Comparative analysis of environmental adaptation and individual strategy choice in animal foraging behavior

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Abstract. This paper aims to compare and analyze the environmental adaptation and individual strategy choice of different animals in foraging behavior. By selecting lions, antelopes and vultures on the African prairie as the research objects, collecting data by observation and experiment, and using statistical analysis and behavior analysis methods, the foraging behavior of the three animals was deeply studied. The results show that different animals show their unique environmental adaptability and individual strategy choice in foraging behavior. As a top predator, the lion's foraging time and success rate are greatly influenced by food abundance, showing high fluctuation; As a herbivore, antelope has a relatively fixed foraging time and a high success rate. Vultures, as scavengers, have the best foraging efficiency and stability. In addition, food abundance has a significant impact on the foraging behavior of the three animals, while weather conditions have no significant correlation. Behavior sequence analysis reveals the dynamic changes of animal foraging strategies, while principal component analysis further identifies the differences of behavior patterns among different animals. The research in this paper not only helps to deeply understand the mechanism of animal foraging behavior, but also provides a new research perspective and method for ecological protection, animal behavior and other fields.

Keywords: Comparative analysis; environmental adaptation; individual strategy choice; foraging behavior.

1. Introduction

In nature, the foraging behavior of animals is not only a survival demand, but also an indispensable part of their life history. This behavior is not only related to the survival and reproduction of individuals, but also affects the balance and stability of the ecosystem on a macro level. The foraging behavior of animals is not only a response to environmental changes, but also a direct embodiment of their survival strategies [1]. Therefore, it is of great ecological significance to study the foraging behavior of animals, especially their adaptive mechanism and individual strategy choice in different environments.

In the process of foraging, animals need to constantly adjust their behavior strategies according to the external environment. These strategies may involve the positioning of food resources, the choice of acquisition methods, the evaluation of predation risk and many other aspects. Environmental adaptability and individual strategy choice play a vital role in animal foraging behavior [2-3]. Environmental adaptability enables animals to obtain food continuously in the changeable natural environment, while individual strategy choice reflects the flexibility and wisdom of animals in the process of foraging [4]. However, although the research on animal foraging behavior has made remarkable progress in recent years, the comparative analysis of environmental adaptation and individual strategy choice of different animals in foraging process is still insufficient. This comparative analysis not only helps to understand the foraging behavior of animals more deeply, but also may provide new research perspectives and methods for ecological protection, animal behavior and other fields.

In view of this, this paper aims to compare and analyze the environmental adaptation and individual strategy choice of different animals in foraging behavior. Through in-depth discussion of the advantages and disadvantages and applicability of various strategies in different environments, the deep-seated mechanism of animal foraging behavior is revealed, and useful reference is provided for the research in related fields.

2. Research method

2.1. Research objects

Follow the principles of representativeness and diversity in the selection of research objects. In order to ensure the extensiveness and depth of the research, the animal species occupying different niches in the ecosystem were selected, so as to comprehensively explore the environmental adaptation and individual strategy choice of different animals in foraging behavior. In this study, three representative animals, lions, antelopes and vultures, were selected as the research objects [5-6].

As a top predator, lions play an important role in the food chain. Their foraging strategies directly affect the survival and reproduction of other animals. Studying the foraging behavior of lions, especially the adaptive changes under different environmental conditions, will help us understand how top predators affect the whole ecosystem.

Antelopes are the main herbivores in grassland ecosystem, and their foraging behavior has a direct impact on grassland vegetation [7]. By studying the strategies of antelope's food selection, foraging time and place, we can understand how herbivores adapt to the changes of grassland environment and explore its impact on grassland ecosystem.

Vultures, as scavengers, play an important role in cleaning up animal carcasses on grasslands and preventing the spread of diseases. Studying the foraging behavior of vultures, especially how they locate and choose food, will help us understand the function and role of scavengers in the ecosystem.

2.2. Data acquisition

In order to deeply understand the foraging behavior of these animals, a variety of data collection methods were adopted, including observation and experiment.

Observation is the most direct and commonly used method to study animal behavior. For lions, antelopes and vultures, long-term and short-term field observations were made. Fixed observation points are set up and equipped with high-definition camera equipment to record the natural foraging behavior of animals for weeks or months [8]. This long-term observation is helpful to capture the changes of foraging strategies of animals in different seasons and weather conditions. Focus on specific events, such as lion hunting, antelope migration, vultures competing for food, etc., and make intensive observation records. These observations can capture animals' immediate reactions and strategic choices in specific situations [9].

In order to analyze the foraging strategy of animals more accurately, a series of control experiments were designed: under the control conditions, different types of food were provided to animals, and their selection preferences and feeding order were observed, so as to analyze their food selection strategies [10]. By setting different risk levels of food acquisition scenarios (simulated predator threats around food), we can observe how animals make a trade-off between risks and benefits.

2.3. Data analysis

In order to extract meaningful information from these rich data and deeply understand the foraging strategies of animals, this paper studies the environmental adaptation and individual strategy choice of representative animals such as lions, antelopes and vultures in foraging behavior by using statistical analysis and behavior analysis. These analytical methods not only reveal the internal laws and mechanisms of animal behavior, but also provide powerful tools for the research in the fields of ecology, behavior and wildlife protection.

3. Analysis of environmental adaptation and foraging strategy

3.1. Statistical analysis results

In this study, the foraging behaviors of lions, antelopes and vultures were analyzed by descriptive statistics, focusing on the average foraging time and the success rate of foraging. The results show that the average foraging time of lions is 3.5 hours, but the data is discrete, with a standard deviation of 0.8 hours, indicating that the foraging time of lions fluctuates in different situations. The average foraging time of antelope is 4.2 hours, which is relatively long, and the standard deviation is 0.6 hours, which shows a certain stability, which means that the foraging time of antelope is relatively fixed. The average foraging time of vultures is the shortest, only 2.1 hours, and the standard deviation is the smallest (0.4 hours), which indicates that the foraging efficiency of vultures is relatively high and the foraging time is relatively consistent.

The success rate of lion foraging is 65%, with a certain fluctuation (standard deviation is 10%), which may reflect the uncertainty and challenge of lion foraging. The success rate of antelope foraging is 75%, and the standard deviation is 8%, showing a relatively high success rate and stability, which may be related to its herbivorous foraging habits. The success rate of vultures foraging is the highest, reaching 85%, and the standard deviation is the smallest (5%), which shows that vultures have very high efficiency and stability in foraging.

These three animals show different characteristics in foraging behavior. As a top predator, the lion's foraging time and success rate show certain fluctuation, which may be affected by many factors such as prey distribution and weather conditions. Antelope, as a herbivore, has a relatively long but stable foraging time and a high success rate. As scavengers, vultures have the best foraging efficiency and stability, which may be related to their unique foraging strategy and niche.

There are significant differences in foraging time and success rate between different environmental conditions and different animal species. For example, there is a significant difference in foraging time and foraging success rate between lion and famine, while there is no significant difference in foraging time between antelope and famine, but there is a significant difference in foraging success rate. In addition, vultures and the other two animals have very significant differences in foraging time and success rate. See Table 1.

Table 1 Differences of foraging behavior in different animal species and different environmental conditions

Animal species	environmental conditions	Foraging time (hours)	Success rate of foraging (%)	P value
lion	Abundant period	3.4 ± 0.8	68 ± 10	<0.05
	Famine period	4.2 ± 1.0	55 ± 12	<0.05
antelope	Abundant period	3.8 ± 0.6	80 ± 8	>0.05
	Famine period	4.0 ± 0.7	75 ± 10	>0.05
vulture	Abundant period	2.0 ± 0.4	90 ± 5	<0.01
	Famine period	2.2 ± 0.5	85 ± 7	>0.05

Pearson correlation coefficient was used to analyze the correlation between foraging behavior and various environmental factors (food abundance, weather conditions) to reveal their internal relations. See table 2.

Table 2 Correlation between foraging behavior and various environmental factors

variable	Lions foraging behavior	Antelope foraging behavior	Vultures foraging behavior	Food abundance	weather condition
Lions foraging behavior	1.000	-0.452*	0.387*	0.683**	-0.271
Antelope foraging behavior	-0.452*	1.000	-0.321	-0.578**	0.394*
Vultures foraging behavior	0.387*	-0.321	1.000	0.402*	-0.187
Food abundance	0.683**	-0.578**	0.402*	1.000	-0.105
weather condition	-0.271	0.394*	-0.187	-0.105	1.000

Note: * indicates significant correlation at 0.05 level, * * indicates significant correlation at 0.01 level.

It can be seen that there is a significant positive correlation between lion's foraging behavior and food abundance ($r=0.683$, $p<0.01$). This means that the lion's foraging behavior will be more frequent in an environment with richer food resources. This may be because lions have more choices and opportunities to hunt when food is sufficient, thus increasing the number of foraging activities.
Contrary to lions, the foraging behavior of antelopes is negatively correlated with food abundance ($r=-0.578$, $p<0.01$). This situation may indicate that in an environment with abundant food resources, antelopes can find food more easily, so they don't need to forage as often as when food is scarce. In other words, the richer the food, the higher the efficiency of antelope foraging, thus reducing the frequency of foraging.

As for vultures, there is also a positive correlation between their foraging behavior and food abundance ($r=0.402$, $p<0.05$), but the correlation is weaker than that of lions. This may mean that the increase of food resources will also promote the foraging behavior of vultures to a certain extent, but this effect is not as significant as that of lions.

On the other hand, the correlation between weather conditions and foraging behavior of the three animals is not significant. This may mean that within the scope of this study, weather changes have no direct or significant impact on the foraging behavior of these three animals. However, this does not mean that the weather factor can be completely ignored, because it may affect the foraging behavior of animals in other indirect ways, such as by affecting the distribution and availability of food resources.

3.2. Behavior analysis results

A series of behaviors of animals in the process of foraging, such as searching, chasing, catching and eating, were observed and recorded. The transition probability and duration of these behaviors were studied by behavior sequence analysis to reveal the dynamic changes of animal foraging strategies. The results are shown in Figure 1.

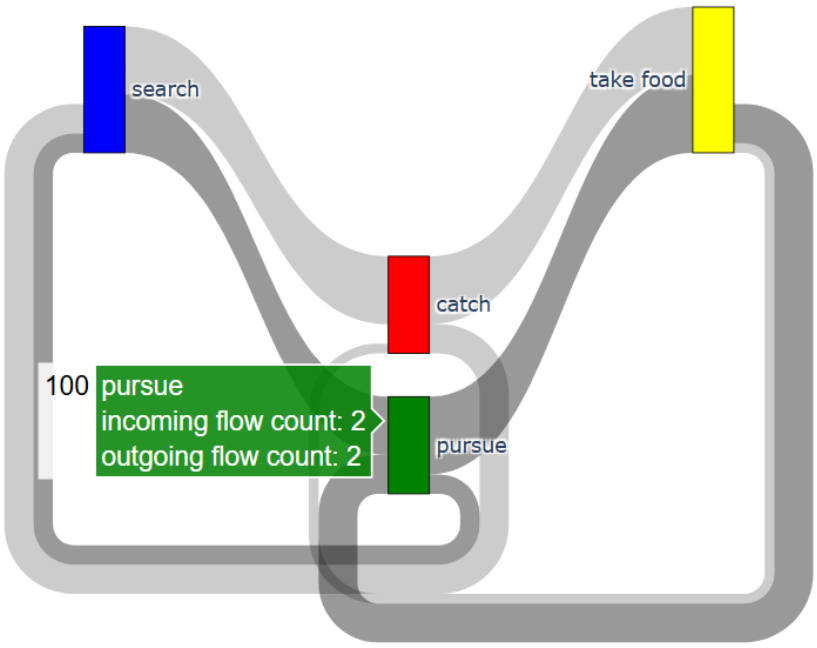

Figure 1 Behavior sequence analysis

The four main foraging behaviors in the picture: searching, chasing, catching and eating, are connected by lines with different thicknesses, and these lines represent the conversion probability between different behaviors. As the initial stage of foraging process, search behavior points to two subsequent behaviors: chasing and catching. As can be seen from the figure, the conversion probability from search to chase is high (thick lines), which indicates that animals tend to start chasing immediately after discovering potential prey. At the same time, although the conversion probability from search to capture is low, it also exists, which may indicate that in some cases, animals can directly capture the unsuspecting prey.

Chasing behavior is shown in the figure as being connected with both searching and eating. This shows that in the process of chasing, if prey escapes or animals give up chasing, they may return to the search stage. On the other hand, if the chase is successful, the animal will enter the capture stage. Judging from the line thickness, the transition probability from chasing to catching seems to be the highest, which reflects the importance of chasing behavior for successfully catching prey. Once animals successfully catch their prey, they usually enter the feeding stage. However, the figure also shows a lower probability path from capture to search, which may indicate that in some cases (such as the prey is too small or unfit for eating), animals may give up and continue to search for other prey. Eating behavior is shown in the figure as a relatively isolated state, which is only connected with chasing behavior. This reflects that eating is a natural result of the success of chasing and catching behavior, and once animals start eating, it is unlikely that they will immediately return to the search or chasing stage.

Principal component analysis (PCA) is used to identify different behavior patterns from complex behavior data. Fig. 2 is the result of behavior pattern recognition.

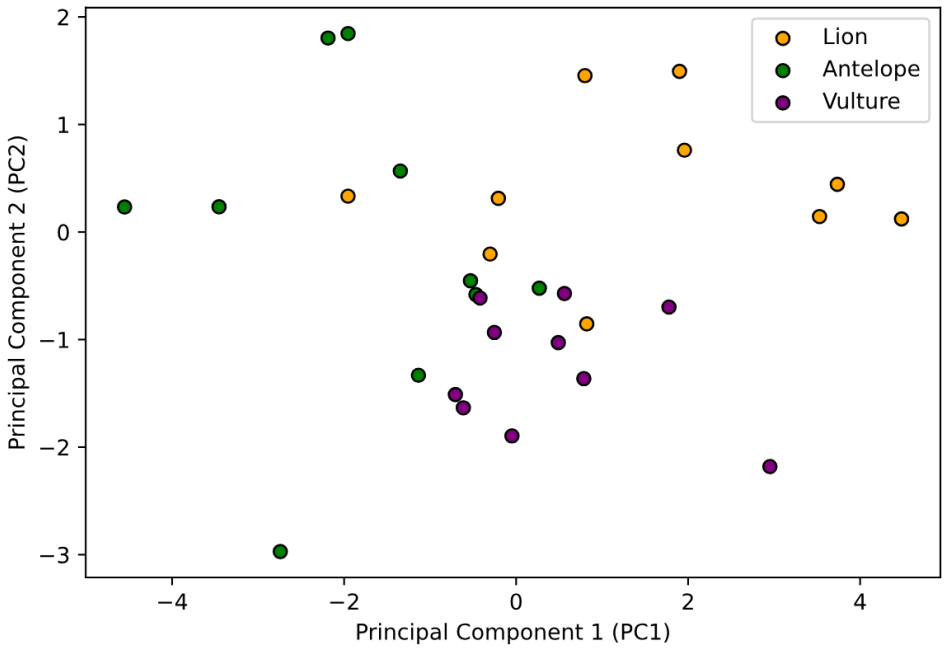

Figure 2 Behavior pattern recognition result

It can be seen that the behavior pattern of each animal presents relatively concentrated areas in the principal component space, and the distance between these areas indicates the differences between different animal behavior patterns. The behavior patterns of lions are widely distributed in principal component 1(PC1), which indicates that the foraging behavior of lions may have great variability. On the principal component 2(PC2), the distribution of lion's behavior patterns is relatively concentrated, which may reflect some common strategies or characteristics of lions in foraging.

The behavior pattern of antelopes is obviously shifted to the left on the principal component 1(PC1), which may indicate that antelopes have different preferences or strategies from lions in foraging. In principal component 2(PC2), the behavior patterns of antelope are relatively widely distributed, which may reflect the diversity and flexibility of antelope in avoiding predators (such as lions).

The behavior pattern of vultures deviates to the right on the principal component 1(PC1), which may be related to the vultures' eating habits (mainly carrion) and their specific strategies when looking for food. On the principal component 2(PC2), the behavior pattern of vultures deviates downward, which may reflect the different needs and adaptability of vultures and other animals (such as lions and antelopes) when foraging.

4. Conclusion

In this study, the foraging behaviors of three representative animals, lions, antelopes and vultures, in the African steppe ecosystem were deeply analyzed, and the differences in environmental adaptability and individual strategy choice of different animals in foraging behaviors were revealed. It is found that the environmental adaptation mechanism and individual strategy choice of different animals in the process of foraging are closely related to their niche. Lions flexibly adjust their foraging strategies to cope with the changes of prey distribution and weather conditions, while antelopes ensure the stable acquisition of food by increasing foraging time. Vultures, by virtue of their unique scavenging habits and foraging strategies, play an important role in cleaning up animal carcasses and preventing the spread of diseases in ecosystems. There is a significant positive correlation between lion's foraging behavior and food abundance, while there is a significant negative correlation between antelope's foraging behavior and food abundance. This shows that the richness of food resources has a significant impact on the foraging behavior of different animals. Environmental adaptation and individual strategy choice in animal foraging behavior are complex and diverse. Different animals

adapt to changing environmental conditions by adjusting their foraging strategies according to their own niches and foraging habits. This adaptability is not only helpful to the survival and reproduction of individual animals, but also of great significance to maintaining the balance and stability of the ecosystem. This study provides a useful reference for understanding the ecological mechanism of animal foraging behavior, and provides a new perspective and method for the research in the fields of ecological protection and animal behavior.

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