Liu *et al. Avian Res (2017) 8:7*
DOI 10.1186/s40657-017-0064-7

Avian Research

RESEARCH Open Access

A revised species population estimate for the Bar-headed Goose (*Anser indicus*)

Dongping Liu[1], Guogang Zhang[1], Fengshan Li[2], Tian Ma[1], Jun Lu[1] and Fawen Qian[1*]

Abstract

Background: The Bar-headed Goose (*Anser indicus*) is a species that relies heavily on the plateau wetlands of Asia and whose population was thought to be declining. Over the past decade, south-central Tibet, one of the most important wintering grounds, supported large numbers of Bar-headed Geese, but the population had not been regularly monitored in this area.

Methods: We surveyed wintering Bar-headed Geese along the Yarlung Zangbo, Lhasa and Nyang Qu rivers, the three major river valleys and their tributaries in south-central Tibet in January 2014 and recorded their location, flock size and habitat utilization. Based on these data and the latest wintering counts elsewhere, we revised the population estimate for this species.

Results: We recorded more than 67,000 Bar-headed Geese in south-central Tibet during January 2014. By geographic area, the geese were most abundant in the Lhasa River valley (38.5%) and the Nyang Qu River valley (31.0%), and by administrative division in Lhunzhub (27.2%) and Shigatse (26.7%). Bar-headed Geese were most often observed feeding in winter wheat fields and ploughed fields, resting on pastureland and marshes. The approximate number of 67,000 geese recorded in Tibet is more than four times the estimate of 1993 for the same region and exceeds the most recent world population estimate of 52,000–60,000. Based on our work in Tibet and the latest wintering counts available from other areas, we revised the estimated population size of this species to 97,000–118,000.

Conclusions: Our result reveals a remarkable increase in the number of Bar-headed Geese wintering in south-central Tibet. This population increase most likely stems from a proliferation of cropland and especially winter wheat fields in south-central Tibet. This habitat improvement may also cause short-stopping of the Bar-headed Goose and thus reduce mortality of the geese that would otherwise undertake a somewhat daunting trans-Himalayan migration.

Keywords: Bar-headed Goose, Species population estimate, Tibet, Wintering ground

Background

The Bar-headed Goose (*Anser indicus*) breeds in the plateau wetlands of Central Asia, from extreme eastern Kazakhstan and Kyrgyzstan across southern Russia to western Mongolia and from the Qinghai–Tibetan Plateau south to Ladakh in India. The species winters in China from southern Tibet east of Guizhou and from Pakistan east to Myanmar (Miyabayashi and Mundkur 1999). Previously, the world population was estimated at 52,000–60,000 birds, based on incomplete counts carried out prior to 2000 (Wetland International 2015). While the Bar-headed Goose is not included in the Threatened category of the IUCN Red List due to its large population and range, BirdLife International (2016) estimated a decreasing trend in its population.

South-central Tibet is a significant wintering ground for the Bar-headed Geese and periodic surveys have been conducted there since the 1990s (Lu 1991; Bishop et al. 1997). Bishop et al. (1997) estimated the number of geese there between 13,000 and 14,500 which represented about 25% of the world population, based on surveys conducted during 1991–1996. Over the past decade, the status of wintering Bar-headed Geese in south-central Tibet has aroused

*Correspondence: cranenw@caf.ac.cn
[1] Key Laboratory of Forest Protection of State Forestry Administration, Research Institute of Forest Ecology and Environment Protection, Chinese Academy of Forestry, Beijing 100091, China
Full list of author information is available at the end of the article

BioMed Central

© The Author(s) 2017. This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated.

increasing concern with respect to the surveillance of a highly pathogenic avian influenza, given that this species is considered to be a major potential carrier for H5N1 across the Qinghai–Tibetan Plateau (Chen et al. 2005; Brown et al. 2008; Prosser et al. 2011; Zhang et al. 2011). To improve the estimate of the current status of the Bar-headed Geese, we conducted surveys in south-central Tibet in January 2014 and present the size of their winter flock, distribution and habitat use in South-central Tibet as of this date. Considering that the latest world population estimate was based on data from well before 2000, a more reliable and up-to-date population estimate is desirable (Ven et al. 2010; Wetland International 2015). We also revised the estimated world population of this species based on the latest wintering counts available in its range of countries. We also discuss possible recent demographic trends in major wintering areas.

Methods

Study area

The winter surveys in 2014 were conducted in three major river valleys and their tributaries, i.e., along the Yarlung Zangbo (Hereafter, Yarlung), Lhasa and NyangQu rivers, as well as Yamdrok Lake. These areas are characterized by high elevations, ranging from 2930 to 5030 m. The primary survey areas stretched west from Lhaze (29°07′N, 87°32′E) to Miling (29°28′N, 94°39′E) and north from Lhunzub (29°56′N, 91°00′E) to Nakartse (28°48′N, 90°53′E; Fig. 1). We divided the survey region into six geographic areas, i.e., the valleys of the West Yarlung, Nyang Qu, Lhasa, East Yarlung and Nyang rivers and Yamdrok Lake (Fig. 1).

Agriculture is the dominant land use in the Bar-headed Geese wintering areas with most croplands planted with highland barley (*Hordeum vulgare*), spring wheat (*Triticum* sp.), winter wheat (*Triticum* sp.), potatos (*Solanum tuberosum*), broad beans (*Pisum sativum*) and rape oilseed (*Brassica campestris*). Winter wheat is grown during late September to August of the following year, while other crops dominate from April through September. Croplands are fallow in winter and are either ploughed and irrigated immediately after harvest for pest control or remain unploughed until the following spring. Grazing is the second dominant land use with sheep and goats, the most important type of livestock.

Population survey

We recorded the number of wintering geese during the brief period from 16–25 January 2014. Two teams, each consisting of four members, simultaneously surveyed the east and west part of the study area. We followed the survey methods used by Bishop et al. (1997) and Gregory et al. (2010). We drove cars on primary roads though each valley and their major tributaries and stopped to scan with 10× binoculars or a 20–60× telescope every 1–2 km over suitable habitat or whenever a flock was seen. Where visibility over suitable habitat was limited, we walked to observe the area using secondary roads.

Whenever Bar-headed Geese were observed, we recorded their location, flock size and habitat type. To avoid double counting, we ignored flocks flying overhead from behind. A flock was defined as a group of Bar-headed Geese found continuously in a specific type of habitat. Habitat types for the goose were categorized as winter wheat, ploughed field, crop stubble (unploughed highland barley and spring wheat croplands), pastureland, rivers and lake, marshes and other habitats.

World population estimate

We reviewed the available wintering survey results of the Bar-headed Geese throughout its range, including papers published in scientific journals, as well as surveys accepted by international conservation agencies or national conservation authorities that reflected the status of the species in their respective countries. Where long-term surveys were conducted, we used the most recent data. Since most estimates outside China were given as a range, we summarized the minimum and maximum values as the world population estimate.

Results

Number of birds and their distribution

A total of 67,000 Bar-headed Geese were recorded in January 2014 (Table 1). The species was observed in the Yarlung River from Lhaze east to Sangri except for Rinpung. No Bar-headed Geese were recorded in the 270 km stretch of the Yarlung River from Gyatsa east to Miling. We recorded geese in all major tributaries, although only several hundred birds were observed in the 68 km stretch of the Maizho Maqu River and 287 km along the Nyang River. Bar-headed Geese were especially abundant in the Lhasa River valley (38.5%), the Nyang Qu River valley (31.0%) and the West Yarlung River valley (19.6%) by geographic area and in Lhunzub (27.2%) and Shigatse (26.7%) by administration division (Table 1; Fig. 2).

Habitat use

Wintering Bar-headed Geese were observed at elevations ranging from 2930 to 4470 m. In January 2014, 86.5% of the geese were found in four major habitat types: winter wheat field (39.3%), ploughed field (16.9%), pastureland (15.2%) and marshes (15.1%), while less than 1% of the geese were found on crop stubble (Table 2). Wheat fields and ploughed fields typically occurred as small plots mixed with unploughed croplands (crop stubble). About 68.6% of the flocks we observed were in these small plots, but the flocks were relatively small in size (mean = 214

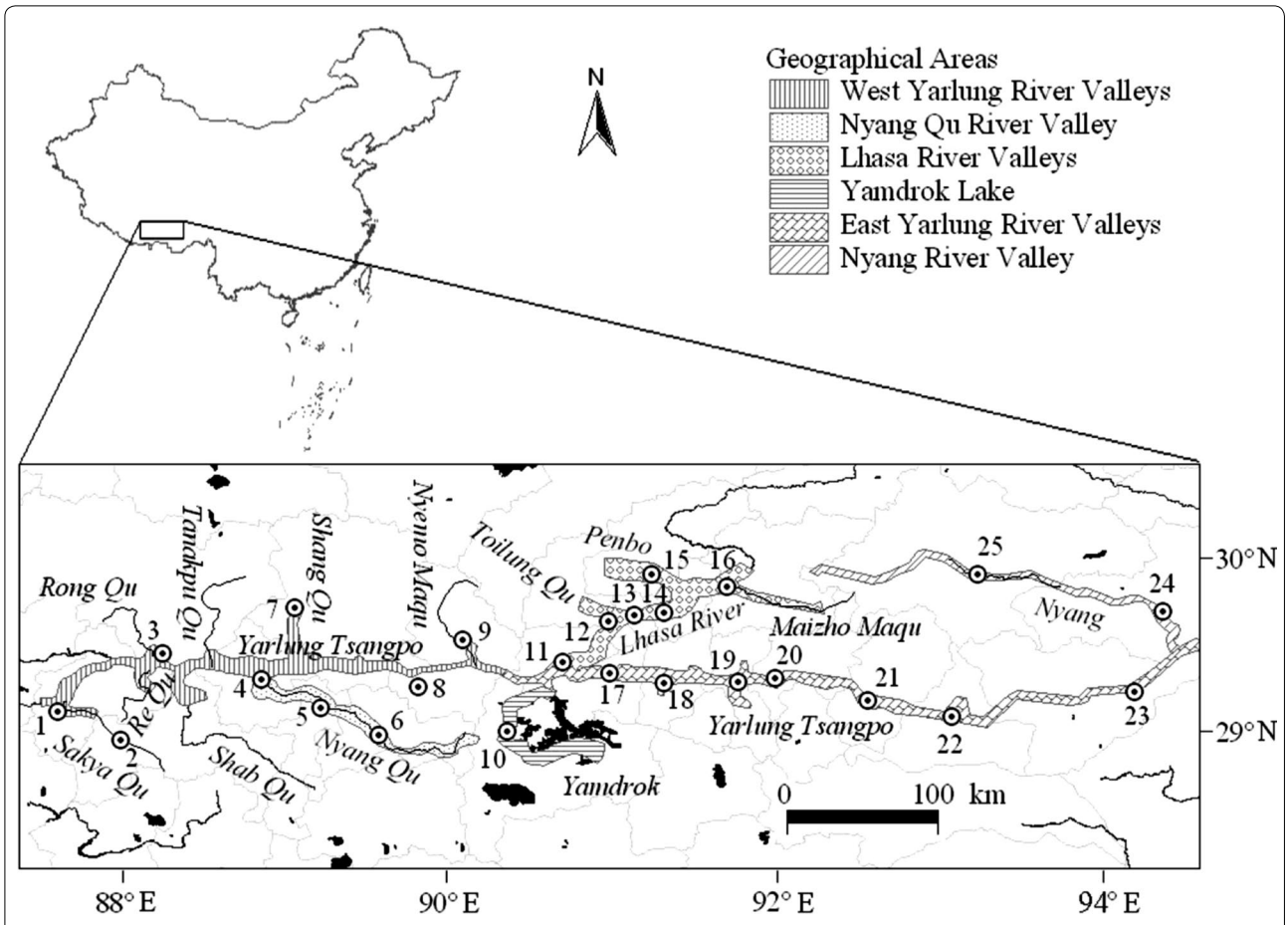

Fig. 1 Survey areas of Bar-headed Geese wintering in south-central Tibet in January 2014. Major rivers are shown on the map; name of locations are given in English, with Pinyin Chinese in brackets: *1* Lhaze (Lazi), *2* Sakya (Sajia), *3* Xiatongmoin (Xietongmen), *4* Shigatse (Rikaze), *5* Bainang (Bailang), *6* Gyantse (Jiangzi), *7* Namling (Nanmulin), *8* Rinpung (Renbu), *9* Nyemo (Nimu), *10* Nakartse (Langkazi), *11* Quxu (Qushui), *12* Doilungdeqen (Duilongdeqing), *13* Lhasa (Lasa), *14* Dagze (Dazi), *15* Lhunzub (Linzhou), *16* Maizhokunggar (Mozhugongka), *17* Gonggar (Gongga), *18* Danang (Zhanang), *19* Nedong (Naidong), *20* Sangri (Sangri), *21* Gyatsa (Jiacha), *22* Namshan (Langxian), *23* Miling (Milin), *24* Nylingchi (Linzhi), *25* Gongbo Gyamda (Gongbujiangda)

individuals). In contrast, pastureland and marshes, mainly used as resting habitats by our geese, had larger flock sizes (mean = 472 birds, maximum = 6350 birds).

World population estimate

A revised world population of Bar-headed Geese was estimated at 97,000–118,000 birds (Table 3), with the highest numbers occurring in China (67.5–69.2%) and India (17.8–30.5%). Myanmar supported 2.8–4.7% of the world total and Pakistan 1.8–4.7%. Less than 1.0% were found in Bangladesh and Nepal.

Discussion

Our results reveal a remarkable increase in the number of Bar-headed Geese wintering in Tibet. Using the same methods, our survey tally in 2014 is four times the 15,500–17,500 geese estimated in December 1993 (Bishop et al. 1997). The number of geese in Tibet during 2014 even exceeded the current world population estimate of 52,000–60,000 birds (Wetland International 2015). Most of the surveyed areas indicated an increase in population, with the exception of Yamdrok Lake. Bar-headed Geese were most abundant in Shigatse City and Lhunzhub County, which agrees with the survey results from 1991 to 1994 (Bishop et al. 1997). Compared with the previous count (Bishop et al. 1997), we surveyed extra valleys of the Maizho Maqu, Nyang River and Yarlung rivers east from Sangri to Miling for the first time, but only small numbers of Bar-headed Geese were recorded, probably because these river stretches are narrow and confined on both sides by steep mountains, where croplands are extremely rare.

Table 1 Number of wintering Bar-headed Geese by geographic area and administration division in south-central Tibet in January 2014

Valleys and counties	Elevation (m)	Number
West Yarlung River valley		13,144
Lhaze County, Yarlung River	3920–4000	1147
Lhaze County, Sakya Qu River	4000–4050	2148
Lhaze County, Re Qu River	3920–4000	211
Xaitongmoin County, Yarlung River	3890–3920	161
Xaitongmoin County, Rong Qu River	3920–3970	91
Xaitongmoin County, Tanakpu Qu River	3890–3930	1146
Sakya County, Shab Qu valley	3900–3970	583
Shigatse City, Yarlung River	3800–3890	6005
Namling County, Yarlung River	3800–3830	1388
Namling County, Shang Qu River	3830–4000	219
Rinpung–Nyemo Cos., Yarlung River	3710–3800	0
Nyemo County, Nyemo Maqu River	3710–3830	45
Nyang Qu River valley		20,800
Shigatse City	3850–3870	11,925
Bainang County	3870–3930	4075
Gyantse County	3930–5030	4800
Yamdrok Lake		190
Nakartse County	4460–4520	190
Lhasa River valley		25,809
Quxu County, Lhasa River	3590–3630	2075
Doilungdeqen County, Lhasa River	3630–3640	81
Doilungdeqen County Doilung Qu River	3640–3740	140
Lhasa Urban, Lhasa River	3640–3680	15
Dagze County, Lhasa River	3680–3790	5158
Lhunzub County, Penbo River	3730–3970	18,210
Maizhokunggar County, Lhasa River	3790–3840	0
Maizhokunggar County, Maizho Maqu River	3830–4450	130
East Yarlung River valley		6786
Quxu County	3590–3710	1317
Gonggar County	3570–3590	2866
Danang County	3560–3570	422
Nedong County	3555–3560	1379
Sangri County	3550–3555	802
Gyatsa-Miling Counties.	2950–3260	0
Nyang River valley		302
Gongbo Gyamda and Nylingchi Counties	2930–4880	302
Grand total		67,031

Our results indicate that winter wheat fields are the most frequently used feeding habitat by the wintering Bar-headed Geese in south-central Tibet. Fecal analyses showed that 65% of the total foods consumed by geese, wintering at Caohai in Guizhou Province China, consisted of leaves of Gramineae (Li and Nie 1998), an indication that this was their principal food source. Compared with crop stubble, our results showed that the Bar-headed Geese prefer the soft and irrigated ploughed fields, although these fields have significantly lower residue cover and surface waste grain (Bishop and Li 2002). We interpret this preference for ploughed fields as evidence of niche partitioning between our Bar-headed Geese and Black-necked Cranes (*Grus nigricollis*), which prefer crop stubble (Bishop et al. 1998). As such, careful consideration is required in cropland management to avoid harmful impacts to either species.

Our updated species population estimate of 97,000–118,000 is almost twice the previous estimate by Wetland International (2015). China recorded the highest population increase (324–367% over the past two decades) according to the estimate of 15,500–17,500 birds in 1995 (Bishop et al. 1997). In China, the Yunnan–Guizhou Plateau is the other major wintering ground outside Tibet, where the number of birds is well monitored and showing a relatively stable trend (Lu 1991; Yang 2005; Yang and Zhang 2014). In India, this species has a nationwide wintering range, but its population has never been surveyed at a full scale and its status has been poorly documented over the past years (Li et al. 2009). Recent surveys suggest there may be a significant and increasing wintering population at Pong Dam in Himachal Pradesh and also in other wetlands in northern India (A. Rahmani, personal communication).

Our population estimate contradicts the global declining trend reported by BirdLife International (2016). The global and regional population increase probably stems from wintering habitat improvements. Over the past two decades, Tibet has been undergoing rapid population and economic growth, which have affected both the environment and agriculture practices. First, cropland areas show an accelerated growth resulting from reclamation of pastures and wetlands (Bai et al. 2014). Second, winter wheat has been grown as a major crop in many areas in south-central Tibet to obtain higher yields. Agriculture development is especially remarkable in the Penbo and the Nyang Qu River valleys, where the Bar-headed Geese is most abundant and shows a rapidly increasing population trend. The wintering habitat improvement in south-central Tibet may also cause short-stopping of the geese, i.e., individual birds normally wintering in south Asia will winter farther north in south-central Tibet (Takekawa et al. 2009; Ven et al. 2010). This behavior may reduce mortality in the Bar-headed Geese that would otherwise undertake a somewhat daunting trans-Himalayan migration (Hawkes et al. 2011).

Conclusions

While bird flu outbreaks caused the decrease in population of birds breeding at the Qinghai Lake in last decade (Chen et al. 2005), our results reveal a remarkable

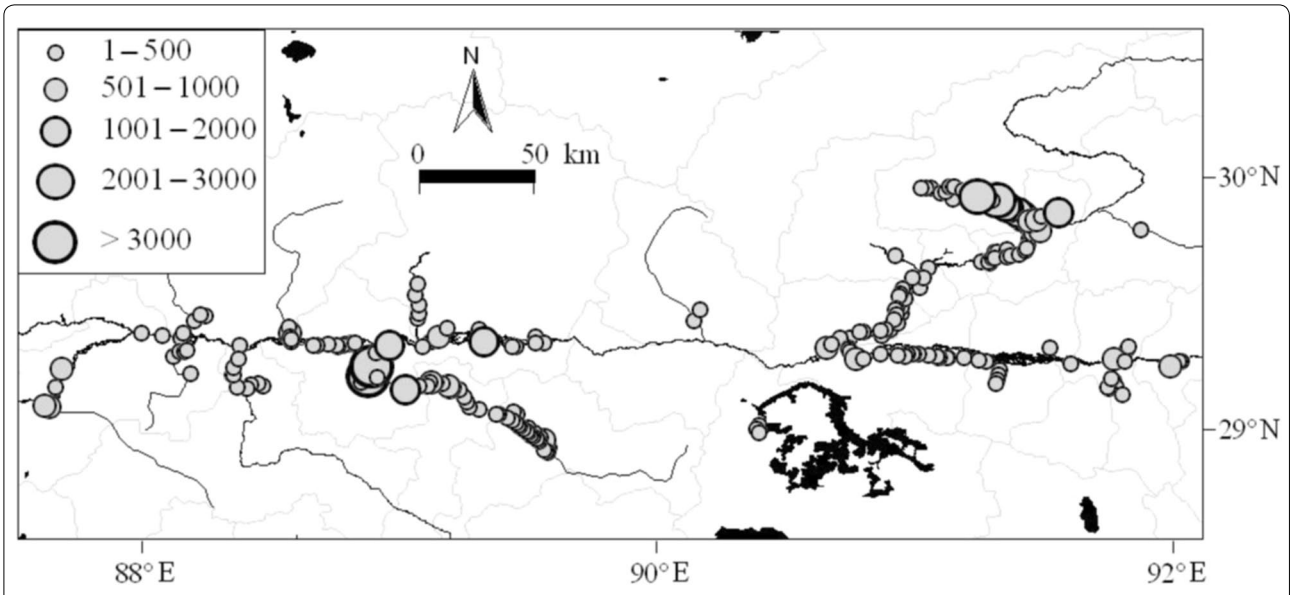

Fig. 2 Number and distribution of Bar-headed Geese wintering in south-central Tibet of China in January 2014. The survey results in Yarlung River from Gyatsa east to Nylingchi and in Nyang River are not shown; only 302 geese were recorded at the confluence of the Yarlung and Nyang rivers

Table 2 Occurrence and details of flocks of Bar-headed Geese by habitat type in south-central Tibet, January 2014

Habitat	Number of flocks	Mean flock size (range)	Number
Winter wheat	140	188 (2–1400)	26,322 (39.3%)
Ploughed field	35	323 (3–2500)	11,309 (16.9%)
Pasture	20	510 (1–6350)	10,199 (15.2%)
Marsh	23	439 (2–3000)	10,105 (15.1%)
River and lake	24	303 (1–3500)	7261 (10.8%)
Crop stubble	8	66 (5–150)	530 (0.8%)
Other habitats	5	261 (15–600)	1305 (1.9%)
Total	255	263 (1–6350)	67,031

increase in the number of Bar-headed Geese wintering in south-central Tibet, as well as a rise of the world-wide population estimate. The population increase most likely results from a proliferation of winter wheat fields, a favorite feeding habitat by the Bar-headed Goose. This provides opportunity for us to understand the conservation importance of agricultural cultivation on related bird species. Long-term and full-scale census is still necessary to monitor the population trend and evaluate the impact of bird flu on this susceptible species.

Authors' contributions

DL performed the experiments, analyzed the data, wrote the paper and prepared figures and tables. GZ and FL designed and performed the experiments. TM performed the experiments. JL conceived the experiments and contributed the reagents, material and tools. FQ conceived, designed and performed the experiments. All authors read and approved the final manuscript.

Table 3 World population estimates for the Bar-headed Geese based on the latest wintering counts available

Country	Number	Survey year	Reference
China			
South-central Tibet	67,000	2014	This study
Yunnan–Guizhou Plateau	5300–7200	2004–2013	Yang (2005), Yang and Zhang (2014)
Indian	19,100–32,800	2003–2007	Li et al. (2009)
Myanmar	3000–5000	1999–2007	Ven et al. (2010)
Pakistan	1800–5000	1999–2005	Li et al. (2009), Ven et al. (2010)
Bangladesh	300–500	2006–2010	Ven et al. (2010)
Nepal	200–300	2000–2007	Li et al. (2009), Takekawa et al. (2009)
Total	96,700–117,800		

Author details
[1] Key Laboratory of Forest Protection of State Forestry Administration, Research Institute of Forest Ecology and Environment Protection, Chinese Academy of Forestry, Beijing 100091, China. [2] International Crane Foundation, Baraboo, WI 53913, USA.

Acknowledgements
The study was funded by the Wildlife Rescue Project from the Department of Wildlife Protection and Nature Reserve Management, State Forestry Administration (SFA) of China and the Project of Surveillance of H7N9 in Wild Birds (No. 201404404) from the Department of Science and Technology, SFA. The survey was also co-funded by the International Crane Foundation. We thank Langjie Wangqiu and Ding Dan for their assistance in the surveys the and Forestry Department of the Tibet Autonomous Region for their support in the field work. We thank Mary Anne Bishop, Beverly Pfister, Elena Smirenski and Jim Harris for improving the manuscript and Asad Rahmani, Simba Chan and Xingyao Zhong for their valuable information.

Competing interests
The authors declare that they have no competing interests.

Received: 17 November 2016 Accepted: 20 January 2017
Published online: 06 March 2017

References

Bai W, Yao L, Zhang Y, Wang C. Spatial-temporal dynamics of cultivated land in recent 35 years in the Lhasa River Basin of Tibet. J Nat Res. 2014;29:623–32 **(in Chinese)**.

BirdLife International. Species factsheet: *Anser indicus*. 2016. http://www.birdlife.org/datazone/speciesfactsheet.php?id=379. Accessed 12 Sept 2016.

Bishop MA, Li F. Effects of farming practices in Tibet on wintering Black-necked Crane (*Grus nigricollis*) diet and food availability. Biodivers Sci. 2002;10:393–8.

Bishop MA, Canjue Z, Song Y, Jim H, Gu B. Winter habitat use by Black-necked Cranes *Grus nigricollis* in Tibet. Wildfowl. 1998;49:228–41.

Bishop MA, Song Y, Canjue Z, Gu B. Bar-headed Geese *Anser indicus* wintering in south-central Tibet. Wildfowl. 1997;48:118–26.

Brown JD, Stallknecht DE, Swayne DE. Experimental infection of swans and geese with highly pathogenic avian influenza virus (H5N1) of Asian lineage. Emerg Infect Dis. 2008;14:136–42.

Chen H, Smith GJD, Zhang SY, Qin K, Wang J, Li K, Webster RG, Peiris JSM, Guan Y. Avian flu: H5N1 virus outbreak in migratory waterfowl. Nature. 2005;436:191–2.

Gregory RD, Gibbons DW, Donald PF. Bird census and survey techniques. In: Sutherland WJ, Newton I, Green RE, editors. Bird ecology and conservation. New York: Oxford University Press; 2010. p. 17–56.

Hawkes L, Balachandran AS, Batbayar N, Butler PJ, Frappell PB, Milsom WK, Tseveenmyadag N, Newman SH, Scott GR, Sathiyaselvam P, Takekawa JY, Wikelski M, Bishop CM. The trans-Himalayan flights of bar-headed geese (*Anser indicus*). Proc Natl Acad Sci. 2011;108:9516–9.

Li F, Nie H. Food analysis for wintering bar-headed goose in Caohai, Guizhou. Chin J Zool. 1998;3:29–33 **(in Chinese)**.

Li ZWD, Bloem A, Delany S, Martakis G, Quintero JO. Status of waterbirds in Asia-results of the Asian waterbird census: 1987–2007. Kuala Lumpur: Wetlands International; 2009.

Lu J. Notes on Bar-headed Geese in China. International Waterfowl Research Bureau Threatened Waterfowl Research Group News. 1991;1:8–9 **(in Chinese)**.

Miyabayashi Y, Mundkur T. Atlas of key sites for anatidae in the East Asian Flyway. 1999. http://www.wetlands.org/Portals/0/publications/Book/WI_AnatidaeAtlas-EAsia_1999.pdf. Accessed 5 Feb 2015.

Prosser DJ, Cui P, Takekawa JY, Tang M, Hou Y, Collins BM, Newman SH. Wild bird migration across the Qinghai–Tibetan plateau: a transmission route for highly pathogenic H5N1. PLoS ONE. 2011;6:e17622.

Takekawa JY, Heath SR, Douglas DC, Perry WM, Javed S, Newman SH, Suwal RN, Rahmani AR, Choudhury BC, Prosser DJ, Yan B, Hou Y, Batbayar N, Natsagdorj T, Bishop CM, Butler PJ, Frappell PB, Milsom WK, Scott GR, Hawkes LA, Wikelski M. Geographic variation in Bar-headed Geese *Anser indicus*: connectivity of wintering areas and breeding grounds across a broad front. Wildfowl. 2009;59:100–23.

Ven JVD, Gole P, Ouweneel G. Bar-headed Geese *Anser indicus*: notes from breeding and wintering areas. Goose Bull. 2010;10:7–17.

Wetland International. Waterbird population estimates. 2015. http://wpe.wetlands.org. Accessed 5 Feb 2015.

Yang F. Report on a three year survey of Black-necked Crane and large-sized waterbirds on the Yunnan and Guizhou Plateau. In: Li F, Yang X, Yang F, editors. Status and conservation of Black-necked Cranes on the Yunnan and Guizhou Plateau, People's Republic of China. Kunming: Yunnan Nationality Publishing House; 2005. p. 59–64 **(in Chinese)**.

Yang F, Zhang Y. Quantities and distributions of the Black-necked Crane (*Grus nigricollis*) and other large waterfowls on the Yunnan and Guizhou Plateau. Zool Res. 2014;35:80–4.

Zhang G, Liu D, Hou Y, Jiang H, Dai M, Qian F, Lu J, Xing Z, Li F. Migration routes and stop-over sites determined with satellite tracking of Bar-headed Geese *Anser indecus* breeding at Qinghai Lake, China. Waterbirds. 2011;34(1):112–6.

Submit your next manuscript to BioMed Central and we will help you at every step:

- We accept pre-submission inquiries
- Our selector tool helps you to find the most relevant journal
- We provide round the clock customer support
- Convenient online submission
- Thorough peer review
- Inclusion in PubMed and all major indexing services
- Maximum visibility for your research

Submit your manuscript at
www.biomedcentral.com/submit


BioMed Central