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Adaptive Strategies Adopted by Herders Against the Decollectivization of Rangeland in the Qinghai–Tibetan Plateau in China

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The domestication of the yak on the Qinghai–Tibetan Plateau probably dates back to 7300 years ago, when the rangelands were also utilized for cultivation. Over time, a complete system of herding and rangeland management

developed. In recent years, however, the rangeland contract policy and nomadic settlement project have reduced the mobility of herds through the decollectivization of the rangeland. This process has destroyed the traditional nomadic lifestyle and caused difficulties, forcing the herders to adapt to new ways. This paper considers 3 issues: (1) the implementation of the contract policy and the settlement project—2 important policies that have caused the

decollectivization of rangeland on the Qinghai–Tibetan Plateau; (2) the effects of the 2 policies on herding at 2 sites; and (3) the adaptive strategies employed by herders against the constraints of the policies. The study incorporates a literature review, fieldwork, key-person interviews, and focus group discussions. Community-based self-management of the rangeland appears to be the best strategy for herders. Policies such as group herding can help herders increase herd mobility, which is crucial for sustainably raising livestock on the Qinghai–Tibetan Plateau.

Keywords: Adaptive strategies; rangeland decollectivization; herding; rangeland contract policy; nomadic settlement project; Qinghai–Tibetan Plateau.

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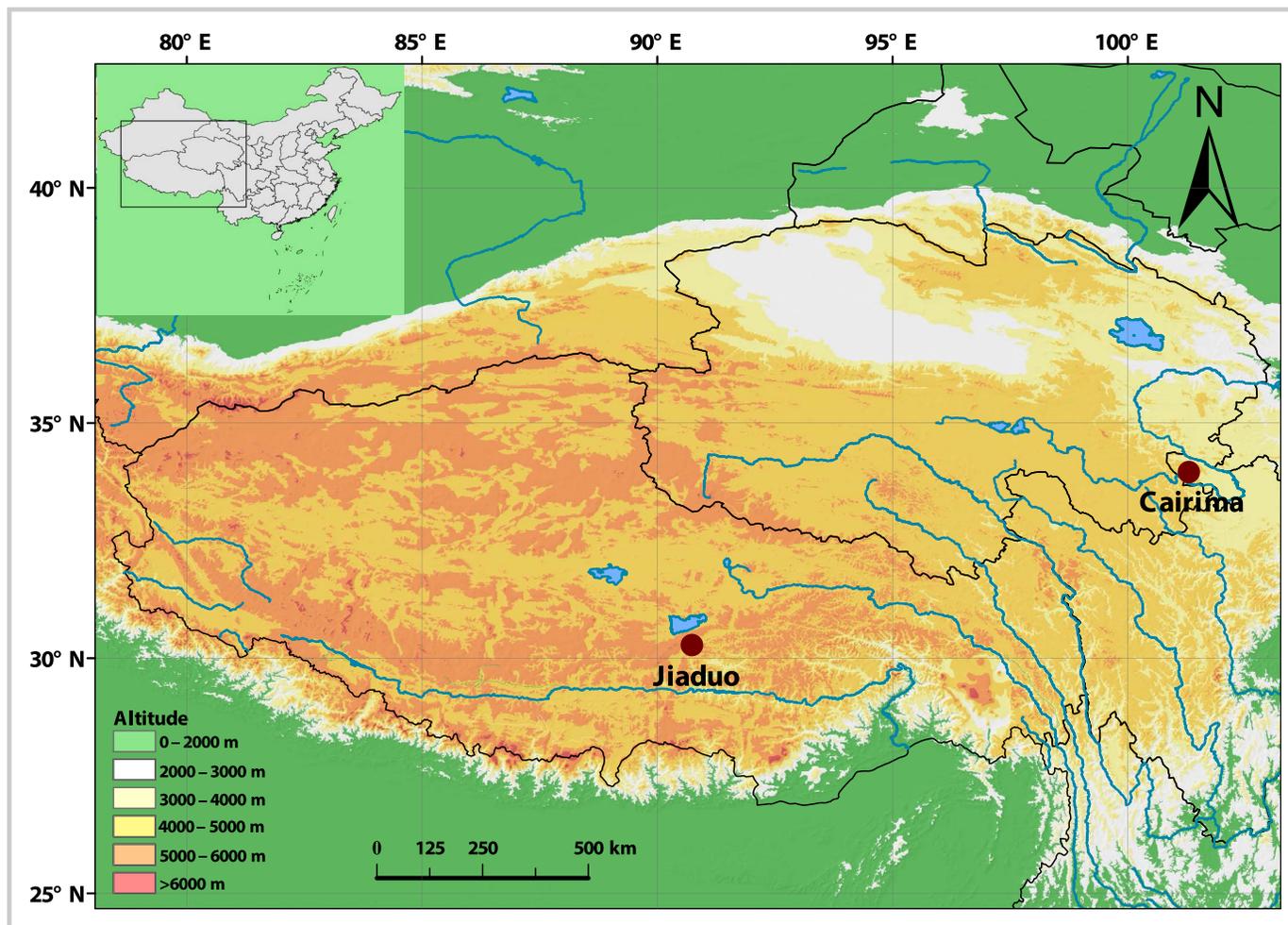
Introduction

The Qinghai–Tibetan Plateau (QTP) forms the center of Asia and is a major pastoral area (Yan et al 2005), spanning 2.5 million km² (Zhang et al 2002). In 2016, it housed 5.6 million pastoralists and 65 million livestock (Tian et al 2016). This high-altitude region is characterized by extreme biophysical and climatic conditions, which constrain the agricultural productivity of the people who live in this area (Zhang et al 2013; Singh et al 2015). Many major rivers originate in the QTP. They supply the immediate QTP areas and large expanses of lowland China (Long et al 2008), as well as South and Southeast Asia (Fan et al 2010). The QTP is highly sensitive to climate change (Duan et al 2006; Wang et al 2007), human activities (Chen et al 2013), and policy changes (Wu and Richard 1999). Around 70% of the land is covered by alpine meadow, swamp pasture, alpine steppe, and desert grassland (Ren et al 2008). These regions cannot be used for large-scale crop cultivation (Long et al 2008) or forestry (Zhang 2001). Thus, animal grazing supported by pastoralism traditionally dominates the regional economy (Dong et al 2011) and Tibetan culture (Miller 1998). This paper focuses on herding; specifically, it examines the views of herders and considers social or policy-driven changes in herding practices.

Before the new policies were implemented, herders within a community used the rangelands under the supervision of community leaders. They followed a series of rules outlining management authority, supervision regulations, and punitive mechanisms. The rules of access to rangeland and water resources were well established, as were conflict resolution mechanisms for disputes within the community or with an adjacent community. Several policy changes have been effected on the QTP since 1983. These include the private ownership of livestock (Miller 1999), plans to return grazing land to natural grassland (Woodhouse 2015), ecological resettlement (Tashi and Foggin 2012), rangeland contracts (contract policy) (Cao, Xiong, et al 2011), and the nomadic settlement project (settlement project) (Ptackova 2011). Among these, the contract policy (Chinese: *caochang chengbao*) and settlement project (Chinese: *mumin dingju*) have led to rangeland decollectivization directly or indirectly, and have deliberately reduced herding mobility.

A literature review revealed some negative influences exerted by these changes, including the uneven distribution of rangeland resources, increased difficulties in accessing water resources, increased problems in obtaining socioeconomic services, intensified boundary conflicts, amplified security concerns, shortage of infrastructure and facilities, higher labor inputs, and heightened gender bias

FIGURE 1 Location of Jiaduo and Cairima on the QTP. The inset map shows the location of the QTP in China. (Map by Yang Zhe)



(Wu and Richard 1999; Banks 2003; Banks et al 2003; Yan et al 2005; Næss 2003, 2013; Richard et al 2006; Cao, Xiong, et al 2011; Ptackova 2011). Most of these studies focused on 2 regions: the first region is the northeastern part of the QTP (Amdo area), which incorporates several counties in Gannan of Gansu and Aba of Sichuan, namely, Maqu, Hongyuan, and Zoige (Wu and Richard 1999; Banks 2003; Banks et al 2003; Yan et al 2005; Richard et al 2006; Cao, Xiong, et al 2011; Ptackova 2011). The second region is Aru Basin, located in the northwest part of the Tibetan Autonomous Region (hereafter Tibet) (Næss 2003, 2013).

However, the QTP is diverse. For example, Tibetan people from Maqu in Gansu must talk to those from Shangri-La in Yunnan in Chinese because they cannot understand each other's Tibetan dialects. The natural environment, cultures, living customs, and policy implementation status of different regions within the plateau are also discrete (Miller 1998; Næss 2003; Zhang et al 2008; Yamaguchi 2011). In a previous paper, the authors of the present study discussed the divergence in the implementation of the contract policy (Li and Yang 2013) in Maqu of Gannan and Dangxiang of Tibet. The current paper offers a more complete description of the distinctions between the northeastern segment of the QTP and central Tibet in policies that lead to decollectivization and in the adaptive strategies employed by

herders to protect their livelihood against potentially harmful influences.

We focus on 3 issues: first, the implementation of 2 significant policies resulting in the decollectivization of rangeland on the QTP—the contract policy and the settlement project; second, the influence exerted by these 2 herding policies on 2 specific sites; third, views of the herders on the adaptive strategies they have adopted to counter the constraints that emerge from these policies.

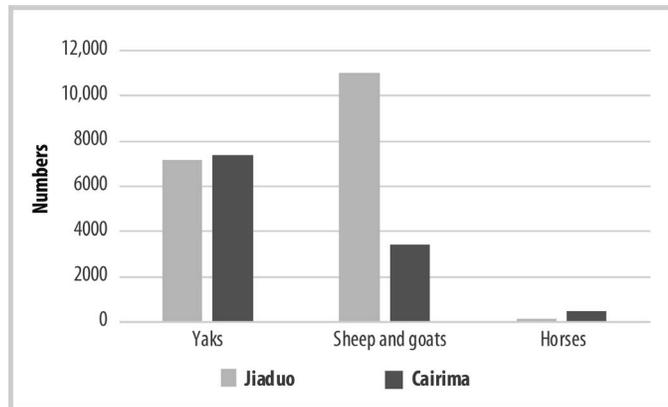
Study areas and methods

Fieldwork was conducted in 2 Tibetan communities, Jiaduo and Cairima, whose members are all herders.

Jiaduo

Jiaduo is located in Dangxiang County (90°45'–91°31'E, 29°31'–31°04'N) (Figure 1), Lhasa, which is in the center of Tibet. Nyainqentanglha Mountain is situated in the north. Jiaduo's average annual precipitation is 320 mm. The average annual temperature is -1°C , ranging diurnally by up to 25°C ; the difference between highest and lowest temperatures can reach 60°C . In 2016, the area housed 196 households and 1146 residents. It spanned 27,003 ha grassland at altitudes extending from 4600 to 5400 m. The

FIGURE 2 Livestock numbers in Jiaduo and Cairima in 2016.



alpine meadows in this region are used for herding; *Kobresia littledalei* and *Kobresia pygmaea* are the dominant species of flora in these pastures. The rest of the grassland is made up of desert steppes and shrubs, which are only suitable for goats in extreme conditions, such as during snowstorms or droughts. Yaks, sheep, goats, and horses are the main livestock raised by the community and numbered 18,269 in 2016. According to our field research, the annual household income was RMB 33,127 in 2015 (1 RMB = US\$ 0.15 on 1 January 2016), of which 35% was derived from animal husbandry and the remainder could be attributed to occupations undertaken by family members as migrant workers, civil servants, or entrepreneurs (off-farm employment), or from government subsidies.

Cairima

Cairima is part of Maqu County (100°45'–102°29'E, 33°06'–34°30'N) (Figure 1) in the Gannan Tibetan Autonomous Prefecture in Gansu Province. The whole community occupies the north bank of the main stream of the Yellow River. Cairima is located on the northeastern edge of the QTP, which forms the transition zone to the Loess Plateau in central China. The whole of Maqu County, including Cairima, receives more precipitation than Dangxiang County because of the transitional geographical conditions. The southeast monsoon brings rain between June and August. At 680 mm, Cairima's average annual rainfall is double that of Jiaduo. Nonetheless, the annual average temperature of Cairima is similar to Jiaduo's at 1°C because of its higher latitude but lower altitude (3300–3700 m). In 2016, Cairima encompassed 198 households with a total of 997 residents who utilized 8187 ha grasslands, mostly alpine meadows with *K. pygmaea* and *Kobresia humilis* as their dominant species. *Potentilla fruticosa* L. predominates in parts of the grassland that are marshy, but these areas are only suitable for livestock grazing for limited periods in the spring and autumn. In 2016, 11,276 livestock were raised by this community. The annual household income of this region was RMB 45,106 in 2015; 63% of this income came from animal husbandry.

Figure 2 shows the herding composition of the 2 communities in 2016. The main difference is the dominant species of fauna: sheep and goats are common in Jiaduo, as the soil in this region is salt rich and alkaline, and is suited to raising goats; in Cairima, yaks predominate. The overall

trends in the QTP conform to this observation: the proportion of sheep and goats increases in communities that occupy the western territories of the region (Miller 1999). Figure 3 illustrates the typical rangelands, houses in winter pastures, and the dominant livestock.

Fieldwork was conducted between May and August 2016. The researchers spent 5 weeks in each community. Semistructured interviews with key individuals and focus group discussions were the main survey methods. Retired community leaders, doctors (who worked in clinics and had more formal education than average members of the community), recognized herding experts, veterinarians, and other herders who had obtained rich experience within the community were regarded as key individuals for the purposes of this study. Finally, a few interviews were conducted with randomly sampled people (Wolcott 2011; David 2013). In the final analysis, 96 herders were interviewed (Table 1). The interviews and discussions focused on herding strategies before the decollectivization of rangeland, the principles and process of rangeland decollectivization, problems that emerged after the decollectivization of rangeland, and the adaptive strategies subsequently adopted by the herders. Additionally, macrolevel data on the community were obtained from the village committees. These data have already been presented above.

Results and discussion

Rangeland decollectivization policies implemented on the QTP

The contract policy and settlement project are the 2 main policies leading to the decollectivization of rangeland in all pastoral areas of China, including the QTP.

The contract policy, also known as the rangeland household responsibility, was extended to pastoral regions in the mid-1990s (Cao, Xiong, et al 2011). This followed extensive implementation, beginning in the 1970s, in cropland regions in China (Lin 1988). Here, it successfully raised the outputs and incomes of farmers (Wang et al 2010). The contract policy was based on the privatization of livestock ownership in the early 1980s (Conte and Tilt 2014) after the dismantling of the commune system (1959–1983) (Banks et al 2003). In the communal period (1959–1983), the rangeland of the QTP was collectivized. The state owned the rangeland, while the livestock belonged to a production team. The herders worked for the production team, which paid them a minimal amount as a salary. This type of production practice negatively influenced the productivity of the herders because they received the same remuneration whether or not they worked hard. In Goldstein's (2012: 266) terms, the government reasoned, "If each nomad household controlled its own pastureland, it would be motivated to invest time and resources to improve the quality of the vegetation and animals. Nomads, therefore, would, in the end, become transformed into something akin to autonomous family ranchers." According to the Grassland Law of China, issued in 1985, the state owned the rangeland, but granted long-term leases (50 years) to individual households. The criteria for dividing the rangeland are based on the number of people and livestock in a household and the quality of the rangeland. However, the reality of distribution process of the rangeland was quite different (Ho

FIGURE 3 Typical rangeland scenes: (A), (C), (E) in Cairima, with characteristic houses in winter pastures and yaks; (B), (D), (F) in Jiaduo, with housing and livestock (sheep and goats). (Photos by Yang Zhe)



2000; Banks et al 2003; Næss 2013). In some parts of the QTP, such as Gannan, Aba, and Guoluo, the rangeland of 1 household was fenced off from that of other households. In other parts, such as Tibet, Ganzi in Sichuan, and Yushu in Qinghai, the rangeland was not fenced, but the herding areas for households were relatively fixed within the community.

The settlement project mainly aims to turn pastureland into ungrazed grassland and to effect ecological resettlement. However, it does not move people away from their original locations or turn their focus away from animal husbandry (Foggin 2008; Ptackova 2011). The presumption that the nomadic lifestyle is backward and that it leads to

TABLE 1 Information about the interviewees.

	Jiaduo	Cairima
No. of interviewees^{a)}	47	49
Gender, no. (%)		
Male	28 (59.6)	43 (87.8)
Female	19 (40.4)	6 (12.2)
Age, no. (%)		
<25	2 (4.3)	4 (8.2)
25–39	13 (27.7)	19 (38.8)
40–59	21 (44.7)	16 (32.6)
≥60	11 (23.3)	10 (20.4)
Years of education, no. (%)		
0	19 (40.5)	15 (30.6)
0–3	20 (42.5)	13 (26.5)
4–6	5 (10.6)	13 (26.5)
>7	3 (6.4)	8 (16.4)

^{a)} Some herders participated in both an individual interview and a focus group discussion; numbers in this table therefore mean the total number of herders we talked with. Herders sometimes expressed different views in private and in public, so we interviewed some herders twice (one in a focus group discussion and once individually).

land degradation in comparison to sedentarization (Davidson et al 2008; Wang 2013) underpins this policy. This project's aim is to build permanent brick-concrete houses for every household in the pastoral areas of the QTP to replace their movable tents and mud or stone houses. The new houses are usually built on winter camps (in winter pastures), where the herders spend 6 or 7 months during the long winter season of the region. Consequently, the pastures encircle the houses within a radius of 5 to 10 km. In the summer, the elderly and children usually remain in the winter camps where living conditions are better, while the herders and livestock move to summer camps at higher altitudes.

Rangeland decollectivization in Cairima

The decollectivization of the rangeland began in 1995 across the whole of Gannan, including Cairima, which was among the first regions to implement the policy. First, the rangeland was classified into 3 grades of productivity, a process undertaken under the purview of the County Grassland Management Agency. All livestock numbers were translated into sheep units according to their daily consumption of fodder and their daily activity range and intensity. For instance, 1 adult sheep or goat is equivalent to 1 sheep unit, while 1 yak and 1 horse are equivalent to 5 and 6 sheep units, respectively (Yan et al 2005). The rangeland was allocated to households depending on the number of household members and number of livestock, using the ratio 40% to 60%.

By 1999, the process was completed, with 90% of the rangeland allocated to herders. The other 10% was

unavailable because of harsh natural or traffic conditions. Usually, a household was allocated 2 patches of rangeland, 1 for summer and autumn and 1 for winter and spring, and the distance between these is between 10 and 25 km. In total, 13 households were assigned a single relatively large patch of rangeland because of considerations of complex topography and water sources. These households must maintain their herds in this pasture throughout the year. The rangelands of different households are separated by fences made of iron wire and cement piers. The cost of construction and maintenance of the fences was initially borne by the government, but neighboring households began to pay to repair fences from 2002 or 3 years after the allocations were made. Nearly two-thirds of the households had spent an average amount of nearly RMB 13,000 over the last 15 years on repairing the fences. This represents an additional burden for herders and causes discord between neighbors.

Rangeland decollectivization in Jiaduo

The situation in Jiaduo is quite different from the conditions observed in Cairima. The contract policy was put into practice in Tibet in 2005. As in Cairima, the contracted rangeland was allocated to households on the basis of the numbers of livestock and household members. Unlike Cairima, however, unincorporated villages (Chinese: *Zirancun*) were used as the basic herding unit in Jiaduo rather than the single household. No fences were built to divide the pastures designated for different herders in Jiaduo. Thus, the rangelands allocated for different households within a single unincorporated village are still grazed collectively. The boundaries between unincorporated villages are demarcated by rivers, ridges, or roads. The herders rarely graze their livestock across these boundaries. Jiaduo has 8 unincorporated villages that were formed naturally through time. All herders were issued certificates allocating land use and registering the exact span of land apportioned to each household. This certificate does not form the basis for the actual herding; instead, it represents a household's credentials allowing family units to access government grants, such as the subsidy for the ecological protection of the grasslands. Herders can graze their livestock wherever they want within their own unincorporated village, as was their practice before decollectivization. Most herders do not know the location of their own contracted rangeland and they do not care about the contents of their certificates (Wang 2009).

On the other hand, the settlement project has exerted a greater impact on rangeland use in Jiaduo than the contract policy. In 2004, a building program was implemented through the settlement project: the government constructed a yard with a 120-m² brick-concrete house, a shed, and a barn for every household. These replaced movable tents or stone-built houses. This project has improved the quality of the domestic life of herders; however, it has negatively influenced the practice of herding. Before 2004, 3 migrations were undertaken annually: in late May, late September, and late October. Now, only 2 migrations occur, in late May and mid-September. The herders return to winter pastures in mid-September directly from the summer pastures, and autumn pastures are rarely used. The autumn meadowlands are significant as transitional pastures: they ensure the recovery of the grassland utilized in winter or spring. The

winter–spring pastures are in use for nearly 7 months, and whether or not the livestock will survive the harsh winters and snowstorms is directly related to the pastures' condition. An interview with a herder, who was the ex-director of the village committee, clarified the reason for the change in traditional herding habits:

In mid- or late September, herders move down from summer pasture, which is on the mountains much higher than the winter camps. And they have spent nearly 5 months in tents in hard living conditions, such as no mobile phone or Internet signal, limited electric power provided by a simply equipped solar generator, and had access to goods for daily use and food. So, the herders don't want to live in tents any more, they move straight to their permanent brick–concrete house.

Adaptive strategies favored by herders in Cairima

Traditionally, herders moved their livestock between discrete rangelands at different altitudes during the course of a year. This custom helped to prevent the overuse of the grasslands. However, as Zhao and Schell (2008: 176) stated, the fences in Cairima, “designed to keep herders and livestock within fixed rangelands, can easily lead to the overgrazing of a particular area because without rotation, the pasture never gets a chance to rest.” Thus, the rangeland becomes degraded (Harris 2010) and herding becomes vulnerable to policy changes, droughts, and snowstorms (Yan et al 2005).

The incumbent village committee director described the implementation of the policy as follows:

At the very beginning (1995), the county government and grassland management agency ordered us to implement the grassland contract policy; they said it's good for protecting the grassland and helping us raise incomes. The civil servants from the government did a full and accurate survey on the status of our rangeland, and divided it into 635 pieces (there were 635 adults in our community that time). Each household got several pieces of rangeland according to their household numbers [ie number of household members and number of livestock] by lottery. Some herders had to move their houses to the new rangeland. After that, the fences were built. The government paid for the materials for construction, and the herders had to build the fences themselves. In 1999, this project was completed. The result is that our rangeland became 107 parts (107 households within the community) instead of the large one before.

Herders in Cairima started applying new ways of herding in 1999. Within 5 years, they began to encounter problems resulting from the new policy: the partial degradation of the grassland, unfair access to grassland and water resources, discord between neighbors, and an increased demand for laborers. A common issue, for instance, entailed the quality of rangelands. Some households were allocated poor grazing land while others benefited from superior pastures; small rivers running through the rangeland were designated for some households, while others had to travel some distance from their pastures for water or had to dig wells on their rangeland. All such difficulties indicate the complexity of the available rangeland and the unfairness of the process of rangeland distribution. All these problems threatened to destroy the herding and community structures that had lasted since the Tang Dynasty (AD619–AD907), when the Tibetan herders settled in this area (Chen and He 2002).

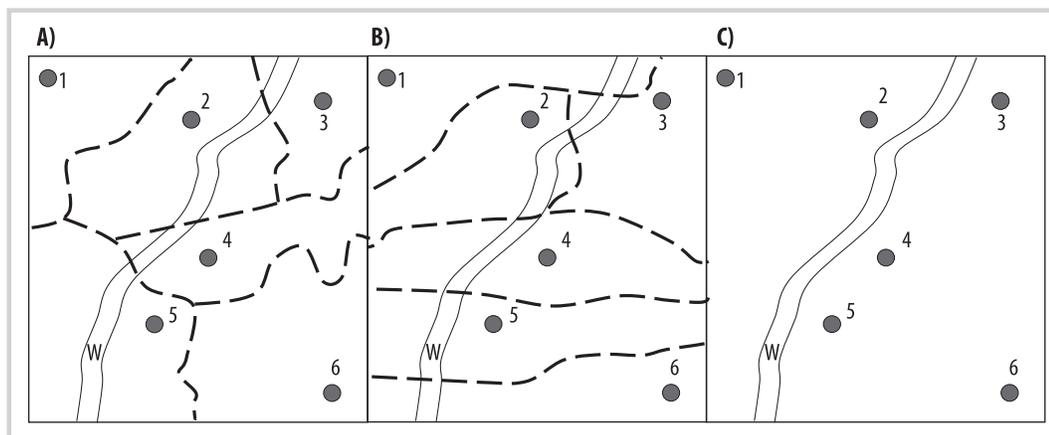
In 2004, in the face of such problems, herders began to demand the dismantling of fences. Initially, the government was strongly opposed to this because it violated the contract policy. The community leaders, elders, and individuals who were closely associated with the government explained to the administration that joint herding conformed to the traditional practices and the indigenous knowledge of the herders and that it was advantageous for the sustainable utilization of grassland resources. The community leaders guaranteed that the households within the joint herding unit would keep their livestock numbers under the carrying capacity of the grassland and that they would control the number of households within a joint herding unit (usually less than a predetermined number of approximately 10 yaks per person). After several rounds of negotiation, the government accepted the demands of the herders. One county government official said that the herders' interpretations were reasonable and that the documents from China's Ministry of Agriculture did not specify the form the contract policy should take.

Joint herding by several households (usually 3 to 9) instead of single-household herding is a crucial adaptive strategy. This approach is also called the “multihousehold grassland management pattern” (Cao, Xiong, et al 2011; Cao et al 2013a, 2013b) or “group household management” (Banks et al 2003; Yan et al 2005). Basically, joint herding takes 2 forms: the first involves households with kinship relations, and the second involves households living in close proximity who associate voluntarily. These joint herding groups have dismantled the fences between their allocated rangelands and have resumed the practice of mobile herding to some extent.

Figure 4 illustrates the 2 rangeland allocation plans under the single-household herding strategy demonstrating the negative effects of the strategy. In Figure 4A, the rangeland of 1 household remained relatively intact (the shape one household's rangeland is more like a circle or rectangle than that in Figure 4B), but households 1 and 6 could not access water resources because of the fences. Figure 4B shows another extreme condition in which every household has access to water resources, but the rangeland is unsuitable for herding because the distance from some parts of the rangeland to the house (black dots) is too long. Figure 4C illustrates the open rangeland and water resources under the joint herding strategy.

In 2016, after 12 years of joint herding, 147 (74.2%) households had formed joint herding units with other households. There were now 29 joint herding units in this region; the smallest consisted of 2 households and the largest included 19 households. In contrast, only 51 (25.8%) single households continued to herd within their own rangeland. This was because of terrain barriers (mountains or rivers) or adverse relationships with neighbors. Previous research in the area showed that coverage and species richness of the rangeland belonging to joint herding units were higher than those of rangeland belonging to single households. A regression indicated that plant species richness increased as the number of households within the joint herding units increased. Financially, the incomes of the joint herding households are higher than the incomes of single herding households (Cao, Xiong, et al 2011; Cao, Holden, et al 2011).

FIGURE 4 (A) and (B) Two hypothetical examples of types of rangeland allocation plans under the single-household herding strategy; (C) rangeland allocation plans under the joint herding strategy. Numbers 1–6: position of households. W: river as water resource. Dotted lines: fences. Black dots: herders' houses.



The adaptive strategies assumed by herders in Jiaduo

The adaptive strategies discussed in this section relate to actions of either the entire community or the unincorporated village, rather than those of 1 or several households as in Cairima. The 2 greatest problems presented by the herding practices in Jiaduo are the abandonment of autumn pastures and grassland degradation around the winter houses of the community.

The decline in grazing mobility was first noticed by a herder with nearly 50 years of experience who asserted:

In about 2009, I first noticed that the herders, especially the young herders, didn't want to herd in the summer pasture at high altitude; they spent less and less time in the summer pasture. What's even worse, they just abandoned the autumn pasture and spent nearly 8 months in the winter camps. The reason is quite simple: the living conditions here, after implementation of the settlement project, are much better than tents. Before that, we spent the whole year in tents or shabby houses; it was the same wherever you lived. But now, there is comparison; everyone wants to live in better houses with convenient electric power, convenient transportation, and better connections to the outside through mobile phones and the internet. This situation, along with the permanent fixation of winter camps, made the pressures from herding on grassland much higher than before. As you see, there is much less grass and it is shorter than before.

The 2 herding practices mentioned above can be seen in Figure 5A, B. Figure 5A shows the herding route within a year *before* the settlement project, and Figure 5B shows the herding route within a year *after* the settlement project and abandonment of the autumn pastures.

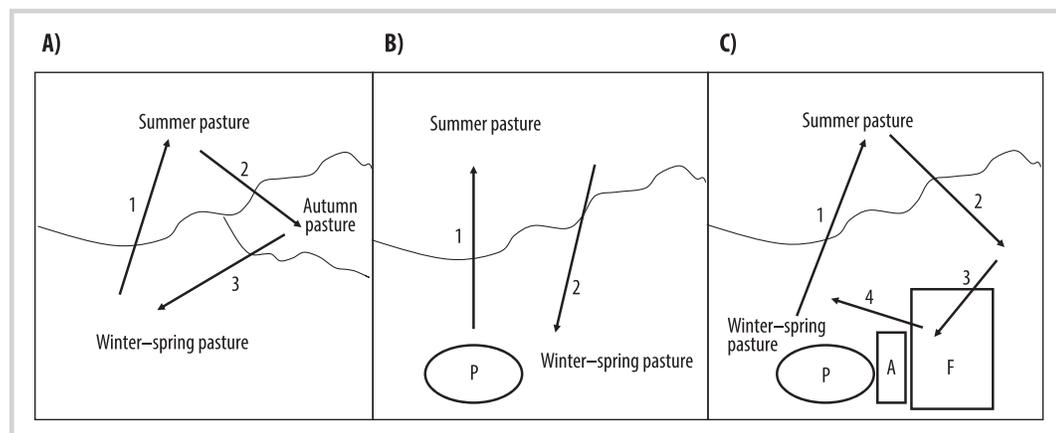
The pasture income comprises the direct or indirect proceeds from grazing. Such earnings include the sale of livestock; meat; foraged items; herbs such as *Ophiocordyceps sinensis* and *Bulbus fritillariae cirrhosae*; byproducts like milk, butter, and yogurt; animal skin and hair products; excreta to be used as organic fertilizer, and so on. However, a part of the total income of the herding families is from sources unrelated to grassland. These include earnings from work, such as entrepreneurship, migrant work, and civic employment, and government subsidies. The pasture income of the people of Jiaduo (35%) is much lower than those of Cairima (63%), suggesting that the inhabitants of Jiaduo depend less on the grassland.

In 2011, the community committee began to address the degradation of the grassland. First, the timing and route of the transhumances in both the winter and summer pastures were reregulated according to the observed growth of the grass, temperature, and precipitation. All the households in Jiaduo must follow the rules, and only pregnant livestock, calves less than 1 year old and lambs less than 4 months old can stay in the winter and spring camps. Herders who do not comply with the rules are fined by the community committee.

Second, livestock diversification was introduced, and the herders were encouraged to raise a variety of animals such as sheep, goats, yaks, and horses. As argued by Wu et al (2014: 1351), "Livelihood diversification is a daily reality that allows a pastoral community to cope with risks, as for pastoral societies, the most important internal diversification strategy is the diversification of livestock." In an earlier publication, Wu (1997: 75) also explains that "[pa]storal societies in the Hindu Kush Himalayan region traditionally practice herd diversification as a form of 'insurance' against major disease outbreaks because the different domestic species are generally not susceptible to the same pathogens. In addition, the different dietary preferences of the various domestic livestock allow for better utilization of pastures that may not be suited to one or another species." In Jiaduo, all herding households raise 3 types of livestock: yaks, sheep, and goats. Ten years ago, there were fewer sheep and goats in this area, but the community committee began encouraging herders to raise more because they are suitable for the environment. Herders can now make money from cashmere and slaughtered sheep instead of yaks (seen in Figure 6). Thus, they can reserve the yaks for dairy products, which are much more important than meat in the daily diets of Tibetan herders (Prins 1989; Akimichi 2006).

Third, the community fenced off new pastures near the winter houses for the transition period. These pastures are restricted to winter and spring grazing. When the herders descend from the summer pastures to the winter houses in September, they are not allowed to graze their animals in the fenced pastures; instead, they have to take their herds further away. When the cold winter comes, the herders are allowed to use the fenced pastures to survive the harsh

FIGURE 5 Annual herding transhumance routes in Jiaduo. (A) Route before the settlement project; (B) route after the settlement project; (C) route after the establishment of the fenced pasture and artificial grassland. P: Permanent houses in winter camps. A: Artificial grassland. F: Fenced pasture. 1, 2, 3, and 4: Annual herding migrations in chronological order, beginning in May.

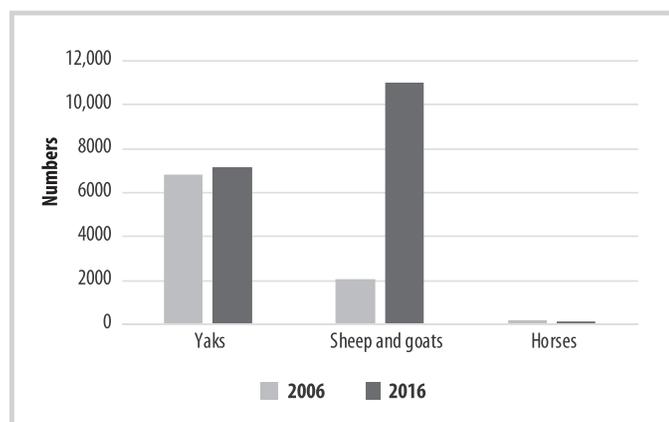


season (F in Figure 5C). This allows the winter and spring pastures to recover.

Fourth, artificial grasslands have been established (A in Figure 5). The grass are fields sown with grass seed in spring and then harvested for forage in autumn. The forage can be used as food for livestock in winter, and the surplus sold. This project was undertaken with the assistance of the Tibet Academy of Agricultural and Animal Husbandry Sciences. Dorji, the project executive, described this project:

Jiaduo belongs to the edge of the Qiang Tang Plateau, which is the northern part of the QTP. The average elevation here is higher than that of the whole QTP, with less precipitation and lower temperatures. The productivity of grassland here is too low to satisfy the demands of livestock through winter. As we see, the grasslands around the herders' winter houses are already seriously degraded due to excess grazing activity. Consequently, we built artificial grassland here. The species are Vicia gigantea Bunge, Avena sativa L., Elymus nutans, and Poa pratensis. All these are suitable for Jiaduo. We use livestock dung as organic fertilizer, which is very good for the environment here. These forage grasses grow well here, and the Avena sativa L. can grow up to 1.5 m high. The herders mow the artificial grasses in early October. These grasses can help the livestock get through the harsh winter with a small amount of surplus.

FIGURE 6 Herding composition of Jiaduo in 2006 and 2016.



Conclusion

This paper reviewed the implementation of 2 crucial ventures, the contract policy and settlement project, undertaken in 2 Tibetan communities in Cairima and Jiaduo. These 2 projects have led to the decollectivization of rangeland to some extent in both communities. Several negative consequences of the 2 projects were reported by herders: the declining mobility, unfair access to grassland and water resources, discord between neighbors, and the increase in labor required to maintain boundary fencing. Of all the difficulties faced after the application of the contract policy and the settlement project, the herders identified declining mobility to be the most deleterious consequence. The 2 sites considered illustrate 2 extremes of precipitation in the QTP, which is 1 of the 2 factors that most limit the growth of animal husbandry (the other is temperature). Thus, the insights obtained here can be applied beyond the specific study sites across the mountainous areas of the QTP.

In Cairima, the most important strategy to address the issues presented by the implementation of the 2 projects is joint herding by several households (usually 3 to 9) instead of single-household herding. This type of herding activity is better for grassland and also financially beneficial for herders. In Jiaduo, the adaptive strategies of herders include actions by the entire community or by unincorporated villages. Here, the strategies adopted include the regulation of the time and the route of transhumances, the diversification of livestock holdings, the demarcation of new pastures near the winter houses for transitional grazing in autumn, and the creation of artificial grasslands. All these strategies can help herders increase their mobility, which is crucial for sustainable herding activities in the QTP.

Additionally, there are several reasons for the reduction of time spent in summer pastures and the abandonment of the autumn pastures in Jiaduo, such as the improvement of living conditions, the diversification of livelihoods, the younger generation's pursuit of a modern lifestyle, etc. The changes in traditional herding may thus be inevitable as the pastoral society moves toward modernization.

Fences have had opposite effects in the 2 communities. In Cairima, fencing led to a decline in mobility. In contrast,

fencing has recently been introduced in Jiaduo to isolate transitional rangeland and to create artificial grasslands in an effort to make grazing more sustainable. Consequently, the effects of fencing grassland cannot be generalized. The results of the present study suggest that fences are better utilized to isolate small patches of the pasture for seasonal purposes or longitudinally (as in Jiaduo) than for the lateral division of pastures for individual herding households (as in Cairima). In the future development of QTP, fences should be used to ensure the sustainable regeneration of grassland resources and to support the livelihoods of herders. Rather than government officials, it is the herders who have been pivotal in the implementation of adaptive strategies to minimize harmful practices. They know much more than government officials about animal husbandry and grassland utilization because they depend on rangelands for their survival and they have centuries of inherited experience (Yeh et al 2017). Consequently, community-based management (Banks et al 2003) or self-governance (Ostrom et al 1992) is the preferred means of development for pastoral areas in the QTP. Self-governance appears to be the best solution for the management of common resources across the world, whether rangeland management (Tenzing et al 2017; Baur and Nax 2018; Schulz et al 2018), forestry (Mathez-Stiefel et al 2017), fisheries (Montgomery and Vaughan 2008; Siegelman et al 2019), irrigation (Dörre and Goibnazarov 2018; Aida 2019), or ecological restoration (Norris et al 2019).

The present study considered only 2 sites: one in the middle of Tibet and the other at the northeastern edge of the QTP. More research is required on communities in other parts of the QTP: areas that receive the least precipitation, such as Ali and Shigatse in western Tibet, and agropastoral grazing regions in Shangri-La and Nyingchi in the southeast part of the QTP. Further studies will help to identify other adaptive strategies of herders in different regions to counteract the social and natural changes resulting from the decollectivization of rangeland.

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