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Spatial and Temporal Distribution of Tibetan Antelope at Hoh Xil National Reserve

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ココシリに生息するチベットアンテロープの時空間分布に関する研究

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1. Introduction

Hoh Xil is an isolated region in the northwestern part of the Tibetan plateau in China. It is China's least and the world's third-least populated area. The region covers 83,000 square kilometers at an average elevation of 4,800 meters, between the Tanggula and Kunlun mountain chains in the border areas of Southwest China's Tibet Autonomous Region, Northwest China's Qinghai Province and the Xinjiang Uyghur Autonomous Region. It is one of the major headwater sources of the Yangtze River and Yellow River. 45,000 square kilometers, at an average elevation of 4,600 meters, were made into a Hoh Xil national nature reserve in 1995. The Qinghai-Tibet railway runs along the eastern boundary of the reserve.

The climate of the area characterizes by severe conditions. The average annual temperature from southeast to northwest gradually reduces, the warmest area is −4.1℃, the coldest −10℃ (estimated value), minimal temperature is −46.4℃, the average precipitation trend is decreasing from southeast to northwest, between 173～495 mm. Precipitation is mainly concentrated in summer, with clear rainy and dry seasons. Within the distribution of annual precipitation the most concentration is from May to September, can account for more than 90% of annual precipitation, including the warm season (June to August) can account approximately 70% of the total precipitation (Zhang and Lu, 2002). There is the high value of wind speed, the distribution of annual average wind speed increases from east to west. The soil types: mostly alpine meadow soil, alpine steppe soil and alpine cold desert soil, followed by swamp land, scattered in a swamp soil, cracked soil, saline, alkaline earth and sand. Region ranges due to geographic location, terrain height, terrain slope and surface position and other hydrothermal differentiation factors, the natural landscape represents by alpine meadow - steppe replacements to alpine desert with a small amount of the grassland distribution. Alpine periglacial vegetation had a greater area of distribution. Alpine meadow, alpine swamp distributed only in very few areas.

In the study area, the vegetation is primarily alpine grassland and alpine meadow dominated by *Stipa purpurea*, *Carex moorcroftii*, *Oxytropis densa*, *Oxytropis falcata*, *Astragalus densifolrus*, *Astragalus confertum* and *Pleurospermum hedinii* (Wu et al., 2006). The biomass of graminoids, sedges and forbs were 6.07±1.39 g, 13.87±5.39 g and 30.23±6.90 g, respectively (Lian et al., 2007).

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Despite the harsh climate, Hoh Xil is home to more than 230 species of wild animals, 20 of which are under state protection, including the wild yak (*Poephagus grunniens)*, kiang (*Equus Kiang*), white-lip deer, brown bear (*Ursus arctos*), and the endangered Tibetan antelope (Feng et al., 2008, Schaller 1998). Biota in this area is poor, but consists of a large proportion of endemics.

Tibetan antelope (Pantholops hodgsonii) belongs to Artiodactyla, Bovidae, has height in shoulders 80–85 cm (male) and 70–75 cm (female), weighs 35–40 kg (male), 24–28 kg (female), hair color: from brown to gray, the abdomen is white, with eye-catching spots, female is yellowish brown, diameter of fiber is generally between 10–12 microns, the smallest 6 micron. Body length: 50–60 cm for adult male. Life period: not more than 8 years, habitat: integration ranges from a dozen to a thousands inside the population, living at an altitude of 4300 m to 5100 m (minimum 3250 m, maximum 5500 m) at alpine grasslands, meadows and alpine desert. Quantity: less than 75,000 (1998 estimation, according to Schaller). The main diet includes *Gramineae, Cyperaceae* and *Artemisia* (*Meconopsis*) plants. Antelope adapted to low oxygen environment (so far, it has not kept to a zoo or other similar place). Antelope grazes mainly in the morning and evening. However, food conditions are poor at winter and spring, it forages extended time, so that animals can often be seen moving around during the day; however, if in summer and autumn pasture became abundant, animals have rest at noon in the lake, river or lower cavity. Tibetan antelope's primary instinct is to run against an enemy, because of strong well-proportioned limbs, good running antelope has a special advantage, running up to 70 km per hour, even a pregnant female can run quite quickly. In summer, the migration period, the Tibetan antelope females required more energy and physical force to give birth to a lamb. The female Tibetan antelopes spent most of their time foraging despite of reproductive status, which could be explained by the food competition associated with the combination of low biomass, short growing season and presence of competing herbivore species (Lian et al., 2007).

The migration and breeding of antelope directly related to habitation area, the vast majority of long-distance migration has conducted to calving, and then antelopes move back to the original habitat. Previous observations also showed that 3 year-old sexually mature female antelope, delivers 1 calf per year. Each year, from mid-November to mid-December is the mating period, calving comes to mid-June to early July, gestation lasts 200 days. In the mating season, males compete intensively and after, the victorious males organize small groups, female and male ratio ranging from 1:1 to 1:26. One month before calving, females began migration to the lake Zhuonai by fixed routes. Widespread distributed antelopes collect to groups to reach the calving ground, the maximum number of group is up to 3000, when the calving begins, wolves, vultures and other predators are also more concentrated in surroundings, cruising and hovering near the birth place. Newborn antelope weights between 1.84–3.2 kg the average value is 2.78 kg, newborn began to suck within half an hour after standing up, in an hour can begin to follow a female. After about a month of physical recovery, a small antelope with a female began to return to the habitat. In a case of the harsh life in the plateau, half or more newborn calf could die less than in two months after birth. After calving period, females with newborn, adult males and fawns, spreads by small groups until next mating time. The total distribution in Qinghai-Tibet Plateau is on about 600,000 square kilometers. Some populations are settled, while others, the largest, migrate. Four such populations are distinguished in Qiangtang region. (*Wildlife Conservation Society of the United States, G. Schaller et al., 1998).* Tibetan antelope's population density: Qinghai Yushu region - 1.58/km, Tuotuohe - 1.47/km (Schaller et al., 1988), at the Hoh Xil region 2.08/km (Feng, 1993); at Kunlun Mountains in Xinjiang region, were 0.6 head, 1.50 and 1.38/km); in northern Tibet is 2.09/km (Feng, 1993).

Earlier research results showed that the infrastructure construction, including the railway and the highway, probably was the main factors that threaten this species (Qiu and Feng, 2004, Xia et al., 2007) (Fig. 4, b). But if there were wildlife underpasses, the antelope soon adjusted their migration routes and crossed the road by using the underpasses (Yang and Xia, 2008). Distant tracking and on-site field observations showed that the migrating Tibetan antelope mostly used a relatively small (200 meters in size) underpass Wu-Bei (N35° 15′; E93° 09′; altitude 4597 m) and also an underpass at the river Chumaru (a total of 33 under and overpasses are exists along the railroad) (Buho H. et al., 2011).

2. Materials and methods

Satellite-based ARGOS platform transmitter terminal (PTT) distant tracking data were collected from Argos satellite transmitters (model ST-20 A-3210, Telonics Inc., USA), putted on 9 adult females of Tibetan antelope. The PTT were programmed to transmit signals in 24 h period every 3 days. The antelopes were captured and collared on August 2007 (2 females), August 2009 (2 females) and August 2010 (5 females) near the Wu-Bei (N35° 15′; E93° 09′; altitude 4597 m) underpass of Qinghai-Tibet railway; main morphological measures and descriptions of animals have been made. Location data received was designated as LC 3, 2, 1, 0, A or B. Argos User's manual state that the estimated accuracy in latitude and longitude is <250 m for LC 3, between 250 and 500 m for LC 2, between 500 and 1500 m for LC 1 and >1500 m for LC 0 (Hays et al., 2001). As if satellite tracking of the migrating Tibetan antelope was successful, previous analyses of two tracked individuals till 2009 showed the exact locations of summer (calving), intermediate and winter pastures; temporal distribution patterns; association of summer habitat selection with conditions of pastures and so on. During the study period numerous data of distribution, morphology, feeding habits, parasites presence had been obtained. Analysis of distances, durations and other specifics of migration of nine Tibetan antelopes were made on a base of satellite information in according to physical parameters of animals and habit. To utilize ARGOS PTT tracking data, ArcGIS10, ENVI software's tools, Aster Global Digital Elevation Model (GDEM, a product of METI and NASA) and a Human Footprint grid (by Wildlife Conservation Society (WCS) and CIESIN) were used. Composite Human Influence Index (HII) of the Earth's land surface was calculated by adding influence scores of eight input variables. The Human Footprint (HF) score was calculated by normalizing the Human Influence Index across the 15 World Wildlife Fund terrestrial biomes.

3. Results

3.1 Features of each animal tracks

The analysis of data obtained from August 2007 till September 2011 represents that Tibetan antelope, which collar is under the identification number 75842 (ID42) and Tibetan antelope ID37 are not migrant. Other 7 individuals are migrant, they share the same area for calving.

Two Tibetan antelopes, ID36 and ID38, use southward habitation area, when the migration begins, they crosses hill through the valley (altitude 4700m) before join the main migration corridor (Fig. 1). ID37, which doesn't go to seasonal migration (with ID42), shares almost the same area with ID44 in winter, which located in a distance of 35-40 km eastward from the railway (Table 1); core area of ID42 is near the railway, 1.2 km from Wu-Bei underpass, on the southern part of main pastures of ID35 (in 2008 and 2011), ID39, ID40, ID41. ID44 use two areas for pasture: one used in autumn and spring, which located more far (to the East) and one - in a winter time, distance between two pastures is around 12 km. ID41 also use different habitation area for autumn and spring, which altitude is higher than on winter pasture (Fig. 2a). This area located northeastward from place used in winter, the distance between two places is 25 km, and also, ID41 spend some time between two zones in late autumn and early spring. The core area of ID35 located near the road in winter 2007-2008 and 2010-2011, in winter seasons 2008-2009 and 2009-2010 antelope changes its core area and inhabits more far to the East, distance between two different areas is around 62 km.

Main habitation areas were used for 8-9 month at the average (Table 1), migration started on the beginning of June in 2008 and 2009, in the second decade of May in 2010 and approximately in the middle of May in 2011; because of data absence in May 2011 the roughly dates could not have been decided (Fig. 5), however, signal, appeared in 31st of May, located at the calving area or near (9 km eastward from calving place for ID40 and 27 km for ID39). Tibetan antelope ID44 began migration at 04-08 of June in 2011. This individual (and ID36) spent more time on main pastures, in comparison with others, in spite of relatively big distance from calving place the average speed of migration was lower but antelope returned from calving to core area in a short period (Table 1). Other individuals used more time for returning and average speed were higher - in a case of delaying on intermediate areas of a migration route. Tibetan antelopes ID38 and ID39 spent more time in a calving ground. All animals investigated had lower average moving speed on a way back to main pastures, when young follows the females.

The "human footprint" map represents the load of highway and railway, which crosses the migration route of Tibetan antelope (Fig. 3). As the Human Footprint grid was reclassified into Wild, HF values less than or equal to 10 and Not Wild HF value greater than 10, we can find out that examined Tibetan antelopes inhabits also on area under the classification Not Wild.

3.2 Estimation of accuracy

Numerous of location points with low accuracy, which doesn't suit to possibility of routehave been

Table 1 Enumeration of *Pantholops Hodgsonii* migration parameters.

Identifier	Distance of main pasture (km)		Average speed (per day, km)		Period of migration (days)		Period of calving (days)	Time, spent on main pastures (days)
	from calving ground	from railway	to the calving ground	from the calving ground	to the calving ground	from the calving ground		
ID75836	172 (±2.5)	37.2	7-8.	4, 9.	28	31	23	272
ID75837	not migrant	35 (±1)	—		—	—	—	—
ID75838	116	12, 5.	6, 3.	4-5.	24	38;23	37;41	249
ID75839	113, 5	0, 3 (±0, 2)	6, 5.	4 (±1)	22 (±2)	19	48	228 (±16)
ID75840	109	-	6	4-15.	22 (±30)	40	27	244 (±30)
ID75841	124;139;151	11, 4;8, 7;2, 8	8, 5	6, 4 (±1, 8)	12 (±18)	23	29	248
ID75842	not migrant	1	1, 3		—	—	—	—
ID75844	227	40, 5;57, 8	5-6.	5, 2	20	19	29	266

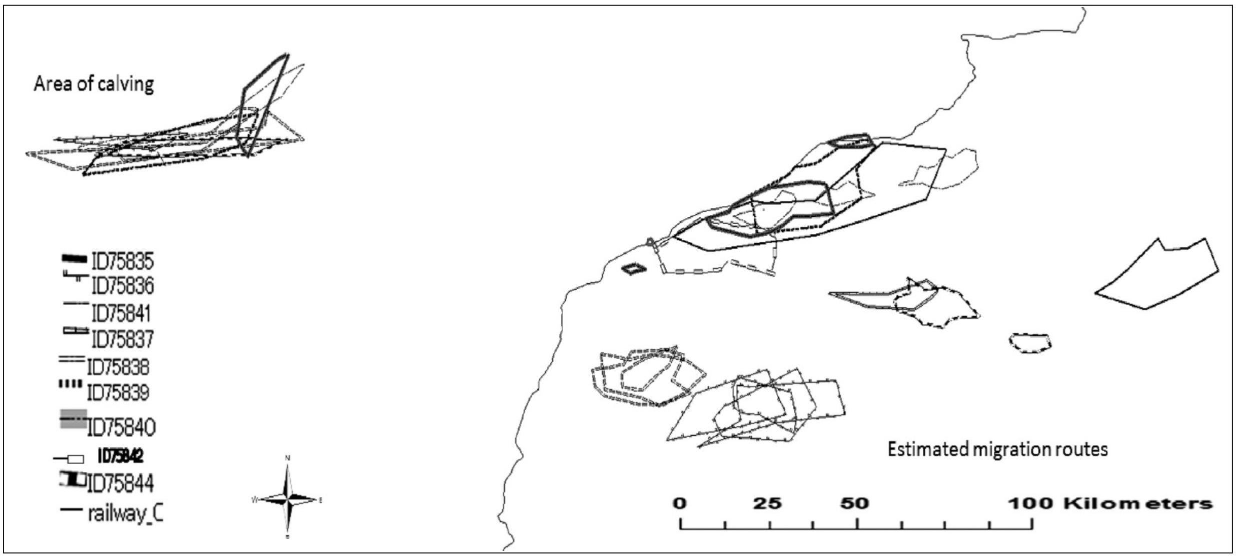
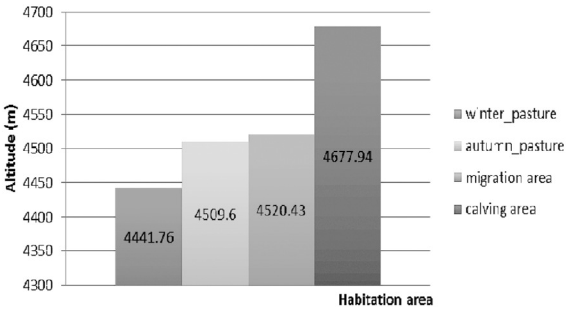
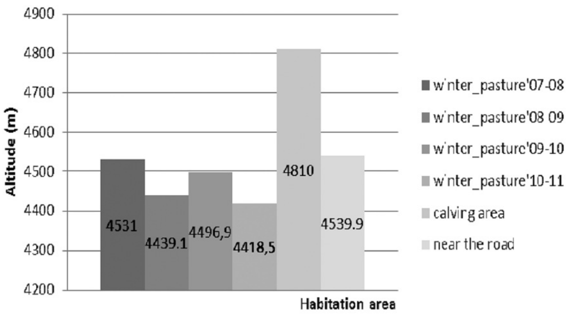


Fig. 1 Calving grounds and main pastures of tracked Tibetan antelope.



(a) Tibetan antelope ID75841.



(b) Tibetan antelope ID75836.

Fig. 2 Average altitude of pastures.

removed (Fig. 4).

No data were available at the period from 13. 04.2011 till 31.05.2011 - the time of initiation of migration (Fig. 5). In addition, for Tibetan antelope ID36 there were low accurate data on the period of migration to and from the calving place and hereby there is no information about migration route in years 2009-2011.

4. Conclusions and discussion

Understanding of major factors, which rouse Tibetan antelope females to migrate into particular site on definite time to high altitude severe area has an important implication in Tibetan antelope biology and conservation. However, logistical and physical difficulties have hindered research and surveys on Tibetan antelope. Aerial census is not profitable in some cases; ground censuses demand far more extrapolation from smaller samples, with greater possibility for initial error and inaccurate or unrepresentative samples to be magnified. It appears difficulties to observe in high mountain remote areas. Therewith, antelopes are sensitive to human intrusion; therefore it is convenient to use equipment to monitor them in a distance.

Tracking results improves previous analyses and added more detailed information about movements. Some of observed Tibetan antelope used different pastures with different conditions (of altitude etc.) for autumn and winter time; some of them can change the main habitation area and then, after two years, return to the old place. Numerous factors could be stimulus for beginning of migration, such as the changes of day length (when there is the longest daylight time), of precipitation (at the end of May to September concentrates 90% of annual precipitation), of pregnancy term or physiological mechanism of

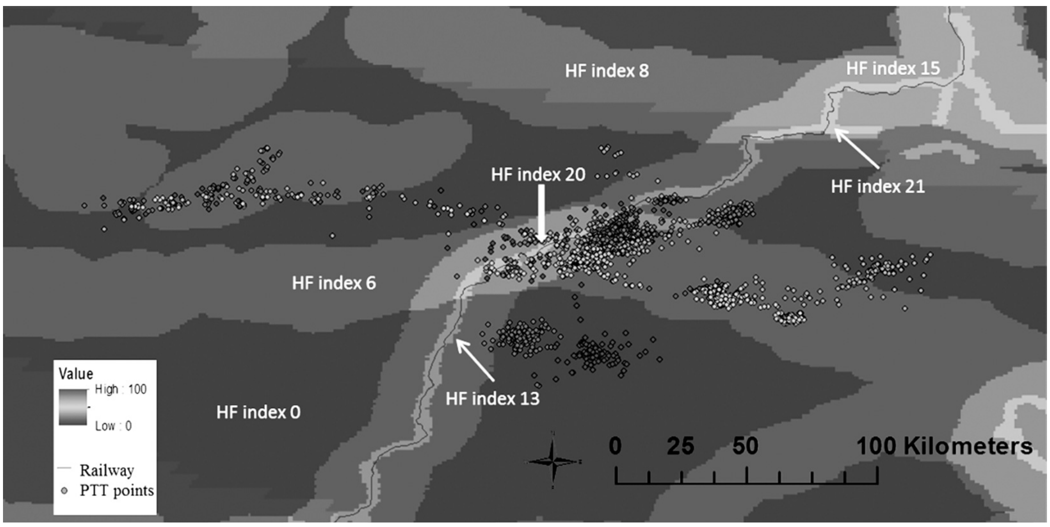


Fig. 3 "Human footprint" map, maximum HF is 20/100.

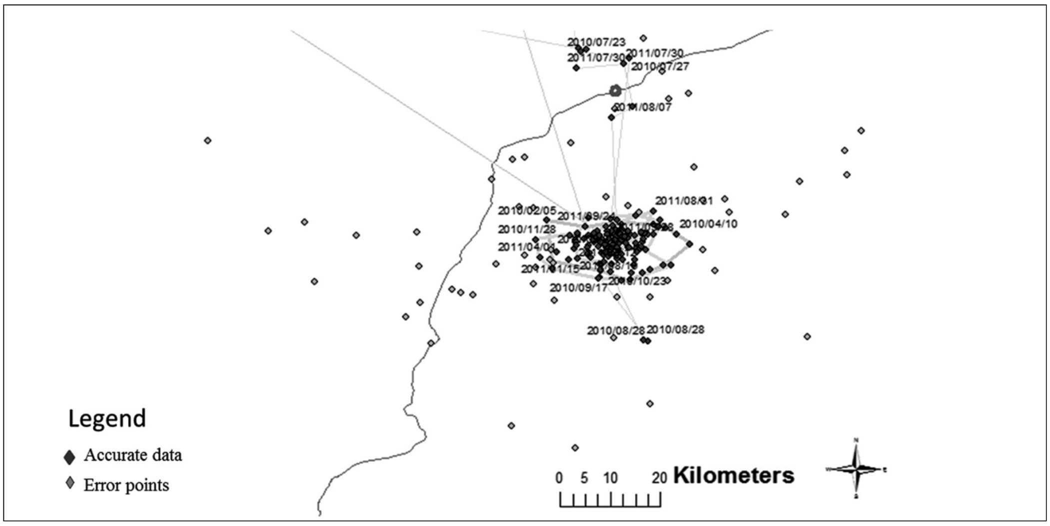


Fig. 4 Location points with low accuracy, which doesn't suit to possibility of route.

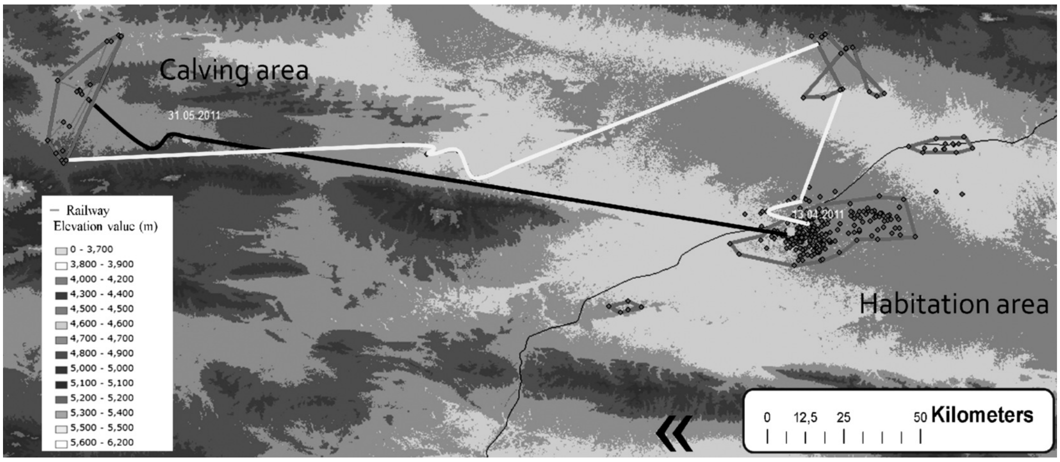


Fig. 5 Location points, consequences of data lack (Tibetan antelope, ID38).

motherhood (Tibetan antelope begins migration a month before calving). Thereby, satellite tracking is useful tool. It could show the concrete direction of animals, through what it is possible to understand real image of movement, reasons of choosing a definite place and time to move etc.

Low accuracy or absence of receiving data could be, in addition to other reasons, in a case of fast moving of the object.

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Abstract

The distribution of nine Tibetan antelope (*Pantholops hodgsonii*), the inhabitant of remote high altitude area, have been studied using satellite-based ARGOS platform transmission terminal tracking data from August 2007 till September 2011, the frequency of receiving transmitter signals was 24 hours per 3 days. The analysis of accurate positional information represents the specifics of spreading on habitat and migration routes of each from nine Tibetan antelope females. The ranges in time and space position have been noticed at different parts of seasonal cycle: wintering, calving period, period of migratory activity, especially when animals crosses the railway and highway which lies on migration route, separating main habitat and place of calving.

和 文 要 約

本研究は衛星追跡 ARGOS システムを用いて 2007 年 8 月から 2011 年 9 月まで，チベット高原の三江源近くに越冬するメスのチベットアンテロープ（チルーとも呼ぶ）9 頭の越冬地と繁殖地における行動を調べ，チベット鉄道がココシリを繁殖地とするチベットアンテロープの生息に与える影響の調査を行った。本研究でチベットアンテロープの越冬地と繁殖地間の詳細な行動が示唆された。また，9 頭のチベットアンテロープは異なる 2 箇所で越冬しながら出産地は同じくココシリの Huiten Lake という標高が比較的高い平坦な草原であることを明らかにした。2 箇所の越冬地の標高，降水量・気温などが異なっていることがデータ解析で分かった。