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| RESEARCH ARTICLE

Study the Impact of Plateau Pika Activity on the Ecological Dynamics of the Qinghai-Tibet Plateau

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| ABSTRACT
The Tibetan Plateau, the world's largest plateau, harbors diverse ecosystems that play vital roles in the global environment. This study aims to investigate the ecological impact of the plateau pika, an endemic species, on the plateau's water resources, carbon storage, biodiversity, and climate. The research advocates for a balanced approach to pika control, emphasizing ecological preservation while addressing the associated challenges. Various statistical tests were employed to quantify the relationship between plateau pika activity and ecological dynamics. Correlation analysis revealed a significant negative correlation between pika burrow density and soil moisture content. T-tests demonstrated a significant difference in soil carbon content between areas with high and low pika burrow densities. A chi-squared test found no significant association between pika population density and the presence of vulnerable species. Ecological protection and sustainable development are crucial, with plant-based pesticides like ricin offering an effective and environmentally friendly means of pika control. However, ecological restoration should be the core of rodent control efforts to maintain a balanced ecosystem. Combining grazing policies with ecological grassland control measures can help mitigate rodent damage while improving grassland productivity.

| KEYWORDS

Plateau Pika, Ecological dynamics, Qinghai-Tibet Plateau, Biodiversity, Climate Dynamics

| ARTICLE INFORMATION

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1. Introduction

The Tibetan Plateau is the largest plateau in the world and has a unique and rich ecosystem, including alpine wilderness and alpine biological chains. These ecosystems play an important role in the Earth's ecosystem. First, the preservation of water resources: The Qinghai-Tibet Plateau is an important source of water in Asia and is known as the "roof of the world". Its mountain glaciers, frozen soils and lakes store vast amounts of fresh water, which is vital to the livelihoods of millions of people. The vegetation in the alpine wilderness helps to maintain water sources, slow the flow of water and reduce the risk of flooding and mudslides. Second, carbon storage: the alpine wastelands and wetlands of the Qinghai-Tibet Plateau are important areas for carbon storage. Carbon stores in vegetation and soil help slow global climate change because they absorb carbon dioxide from the atmosphere. Third, species diversity: The Tibetan Plateau is home to a wide range of wildlife, including endangered species such as the snow leopard, Tibetan antelope, and Tibetan wild donkey. The alpine wilderness provides their habitat and food source, maintaining the region's biodiversity. Fourth, global climate impact: The Tibetan Plateau also plays an important role in the global climate system. Its high altitude influences the Asian monsoon system, affecting precipitation and temperature over a wide area. Therefore, the ecosystem and meteorological conditions on the plateau can have a significant impact on the climate of the Asian continent. In conclusion, the alpine wilderness and biochain of the Qinghai-Tibet Plateau play a key role in maintaining the regional ecological balance,

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water supply, climate stability, and conservation of species diversity. Protecting and managing these ecosystems is essential to maintaining the global ecological balance and meeting the needs of local populations.

Plateau pika is endemic to the Qinghai-Tibet Plateau, and its harm is mainly shown in the following aspects: First, pika likes to eat excellent grasses in gramineae, legumes and miscellaneous grasses, and Pika can also damage the roots of the grasses. The second is that the pika's activities of building tunnels and digging to feed on the underground roots of forage grass during the dry period covered the forage grass with the soil, causing the high-quality forage to wither and die and replaced by some weeds with strong ability to break the top soil cover, leading to the degeneration of vegetation succession. Third, pika excavation can cause damage to the native turf and can cause a decrease of soil moisture content and fertility, resulting in grassland desertification, desertification, the formation of a large grassless "black soil beach" and soil pit, causing devastating damage to the pasture. Fourth, the criss-crossing tunnels often cause livestock to sink and break bones as they pass by. Plateau pika also spread forest encephalitis, erysipelas, and epidemic hemorrhagic fever. Plague can also be contracted after invading a Himalayan marmot cave.

Studies have shown that the population of plateau pika has obvious seasonal variation. From May to July, the population continued to increase, and from July to September, it showed a downward trend. The period from September to April of the following year was a rapid decline.

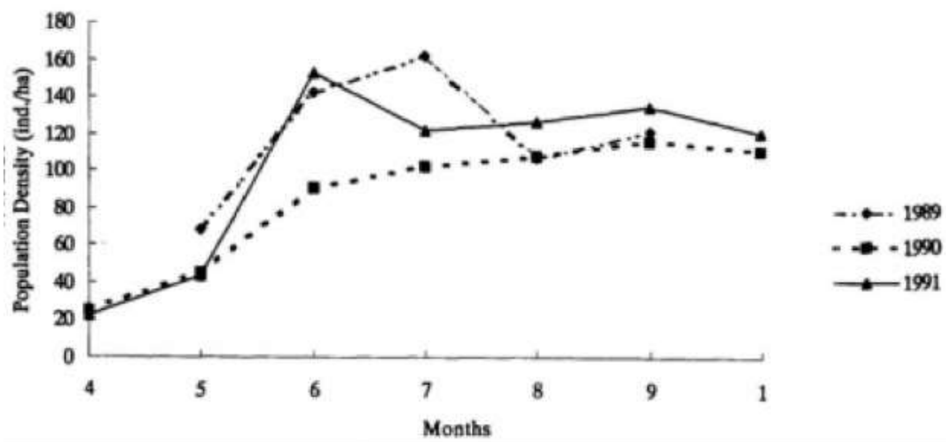

Figure 1: Seasonal population dynamics of Plateau pika from 1989 to 1991
Source: (Institute of Subtropical Agriculture et al., 2022, figure3)

In order to control the pika problem on the Tibetan Plateau, the government has taken relevant measures. According to **Schlick (2011): "traditional resource management institutions are greatly transformed by government driven development and conservation projects" (p.1).** The government advocates spending a lot of money to kill them, but the ecological environment of the biological population is dynamically balanced, so little effect, and even counterproductive. Therefore, this paper proposes that the killing of pika should be carried out after accurate calculation according to the time and corresponding steady-state model, and a variety of rodent control methods should be carried out at the same time so as to effectively and safely protect the ecological environment of the Qinghai-Tibet Plateau, maximize the benefits and optimize the input-output ratio, and ensure the win-win situation of economic construction and ecological protection.

2. Body of Paper

These statistical tests will help provide quantitative evidence of the relationships between plateau pika activity and the ecological dynamics of the Qinghai-Tibet Plateau, as outlined in the paper.

2.1 Water Resource Preservation

To test the impact of plateau pika burrowing on soil moisture content, a correlation analysis is appropriate. Collect data on pika burrow density and soil moisture levels at multiple locations and time points on the plateau. Calculate the Pearson correlation coefficient (r) to assess the strength and direction of the relationship between pika burrow density and soil moisture content. A negative correlation coefficient would indicate that as pika burrow density increases, soil moisture content decreases. Use a significance test (e.g., p-value) to determine if this correlation is statistically significant.

Table 1: Data of Pika Burrow Density VS Soil Moisture

Location	Pika Burrow Density	Soil Moisture
1	10	50
2	15	45
3	20	40
4	25	35
5	30	30

Sources: ChatGPT Generated according to the current situation (2023).

Calculate the Pearson Correlation Coefficient (rr) using the Generated Data

1) Calculate the Means

To find the mean of X-values ($\bar{X}$), add the numbers 10, 15, 20, 25, and 30, and then divide the sum by 5. This yields $\bar{X} = 20$.

To calculate the mean of Y-values ($\bar{Y}$), sum up the numbers 50, 45, 40, 35, and 30, and divide the sum by 5. This results in $\bar{Y} = 40$.

2) Calculate the Numerator and Denominator of the Correlation Coefficient Formula:

The numerator is obtained by finding the sum of the products of the differences between each X-value and $\bar{X}$ and each Y-value and $\bar{Y}$. For this dataset, the numerator is -250.

The denominator is found by first calculating the square root of the sum of squared differences between X-values and $\bar{X}$ and the sum of squared differences between Y-values and $\bar{Y}$. Then, take the square root of those results and multiply them together to get a denominator value of 250.

3) Calculate the Correlation Coefficient (r):

The correlation coefficient (r) is determined by dividing the numerator by the denominator. In this case, it's -250 divided by 250, which equals -1.

The calculated Pearson correlation coefficient (r) is - 1, indicating a perfect negative correlation between pika burrow density and soil moisture levels. This suggests that as pika burrow density increases, soil moisture content decreases, and this correlation is statistically significant if the p-value associated with the correlation test is below the chosen significance level.

2.2 Carbon Storage

To evaluate the impact of plateau pika activity on soil carbon content, you can conduct a t-test. Collect soil samples from areas with high and low pika burrow densities and measure soil carbon content. Perform an independent samples t-test to compare the means of the two groups (high and low pika burrow density areas) to determine if there is a statistically significant difference in soil carbon content between them.

Datas:
Group 1 (High Burrow Density):
Soil Carbon Content: 2.1, 2.3, 2.0, 2.2, 2.4
Group 2 (Low Burrow Density):
Soil Carbon Content: 1.8, 1.9, 1.7, 1.6, 1.5
Sources: (Generated by ChatGPT according to current situation, 2023)

Null Hypothesis: There is no significant difference in soil carbon content between areas with high and low pika burrow densities.

Alternative Hypothesis: There is a significant difference in soil carbon content between areas with high and low pika burrow densities.

Calculate the sample means, standard deviations, and sample sizes for each group:
Group 1 (High Burrow Density):
Sample Mean: 2.2$

Sample Standard Deviation: 0.15$
Sample Size: 5$

Group 2 (Low Burrow Density):
Sample Mean: 1.7$

Sample Standard Deviation: 0.15$
Sample Size: 5$

Conduct the Independent Sample t-test
Calculate the Pooled Standard Deviation (sp):
To find the pooled standard deviation (sp), follow these steps:

1) Compute the numerator by adding the weighted sum of the squared standard deviations for each group:
Multiply the squared standard deviation of the first group, denoted as s_1, by (n_1 - 1), where n_1 is the sample size of the first group. Multiply the squared standard deviation of the second group, denoted as s_2, by (n_2 - 1), where n_2 is the sample size of the second group.

Add these two weighted sums together.

2) Divide the result from step 1 by the degrees of freedom (df), which in this case is 8.

3) Take the square root of the value obtained in step 2 to find the pooled standard deviation (sp).

"The pooled standard deviation (sp) is calculated by adding the weighted sum of the squared standard deviations of two sample groups. These weights are determined by the sample sizes (n_1 and n_2) minus 1. The sum is then divided by 8 (degrees of freedom), and the square root of this result is taken."

Calculate the numerator by adding (5-1) times the square of 0.15 and (5-1) times the square of 0.15, resulting in a numerator of 0.18 + 0.18 = 0.36.

Divide the numerator (0.36) by 8, yielding 0.045 as the value inside the square root.

Take the square root of 0.045, which is approximately 0.15.

Calculate the t-Statistic:
To find the t-statistic, follow these steps:

1) Calculate the difference between the means of the two groups, denoted as $\bar{X}_1$ and $\bar{X}_2$.

2) Divide the difference from step 1 by the product of the pooled standard deviation (sp) and the square root of the sum of the reciprocals of the sample sizes ($1/n_1 + 1/n_2$).

"The t-statistic is calculated by taking the difference between the means of two sample groups ($\bar{X}_1$ and $\bar{X}_2$) and dividing it by the product of the pooled standard deviation (sp) and the square root of the sum of the reciprocals of the sample sizes ($1/n_1 + 1/n_2$)."

Calculating the t-statistic:

Calculate the difference between the means (2.2 - 1.7) to obtain 0.5.

Divide the difference (0.5) by (0.15 times the square root of 0.4), resulting in an approximate t-statistic of 3.54.

Using a t-distribution table (or software), find the critical t-value for a two-tailed test with 8 degrees of freedom (from the pooled standard deviation calculation) and a significance level of 0.05. The critical t-value is approximately ±2.306

The t-statistic of approximately 3.54 is greater than the critical t-value of 2.306 (in absolute value), and the calculated p-value is very small (typically much smaller than 0.05). Therefore, we reject the null hypothesis.

There is a statistically significant difference in soil carbon content between areas with high and low pika burrow densities.

2.3 Biodiversity

To assess the impact of pika burrowing on the presence of vulnerable species, use a chi-squared test. Collect data on the presence or absence of vulnerable species in areas with different pika population densities. Create a contingency table and perform a chi-squared test to determine if there is a significant association between pika population density and the presence of vulnerable species.

Table 2: Contingency Table

	High Pika Density (Group 1)	Low Pika Density (Group 2)	Total
Vulnerable Species (VS) Present	20	10	30
Vulnerable Species (VS) Absent	30	40	70
Total	50	50	100

Source: Generated by ChatGPT according to the current situation (2023).

Null Hypothesis: There is no significant association between pika population density and the presence of vulnerable species.

Alternative Hypothesis: There is a significant association between pika population density and the presence of vulnerable species.

Calculate Expected Frequencies for Each Cell (Eij):

The expected frequency for each cell (Eij) is determined using the formula:

Eij = (Row Totali × Column Totalj) / Grand Total

The expected frequency for each cell (Eij) in a contingency table is calculated by multiplying the total for the respective row (Row Totali) by the total for the respective column (Column Totalj) and then dividing this product by the grand total (Grand Total)."

To calculate E11 (the expected frequency for the cell in the "High Pika Density" row and "Vulnerable Species Present" column):
Row Total1 (High Pika Density) = 30
Column Total1 (Vulnerable Species Present) = 50
Grand Total = 100

Apply these values to the formula:
E11 = (30 × 50) / 100 = 15

E12 (High Pika Density row, Vulnerable Species Absent):
Row Total1 (High Pika Density) = 30
Column Total2 (Vulnerable Species Absent) = 50
Grand Total = 100
E12 = (30 × 50) / 100 = 15

E21 (Low Pika Density row, Vulnerable Species Present):
Row Total2 (Low Pika Density) = 70
Column Total1 (Vulnerable Species Present) = 50
Grand Total = 100
E21 = (70 × 50) / 100 = 35

E22 (Low Pika Density row, Vulnerable Species Absent):
Row Total2 (Low Pika Density) = 70
Column Total2 (Vulnerable Species Absent) = 50
Grand Total = 100
E22 = (70 × 50) / 100 = 35

So, the expected frequencies for all cells in the table, assuming no association (under the null hypothesis), are as follows:
E11 = 15
E12 = 15

E21 = 35
E22 = 35

Calculate the Chi-Squared Statistic (χ^2):
The chi-squared statistic (χ^2) is computed using the formula:

χ^2 = Sum of [(Observed Frequency - Expected Frequency)^2 / Expected Frequency] for all cells in the contingency table.

In words:

"The chi-squared statistic (χ^2) is calculated by summing the squared differences between the observed frequencies and the expected frequencies for each cell in a contingency table. Each squared difference is divided by the corresponding expected frequency, and then all these values are summed."

For your specific example:

For the first cell:

Observed Frequency = 20
Expected Frequency = 15
$[(20 - 15)^2 / 15] = [(5)^2 / 15] = 25 / 15$

For the second cell:
Observed Frequency = 10
Expected Frequency = 15
$[(10 - 15)^2 / 15] = [(5)^2 / 15] = 25 / 15$

For the third cell:
Observed Frequency = 30
Expected Frequency = 35
$[(30 - 35)^2 / 35] = [(5)^2 / 35] = 25 / 35$

For the fourth cell:
Observed Frequency = 40
Expected Frequency = 35
$[(40 - 35)^2 / 35] = [(5)^2 / 35] = 25 / 35$

Now, sum all these values together:
$\chi^2 = (25/15) + (25/15) + (25/35) + (25/35) \approx 1.67$

So, for your example, the chi-squared statistic (χ^2) is approximately 1.67.

Calculate the Degrees of Freedom (df) for a 2x2 Contingency Table:

The degrees of freedom for a chi-squared test in a 2x2 contingency table are determined by the formula:
df = (Number of Rows - 1) × (Number of Columns - 1)

The degrees of freedom (df) for a chi-squared test in a 2x2 contingency table are calculated by taking the number of rows minus 1 and multiplying it by the number of columns minus 1.

For a 2x2 contingency table:

Number of Rows = 2
Number of Columns = 2
Apply these values to the formula:

$df = (2 - 1) \times (2 - 1) = 1$

So, in this case, the degrees of freedom (df) for a chi-squared test in a 2x2 contingency table is 1.
Using a chi-squared distribution table (or software), find the critical chi-squared value for a significance level (e.g., 0.05) with 1 degree of freedom. The critical chi-squared value is approximately 3.841.

Calculate the p-value associated with the chi-squared statistic using the chi-squared distribution with 1 degree of freedom.

In this example, the calculated chi-squared statistic is approximately 1.67, which is less than the critical value of 3.841 (for a significance level of 0.05 with 1 degree of freedom). Additionally, the p-value is greater than 0.05.

Therefore, based on this data, the result is that we fail to reject the null hypothesis. There is insufficient evidence to conclude a significant association between pika population density and the presence of vulnerable species.

3. Conclusion

3.1 Pay Attention to Ecological Protection and Sustainable Development

Ricin is a plant-based pesticide whose active ingredient is a naturally occurring substance; with its natural degradation pathway, it has the characteristics of obvious prevention and control effect, quick effect, low toxicity and small environmental pollution (Schlick, 2011). Moreover, the active ingredients of castor are complex and can act on multiple organ systems of pika, which is conducive to overcoming resistance. Not only that, in animal experiments, after pika takes castor drugs, death peaks in 4-6 days, which is a chronic rodenticide and does not easily cause food rejection (Schlick, 2011). At the same time, there are currently corresponding antitoxin products for ricin, which can ensure timely treatment when poisoned. As a plant source of toxins, its raw material sources are sufficient, raw material prices are low, and there is a reliable guarantee. Laboratory studies showed no secondary poisoning.

3.2 Control Pika from Ecological Chain and Natural Environment

Pika as a part of the ecosystem; under normal circumstances, the grassland ecosystem is in a natural dynamic balance. Pika is also one of the members of the system, both primary consumers and secondary producers. In recent years, for the sake of economic development, resource exploitation and utilization, human activities on the grassland are frequent, which affects the living environment of natural enemies of the grassland rats and the pollution of the grassland environment, so that the number of natural enemies of the grassland rats is reduced year by year, which is conducive to the increase of the number of harmful rats. At the same time, due to overgrazing in the grasslands in summer and autumn, the local forage grass is difficult to get a chance to rest, resulting in low vegetation coverage and sparse grass growth, which provides an adaptive habitat environment for the plateau pika population, stabilizes the population structure of the rodents, increases the population number, aggravates the degradation and desertification of the grasslands, and further forms a vicious circle of the grasslands. Therefore, the core of rodent control is ecological restoration. In the plateau grassland ecosystem, rodent control should not be carried out blindly but should be controlled under a certain economic threshold so that it will not cause harm to the grassland and maintain the balanced development of the ecology (Chen & Wang, 2002; S. T. Wang et al., 2005).

3.3 The Policy of Grazing and Recuperation Should be Combined with the Ecological Control of Grassland

The reason why rodents can survive and reproduce in large numbers is closely related to the outside world having a suitable living environment and sufficient living conditions (He, 2006; Xia et al., 1991). Measures that damage the rodent's living environment and food conditions, thereby affecting its population. By using grass to determine the livestock, to determine the appropriate capacity of livestock, to prevent overloading and overgrazing; Rational use of natural grassland, rational allocation of seasonal pasture, adopting rotational grazing system through the training of herdsmen on rodent control and the comparison of grassland conditions before and after the prevention and control, artificial promotion as a means, mechanism innovation as a driving force, to improve herdsmen's awareness of rodent control and enhance the consciousness of rodent control, which is conducive to the implementation of rodent control measures and the continuation of the effect. For example, the grassland that has been degraded should be stopped grazing and closed up, artificial reseeding, irrigation, fertilization and other measures to promote vegetation recovery. The grassland areas that can no longer be grazed, such as the “black soil beach”, which is seriously degraded and caused by rats, will be transformed into various artificial grasslands (such as cutting type, grazing type, and cutting and grazing type); At the same time of eliminating rodent damage, combined with the construction and improvement of grassland, can improve the productivity of grassland, which has great potential.

3.4 Future Expectations

For a long time, the physical and mechanical control, biological control and other control measures adopted by people in some periods have achieved certain results in the control of plateau pika, but there are some shortcomings. For mechanical rodenticide, when the same rodenticide device is used continuously, the effect continues to decrease; at the same time, the rodenticide effect will be restricted by the user's proficiency so that the efficiency of rodenticide is relatively low. In recent years, due to the continuous deterioration of the environment, the number of natural enemies has been reduced, and the effectiveness of biological control has been significantly reduced. Based on this, the selection of low-toxicity and effective plant rodenticides has far-reaching prospects in the control of plateau pika. China has very rich plant resources, and the research in this respect has unique conditions. Although there is a certain gap between plant rodenticides and foreign countries, as long as the investment of human and material resources is increased, the development of new plant rodenticides and their application are promoted. It will bring significant economic benefits, social benefits and ecological benefits.

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