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Abstract: Between 7 May and 5 August 1991 we counted 298 black-necked cranes (*Grus nigricollis*) on breeding grounds in central and southwestern Tibet Autonomous Region (TAR). We confirmed breeding for 32 pairs: we found 17 nests at 8 wetland sites and 15 broods of 25 chicks, including 5 transitional fledglings. Mean altitude of nest wetlands was 4694 m. Nest height averaged 21.3 cm above water, and water depth averaged 14.8 cm. Black-necked cranes nested a mean of 140.5 m from uplands and 803 m from potential disturbance such as a road or dwelling. Mean nest initiation date was 28 May.

Key Words: black-necked crane, China, *Grus nigricollis*, nesting ecology, Tibet

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The black-necked crane, least known of the 15 crane species, nests above 3,000 m altitude on the Tibetan Plateau of western China. Due to its limited distribution and small population, this crane is considered a vulnerable species (IUCN 1988) and is under China's First Order of Protection for endangered and rare species.

Nesting of black-necked cranes has been studied in Qinghai (Lu et al. 1980, Lu 1986, Liao 1986, Wang et al. 1989) and Sichuan (Li 1985, Li et al. 1991, Scott 1991) Provinces of China and in Ladakh, India (Gole 1981), but not in TAR. However, Feng (1989), Johnson (1989), and G. Schaller (Wildlife Conservation International, pers. commun.) observed cranes, and in some cases chicks, in TAR during the nesting season. Archibald and Oesting (1981) reviewed black-necked crane literature.

The International Crane Foundation (ICF), with support from the Brehm Fund for International Bird Conservation and in cooperation with the Tibet Plateau Institute of Biology (TPIB), surveyed TAR for breeding cranes during summer 1991 (Figs. 1 and 2). ICF and TPIB researchers documented over 2,800 black-necked cranes wintering in southcentral Tibet during the 1990–91 portion of this study (Bishop 1991).

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STUDY AREA AND METHODS

The Tibetan Plateau, a treeless grassland, encompasses about 20% of China's total land area and is the most extensive high-elevation region in the world. High mountain desert, alpine meadow, and alpine semidesert are the major community types. However, wet meadows dominated by sedges of the genus *Kobresia* occur commonly and provide an important grazing resource for livestock during the summer (Miller 1990). The occurrence of alkali and saline lakes increases in a gradient toward the northwest as rainfall decreases. The Plateau receives about 10–25 cm of precipitation in the northwest and 25–50 cm in the southeast annually, with the wet season in summer. Mean July temperatures range from 10–15 C in the highlands and 15–20 C along the Yarlung river valley in southern TAR (Fullard 1968). Snow can fall in any month.

Between 7 May and 5 August 1991, we surveyed in Damxung, Nagchu, Amdo, Bange, Shenzha, Amren, Saga, and Zhongba counties of northcentral and southwestern TAR. We traveled 8,366 km by vehicle and searched wetlands for cranes using 10X binoculars and a 20X spotting scope with tripod and car mount. Focusing on sites of historical sightings of cranes, we scanned wetlands accessible to within 5 km by vehicle. We observed black-necked crane behavior to determine if they had a nest or young. If more than 2 cranes were feeding or loafing within 30 m of each other, we assumed they were nonbreeders. If a crane was sitting, we searched that area for a nest.

Wetland features recorded at nest sites included type, location, altitude, water temperature, pH, and conductivity.

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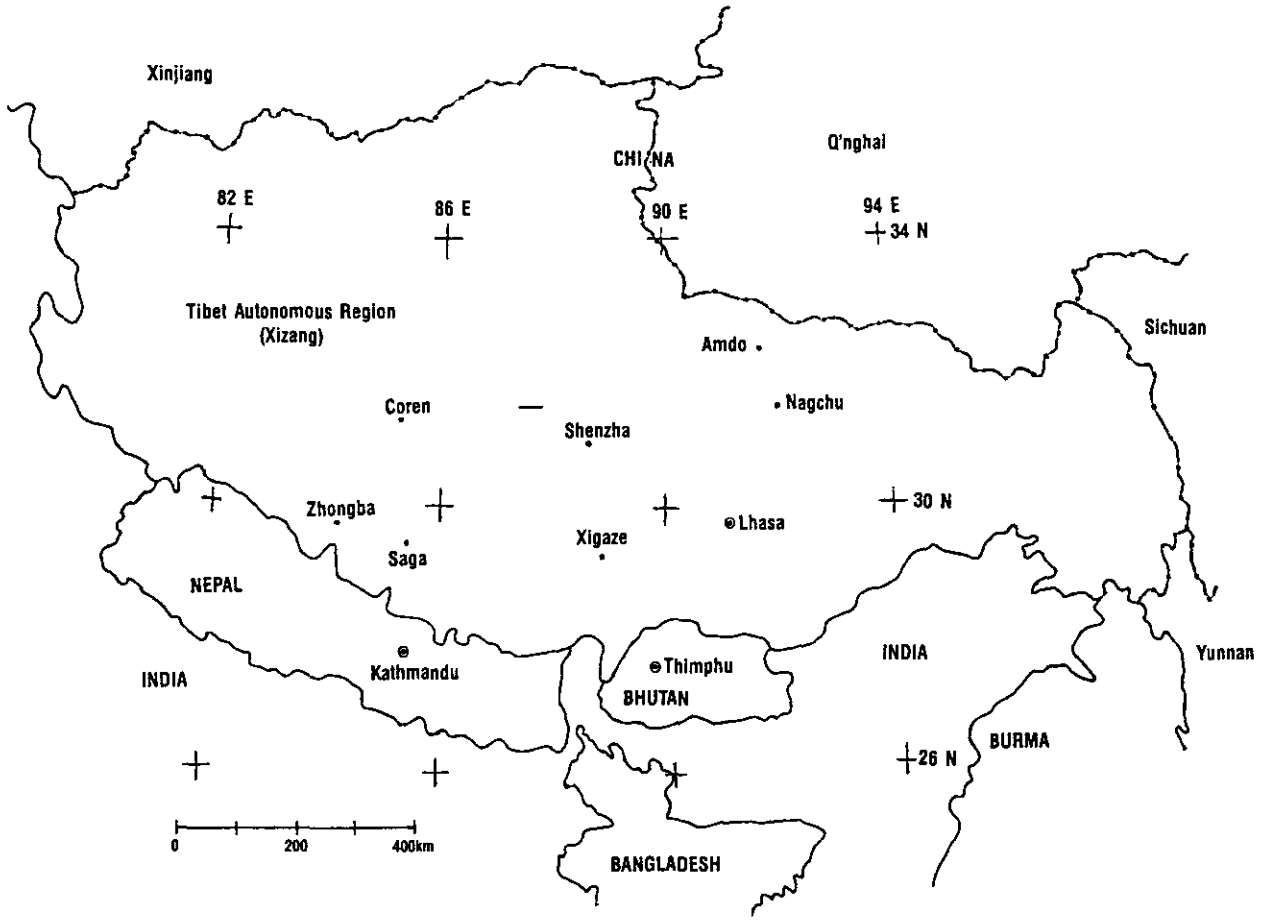

Fig. 1. Tibet Autonomous Region and adjacent countries and Chinese provinces.

Nest characteristics recorded were size, composition, nest height above water, mean water depth 1 m from nest edge (from 8 readings), nest-island dimensions, and distance to nearest upland. For all nests, we recorded clutch size and age of eggs, or any evidence of hatching success. To estimate incubation stage, we floated eggs in warm (40 C) water disinfected with iodine (Westerskov 1950, Fisher and Swengel 1991). When possible, we recorded the time cranes spent off the eggs due to our nest visits. We also estimated distance(s) to nearest road, dwelling and/or livestock. We assumed a 30-day incubation period to estimate the first-egg, or initiation, date. Whenever possible, we revisited nests after 7 days. We interviewed local people to help us determine the status of wetlands and cranes in the area. We also recorded all sightings of other vertebrates.

RESULTS

We observed 298 cranes in 8 counties of TAR; we found 17 nests in Bange, Shenzha, and Saga counties and 25 chicks in Shenzha, Saga, Zhongba, Nagchu, and Damxung counties (Fig. 2). Twenty-one percent of the observed cranes had a nest or chicks when sighted, and 39% were nonbreeders and subadults. In addition to 298 cranes on breeding or summering grounds, we observed 198 cranes staging at Damxung marsh on 8 May.

Cranes nested in wetlands ranging from 2-ha ponds in alpine bog meadow to 7,000-ha lakes, such as Mujiu Cuo. Mean wetland size was 1,490 ha (SE = 640.8). We observed 10 pairs of cranes at 450-ha Luobo Cuo: 5 pairs were incubating eggs, 3 pairs had chicks and 2 pairs were potential breeders.

Water in nest marshes ranged from neutral to alkaline, with an average pH of 8.4 (n = 11, SE = 0.23). Water temperatures fluctuated with time of day, ranging 2–23 C; the mean was 16.5 C (n = 11, SE = 1.8) at time of nest visit. Salinity was estimated by the water's conductivity, which averaged 0.56 mmhos/cm (n = 14, SE = 0.15).

Mean altitude of nest sites was 4,694 m (Table 1), but we found chicks at 4,360 m in Damxung (Table 2). Thus,

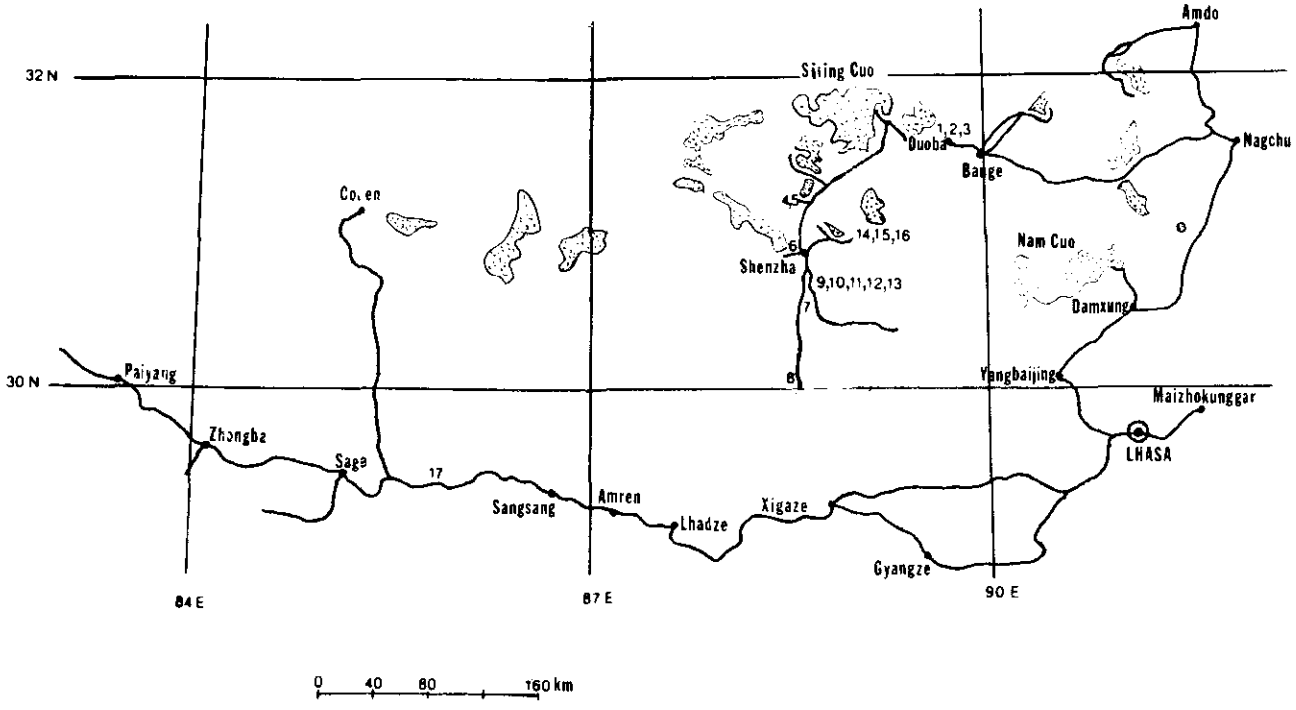

Fig. 2. Route followed during summer 1991 surveys for breeding black-necked cranes in the Tibet Autonomous Region of China. Numbers indicate nest locations. Lakes are stippled.

in this study, breeding occurred at a mean elevation of 4,646 m (n = 32, SE = 20.6) and range of 4,360–4,860 m.

Hippuris vulgaris was a dominant plant at 7 nest sites. Eleven nests were located in 4 lacustrine wetland areas, and 6 nests were situated in 4 palustrine sites, including alpine bog meadow typified by hummocks of *Kobresia* sp. Many sites were associated with flowing water. Chicks were observed in emergent marsh vegetation (including *H. vulgaris*), hummocky lake shore and river bank, alpine bog meadow, and mud islands and were 0–300 m from uplands.

Most nests (12) were built on pre-existing islands ($\bar{x}$ = 11.0 × 5.7 m) and were small ($\bar{x}$ = 61.5 × 51.7 cm), consisting of 1–3 species of sedge, grass, and/or aquatic vegetation. Nests built directly in the water (5) were larger, averaging 106.4 × 91.2 cm; these nests contained more mud and plant rhizomes. Plants used for nesting material included *H. vulgaris*, *Batrachium bungeii*, *Kobresia* sp., *Carex* sp., and grasses (Poaceae). Mean nest height was 21.3 cm (range = 4–100) above water, which averaged only 14.8 cm deep around nests. Nest height above water was greater than the depth of surrounding water at 12 nests.

Sixteen nests contained 2-egg clutches and 1 nest contained 1 egg. One egg of a 2-egg clutch was cracked open, exposing a partially developed embryo. Mean dimensions of 4 eggs from 2 nests were 105 × 61 mm; weights ranged from 200 to 255 g. We monitored 1 nest from 1 June until both eggs hatched 20 June.

Mean estimated laying date of the first egg at 17 nests was 28 May, whereas the median date was 25 May. Mean initiation date, including estimated first-egg dates based on ages of 15 sets of chicks, was 21 May (n = 32, SE = 2.4). Only 2 nests were initiated in June; the later nest was apparently a second attempt. Another apparent second nesting attempt was begun 13 July. In both cases of renesting, a second nest was built within 5 m of the first nest, 1 of which contained the egg shell and membrane of an apparently successful egg; the other first nest contained an addled egg.

Black-necked cranes nested 200–2,000 m from a fixed source of disturbance, either a road or dwelling. Livestock, primarily yak and sheep, but also goats and horses, were constantly moving, thus distances to nests varied from 20 to 500 m. Yak were the most common domestic animals grazing in marshes and were able to range farther into marshes. Therefore, these animals were observed closest to an incubating crane. All nests were within view of human habitations or domestic animals. Domestic dogs were common at human dwellings and ranged widely. We

Table 1. Black-necked crane nest-site data from Tibet Autonomous Region of the People's Republic of China, 1991.

Nest[a] no.	Location		Altitude (m)	Mean water depth (cm)	Height above water (m)	Distance to upland (m)	Distance to disturbance (m)	First egg laid	Nest island dimensions (m)	Nest dimensions (cm)	Site name
	Lat.[b]	Long.[b]									
1	31°30′	89°46′	4,650	14.1	42	14.8	1,100	21 May	17.1×6.4	86×49	Duoba
2	31°29′	89°45′	4,650	13.9	40	100.0	500	12 May	30.5×6.3	NA	Duoba
3	31°28′	89°48′	4,650	15.0	100	9.0	2,000	22 May	6.0×5.0	50×50	Duoba
4	31°23′	88°44′	4,570	12.1	14	120.0	1,000	16 May	0[c]	117×95	Shibu Cuo
5	31°22′	88°41′	4,570	13.6	9	245.0	550	16 May	0	84×70	Nari Cuo
6	30°56′	88°40′	4,654	11.0	13	40.2	200	20 May	2.2×2.3	46×44	Shenza
7	30°39′	88°42′	4,840	15.2	8	45.3	600	19 May	2.8×3.8	52×47	Shenza
8	30°15′	88°35′	4,860	5.1	7	90.0	1,000	25 May	30.0×20.0	72×54	Qiazhang
9	30°49′	88°48′	4,700	11.8	19	83.4	2,000	28 May	2.9×3.7	50×47	Luobo Cuo
10	30°48′	88°48′	4,700	8.7	15	150.0	500	28 May	2.6×3.1	89×82	Luobo Cuo
11	30°46′	88°48′	4,700	16.0	19	150.0	400	28 May	4.8×3.0	49×44	Luobo Cuo
12	30°46′	88°48′	4,700	15.1	16	100.0	400	29 May	17.8×11.4	56×49	Luobo Cuo
13	30°45′	88°47′	4,700	15.2	12	300.0	550	24 May	14.1×2.7	84×77	Luobo Cuo
14	31°01′	89°04′	4,668	18.2	8	350.0	850	31 May	0	110×101	Mujiu Cuo
15	31°01′	89°03′	4,668	19.4	4	250.0	1,000	3 Jun	0	108×98	Mujiu Cuo
16	31°02′	89°03′	4,668	20.3	10	300.0	700	11 Jun	0	113×92	Mujiu Cuo
17	29°28′	85°54′	4,850	27.4	26	40.0	250	13 Jul	1.4×1.2	42×26	QangXiong
		$\bar{x}$	4,694	14.8	21.3	140.5	800	28 May	11.0×5.7	76×64	
		SD	84.3	4.9	22.9	108.9	524.8	14.0	10.7×5.2	27×24	

[a] Nest numbers in Fig. 2 show general location.
[b] North latitude and East longitude.
[c] Nest built directly in water.

found 1 black-necked crane, dead from an apparent rifle wound, 40 m from a road and 20 km from a soldier outpost. Although our nest visits disturbed the cranes, they returned to incubate the eggs in a mean of 64 minutes (n = 15, SE = 6.7). Nests were built 9–350 m from uplands; the mean was 140.5 m.

Many water birds used the same wetlands as black-necked cranes. In wetlands used by nesting cranes, we found the nests of the great-crested grebe (*Podiceps cristatus*), bar-headed goose (*Anser indicus*), coot (*Fulica atra*), common redshank (*Tringa totanus*), brown-headed gull (*Larus ridibundus*), common tern (*Sterna hirundo*), and long-billed calandra lark (*Melanocryphora maxima*). We observed aggression from nesting cranes toward *A. indicus*.

DISCUSSION

During 1991 only 17 black-necked crane nests were found, however many remote wetlands were not surveyed in TAR. Because the 198 cranes sighted at Damxung on 8 May were staging, some may have been counted later on their breeding grounds and therefore were excluded from our total count.

We hesitate to estimate the amount of suitable crane habitat surveyed based on our data, and thus cannot give proportion of censused wetlands used by cranes. We can say that cranes used organic wetlands typified by peat and were rarely observed in oligotrophic wetlands, typified by mineral deposits, that lacked emergent vegetation. We failed to find cranes at many wetlands that we considered suitable habitat. Although black-necked cranes nested in shallow water (14.8 cm), the deep mud substrate of wetlands with nests probably served as an impediment to predators. The sticky mud was our greatest hindrance in reaching most of the nests (Liao 1986).

We found cranes breeding in 1 450-ha wetland at a density of 1.8 pairs/km^2, or 2.2 pairs/km^2, if 2 pairs of

Table 2. Sightings of black-necked crane chicks in Tibet Autonomous Region of China, 1991.

No. of chicks	Lat.[a]	Long.[a]	Altitude (m)	First egg laid[b]	Site name
2	30°48′	88°48′	4,700	11 May	Luobo Cuo
1	30°46′	88°47′	4,700	9 May	Luobo Cuo
2	30°46′	88°48′	4,700	11 May	Luobo Cuo
1	31°00′	89°04′	4,670	10 May	Mujiu Cuo
2	31°01′	89°03′	4,670	17 May	Mujiu Cuo
2	31°02′	89°03′	4,670	17 May	Mujiu Cuo
2	31°01′	89°04′	4,670	15 May	Mujiu Cuo
2	29°52′	83°44′	4,580	17 May	Zhu Zhu Cuo
2	29°59′	83°32′	4,580	22 May	N of Ganjiu
1	30°13′	82°59′	4,630	3 Jun	Maquan River valley
2	30°04′	83°26′	4,580	23 May	6 km NW of Paiyang
2	31°03′	91°40′	4,650	5 May	Sang Xiong
1	30°30′	91°10′	4,360	5 May	Damxung marsh
1	30°30′	91°13′	4,360	5 May	Damxung marsh
2	30°30′	91°15′	4,360	5 May	Damxung marsh
$\bar{x}$ 1.7			4,592	14 May	
SD 0.5			127.1	8.3	

[a] North latitude and East longitude.
[b] Estimated according to approximate age of chicks.

unconfirmed breeders are included. Mujiu Cuo probably supported comparable densities if only suitable marsh habitat was included. At Longboatan marsh in Qinghai, Lu et al. (1980) found 0.38 pairs/km^2, with a maximum of 0.73 pairs/km^2, and Li (1985) reports the highest density (0.53 cranes/km^2) occurred in alpine bog meadow.

Liao (1986) and Wang et al. (1989) also found large nest heights ($\bar{x}$ = 30.7 cm, n = 8, and $\bar{x}$ = 36.1 cm, n = 9, above water, respectively) but neither specify water depths around nests. Perhaps cranes nest on high mounds for protection from flooding.

We found the first 2 observed cases of renesting in black-necked cranes. The ability to recycle, even in the short nesting season on the Tibetan Plateau, implies that these cranes can rebound from a nest failure and fledge young.

Black-necked cranes seemed to acclimate to disturbance such as road traffic, human dwellings, and livestock grazing (Scott 1991). However, human and livestock activity could result in cranes remaining off their eggs, and domestic dogs possibly prey on crane eggs and chicks. Li et al. (1991) stated that, in Sichuan, black-necked cranes selected inaccessible nest sites where people, livestock and wild animals rarely come. Other potential predators in TAR included raptors (see Lu et al. 1980), fox (*Vulpes vulpes*), lynx (*Felis lynx*), bear (*Ursus arctos*), wolf (*Canis lupus*), and common raven (*Corvus corax*).

CONSERVATION IMPLICATIONS

Because of Tibet's dry climate, people, and thus livestock and dogs, tended to live near the same wetlands that attracted black-necked cranes. Therefore, although the cranes seemed acclimated to human sources of disturbances, potential competition exists between cranes and humans for wetland space. Most of the native inhabitants of the Tibetan Plateau use wetlands only for livestock grazing. These people also regard cranes as auspicious birds and thus welcome their presence (Feng 1989). However, the increasing influence of nonnative culture in TAR promotes the use of other wetland resources such as waterfowl and fish. Also human population growth in TAR exerts increasing pressure on the land's resources, especially in the form of grazing and agriculture.

Dense nesting areas such as Luobo Cuo and Mujiu Cuo should be protected by limiting human population in these areas and prohibiting further resource development such as drainage or peat mining (Scott 1991). Further studies of black-necked cranes by Chinese biologists and educating people in remote areas about crane conservation would contribute to the preservation of this species.

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