FINAL REPORT

An Assessment of the Traffic Disturbance to Tibetan Antelopes in Hoh-Xil National Nature Reserve

(Project No.26.01.05)

Period covered: May 1, 2005 – December 20, 2005

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1. SUMMARY

The Tibetan antelope (*Pantholops hodgsonii*), otherwise known as chiru is one of the world's most endangered species.Chiru are virtually exclusive to the Tibetan Plateau, though they occasionally wander into India's Ladakh region. It is listed as endangered animal by the World Conservation Union (IUCN) and has been listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1979. The People's Republic of China gives them the highest level of legal protection under its Wildlife Protection Law, prohibiting chiru hunting and trade in chiru parts without government permission.

Chiru are noted for their poaching massacre, and that their fine wools were smuggled and weaved to high-priced scarves and shawls for rich women in western countries. In the last one century, hunt grazing was the main threat to this species. These years the actions of governments and wildlife protection organisations have brought poaching under control. But there are still other dangers, the deterioration of the antelope's natural habitat and the degradation of the environment are continuing threats to the survival of the species. Tibetan Antelopes habitat in the vast expanse of 880,000 square kilometers in Qinghai-Tibet Plateau. Hoh Xil is one of the main distribution areas of the chiru. Each year, flocks of Tibetan antelopes will move to *Zhuonai Lake* and *Taiyang Lake* to give birth. The Qinghai-Tibet Highway and the newly built Qinghai-Tibet railway are both on their migrating corridor. In order to ensure the chiru pass through the railway safely, 15 passages were built in Hoh-Xil, but still no wildlife crossing structure over the highway. From 2004 a monitoring project was started to evaluate the efficiency of wildlife passages in migration season of Tibetan Antelopes, supported by the Military of Railway and BP Conservation Program. Till now we have continued monitoring the migration of this chiru population for three years, recorded all the passes of chiru through their main migration corridors, and the road and rail disturbance to them. In 2004, the main structure of wildlife corridors along Qinghai-Tibet Railway was finished but the rail bed was still in construction . We recorded 1660 individuals moved in Hoh Xil through Wubei Bridge(*Hoh-xil Passage*, which is an under bridge corridor), and 2303 in return migration, among them 1/3 were new born babies, about 56% using crossing structures, the others over passed the railway directly. The human activities in construction of the railway and road traffic both had great impact on migration of Tibetan Antelopes. In 2005, with the support of Rufford Small Grant we continued the project, and it was the first year that all 15 wildlife passages put into use. From May 31st to July 30th, 1509 chiru individuals passes were detected at *Wubei Bridge*, including females, sub-adult females and 8 new-born babies. In return migration till our fieldwork finished, 2182 individuals were recorded to cross

the Qihinghai-Tibet highway, among which 88.5% used wildlife corridors, 11.5% over passed the rail bed. The efficiency of wildlife passages increased. The main disturbances were road traffic and the human activities brought by the Qinghai-Tibet highway. On July 1st, 2006, the Qinghai-Tibet railway began trail operations. In our fieldwork of this migration season, we recorded 2122 chiru moved from their winter ground to their summer calving ground and 2854 in return. The Tibetan Antelopes passed through the railway smoothly using wildlife corridors, but were greatly affected by the busy traffic on highway and the disturbance of hundreds of tourists to Lhasa.

This project is not only a monitoring project but also a conservation plan. Together with the staff from the Reserve Management Office, we cleared the rubbish under the bridge, limited the activities near passages, assisted in stopping the traffic to help the chiru cross the road. Our monitoring results and recommendations were provided to Bureau of Forestry, transportation department. It will be used to make conservation plan for the next migration season.

Key words:Assessment, Traffic Disturbance, Migration, Tibetan Antelopes

2. INTRODUCTION

The Tibetan antelope (*Pantholops hodgsonii*), otherwise known as chiru is one of the world's most endangered species, endemic to the Tibetan plateau. On the plateau, chiru distribute throughout much of Tibet, Qinghai Province and along the southern part of Xinjiang Uygur Autonomous Region. They are virtually exclusive to the Tibetan Plateau, though they occasionally wander into India's Ladakh region (Wu & Feng, 1996, Schaller et al, 1998). The Tibetan Antelope is listed as Endangered animal by the World Conservation Union (IUCN) （EN 2d ver.3.1, 2001）and have been listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1979. The People's Republic of China gives them the highest level of legal protection under its Wildlife Protection Law (State Forestry Administration of China, 1998), prohibiting chiru hunting and trade in chiru parts without government permission.

The habitat of Tibetan Antelopes lies above 4,000 meters in elevation, but in parts of Xinjiang they formerly occurred as low as 3,250 m. They prefer flat to rolling topography and alpine steppe or similar semiarid plant associations. The current range of Tibetan Antelopes can be divided into two large areas: A northern part of about 490,000 km2 and a central part of about 115,000 km2. The distribution was probably continuous previously, but more recently, fragmentation and contraction of the population ranges in Qiang Tang Country and eastern Qinghai Province has occurred, and the southern and western margins of the former distribution ranges, such as the Dong Co Valley, are now devoid of chiru (Schaller 1998).

Although the chiru has been studied intermittently (Feng, 1991; Harris and Miller, 1995; Schaller,1998;Fox and Bardsen,2005;Schaller et al. ,2005; Schaller et al. ,2006),many aspects of its life remains little known till now. There are no accurate estimates of Tibetan antelope numbers from the past, although a few early explorers had made some occasional observations (Schaller, 1998). In 1900, the historical population of Tibetan Antelopes may have been a robust 1 million, estimates by Schaller based on the limited information available. (Schaller, 1998). Despite legal protection and trade bans, the burgeoning Western market for shahtoosh caused a dramatic increase in chiru poaching in the late 1980s and early 1990s—Schaller estimates in *Wildlife of the Tibetan Steppe* (1998) that "tens of thousands of animals must have been killed" to supply the trade during that time. In a report issued in December 1998, China's State Forestry Administration (SFA) cited Schaller's estimate that fewer than 75,000 chiru remained in the wild in 1995, which represents a population decline of greater than 85 percent.

Seasonal migration and sexual segregation are considered as main characteristics of Tibetan Antelope ecology and reproduction. The movement pattern of chiru is quite complex, both resident and migratory populations exist. Resident populations make only local movements, but also adopt seasonal sexual segregation during calving seasons (Schaller, 1998). In migratory population, there are differences between the movement patterns of the females and males. Field investigations indicated that chiru ranges are divided into distinct wintering and calving areas. Each summer, female adults and their female offspring of last year will move between their winter mating grounds and summer calving grounds, while males tend to remain near their wintering grounds. In late June to July single calves are born. The grasslands surrounding *Zhuonai* and *Taiyang* lakes have been identified as major calving grounds of Tibetan antelopes, located in the northwest of Hoh-xil National Nature Reserve (Feng, 1991b), where the climate is moderate, and the water and grass are abundant. Schaller reported that there were at least four and possibly more major migratory populations on the Tibetan plateau (Schaller, 1998). Hoh Xil is one of the most important calving grounds of the four populations mentioned above. Females of the subpopulation studied here migrates from Sanjiangyuan to Hoh Xil each summer, then return by fall.

Recent study on genetic variation among current population of chiru (Ruan, 2005) suggested high degrees of gene flow among all the sampled populations based on mitochondrial DNA control region sequences analysis. It was inferred that though the winter range of different population are separated, but the populations do have gene exchanges through their calving ground. During the course of migration for calving, it is more probable that a number of individual females from the original location translocated (Silvester and Peter 1999), thereby helping to promote gene exchange between populations of different localities. The migration of chiru may play a significant role in the course of gene exchange. So the protection of migration route is quite important.

Among all migration populations of Tibetan Antelopes, the one we studied was the most seriously affected by human activities. Until recent years, this population and their migration route was affected by poachers, but the population now is one of the best protected in China. The newly built Qinghai-Tibet Railway parallels the existing Qinghai-Tibet highway, and both cut across the study population’s migration corridor on the boundary between Hoh Xil Nature Reserve and Sanjiangyuan Nature Reserve (Xia and Yang 2004a,b,c), about 130-150 kilometers from the calving ground. In order to ensure the Tibetan Antelopes and other species pass through the railway smoothly, 15 passages were designed in the reserve, but no corridors have been built across the highway (Yang and Xia, 2003). "Passageways" -- trestle bridges, mostly -- have been incorporated into the railway's design at key points along the route where the antelopes are believed to cross during their seasonal migration to grazing

grounds. At these locations, the antelopes could theoretically use underpasses to traverse the rail route without risking crossing over the tracks. But wildlife experts doubt that the antelope will actually use the underpasses, since their instincts may instead prompt them to climb up to the high ground of the rail bed and have a wary look around before proceeding. From 2004 a monitoring project was started to evaluate the efficiency of wildlife passages in migration season of Tibetan Antelopes, supported by the Military of Railway and BP Conservation Program. During 2004-2006 we recorded the passes of chiru through their main migration corridors, covered about ten kilometers from Chumaer River to Wudaoliang. Monitor the impacts of transportation infrastructure on this migratory herd of Tibetan Antelope and mitigating those impacts is extremely important.

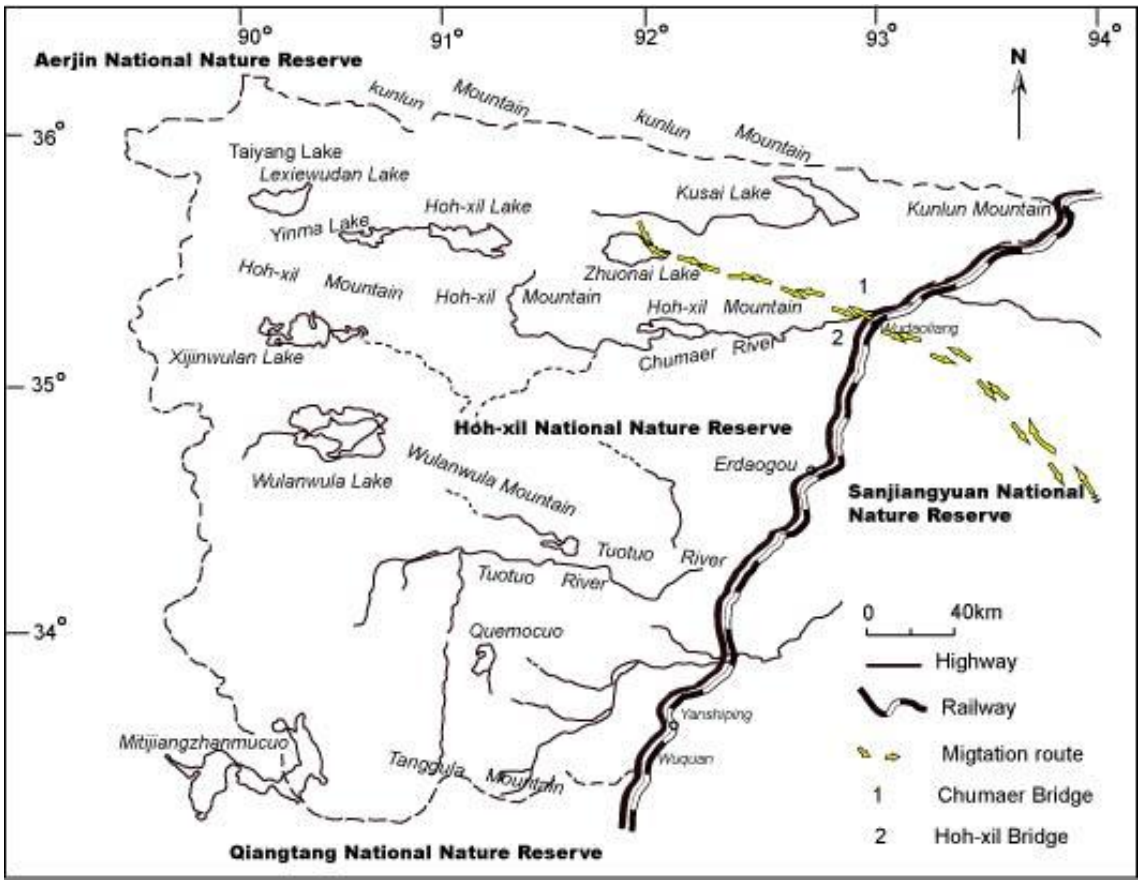

Fig.1 Distribution and migrating route of Tibetan Antelopes in Hoh-xil nature reserve

3. STUDY AREA

The Hoh Xil National Nature Reserve is located in the territory of Qinghai Province. On the Qinghai-Tibet Plateau, it extends from the Tanggula Mountains in the south to the Kunlun Mountains in the north, with an average altitude of 4,500 meters above sea level (Liu & Yin, 1993). The reserve is a hostile land of cold, thin air, typically a forbidden zone for man. The topography is rolling hills and shallow gullies; habitat is high altitude steppe, alpine meadow and gravel-filled gullies, entirely without trees or shrubs.

Fig 2. Hoh-xil and wild animals in the reserve.

Whole working area covered 257 kilometers from Kunlun Mountain to Tuotuo River. Fieldwork was conducted along the newly built Qinghai-Tibet Railway and the parallel highway on the boundary of Hoh-xil Reserve and the adjacent Sanjiangyuan Reserve. The main monitoring area covered a thirty kilometer stretch of concentrated migration from Chumaer River to Wudaoliang, including *Chubei* Overpass corridor, *Chumaer* Underpass Passage (*Chumaer* Bridge), *Hoh-xil* Wildlife Passage (*Hoh-xil Bridge*) and some other crossing structures not specifically designed for wildlife.

Fig 3. Newly built Qinghai-Tibet Railway and the parallel highway.

3.1 Crossing structures

Chumaer Bridge **–** Main wildlife corridors in this area, used to be the main migration corridor. The main structure was finished in 2003 and put into use in 2004. The distance between highway and railway is about 800 meters. From 2004 to 2006, the construction was halted in each migration season of chiru, but the workers were not removed from the working sites. The surface of land under the bridge was destroyed by construction machinery and was not restored till 2005.

Fig 4. Chumaer Bridge.

Chubei Passage -This overpass passage is about 2 km southwest of Chumaer Bridge, near Chumaer River, and the situation is similar to Chumaer Bridge. Unfinished construction and human activities are main impact factors.

Fig 5. Chubei Passage.

Hoh-xil Bridge – An underpass bridge, which has become the main corridor for Tibetan Antelopes. The main construction completed in June 2004. There is an open area between the highway and the railway.

Fig 6. Hoh-xil Bridge.

Wudaoliang Railroad Bridge - North of Wubei Corridor. Although it was not designed for Tibetan Antelopes passage, but may be one corridor for migration. The structure is similar to Wubei Bridge and a bit far from the highway, with a large open area near the passage. The main construction sites located near the bridge in construction period during 2001-2005.

Fig 7. Wudaoliang Railroad Bridge

Kulun Mountain Wildlife Passage- Wild life Passage designed for large mammals. A tunnel with an underpass bridge.

Fig 8. Kulun Mountain Wildlife Passage

Budongquan Wildlife Passage- An underpass bridge designed for large mammals.

Fig 9. Budongquan Wildlife Passage

Wuli Bridge- Underpass bridge. It is not designed as wildlife corridors, but could be used by the animals.

Fig 10. Wuli Bridge

Other small bridges and culverts – Most of these structures are about 1-2m in height, and 5-10m long. They are dark, narrow corridors, and the land surface under the bridge is not cleared of debris or restored.

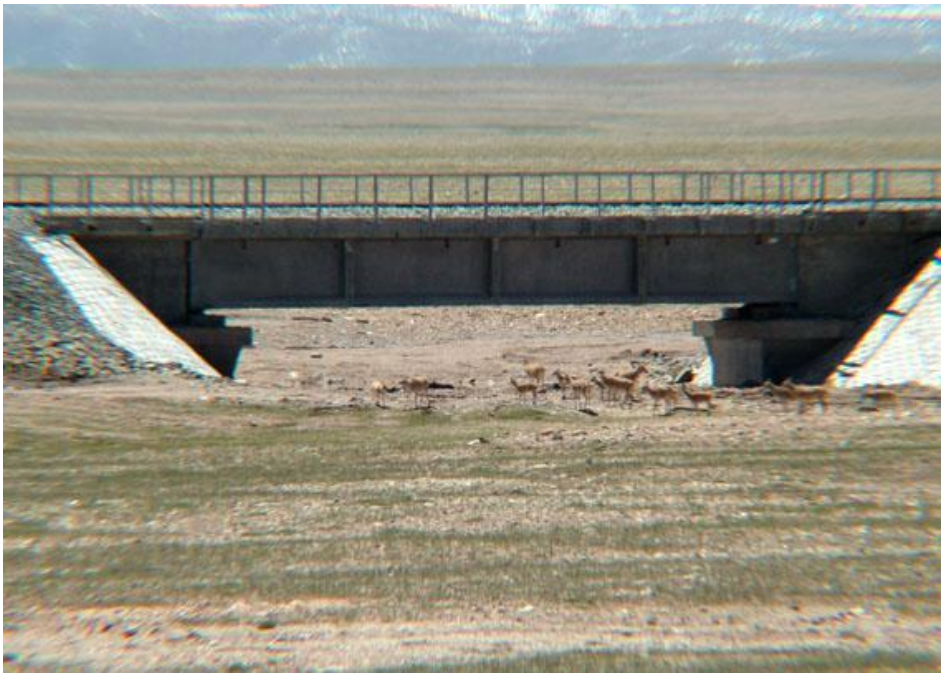

Fig 11. Small bridges.

Fig 12.Culverts.

3.2 The Qinghai-Tibet Highway

Qinghai-Tibet Highway (Xining-Lhasa section of No.109 National Trunk Highway) starts form Xining of Qinghai Province on the north and ends at Lhasa of Tibet. The highway was first built in 1950 and opened on December 25, 1954. Being one of the highways in the world, it crosses the Kunlun Mountain, Hoh Xil and Tanggula mountains and the beautiful Zangbei Plateau with the average elevation of above 4,500 meters. Since 1991, the road conditions have tangibly improved and basically reached Class 2 highway criteria. The total length of the highway is 1900km, with the roadbed being 10-meter wide, and an incline of less than 7%. The speed limit of drive is 80 km per hour.

Qinghai-Tibet Highway is a major passage between Tibet and hinterland, undertakes transport of over 85% inbound Materials and over 90% outbound materials, plays an important role in Tibet economic development and social stability. Among the four highways to Tibet Plateau, the road condition of Qinghai- Tibet highway is the best due to weather condition and landscape. In the rainy season, the coach, trucks and other transportation vehicles all selected this route due to safety consideration, brought more traffic pressure on the highway.

Fig 13. The busy traffic on Qinghai-Tibet Highway in summer.

3.3 The Qinghai-Tibet Railway

The Qinghai-Tibet railway is the China's first highland railway; it is 1956 km in whole length, with the newly built section between Golmud and Lhasa owning 1118 km. The construction of Xining-Golmud Section started in 1958 and was opened on May 1984. On June 29th, 2001, the construction of the Qinghai-Tibet Railway (Golmud to Lhasa section) began; it is built along the Golmud River, goes across the Kunlun Mountain, through Hoh Xil and Fenghuo Mountain, across Tuotuo River and into Tangula Mountain, passes along the Damxiong and Yangbajing Valley, with the final destination being Lhasa, the capital of the Tibet autonomous region. The newly built Qinghai-Tibet railway has a 965-kilometer section with an elevation above 4,000 meters and a 550-kilometer section featuring permafrost. The railway goes through three national nature reserve, Sanjiangyuan National Nature Reserve, Hoh-xil National Nature Reserve in Qinghai Province and QiangTang National Nature Reserve in the Tibet autonomous region. To protect the animals and plants, railway bridges and culverts and 33 animal passages are built, and this is the first time wildlife corridors used in China. All corridors were put into use in 2005, and the railway start operations on 1st July, 2006.

Fig 14. The newly built Qinghai-Tibet Railway began trail operations on 1st July, 2006.

4. AIMS AND OBJECTIVES

The aim of this project is to assess the disturbance of construction of the newly-built QTR to the migration of chiru, survey the status of the species using field-monitoring techniques. Results from this study may diagnose any potential problems with transportation development at an early stage and provide solutions to reduce conflict between railway construction and conservation.
of Forest, transportation angency and NGOs are strengthened or created.

l Provide reliable information on behavioral ecology and migration of chiru.

Our field work will provide valuable information on behavioral ecology and the conservation status of this species in their habitat.

l Disturbance caused by the railway and highway is identified.

The assessment of the disturbance caused by the railway and the efficiency of the crossing structures will help the railway construction team to schedule a conservation plan for this and related species.

l Efficiency of the different wildlife corridors is assessed.

It is the first time wildlife safe passages have been built in China; with increasing development, more highways and railways will be built in western China in the future, and it is particularly important that these efforts be monitored and the lessons learned from these mitigation experiments be shared with others.

l A reasonable conservation plan for the construction period and for the future generated.

Results from this study on traffic disturbance may diagnose any potential problems of infrastructure development at an early stage, which will help the reserve and policy makers to design a long-term conservation plan.

l Mornitoring techniques and field skill of the local students and residents are improved.

An effective network will be created between the protected area and the local government, and will initiate a long term mornitoring plan to provide data continuously.

l The links with the local staff of the Department of Forest, transportation angency and NGOs are strengthened or created.

The involvement of the staff of the reserve, local residents, and local government officials will ensure the long-term conservation impact of the project.

l Public awareness of the species is improved.

5. METHODS

5.1 Training

Before the field survey starts, we conducted a training workshop in field monitoring techniques for the staff of the reserve and local residents who were involved in our project.

5.2 Field survey:

From early June to late August we monitored the movement pattern of the migrating population along the rail line and highway, recorded their population size, population structure and behavior when they pass through. We also recorded the traffic flow and disturbance by tourists, which will help to assess the impact of the infrastrure itself and of other human activites. Following methods were used.

Video Cameras**:** Using video cameras to record the passage of the chiru. It also could help to observe behaviors that may indicate hesitancy or stress in animals using the crossings.

Counters: We also counted the number of chiru which pass through the crossing structures and those acrossed the railway not using the passages. Counts was carried out with 15-45X spotting scope in the daytime, as Tibetan Antelopes rest at night. We also drove a vehicle along the highway to inspect the whole working area. The group size in migration was also recorded. A group was defined as all individuals within 50 meters of each other.Yearlings and adults are difficult to differentiate at a distance, and only composition of those herds for which determinations are judged to be reliable were included in subsequent analysis of herd composition.

Fig 15.Counters

Fig 16.Counters

6. Other Project Components

6.1 Supporting institutions

Rufford Small Grant

BP Conservation Programme

Institute of Zoology Chinese Academy of Sciences

China Ministry of Railways

6.2 Local participation

Institute of Zoology Chinese Academy of Sciences

Administration Bureau of the Hoh-xil Nature Reserve

Bureau of Forestry, Qinghai Province (BFQH)

China Ministry of Railways

6.3 Government permission

No animals will be handled, so special government permission will not be needed. We have got fully supporting by BFQH, MOR and HXNR.

6.4 Public Awareness and Education

The data of the monitoring was presented back to the local community members and the related government units we mentioned above. The results will also be presented to the scientific community and some non-government organization.

7. MONITORING RESULTS

7. 1 Migration from winter range to summer calving ground (From Sanjiangyuan to Hoh-xil)

During late May to early June, Sanjiangyuan population migrated from *Sanjiangyuan* Reserve into Hoh-xil National Nature Reserve for calving. From May 31st to July30th, 2005, 1509 chiru passes were recorded to cross the Qinghai-Tibet railway and highway, including pregnant female, yearling female and 8 new offspring. All chiru crossed the railway through Hoh-xil wildlife corridors. In 2004, 1660 chiru individuals were recorded to use this crossing structure. We continued monitoring the migration in 2006, on May 17th, the first group of chiru passed through the *Wubei Bridge* then crossed the highway, about two weeks earlier than past three years (2003-2005). The number in 2006 increased to 2122 in migration to the calving ground (Table 1, Fig 17).

Table 1. Summary of chiru passes at Qinghai-Tibet Highway and Railway in migration to the calving ground (2005-2006)

Date		May						June																	Total
		17	18	24	25	30	31	5	6	7	8	9	10	13	14	15	20	21	22	23	24	26	27	29	30	
Number of individuals	2005	0	0	0	0	0	134	0	0	0	0	0	0	183	0	0	310	151	18	339	77	38	72	54	133	1509
	2006	80	34	21	70	83	0	40	477	264	298	116	5	331	100	98	0	0	0	0	0	105	0	0	0	2122

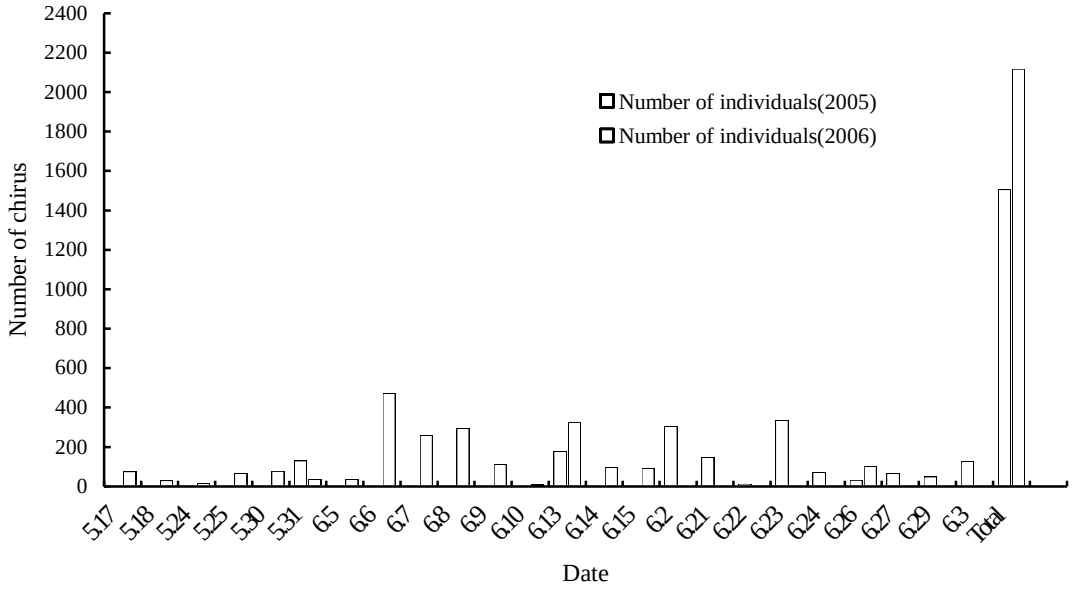

Fig17. Summary of chiru passages at Hoh-Xil Passage in migration to the calving ground (2005-2006)

7. 2 Migration from calving ground to the winter range

Antelopes came back with newborn offspring. Our working sites were set about 300 km from the calving ground, when the chiru returned, the babies were at least one month old. In return migration of 2005, 2182 individuals were recorded. The number in 2004 and 2006 is 2303 and 2854, respectively.

We also observed the composition of the return population, 66 populations were sampled randomly, the ratio of offspring to total varied in different groups from 16.67%-55.56%, with an total average of 35.24 (Table 3). This ratio was 34.73% in 2004 and 32.12% in 2006 .

Table 2. Summary of chiru passes in return migration (2005-2006)

Date		July				August																					Total
		23	24	27	31	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	18	21	22	23	25	
Number of individuals	2005	0	0	0	0	0	0	100	0	0	0	31	0	525	0	250	87	0	34	174	132	6	320	250	247	26	2182
	2006	29	25	7	51	16	7	0	367	17	8	232	105	374	809	150	16	70	255	45	206	65	0	0	0	0	2854

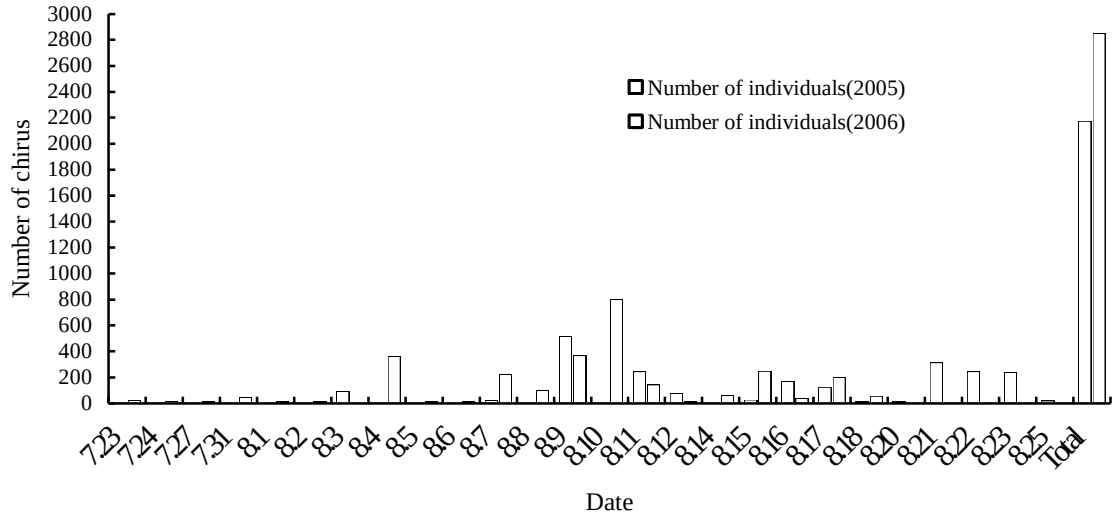

Fig. 18 Summary of chiru passes in return migration (2005-2006)

Table 3. Population composition in return migration, 2005

Group	Adult and Sub-adult female	New born Offspring	Offspring/ Total (%)	Group	Adult and Sub-adult female	New born Offspring	Offspring/ Total (%)
1	56	27	32.53	36	3	3	50.00
2	5	2	28.57	37	74	30	28.85
3	38	22	36.67	38	60	49	44.95
4	9	7	43.75	39	19	8	29.63
5	61	23	27.38	40	4	5	55.56
6	30	24	44.44	41	25	12	32.43
7	6	5	45.45	42	19	9	32.14
8	5	1	16.67	43	34	13	27.66
9	21	11	34.38	44	59	22	27.16
10	14	8	36.36	45	5	5	50.00
11	42	40	48.78	46	13	9	42.86
12	3	3	50.00	47	10	4	28.57
13	10	6	37.50	48	3	3	50.00
14	29	15	34.09	49	38	23	37.70
15	15	9	37.50	50	23	8	25.81
16	36	21	36.84	51	50	35	41.18
17	105	41	28.08	52	35	32	47.76
18	19	17	47.22	53	5	3	37.50
19	5	4	44.44	54	2	2	50.00
20	4	3	42.86	55	11	5	31.25
21	7	6	46.15	56	21	8	27.59
22	46	29	38.67	57	79	36	31.30
23	18	10	35.71	58	4	4	50.00
24	24	15	38.46	59	15	9	37.50
25	6	3	33.33	60	210	75	40.54
26	13	7	35.00	61	37	17	31.48
27	77	37	32.46	62	4	2	33.33
28	55	36	39.56	63	12	5	29.41
29	22	8	26.67	64	19	20	51.28
30	20	8	28.57	65	14	14	50.00
31	31	10	24.39	66	11	12	52.17
32	85	56	39.72	Σ	1928	1049	35.24
33	39	17	30.36				
34	9	7	43.75				
35	45	29	39.19				

7.3 Efficiency of wildlife corridor and other crossing structures

The Efficiency of wildlife corridors is defined as the number of successful passes divided by the total number of individuals. Our monitoring results showed that from 2004-2005 all Tibetan Antelopes used the Hoh-xil Passage in migration to the calving ground, the efficiency of the corridor was 100%. In 2006, we found the antelopes began to use other wildlife passage

and bridges. In return migration of 2005, we detected 251 individuals overpass the rail bed, occupying 11.5%, all the other passes were recorded at Hoh-xil Passage, the efficiency was 88.5%. While only 56.1% used this corridor on the return trip in 2004. In 2006, we recorded 39 individuals cross over the rail bed, 2815 antelopes used crossing structures to pass through the railway, including Hoh-xil Passage, Wudaoliang Railroad Bridge and some other bridges in Budongquan, Wuli and Kunlun Mountain. The passage use was increased to 98.63%. The use of crossing structures appeared to be negatively associated with the presence of construction material, un-removed equipments, transportation vehicles, the proximity between highway and railway, and human activities.

Table 4. Efficiency of different crossing structures in migration to and from the calving ground (2004-2006)

Structure Name	year	Number of Individuals crossing the railway		Efficiency of crossing structures/ over passing the rail bed	
		To calving ground	From calving ground	To calving ground	From calving ground
Number of individuals using crossing structures	2004	1660	1291	100%	56.06%
	2005	1509	1931	100%	88.50%
	2006	2122	2815	100%	98.63%
Number of individuals over pass the rail bed	2004	0	1012	0	43.94%
	2005	0	251	0	11.50%
	2006	0	39	0	1.37%

7.4 Disturbance to migration of Tibetan Antelopes

The railway structure itself - The railway itself is a physical barrier and the impact of the huge structure on Tibetan Antelopes activities is apparent. When Tibetan Antelopes faced this infrastructure, they hesitated under the sharp slope of the rail bed and gathered into large groups, which was not observed before the construction of the railway. Though the "passageways" – mainly trestle bridges - have been built at key points along the migration route, the Tibetan Antelopes instead may climb up to the high ground of the rail bed and have a wary look around before proceeding, in the same way in which they cross the highway.

Destruction to land surface- The destruction to land surface under the wildlife corridors and along the rail line is another major impact of Tibetan Antelopes activities. Tibetan Antelopes are very sensitive animals and any change on the land surface may affect or even stop the Tibetan Antelopes from moving. They seemed very careful with anything happened on the land surface, although they sometimes ignored the train running over their head.

Predators- When the Tibetan Antelopes accumulated under the bridge, it provided an

opportunity for the wolves. Chasing by wolves sometimes affected the use of the corridors, scattering the Tibetan Antelopes.

Traffic flow on highway- We recorded the traffic flow on Qinghai-Tibet highway during the most concentrated migration period from 2004 to 2006. In 2005 the average traffic flow was 63.7/hour in the daytime, the peak occurred in 15:00-16:00pm (Table 5, Fig. 19), the flow reached 70.41/hour. In 2004, when the railway was still in construction, the day traffic flow was 74.61/hour on average, and in 2006 it decreased to 57.48/hour.

Table 5. The traffic flow on Qinghai-Tibet highway, and crossing attempts made by chiru in return migration, 2005

Time period	Average traffic flow (per hour)		
	2004	2005	2006
7:00-8:00	-	52	48.13
8:01-9:00	-	61.66	58.42
9:01-10:00	72	63	75.9
10:01-11:00	69.33	68.67	72.23
11:01-12:00	74.93	64.42	50.5
12:01-13:00	69.35	55.34	57.85
13:01-14:00	98.40	72.25	66.33
14:01-15:00	87.0	70.09	53.17
15:01-16:00	80.53	74.58	58.69
16:01-17:00	75.40	70.41	62.37
17:01-18:00	65.40	66.84	58.50
18:01-19:00	63.20	56.84	47.60
19:01-20:00	65.15	52	37.57
Average	74.61	63.7	57.48

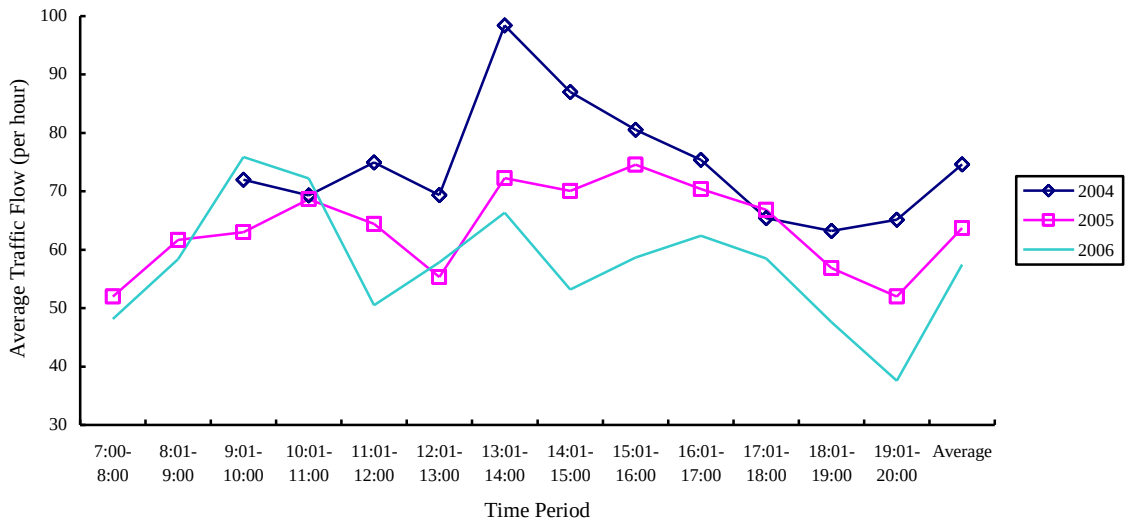

Fig.19 The traffic flow in Qinghai-Tibet highway, 2004- 2005

8. DISCUSSTION

8.1 Disturbance to migration of chiru.

8.1.1 Rail disturbance

The results indicated that the railway structure itself have significant impacts on behavior of Tibetan Antelopes, but do not disrupt their migration corridors after the wildlife corridors putting into use. In main construction period of 2003, most of bridges and wildlife passages were still in building, about 1/3 of chiru failed to cross the railway and gave birth near the rail bed on their way to the calving ground. The main structure of wildlife corridors finished in 2004 and put into use in 2005, all chiru crossed the railway successfully.

According to railway construction planners and the Qinghai Environmental Protection Bureau, the area affected by the rail bed's construction is to be returned to its original condition, and we saw some turf transplanted back to the rail bed. In fact the swathe of tundra disrupted by railway construction is quite narrow. The most worrisome sites are the intermittent staging areas and sand quarries located off to the side of the railway construction site. During the migration of 2003, the Tibetan Antelopes did not use the corridors partly due to this reason. In 2005, as the main structure of the railway in Hoh-xil has been finished, most of sand quarries and material were moved off, and the condition of passage improved. Where such construction debris still occurs under the crossing structures or along the railway, this affects the use of passages. In 2006, all equipment and construction sites removed from the migration corridor and the land surface under the passage restored, the condition of crossing structures was greatly improved. The Qinghai-Tibet railway began rail operation on July 1st, from the monitoring results, we can see the disturbance or train is not significant, all chiru crossed the railway in return migration and the passage use improved.

With three years' of experience, the chiru began to adapt themselves to the new circumstances. The learning ability of chiru gave us strong impression. Long-term monitoring work is still necessary. The data is not sufficient to get the conclusion whether the wildlife passages is successful of not, it is the first year that the railway operated, the efficiency may changed annually.

8.1.2 Road effect

It's difficult to distinguish whether the disturbance on chiru caused by road or railway in the narrow zone between railway and highway, especially in return migration. The road effects included traffic flow, human activities and features of the roadbed.

The Qinghai-Tibet Highway is the most important transportation lifeline to Tibet Plateau. To take advantage of the short summer work season on high plateau, the construction period concentrated during June to September, increased the already busy road traffic in the migration season of Tibetan Antelopes.

We hope the situation will be advantaged when the railway put into use. By 2007, 16 trains will shuttle between Golmud and Lhasa every day, the railway will offer a safer, convenient and reasonably-priced means of travel for Tibetan people and tourists, it can carrying nearly eight million tons of cargo annually, coal, cement, oil and other essential raw materials will be transported to Tibet from China's resource-rich regions by train instead of road transportation. The flow may be reduced.

8.1.3 Direct Disturbanc**e**

The Qinghai-Tibet railway runs along the eastern boundary of the Hoh-xil Wildlife Protection Reserve, all human activity has been banned in this area. The construction of the Qinghai-Tibet Railway and the nearby highway brought human activities to the reserve. In all disturbances to migration of chiru, human activities might be the most serious one, which including activities of tourists, construction workers of the railway and other persons brought by highway. Tibetan Antelopes are active in the daytime, could not avoid the disturbance of human activities. The migration season is in summer, which is the busiest period for construction of the railway and other activities on the Plateau. In 2004-2005, the main disturbance is caused by construction workers. During the short concentrated period both in westward migration and their return trip, all construction activities was limited near the main passages, but the activities of tourists and truck drivers were not under control, and greatly affected the migration.

In 2006, an increase in tourists to Tibet poses a threat to the migration of Tibetan antelopes. The operation of Qinghai-Tibet Railway has helped promote Tibet as a tourism destination, but the transportation ability was limited, the highway was still an important path to the Tibet to most of tourists. The attempts of crossing highway or railway made by chiru were often interrupted by exciting tourists. Increase of the human presence associated with railways and highways may be the main threat to this species now and in the future, even greater than the infrastructure itself.

8. 2 Evaluation of different crossing structures

The Efficiency of wildlife corridors is defined as the number of successful passes divided by the total number of individuals. All Tibetan Antelopes passed through the crossing structure on their migration to the calving ground. In return migration, the efficiency of corridors greatly increased from 56.06% to 98.63% during the observation period of 2004 to 2006, with the condition of the corridor improved. The using of crossing structures affected mainly by unclear construction material, un-removed equipments, transportation vehicle, the distance between highway and railway, human activities.

Table 6. Efficiency of different crossing structures over the Qinghai-tibet Railway

Structure Name	Structure Type	year	Number of Individuals crossing the railway		Efficiency of the structure	
			To calving ground	From calving ground	To calving ground	From calving ground
Chumaer Bridge	under pass wildlife passage	2004	0	41	0	1.78%
Hoh-xil Bridge	underpass wildlife passage	2004	1660	1248	100%	54.19%
		2005	1509	1931	100%	88.50%
		2006	1796	2343	84.64%	82.10%
Wudaoliang Rail Road Bridge	underpass bridge	2006	40	0	1.89%	0
Chubei Passage	overpass wildlife passage	2006	34	0	1.60%	0
Kunlun Mountain Wildlife Passage	tunnel and underpass bridge	2006	47	115	2.21%	4.03%
Budongquan Wildlife Passage	underpass wildlife passage	2006	100	7	4.71%	0.25%
Wuli Bridge	underpass bridge	2006	105	350	4.95%	12.26%
Other Small Bridges	underpass bridge	2004	0	2	0	0.09%

8.2.1 Chumaer Bridge

The human activities was the most serious factor which affected the efficiency of all crossing structures, including the tourist, builder of the railway and other human activities brought by highway. Chumaer River used to be main migrating corridors, and the bridge was designed as wildlife corridors for chiru use, but the efficiency of the Chumaer Bridge is quite low, we have only recorded 41chiru passes under the bridge in three years of observation. The bridge itself is an underpass bridge almost the same as Hoh-xil Passage in structure, the difference is the less distance between highway and railway, and the surface of

land was destroyed by the construction machine and not restored till now. We saw some raw material such as sand, brick were not cleared. the builder of the railway lived in camp just near the bridge. Workers were not removed from the working sites till 2005; their activities affected the using of passages. The migration was affected both by the railway and by the traffic on highway in this narrow area.

8.2.2 Chubei Passage

This over-cross passage is about 2km southwest of Chumaer Bridge, near Chumaer River, the situation is similar to Chumaer Bridge, the unfinished construction and human activities are main impact factors. When the railway was still in construction during 2004-2006, it was not used by chiru. In return migration of 2006, a group of 34 antelopes were detected over pass this corridor.

8.2.3 Wubei Bridge

The monitoring results show Wubei bridge was the most effective corridor in migration season(fig 6). The efficiency increased annually. In the main construction period of 2003, the bridge was still in building, the rail bed near the passage was not covered with stone which is used for protecting the rail bed. Only 400-450 individuals using the built-in passages. In June 2004, the main structure of the corridor was completed, all chiru went through the bridge in migration to the calving ground and 54.19% used the passage in return migration. The workers were removed from the working sites, together with most of the machines, but still something left or unclear under the bridge which decreased the efficiency of that year. From 2005, with the improvement of the condition in environment near the passage, the efficiency of the corridor increased to over 80%. There is another advantage of this passage - the open area between highway and railway, providing chiru enough space to stay and being kept away from the noisy road.

8.2.4 Wudaoliang Railroad Bridge

This bridge is in north of Wubei Corridor, though it is not designed for chiru passage, but it began to be one corridor for migration. In 2006, a small group of 40 individuals were detected under the bridge. The structure is similar to Wubei Bridge and a bit far from the highway, with a large open area near the passage. In 2004 and 2005, the main construction sites located near the bridge and part of the structure are still in built, which limited its use. But with the environment restored in this area, the efficiency of this corridor may improve in the future.

8.2.5 Kunlun Mountain Wildlife Passage, Budongquan Wildlife Passage and Wuli Bridge

The migration corridor was much wider before the construction of railway (), covered our whole working area from Kunlun Mountain to Tuotuo River. These bridges were not in the main migration corridor of chiru, but we recorded chiru passes in migration season of 2006. When the environment restored near the railway, the chiru began to use more corridors to cross the railway.

8.2.6 Other small bridges and culverts

This kind of structure is most used by brown bear (*Ursus arcto*s), wolf (*Canis lupus*), fox （*Vulpes ferrilata* ） and Tibetan gazelle (*Procapra picticaudata*), but unlikely used by chiru. Most of such structure is about 1-2m in height, 5-10m long. It's dark in the narrow corridor, and the land surface under the bridge is not cleared or recovered. We detected only two individual passed through a small bridge in 2004. The prospect of such structures needs further investigation in the future.

8.3 Recommendations & Conservation actions.

8.3.1 Recommendations

Based on monitoring results and evaluation of crossing structures showing above, we made following recommendations.

a. Stop or limit the human activities near wildlife passages

In the construction period, construction work was halted for the antelopes in the concentrated migration period. From 2006 the railway put into operation, the activities of tourist, researchers and truck drivers should be limited by the manager of the reserve.

b. Advantage or modify the wildlife passages

We have mentioned above, over 40% of chiru over cross the rail bed in return trek of 2004. Though the efficiency of wildlife corridor improved from 2005, there are still some chiru individuals over passed the rail bed. Some researcher had advised to modify the sharp slope of the rail bed and remove the stone, which covered on its surface. This will make the chiru to climb the rail bed easier but not safe for the running train and the chiru itself. We don't agree with their mind, as most of chiru began adapting to the new-built wildlife passages, the best is to lead them pass through the corridors safely and avoid from the rail accident. Due to the safety consideration, we recommend building fence in the most frequent sites of chiru over passing.

c. Ensure the rail department to restore the environment near the rail line.

d. Reduce the road disturbance in rebuilding of Qinghai-Tibet Highway, by building more passages.

Now there are not any crossing structures on Qinghai-Tibet Highway, and the environment is degraded due to busy traffic recent years, we could not ensure the traffic flow to be reduced in the future, stopping the traffic will cause traffic jam on the highway and economic loss, it will not solve the problem completely. The highway will be renew in the next several years, it's possible to build some wildlife passages and change the route in some area, further investigation is necessary to provide reliable and sufficient data in future designing.

e. Enhance management of the Reserve and conservation capability building

The railway is on the boundary of two reserves, the west region is controlled by management department of Hoh-xil National Nature Reserve and the east area is managed by Sanjiangyuan National Nature Reserve. The railway and highway is in charged of transportation department. The chiru's activities covered all these areas. The cooperation of the three management departments should be enhanced in ensuring the smooth migration of chiru. Till now most of conservation actions were taken by 5 wildlife protection stations belonging to Hoh-xil Reserve, ethnic Tibetan wildlife enforcement officials were employed by the Forestry Bureau of Qinghai province, working at wildlife protection stations. Their duty is to patrol the construction sites, stop traffic when herds of antelope cross the road.

Some non-government organizations such like Green River, and other volunteer league also made some contribution to protecting the antelope, mainly in improving the public awareness of chiru, their work is well known to public through media. Each summer the volunteers from all over the country will work for the protection stations and take part in some conservation projects. Everyone with good health, work attitude and love of animals could be volunteers, no particular requirements for an applicant's age, gender or vocation. They will pay for their trip and all other living expense during the one-month working in Reserve. They are passionate young people; their efforts and passion can inspire the people around them. But we found there exist some problems in their work due to different education background of the volunteers. Most of them full of passion but lack of enough field experience, basic knowledge of chiru and wildlife conservation, this may reduce the effectiveness in coping with real problems. And there is another factor which limited the activities of the volunteers, considering Hoh Xil's harsh natural conditions and frigid winter

weather; volunteers will be on patrol only from June to August. Each team will be consisted of five or six volunteers and each volunteer will work on Plateau for only a very short period (about 10 days). It will take a week or more for them to adapt themselves to the environment of high altitude. So the most effective measure is to enhance the management of the Reserve and capability building. Most of staff of the management office in Hoh-xil is ethnic with abundant field working experience; in our fieldwork we found their work is quite efficient. They managed to strike the right tone in their relationship with the powerful construction companies - cooperating in sharing information but maintaining credible independence of action. Powerful financial support is necessary to maintain their work in the reserve.

f. Improve the public education work.

Too much work has been reported on improving the public awareness of conservation the chiru, on newspaper, popular journals and websites. Till now most conservation action succeeded in making people be aware of the importance of protect the Tibetan Antelopes. But we found most of people still lack of general knowledge of the species and wildlife conservation. A college student asked me: “Why not cut off the migration of corridor of chiru? Though this may cause damage to the population in the first several years, but at last their behavior will be changed, we don’t need to spend so much money to build crossing structures for them.” We have been in touched with some of the tourists and truck drivers mentioned above in highway, most of them knew the chiru are protected animals, but they didn’t realized their behavior seriously disturbed the chiru activities. They were excited when facing a large herd of chiru which is fresh to them, could not help shouting or closing the chiru to take photos, the wildlife passages are unfamiliar to most of people in China, sometimes they approached to the bridges, because they didn’t know the use of those structures. More efforts should be made to strengthen the education in public from children to adults, for people with different education background including constructors of the railway and drivers on highway, not only in improving the awareness of chiru conservation and poaching but also on general knowledge of conservation and wildlife passages.

g. Further research on rail and road disturbance to migration of chiru; long-term monitoring on migration of chiru

The rail and road disturbance to migration of chiru are still lack of systematic monitoring and research. No sufficient data are available in the research area in China. In the future transportation development, information will be required for the government and transportation agency in making reasonable conservation plan in construction period. The

record needed to be completed and accurate, while we found past record could not be used for scientific research and analysis, because the data collection method was not scientific. The rail and road will produce long-term effect and may be main threat to migration of chiru, more problems may occur in the future. The passages are the first to be built and used in China, there is still much to be learned about the effects of development on their habitat and migration. Long-term monitoring and financial support in further research are vital in protection of chiru.

8.3.2 Conservation actions.

a. Monitoring report to department of railway, Bureau of Forestry and local government.

Our monitoring results were submitted to department of railway, Bureau of Forestry and local government, and cited in their annual report. The data will be used in making conservation plan in next migration of chiru.

b. Assisting the park police from the reserve to stop traffic in highway.

On return trek, park police in the Hoh-xil National Nature Reserve stopped the traffic to assist the journey of chiru. Our team members took part in their conservation actions, and help to monitor the human activities near passage.

c. Public education

After the field survey finished, our monitoring results were presented by our team members in middle school, colleges, universities and some conference, we also wrote some articles for popular journals [14-16], the response was active, published on websites[19-24] and newspapers (Appendix 1)

9. Reference

Anon., Law of the People's Republic of China on the Protection of Wildlife, 1989.

Anon., ‘‘Conservation Status of the Tibet Antelope’’ [*sic*]. State Forestry Administration of China, December 1998. Translated by World Wide Fund for Nature (WWF), China.

Conservation of and control of trade in Tibetan antelope

http://www.cites.org/eng/resols/11/11_8.shtml

Feng. Z. 1991. Wild animal resources in the Hoh Xil region. Chinese Journal of Arid Land Resources 4: 247-253.

Fox J, Bardsen B. 2005. Density of Tibetan antelope, Tibetan wild ass and Tibetan gazelle in relation to human presence across the Chang Tang Nature Reserve of Tibet, China. *Acta Zoologica Sinica*, 51:586-597.

Harris, R. B., D. H. Pletscher, et al. 1999. ‘‘Status and trends of Tibetan plateau mammalian fauna, Yeniugou China.’’ Biological Conservation 87: 13-19.

Harris R, Miller D. 1995. Overlap in summer habitats and diets of Tibet and Plateau ungulates. Mammalia, 59:197-212.

IUCN website, www.redlist.org,

Liu, W., and B. Yin, eds. 1993 Precious and rare wildlife and its protection in Tibet Beijing: China Forestry Publishing House. (In Chinese.)

Qiu L. ,Feng Z. J.(2004) Effects of traffic during daytime and other human activities on the migration of Tibetan Antelope along the Qinghai Tibet highway, Qinghai Tibet Plateau. Acta Zoologica S inica 50 (4) :669 – 674.

Ruang Xiangdong, He Peijian, Zhang jianlong, Wang qiuhong and Fang Shengguo, 2005. Evolutionary history and current population relationships of the chiru (*Pantholops hodgsonii*) inferred from mtDNA variation. Journal of Mammalogy, 86(5):881-886.

Schaller, G.B., J. Ren et al. 1991. Observations on the Tibetan antelope (*Pantholops hodgsonii*). Applied Animal Behavior Science 29: 361-378.

Schaller, G. B. 1998. Wildlife of the Tibetan Steppe. University of Chicago, Chicago.Wildlife Conservation Society & Tibetan Plateau Project, A Petition to List the Tibetan Antelope (*Pantholops hodgsonii*) as an Endangered Species Pursuant to the U. S. Endangered Species Act of 1973

Schaller G, Lu Z, Wang H, Su T. 2005. Wildlife and nomads in the eastern Chang Tang Reserve, Tibet. Memorie della Societa Italiana di Scienze Naturali e del Museo Civico di Storia Naturele di Milano, 33(1):59-67.

Schaller G. B., Kang A.L, Cai X.B. and Liu Y. L. (2006). Migratory and calving behavior of Tibetan antelope population. Acta Theriologica Sinica 26(2):105-113.

Scott D. Jackson, Overview of transportation related wildlife problems, University of Massachusetts, Amherst, Massachusetts

TRAFFIC. 1999. ‘‘Shahtoosh Dealer Sentenced in Hong Kong,’’ April 13, 1999.

The first survey and design institute of the Ministry of Railways, 2002. Report of Environment impact assessment on railway from Qinghai to Xizang (unpublished in Chinese)

Wu Sugong, Feng Zuojian, 1996. The biology and human physiology in the Hoh Xil Region. Sciences press, Beijing, China. (In Chinese)

Xia Lin, Yang Qisen. Wildlife passages, Discovery of Nature, 2004(4):26-28

Xia Lin, Yang Qisen. Wildlife conservation along Qinghai-Tibet Railway, Discovery of Nature, 2004,(4):29-31

Xia Lin, Yang Qisen, 2004. Wildlife crossing structure and conservation of Tibetan Antelopes, China Nature, 2004, (2):6-8.

Yang Qisen, Xialin, Lei Fumin and Feng Zuojian, 2003. Present situation of wild animal resources along Qinghai-Tibet railway line and countermeasures of protection. Journal of Shen Yang Normal University 2003(21):69-77. (In Chinese)

Yin Binggao, Liu Wulin,1993.Wildlife protection in Tibet. Press of Forestry, Beijing.

10. Appendix (Photos)：

Chiru in migration:

Mother and babies

Cross the railway

Cross the railway

Road disturbance

In 2006, an increase in tourists brought by highway poses a threat to the migration of Tibetan antelopes.

Road killed chiru.