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TABLE 2 Counts of black-necked cranes, nests, and chicks; common cranes; and livestock in the main Longbao Wetland in 2011 and 2012. (Table continued on next page.)

Survey transect date	Survey transect route	Adult black-necked cranes	Number of nests	Number of chicks	Adult common cranes	Number of yaks	Number of sheep and goats
2011							
2011.04.06	Entire wetland loop	130	0	0	6		
2011.04.12	Entire wetland loop	135	0	0	7	3393	238
2011.04.18	Entire wetland loop	144	0	0	14		
2011.04.25	Entire wetland loop	216	0	0	5		
2011.05.05	Entire wetland loop	156	6	0	12		
2011.05.12–13	Entire wetland loop	125	7	0	8	5357[a)]	764[a)]
2011.05.27	Entire wetland loop	103	29	0	2		
2011.06.03	Entire wetland loop	109	29	1	5		
2011.06.08	Entire wetland loop	129	28	6	6	1268	84
2011.07.04	Entire wetland loop	102	6	31	0	3152	388
2011.07.28	Entire wetland loop	115	0	43	1	3535	
2011.09.12	Entire wetland loop (21 of 22 points only)	88	0	30	3		
2011.09.26	Entire wetland loop (21 of 22 points only)	88	0	31	0	1784	505
2011.10.09	Entire wetland loop (21 of 22 points only)	100	0	34	0		
2011.10.23	11 survey points on north side of the wetland only	81	0	28	0	1962	244
2011.11.06	11 survey points on north side of the wetland only	153	0	24	0		

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TABLE 2. Continued. (First part of Table 2 on previous page.)

Survey transect date	Survey transect route	Adult black-necked cranes	Number of nests	Number of chicks	Adult common cranes	Number of yaks	Number of sheep and goats
2011.11.16	Entire wetland loop	0	0	0	0	3804	241
2012							
2012.04.20	Entire wetland loop	178	0	0	7		
2012.06.30	Entire wetland loop	128	3	21	6	1277	

[a)]These livestock counts were made on 11 May 2012.

good viewing locations giving full coverage of the wetland (Figure 1). No distinction was made between breeding adults and returning nonbreeding juveniles when counting, with all being counted simply as adults. Nevertheless, the number of breeding adults can be estimated from the number of nesting sites counted. In order to gauge seasonal changes in grazing pressure on the wetland, domestic yaks present on the wetland were counted about once per calendar month during the course of the survey.

In total, 17 survey circuits were conducted between 6 April and 16 November 2011 by a rotating team of 4 counters using both binoculars and spotting scopes. Notably, however, the 12 and 26 September and 9 October counts were only made at 21 of the 22 set survey points, while due to snow covering the jeep track south of the wetland, the 23 October and 6 November counts were conducted from the 11 points on and/or near the Yushu–Zhiduo Highway on the north side of the wetland. No count was made during the month of August. The transect loop was bounded roughly by the Longbao Monastery at the eastern end of the Longbao Wetland and the concrete bridge over the outflow river at the west end of the main wetland. In general, the entire circuit was counted in 1 day, although one circuit was divided between 2 days (Table 2). In 2012, 2 follow-up survey circuits of the wetland were conducted on 30 April and 30 June.

Results

Survey results are summarized in Table 2. The peak 2011 count of adult black-necked cranes (including returning nonbreeding juveniles) at Longbao was 216 individuals counted on 25 April 2011. However, this number quickly fell by nearly half in May, with the average of 6 counts conducted between 12 May and 28 July being just 114 adult cranes (Table 2). This suggests that in addition to being the location of one of the densest concentrations of breeding black-necked cranes known to exist, the Longbao Wetland is also an important stopover site for migrating black-necked cranes bound for other breeding sites in Qinghai and perhaps Gansu Province.

Locations of black-necked crane nests on the main Longbao Wetland in 2011 are shown in Figure 1. In total, there were 29 crane nests counted within the survey area on the main wetland, while an additional crane nest was found on a river within the reserve boundaries some 13 km northwest of the reserve headquarters, well beyond the area covered by this survey. These nesting sites were concentrated in the wetter sections of the main Longbao Wetland, particularly in the western and central parts of the wetland. In these areas, cranes generally nested on grassy mounds or islands in water less than 50 cm deep, presumably as protection against predators that would have to splash through water to reach these nests, in the process alerting breeding cranes to approaching danger (Li and Ma 1989). Notably, however, most large groups of cranes (10–55 individuals) were sighted in the higher, drier eastern end of the reserve, which seems to be a preferred feeding area for nonbreeding cranes and cranes stopping over on migration.

In 2011, the crane nesting period at Longbao appeared to start at the beginning of May, and it continued over about a 2 month period until early July, with the peak of nesting occurring in late May and early June. Crane chicks began to be sighted in early June. Observations indicate that breeding cranes stayed on or near their nesting territories until just before departing on autumn migration, although this requires further research to confirm.

In terms of reproductive success, in 2011, the peak count of crane chicks was 43 on 28 July 2011; this total had fallen to 30 surviving chicks on 12 September 2011—presumably well before the expected arrival of southward-migrating black-necked cranes in October. Thus, the survival rate of black-necked crane chicks at Longbao in 2011 appeared to average about 1 chick per nesting pair, although of the 30 surviving young there appeared to be 9 crane families with a surviving pair of chicks and 12 crane families with an individual surviving chick, or 21 of 29 breeding pairs with offspring that had

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survived up to the end of summer. This makes for a chick recruitment rate of 34% based on the counts of 12 September 2011 (Table 2). Reproductive success appears to have declined steeply in 2012, with only 21 black-necked crane chicks having been counted at Longbao on 30 June 2012.

While there was an average of 114 adult black-necked cranes present during the 12 May–28 July counts, only 88 adult cranes were seen during the count of 12 September 2011. However, between 23 October and 6 November, the total number of adult black-necked cranes at Longbao increased from 81 to 153, presumably with the return of cranes from locations in northern Qinghai en route to winter sites, although this will need to be confirmed through banding and satellite tracking studies.

The only previously published arrival date for black-necked cranes at the Longbao Wetland was 10 March 1996 with the cranes' usual departure date during this period said to be "around October 20" (Wong 2002). In terms of the arrival date of black-necked cranes at Longbao in 2011, when the survey team first reached the wetland on 5 April, there were already large numbers of black-necked cranes present, with 130 counted the following day. However, black-necked cranes were recorded as arriving at the Naren Wetland in Gangcha County on the north shore of Qinghai Lake, some 550 km to the northeast of Longbao, on 3 April 2011. So it is fairly safe to assume that black-necked cranes arrived at Longbao perhaps several days earlier. As for their departure date, 153 adult black-necked cranes and 24 chicks were counted on 6 November 2011 at Longbao, which was presumably during a short pre- or midmigration staging period. No cranes were sighted during partial observations made along the highway past the wetland on 12–13 November, and no cranes were sighted during a full circuit of the wetland made on 16 November. Therefore, it is assumed that in 2011, the last black-necked crane departed Longbao sometime between 7 and 11 November. In 2012, the Longbao Reserve staff did record the arrival and departure dates of black-necked cranes at the wetland, which were 25 March and 3 November, respectively.

Also of note, the peak count of common cranes (*Grus grus*) at the Longbao Wetland in 2011 was 14 counted on 18 April (Table 2). No common cranes were observed nesting at Longbao, and in 2011, the species appeared to use the wetland only as a migration stopover site, primarily in spring, with only 3 common cranes counted during the autumn migration.

Livestock grazed on the Longbao Wetland consists predominantly of yaks, although some families continue to keep a small number of sheep and goats, as well as a few horses, on the wetland. In 2011, the peak counts of yaks and combined sheep and goats were 5357 and 764, respectively, made on 11 May 2011, which, incidentally, coincides with the peak period of nest building for cranes on the wetland. In 2011, low counts for the same livestock categories were 1268 and 84, respectively, made on 8 June 2011 (Table 2).

Discussion

Increases in crane numbers

The staff of the Longbao Nature Reserve attribute the quadrupling of the summer adult black-necked crane population at Longbao since the 1980s to improved protection of cranes, and especially crane eggs, following establishment of the nature reserve in 1986. While formerly locals collected crane and other waterfowl eggs, particularly bar-headed goose eggs, for personal consumption, this practice was strictly banned with creation of the reserve in 1986, permitting a higher rate of reproductive success for the affected waterfowl species. However, there have no doubt been a variety of other factors that have contributed to the dramatic increase in Longbao's crane population over the past 25 years. Arguably the most important is perhaps the improved protection of the black-necked crane throughout the species' range, including both its summer breeding and wintering grounds. This has been achieved in large part through the establishment of a series of nature reserves specifically for the protection of black-necked cranes, such as the Napahai (established 1984), Dashanbao (established 1990), and Huize (established 1990) Nature Reserves in Yunnan (Yu 2004; DNR 2012; Chou and Yang 2012; Wu et al 2013, in this issue). At the same time, the large-scale poaching of wildlife on the Tibetan Plateau, which was rampant through the end of the 1990s and which included black-necked cranes, has largely been brought under control through improved law enforcement (eg see Wright and Kumar 1997; Wong 2002). Nevertheless, MaMing et al (2012) report that waterfowl continue to be hunted on a large scale in China. Although few details are provided, he and his coauthors have compiled records of 5 species of cranes having been killed by poachers between 2009 and 2012, including 3 black-necked cranes.

Although highly speculative, other factors that may have contributed to an increase in crane numbers at Longbao include increased grazing pressure on the wetland and climate change. Interviews with local herders have shown that over the past 2 decades, the hillslope pastures surrounding the Longbao Wetland have become severely degraded. Large areas of these upland pastures now suffer from "black beach" erosion, in which large areas of the turf layer have completely eroded away, laying bare low-productivity, highly erodible, mineral soils. In all likelihood, this is probably largely the result of earlier overgrazing damage caused by overstocking of livestock during the collective period from the 1960s to the 1980s. Although herders at Longbao have slashed their livestock holdings in recent years, this pasture degradation persists. At the same time, while most

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herders residing around the main wetland formerly moved their livestock to distant highland summer pastures from about June to early September each year, today many herders have discontinued use of remote summer pastures or only use these pastures for shorter periods. This has resulted in increased grazing pressure on the wetland and surrounding hillslopes as herders leave their livestock on these pastures for longer periods annually. The staff of the Longbao Nature Reserve even reported that some families are now leaving their livestock on the Longbao Wetland for 10–12 months per year.

One consequence of overgrazing and recent changes in herding practices is that, due to increased grazing pressure, and also possibly climate change effects (see below), herders report that vegetation on the wetland and surrounding hillslopes is now much shorter growing than in the past. One herder illustrated the situation by saying that formerly the grass reached their stirrups when riding on horseback but is now typically no more than knee high when standing. In general, black-necked cranes prefer habitat with good views of possible approach routes of predators, and planting of trees and willows along riparian corridors can make these areas unsuitable for cranes (Bishop et al 2000). The same may be true of tall grass, which has largely been eliminated at Longbao through intensive grazing. Thus, the elimination of tall grass meadows on the Longbao Wetland may have actually increased the area of habitat suitable for cranes, although this would need further research to prove, such as a multiyear grazing exclosure experiment at the wetland.

A second factor, again highly speculative, that may have contributed to increased crane numbers on the Longbao Wetland is climate change. Climate change impacts on the central Tibetan Plateau over the past few decades have included the widespread loss of shallow, permafrost-controlled wetlands, since, as temperatures rise, the upper surface of the permafrost layer melts, allowing surface water to percolate into the ground (eg see Wang et al 2006; Farrington 2009; Qiu 2012). One remote-sensing-based study found that in a 9252 km^2 research area in the Longbao region, between 1990 and 2004 the area of wetlands declined from 527.217 km^2 to 454.119 km^2, a rate of decrease of 4.873 km^2/y (Ma et al 2009). Ma and coauthors believe that the disappearance of these wetlands is due to rising temperatures in the Longbao region and the subsequent degradation of permafrost and increased rates of evaporation that have resulted. Meanwhile, it has also been reported that the areas of alpine wetlands and high-vegetation-cover alpine meadows on the Tibetan Plateau have decreased in recent decades by 37% and 16%, respectively, which is believed to be largely a result of permafrost degradation (Qiu 2012).

Given this situation, it is entirely possible that black-necked crane numbers at the larger, more resilient Longbao Wetland have increased in part simply because many other shallow wetlands formerly used by cranes in the Longbao region have dried up. Climate change may also be contributing to the decline of tall-growing grasslands at the Longbao Wetland, since as permafrost degrades and the water table is lowered, the top soil layer ceases to be saturated, and ecosystems are slowly transformed from tall-growing wet meadows to shorter-growing dry meadows (Wang et al 2006). At the same time, climate change has no doubt exacerbated overgrazing damage on hillslopes surrounding the wetland, such as by causing a widely reported increase in the intensity of precipitation in the region in recent years, which is presumably accelerating the erosion of degraded hillslope pastures in the Longbao Basin. Again, this widespread pasture erosion is forcing affected households to leave their livestock on the more resilient wet meadows of the main Longbao Wetland for longer periods each year. In turn, this increased grazing pressure in itself could be leading to shorter-growing vegetation cover, increased ground heat absorption, and further permafrost degradation (eg see Qiu 2012).

Notably, increases in the black-necked crane population at Longbao closely parallel those that have occurred at the much larger Ruoergai Wetland in northern Sichuan, in spite of the well-documented degradation that has occurred from overgrazing and draining of wetland pastures at that wetland in recent decades (eg see Yan and Wu 2005; Zhu et al 2009). At Ruoergai, Scott (1993) estimated there to be 600–900 black-necked cranes present in late May and early June of 1991, while He and Zhao placed this figure at 710 in 1999 (Scott 1993; He and Zhao 1999). However, by the summer of 2009, black-necked crane numbers at Ruoergai appear to have more than tripled to an estimated 2600 (Liu et al 2009; Li 2010).

Current threats to cranes

While the black-necked crane population at Longbao has clearly thrived since creation of the Longbao Reserve, several threats to cranes persist at Longbao. Threats to cranes and their eggs include the red and Tibetan sand foxes that are frequently seen on the Longbao Wetland, as well as untied and feral herder dogs, which are also known to kill birds and eat eggs on the wetland. While predation of crane eggs and chicks by foxes should be viewed as a natural part of ecosystem functioning at Longbao, the fencing off of the wetland since 1997 may create barriers for crane chicks trying to flee both foxes and dogs until such time as they have fledged. However, the issue of fencing impacts on predation of crane chicks has yet to be examined. Untied and feral herding dogs continue to be regularly sighted on the wetland, with six having been counted on the wetland on 23 October 2011, although dogs are obviously only a threat to eggs and unfledged crane chicks in spring and early summer.

Another new direct threat to cranes at Longbao is the appearance of high-voltage power lines and towers along

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the entire length of the north side of the wetland, which were erected in late 2011. These power lines are set back from the wetland, being located just north of the Yushu-Zhiduo Highway, and to date there have been no reports of cranes striking them. However, these power lines do pose a threat to large birds that have limited ability to swiftly change flight course when encountering hard-to-see obstacles, and records of black-necked cranes hitting similar power lines do exist (eg see Li 2002; Li et al 2011). Nevertheless, this hazard can be easily mitigated by mounting these power lines with colorful markers that allow cranes and other large birds to see them from a distance (Li et al 2011).

Notably, livestock numbers on the wetland peak in May, when the first nutritious shoots of green grass in the basin appear on the wetland, at precisely the same time as cranes are building nests and beginning to lay eggs (Table 2). While black-necked cranes at Longbao exhibit minimal fear of yaks, they do exhibit fear of yak herders, who are at times accompanied by their children and untied dogs as they drive their yaks from their homes out onto the wetland and back each day. The impact of human activity on crane egg incubation and habitat selection was only casually observed during this survey, but in general cranes moved away from both nests and feeding sites when approached by humans and especially their dogs. Li and Ma recorded more detailed observations on this issue and described disturbance to incubating cranes from humans, dogs, and yaks as serious, which may result in lower reproductive success amongst cranes (Li and Ma 1989).

Naturally, as the pastures surrounding the wetland continue to degrade, the question arises: What is the carrying capacity of livestock on the wetland with respect to both fodder resources and maintaining a stable crane population? This question is further complicated by the issue of climate change, which is having adverse impacts on pastures, such as increasing rates of pasture erosion and contributing to a general decline in grassland productivity, while also apparently causing the large-scale drying up of shallow wetlands in the region. Under these circumstances, it can only be anticipated that grazing pressure on the wetland will increase in coming years, and with it, disturbance to cranes. Also, given the black-necked crane's preference for nesting, roosting, and spending at least part of the day feeding in shallow water, the continuing widespread loss of shallow wetlands on the Tibetan Plateau can only be expected to lead to a decline in the numbers of these cranes.

Ramsar qualification

The Longbao Wetland has a population of black-necked cranes that fluctuates between about 100 and 200 during the breeding season, with high counts of 118, 216, and 178 black-necked cranes having been recorded in 2010, 2011, and 2012, respectively. Given the 2007 estimate of 11,000 for the total global population of black-necked cranes, the Longbao Wetland clearly qualifies for designation as a Ramsar Wetland of International Importance under Ramsar Criterion 6. This criterion states that "a wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird," which in the case of the black-necked crane is about 110 individuals (Bishop and Drolma 2007; Ramsar 2009). Given the black-necked crane's current "vulnerable" IUCN Red List classification, the Longbao Wetland also appears to qualify for Ramsar designation under Criterion 2, which states that "a wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities" (Ramsar 2009).

Conclusions

The Longbao Wetland is one of the most important breeding sites of the vulnerable black-necked crane, and through the foresight and wisdom of China's protected area planners, it was set aside as a nature reserve in 1986. While the population of black-necked cranes at Longbao has flourished since that time, due in large part to improved protection of cranes and their eggs throughout the species' range, in recent years new threats to crane habitat at Longbao have arisen, primarily in the forms of increasing grazing pressure and climate change impacts on the wetland. The point at which grazing and climate change impacts on the wetland will diminish the reserve's ability to support a large population of breeding cranes remains unclear.

However, there is an urgent need to begin long-term research on pasture management practices, livestock carrying capacity, crane numbers and distribution, wetland water levels, and the impacts of intensive grazing and climate change on both cranes and crane habitat at Longbao. Only in doing so can appropriate, informed measures be taken for the long-term preservation of this remarkable, yet extremely fragile, high-altitude wetland—for the benefit of both cranes and local livestock herders.

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