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Plateau pika and grassland degradation: Relationships and management in the Sanjiangyuan Region, China

Baoyao Cheng[1,3,†], Lele Han[2,†]

[1]The Hong Kong University of Science and Technology, Kowloon, Hong Kong, China
[2]Central China Normal University, Wuhan, Hubei 430079, China

[3]bchengac@connect.ust.hk
[†]These authors contributed equally to this work.

Abstract. In this paper, we investigated the controversy over the keystone species plateau pika, its relationship with grassland degradation, and the suggested solution to the rodent problem in the Sanjiangyuan region of Qinghai Province, China. We argue that the plateau pika plays a pivotal role in maintaining biodiversity and vegetation diversity and that its population should be maintained at an appropriate level. Meanwhile, the root cause of pasture degradation is overgrazing, and the plateau pika further contributes to the degradation of pastures. We propose a three-step solution of ecological management, pika management, and grassland rehabilitation for addressing the issue, suggesting the use of multi-paddock grazing and non-lethal contraceptive control for long-term reduction of pika populations, and finally re-seeding and weed control for restoring the health of the pastures.

Keywords: plateau pika, Ochotona curzoniae, grassland degradation, rodent management

1. Introduction

1.1. Study area

Sanjiangyuan Region in the Qinghai Province, China (N31◦390 –36◦120, E89◦450 –102◦230). It lies in the eastern part of the Tibetan Plateau, with an area of about 0.36 million km^2. The altitude ranges from 3335 to 6564 meters and includes extensive plains and mountains such as Kunlun, Anyemaqin, Tanggula, and Bayan [1]. Significantly, this area encompasses the source of Asia's major rivers, the Yangtze, Yellow, and Mekong, collectively supplying water to over a billion downstream inhabitants (Editorial Committee of Ecological Environment of Sanjiangyuan Nature Reserve,2002). This area's abundant plant and animal life ranks it among the world's most ecologically varied regions [2].

1.2. Research objective

Pikas form a monotypic genus within the family Ochotonidae, Order Lagomorpha and the plateau pika is an endemic species of the Qinghai-Tibet Plateau of the pika family. They are a species of small herd mammal and prefer to live in elevations of 3,100 to 5,000 m. Meanwhile, plateau pikas are typically herbivorous, specializing in digging holes to move grassland soil and vegetation from one place to another. They reproduce quickly and have large populations.

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2. Controversy over the plateau pika

Plateau pikas' habits have triggered controversy. Some people believe that plateau pikas compete with livestock for food, and digging holes leads to the degradation of the grasslands [3]. Thus, they consider that pikas should be hunted and killed in large numbers. Others believe that plateau pikas play a crucial role in maintaining the biodiversity and environment of the Tibetan Plateau and should be protected.

2.1. Plateau pikas are pests

According to the research on plateau pikas' impacts, it is identified that they have negative impacts on ecosystem services such as plant production and soil carbon sequestration [4]. Utilizing the chamber technique to analyze the plant and soil properties in alpine meadow steppe regions, which exhibit varying densities of pika burrows. Research revealed a reduction in NEE, GEP, and ER due to increased burrow density. As the density of pika increased, there was a corresponding decline in above-ground biomass, species count plant coverage, and leaf area index. An increased density of burrows correlated with reduced soil moisture and elevated soil temperatures [3]. According to another research, increased pika population density led to a decline in net ecosystem CO_2 exchange, gross ecosystem productivity, and ecosystem respiration. Additionally, above-ground biomass, species diversity, plant cover, and leaf area index decreased as pika density increased. The reduction in net ecosystem CO_2 exchange caused by plateau pikas may negatively impact the carbon sink balance of the grasslands in the Qinghai-Tibet Plateau [3].

At the same time, due to the burrowing habits of pikas, the destructive effect of many pikas on the ecosystem cannot be ignored. The findings indicated that the burrowing behaviours of plateau pika led to a reduction in plant cover, biodiversity, and biomass in both alpine meadows and steppes. The exposed areas resulting from pika burrowing exhibit reduced SM, SOC, STN, MBC, and MBN compared to the vegetated areas. The burrowing behaviours of pika led to a reduction in Re and Q10 levels in the alpine vegetation [5]. Local herders believe that plateau pikas compete with livestock for food and that their burrowing habits lead to soil erosion.

In recent decades, plateau pika populations have also exploded due to the rapid increase in livestock numbers on the Tibetan Plateau. Grassland degradation has become a severe problem [6]. Some scholars insist that plateau pikas' activity reduced grassland biomass and buried seed count, accelerating the degradation of alpine meadow pastures. Their foraging and burrowing activities accelerate the rate of degradation of alpine meadow pastures and have a significant negative impact on the sustainable development of local pastoral farming [7].

Combining the above discussion, we can easily find that overgrazing by humans allows the plateau pikas to reproduce in large quantities, and the occupancy of the pikas leads to further degradation of the grassland.

2.2. Plateau pikas are beneficial animals

There are way more benefits than the destruction caused by the plateau pikas. In Smith and Foggin's study [8], it was concluded that plateau pikas play a key role in four respects, which include digging out many burrows to provide a major habitat for small birds and lizards and increasing plant species richness. Besides, they are the main prey of almost all plateau predators and contribute positively to the ecosystem-level dynamics.

Pikas have been proven by numerous researchers to maintain local biodiversity: Smith and other researchers found a decrease in carnivore abundance in areas of pika poisoning compared to non-poisoned sites, suggesting that eradication of pikas at regional scales may alter or disrupt ecological communities on QTP [9]. In field studies in Qinghai Province, it was shown that the abundance and abundance of birds were also affected by the number of pikas [10]. Five years after the pika poisoning initiative, there was a significant reduction in bird colonies, with Hume's groundpecker and two native plateau snow finch species only spotted in areas free from poison. This decline is largely due to the rapid deterioration of pikas' burrow systems post-poisoning, leading to the near extinction of bird species that depend on these burrows for nesting and shelter.

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Several pikas are known to beneficially impact the highland meadow ecosystem, as the accessible burrows in the alpine meadow enhance soil permeability, hasten the penetration of soil moisture, augment the amount of soil silt, and better the soil's nutrient content [11].

Besides, the perception that pikas compete with livestock for food, depends on the density of pikas and the grassland quality. According to research [12], at high densities, there can be significant dietary overlap between plateau pikas and livestock. Overgrazing, resulting from high livestock densities, can lead to an increase in the abundance of unpalatable or toxic plants, which are often preferred by pikas. Paradoxically, this can create favourable conditions for the growth of grasses that are preferred by livestock. Consequently, on well-managed pastures, it seems that pikas and livestock do not compete for forage resources. This indicates a misunderstanding in people's perception of the plateau pikas, which is not a total pest but a critical factor in ensuring local biodiversity and ecosystems. Therefore, poisoning the plateau pikas in large quantities is not desirable. Instead, we should first target the origin of the problem, and manage the pastureland with conservative grazing. Then, proper control should be carried out for areas where the number of pikas is too large.

3. Multiple relationships between pika and meadow degradation

In this part, through the exploration of the relationship between pika and plateau meadow ecosystem, we find that pika is not the direct factor of meadow degradation, but the overgrazing of human beings leads to the overuse of meadow and the degradation of meadow. However, the degradation of the meadow will lead to an increase in the pika population, increase the burden on the meadow ecosystem and aggravate meadow degradation.

3.1. In the early stages of meadow degradation, the dominant cause of meadow degradation is overgrazing

Grazing is an important means of livelihood for herders in the Sanjiangyuan area, and at the same time, rational grazing can also promote the sustainable use of grassland resources globally [13]. Practice in various countries has shown that rational grazing is an economical and effective way of using grassland, which can promote the synergistic evolution of grassland and grazing livestock and maintain grassland health and ecological balance. However, because most herders tend to pursue high levels of interest in the short term when conditions permit, they tend to focus on high levels of short-term interest and ignore long-term interests, which increases the intensity of grazing in pastoral areas, and overgrazing breaks the balanced grass-animal relationship, reduces the carrying capacity of the ecological environment and eventually becomes an important external shock to pastoral grassland degradation [14]. Several studies have shown that the ammonification, nitrification and nitrogen fixation of soils that have been grazed for a long period have been reduced, microbial diversity has declined, and soil fertility has been seriously reduced [15]. These factors have led to a weakening of energy flow and material circulation in the Sanjiangyuan ecosystem, which in the long term will inevitably lead to structural disorders and dysfunctions in the ecosystem.

3.2. Excessive pika populations exacerbate meadow degradation in the Sanjiangyuan area

Studies have shown that plateau pikas prefer open habitats with low vegetation and avoid habitats with tall plants, and that pikas have an obvious tendency to choose vegetation for their habitat [16]. The habits and biology of the pika are such that it prefers meadow ecosystems that are degraded to some extent. Overgrazing of meadows leads to a decrease in the height of the grass layer, and the sparse spatial environment is favourable to the survival of plateau pikas. Long-term overgrazing has led to changes in the composition of vegetation communities and serious degradation of grazing land, providing a suitable environment for rodents to live in, and the number of rodents has increased dramatically [17].

Rodent infestation exacerbates soil "degradation" and stagnates vegetation succession, and the degree of rodent infestation is significantly correlated with the degree of meadow vegetation destruction [18]. Studies have shown that too many or too few plateau rats are not suitable for stable ecosystem

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development and that species diversity is greatest when the area of plateau rats' mounds is maintained at 15 percent of the area of grazing lands [19].

4. Management of plateau pikas

To rationally control plateau pikas' populations and maintain grassland health, three main steps are proposed to address this issue: ecological management, rodent control, and grassland rehabilitation

4.1. Ecological management

Interventions such as reseeding and weed control are often used to restore degraded grasslands, but they are expensive and often cause other environmental problems [20]. With previous analyses showing that overgrazing is the main cause of severe rodent infestations, proper grazing management becomes a key factor in rehabilitating degraded grasslands and preventing their degradation [21]. Adopting a multi-paddock grazing management approach is a strategy employed in grazing lands [20]. This approach involves dividing the grazing area into multiple paddocks and implementing short grazing periods followed by extended recovery periods, in which smaller paddocks tend to exhibit more uniform grazing patterns [21]. With such management, pastoralists will be able to maintain a healthy pasture with appropriate grazing by varying management parameters according to local conditions, such as the length of grazing and recovery periods, livestock numbers, forage management, and so on.

4.2. Rodent control

Rodent control is divided into two main categories, lethal control and non-lethal control, while lethal control includes chemical control and physical control.

4.2.1. Lethal control. The two commonly used methods for lethal chemical control are poisons and anti-coagulants. The use of poisons to control pikas populations was widely used and developed rapidly in the 1980s and 1990s, increasing the pikas poisoning rate to more than 95%. However, the use of such rodenticides may result in impacts on non-target species, environmental contamination, or even low populations of plateau pikas [3].

Another type of chemically controlled agent is anti-coagulants, which are popular because they do not produce secondary by-products and environmental damage [22]. However, large-scale deployment of anti-coagulants requires the use of large quantities of fresh cereals as bait and need to be applied several times and in large quantities to be effective [22]. The high cost of anti-coagulants makes it challenging to sustain widespread and large-scale use.

For physical control, there are traps, cages, and a trap barrier system, which is a method of using bait with plastic fences containing traps [23]. However, such devices require significant labour and time costs and may be hazardous to non-target animals, thus improvements are still necessary.

However, the use of single lethal controls would not achieve long-term effects because pika populations can multiply rapidly to environmentally threatening levels in a short time [3]. Non-lethal control thereby becomes a focus for pika control.

4.2.2. Non-lethal control. Pikas possess a remarkable ability to reproduce rapidly, thanks to their substantial population base and high population growth rate. With the capacity to breed two to three times annually, pikas give birth to litters averaging 4.7 ± 1.3 offspring per litter [22]. With such a large population size and high reproductive rate, contraceptive control is more effective and environmentally friendly in the long term. Contraceptive control refers to the use of non-transmissible contraceptive drugs and genetically modified viral infections through self-disseminating to induce infertility in pikas, preventing embryo implantation or development [3]. This method effectively lowers the birth rate, significantly impeding the population's ability to recover. As for the implementation time, it is proved by experiments that contraceptive control is more effective when implemented at a fixed time during the growing season and earlier in the breeding season [3].

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4.3. Grassland rehabilitation

After controlling the pika population, reseeding the grassland and weed control are indispensable steps to restore grassland health. Pikas prefer habitats with low, sparse grass [22]. Thus, with unchanged vegetation, the population of plateau pikas will experience a rapid rebound. However, partial vegetation recovery could slow that [24]. Once vegetation reaches a certain threshold of recovery, it will permanently restrain the population of plateau pikas, mitigating their impact [24].

5. Conclusion

In general, we investigated the relationship between plateau pikas and grassland degradation and identified overgrazing as the root cause. Local pastoralists failed to practice appropriate grazing, resulting in an imbalanced relationship between pasture and animals, exacerbating grassland degradation. To address this, we propose three steps. Firstly, pastoralists should be educated on adopting multi-paddock grazing management and practicing rational grazing. Next, we recommend employing non-toxic, non-lethal contraceptive methods that do not harm the environment or non-target species to manage pika populations. Finally, reseeding and weed control measures should be implemented to eliminate potential pika habitats while restoring grassland health. Further studies on contraceptive control for pikas and discussions on pasture management education and supervision are crucial, as effective pika management relies on addressing overgrazing appropriately.

References

[1] Li, J., Yin, H., Wang, D., Jiagong, Z., & Lu, Z. (2013). Human-snow leopard conflicts in the Sanjiangyuan Region of the Tibetan Plateau. Biological Conservation,166,118-123. https://doi.org/10.1016/j.biocon.2013.06.024

[2] Zhang, J., Jiang, F., Li, G., Qin, W., Li, S., Gao, H., Cai, Z., Lin, G., & Zhang, T. (2019). Maxent modeling for predicting the spatial distribution of three raptors in the Sanjiangyuan National Park, China. Ecology and evolution, 9(11), 6643-6654. https://doi.org/10.1002/ece3.5243

[3] Liu, Y., Fan, J., Harris, W. et al. (2013). Effects of plateau pika (Ochotona curzoniae) on net ecosystem carbon exchange of grassland in the Three Rivers Headwaters region, Qinghai-Tibet, China. Plant Soil, 366, 491–504. https://doi.org/10.1007/s11104-012-1442-x

[4] Li, X., Wang, Z., Wang, D., Wang, L., Pan, D., Li, J., & Seastedt, T. R. (2019). Livestock grazing impacts on plateau pika (Ochotona curzoniae) vary by species identity. Agriculture, Ecosystems & Environment, 275, 23-31. https://doi.org/10.1016/j.agee.2019.01.007

[5] Zhao, J., Tian, L., Wei, H., Zhang, T., Bai, Y., Li, R., & Tang, Y. (2021). Impact of plateau pika (Ochotona curzoniae) burrowing-induced microtopography on ecosystem respiration of the alpine meadow and steppe on the Tibetan plateau. Plant and Soil, 458, 217-230. https://doi.org/10.1007/s11104-019-04122-w

[6] Jing, Z., Fan, N., Zhou, W., & Bian, J. (1991). Integrated management of grassland rodent pest in Panpo area. Chinese Journal of Applied Ecology, 2(1). 32-38. http://www.cjae.net/EN/Y1991/V2/I1/32

[7] Zhang, W. H., Miao, Y. J., Zhao, Y. H., Wang, X. T., Xu, Y. M., Wei, X. H., & Sun, L. (2018). Effects of plateau pika (Ochotona curzoniae) on alpine meadow in Tibet. Acta Prataculturae Sinica, 27(1), 115. http://cyxb.lzu.edu.cn/EN/volumn/current.shtml

[8] Smith, A. T., & Foggin, J. M. (1999). The plateau pika (Ochotona curzoniae) is a keystone species for biodiversity on the Tibetan plateau. Animal Conservation, 2(4), 235–240. https://doi.org/10.1111/j.1469-1795.1999.tb00069.x

[9] Smith, A. T., Senko, J., & Siladan, M. U. (2016). Plateau pika Ochotona curzoniae poisoning campaign reduces carnivore abundance in southern Qinghai, China. Mammal Study, 41(1), 1-8. https://doi.org/10.3106/041.041.0102

[10] Lai, C.H., Smith, A.T. (2003). Keystone status of plateau pikas (Ochotona curzoniae): effect of control on biodiversity of native birds. Biodiversity and Conservation, 12, 1901–1912. https://doi.org/10.1023/A:1024161409110

DOI: 10.54254/2753-8818/37/20240189

[11] Guo, Z. G., Zhou, X. R., & Hou, Y. (2012). Effect of available burrow densities of plateau pika (Ochotona curzoniae) on soil physicochemical property of the bare land and vegetation land in the Qinghai-Tibetan Plateau. Acta Ecologica Sinica, 32(2), 104-110. https://doi.org/10.1016/j.chnaes.2012.02.002

[12] Jiang, Z. & Xia, W. (1985). Utilization of food resources by plateau pikas. Acta Theriol, 251–262. http://www.mammal.cn/EN/Y1985/V5/I4/251

[13] Boone, R. B., Conant, R. T., Sircely, J., Thornton, P. K., & Herrero, M. (2018). Climate change impacts on selected global rangeland ecosystem services. global change biology, 24(3), 1382-1393. https://doi.org/10.1111/gcb.13995

[14] Sun Y., Guo R., Liu H., Zhang S., & Sun Z. (2022). Evolutionary game of overgrazing and grassland degradation management on the Tibetan Plateau. Science and Technology for Development (05), 665-673. https://www.jstor.org/stable/1686631

[15] Zhou X. (2001). Songcao Meadow, China. Science Press

[16] Qin, J., Yun, X., Su, H., Shi, D., & Yang, J. (2009). Effect of Bryde's vole on grassland vegetation under simulated conditions: Effect of vegetation biomass. Pratacultural Science, (06),140-145. https://caod.oriprobe.com/articles/15565466/Brandt%E2%80%B2s_voles_Impact_of_Brandt%E2%80%B2s_voles_on_grassla.htm

[17] Wu, Y. N., Ma, Y. J., Liu, W. L., & Zhang, W. Z. (2019). Modeling the spatial distribution of plateau pika (Ochotona curzoniae) in the Qinghai Lake Basin, China. Animals, 9(10), 843. https://doi.org/10.3390/ani9100843

[18] Fan N., Wang Q., Zhou W., & Jing Z. (1989). Relationship between plateau squirrel population and vegetation destruction. Proceedings of the International Symposium on Alpine Meadow Proceedings of the International Symposium on Alpine Meadow Ecosystems, 106-109.

[19] Jiang X., Zhang W., Yang Z., & Du G. (2004). Plant diversity variations in zokor-mound communities along a successional stage. Chinese Journal of Applied Ecology, 15(5), 814-818. https://pubmed.ncbi.nlm.nih.gov/15320400/

[20] Papanastasis, V. P. (2009). Restoration of Degraded Grazing Lands through Grazing Management: Can It Work?. Restoration Ecology, 17(4), 441-445. https://doi.org/10.1111/j.1526-100X.2009.00567.x

[21] Teague, R. & Barnes, M. (2017). Grazing management that regenerates ecosystem function and grazingland livelihoods. African Journal of Range & Forage Science, 34(2), 77-86. https://doi.org/10.2989/10220119.2017.1334706

[22] Zhang, Z., Zhong, W., & Fan, N. (2003). Rodent problem and management in the grasslands of China. Rats, mice and people: rodent biology and management, 316–319. http://hdl.handle.net/123456789/91237

[23] Lam Y M. (1983). Reproduction in the rice field rat, Rattus argentiventer. Malayan Nature Journal, 36, 249–282. http://scholar.google.com/scholar_lookup?&title=Reproduction%20in%20the%20rice%20field%20rat%2C%20Rattus%20argentiventer&journal=Malayan%20Nat%20J&volume=36&pages=249-282&publication_year=1983&author=Lam%2CYM

[24] Liu, H., Chen, Y., Zhou, L., & Jin, Z. (2013). The effects of management on population dynamics of plateau pika. Mathematical and Computer Modelling, 57(3-4), 525-535. https://doi.org/10.1016/j.mcm.2012.06.032