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RESEARCH PAPER

Predating strategy of rodents on acorns of *Quercusaliena* var. *acuteserrata* under different predating risks and fate of acorns

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Abstract: The effects of rodents on forest regeneration have been highlighted in many ecological studies. In 2002 and 2003, the acorns of *Quercus aliena* var. *acuteserrata* were subjected to 12 different treatments. The daily dynamics and the amount of acorns that were finally left intact, predated *in situ*, or removed off were examined and documented. The ratios of acorns that were infested by bugs before and after predation by rodents were carefully documented. It was found that: (1) the ratios of acorns infested by bugs before and after predation by rodents showed significant difference ($P > 0.05$), suggesting that rodents would not prey on acorns during the predating process if acorns had been already infested by bugs. (2) When compared with the controls, the fate of acorns could be roughly classified into four types: ①acorns that were simply buried or placed on black paper showed no significant differences with the controls in their response to rodents, suggesting that rodents have no sensitivity to the little change of odor resulting from burying and may be more adapted to black background. ②Acorns attached with strings, dyed with black ink, cut into halves, or placed on white/green/red paper were predated *in situ* with much lower predation rates and lasted the same duration. Compared with the controls, the acorns were removed away by rodents with the same first day rate and the removal lasted longer. The final removal rate of the acorns by rodents was increased, whereas that of predation *in situ* was decreased, and none were left in the spot. This may suggest that rodents in this case increased their predation risk expectation and adopted a strategy of "less predation proportion *in situ*". ③Acorns that were burnt were not predated *in situ* as well as removed in the first day, but the rates were raised to the maximum in the forth and fifth day and then declined to zero. Consequently, the final ratios of predation *in situ* and removal considerably decreased with many acorns, nearly 50%, being left intact. It can be hypothesized that the rodents responded to the change in odor of acorns by using the strategies of "less predation proportion *in situ*" and "less predating activities", thereby resulting in larger number of acorns remained intact. ④ Acorns that were enwrapped were barely predated *in situ*, removed in the first day with a normal predation rate, which declined to nearly zero in the second day and then increased till it declined again from the fourth day to the final day. The final rate of predation *in situ* was lower than 5% without acorns remained intact, and the rate of removal of acorns showed a considerable relative increase. This suggests that when there was a change in both odor and status of acorns, rodents also adopted the "spying" and "less predation proportion *in situ*" strategy, Because the predation risk is critical, the sense of sight would play an important role in rodent's living. (3) Definite amounts of acorns were predated *in situ*, discarded, removed away, predated *ex situ*, lost and hoarded separately.

Key Words: sharptooth oak (*Quercus aliena* var. *acuteserrata*); rodent; acorn; predation strategy; forest regeneration; oak.

1 Introduction

The effect of animals on the regeneration of oak forests has been under intensive study for ecologists and foresters since the last century. As a genera, Quercus includes more than 400 species, many of which are also the dominant species in the vegetation of temperate and sub-tropical regions[1]. *Quercus aliena* var. *acuteserrata* is widely distributed in many prov-

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inces of China, such as Liaoning, Shanxi, Gansu, Shandong, Henan, Hubei, Hunan, Jiangsu, Sichuan, as well as many regions of the Korean peninsula and Japan[2]. Seeds of the genera, often called acorns, are usually large and nutritious, and therefore serve as a nutritional source of food for some birds and many mammals. Although rodents predate on most of the seed crops, they play pivotal roles in the redistribution of acorns[4]. Several reports are available on predation, hoarding, or deposition of acorns by rodents; in the interaction among rodent activity, environmental conditions, and predating risks; in the differentiation of acorns by rodents[5−14]. Rodents usually predate, remove, discard, leave, and hoard acorns, and this process is often largely affected by the environmental factors, the changes in the status of acorns, etc. However, very few studies have ever focused on the following questions: How do rodents "feel" these factors? What is their response or predating strategy to the variation in environments or the status change of acorns? How will the final fate of rodents be affected?

This paper focused on further understanding of these aspects by trying to know that, under certain treatment, how the fate of acorns varies in the dynamics and final result, and what the pattern is. Further experiments were also carried out to analyze if rodents can discriminate the health status of acorns before predation.

Cage capture experiments and individual observation were combined to estimate the species inventory of small animals. And the results suggested that the following animal species predated acorns in three main different vegetation types of the region, which includes *Pinus tabulaefomis* forest, deciduous coniferous mixed forest, and bushes, *Niveventer excelsior*, *Rattus norvegicus*, *Rattus nitidus*, *Apodemus draco*, *Apodemus chevrieri*, *Apodemnus latronum*, *Eothenomys inez*, and *Sciurotamias davidianus*.

2 Methods

2.1 Study site

Field studies were conducted in five sites: Two were located in the Ecology Station of Mao County, Chengdu Institute of Biology, Chinese Academy of Sciences, China; the other three were located in Mati Village of Mao County, Sichuan province, China. The general information on the sites was also collected (Table 1). Further details on the location of the study site have been provided in other papers by the authors[15].

2.2 General approach

Forty-eight points were randomly selected in three sites of Mati Village on September, 2002; ten acorns of *Quercus aliena* var. *acuteserrata* were placed on the ground at each point, and were treated in two ways: 1) as controls; 2) a 50cm yellow fine plastic string was fixed at the lower part of each acorn by pulling it on. The statistics of acorns under different fates were completed 3 days later. The discarded acorns, which were slightly broken by rodents were collected and examined to check if they were healthy, that is, if they were damaged by pests or bacteria, or were rotten. A total of 400 acorns were also randomly collected and examined in the same way. It was also noteworthy to check whether the string was broken.

A large amount of acorns were also randomly collected and placed on the two sites of the Ecological Station, and 12 different kinds of treatments were performed on them: 1) to burn until they were completely charcoalized; 2) to enwrap fully with transparent plastic tape; 3) to enwrap fully with yellow opaque plastic tape; 4) to fix fine transparent plastic string at the lower part of each acorn by pulling it on, and mark the information of its position on it; 5) to place acorns on white paper of 20cm×20cm size; 6) to place acorns on green paper of 20cm×20cm size; 7) to place acorns on red paper of 20cm ×20cm size; 8) to enwrap the acorns to a depth of 2–3 cm with litter and a small amount of soil; 9) to dye the acorns with black charcoal ink; 10) to place acorns on black paper of 20cm×20cm size; 11) to cut the acorns into halves, each half as an individual; 12) as controls. Ten acorns under one treatment were considered 1 unit, and 12 different units formed 1 group. Twenty- five such groups were placed in 1 site, and 2 sites of the Ecological Station were finished. Observations were made on a daily basis to determine the exact number of the acorns that remained intact, predated *in situ*, or removed away until each kind of acorns were dispersed or consumed or remained unchanged for a long time. Acorns with fixed strings

Table 1 Characteristics of plots

Sites	Plots	Acorn number	Area (m^2)	Arbor/Brush coverage (%)	Dominant plants*
Mati Village	Gap	16×20	400	15/20	1, 2, and 3
	Forest Edge	16×20	400	50/40	4, 5, and 2
	Gap	16×10	520	20/30	6 and 4
Ecological Station	Slope beside the Shanzha field	12×10×25	800	10/90	4, 2, and 7
	Wayao Valley	12×10×25	1200	30/70	8, 7, and 9

*The numbers indicate the following:1 *Cariaria sinica*; 2 *Rosa* sp.; 3 *Pyrus* sp.; 4 *Quercus aliena* var.*acuteserrata*; 5 *Ilex purpurea*; 6 ferns; 7 *Corylus heterophylla* var. *sutchuenensis*; 8 *Pinus armandi*.; 9 *Fargesia* sp.