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Control of *Eospalax baileyi* (Plateau Zokor) with Arrow Traps in Western China

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ABSTRACT

In order to manage *Eospalax* (*Myospalax*) *baileyi* (Plateau zokors) pests with physical method, the efficacy of four different arrow traps was tested to control the plateau zokor in Sichuan Northwest Prairie, China. Population densities of 39.7- 42.1 ha^{-1} were found in the test plots. Such densities require control measures since pasture damages and economic losses are huge. Traps differed in trigger rates, from 83.8% (three-arrow type), 93.8% (infrared type), 93.9% (T-type), to 94.3% (one-arrow type). Capture rates ranged from 84.1 (three-arrow type), 91.8% (infrared type), 93.7% (T-type) to 93.8% (one-arrow type). The single-arrow trap has the highest efficacy and is also the cheapest, which is important knowledge for zokor control in western China.

INTRODUCTION

The *Eospalax baileyi* (plateau zokor, formerly *Myospalax baileyi*) is a subterranean burrowing endemic rodent (blind mole rat) inhabiting areas of 2600-4600 metres above sea level on the Qinghai-Tibet Plateau (Fan and Shi, 1982). It belongs to the Cricetidae, with a relatively large head, a short neck, a body length of 15-25 cm and weighs around 200-480 g. It breeds between March and May and hoards food in September/ October in its burrow in order to live through the severe winter conditions. During both these periods the animals are very active. As the rest of the year they spend their life solely underground in sealed burrows (Fan and Shi, 1982).

Documents showed that the population density of plateau zokors on alpine meadows was 21.3 individuals ha^{-1} in 2002 (Yu and Liu, 2002) and 19.5-28.5 individuals ha^{-1} in 2007. Plateau zokors have became a substantial pest species in large areas of the Tibetan highlands due to its density exceed 8 ha^{-1} in which density will lead to serious damage to the pastures (Tang and Yang, 2011). With their strong incisors they hold the roots and drag plants into their burrow system (Zhang *et al*., 2003, 2004) and make mounds by digging, wriggling, pushing up and mixing the soil while foraging. Zokors consume 90-120 g of fresh grass each day (Xie *et al*., 2014b). A plateau zokor can push the total 1024 kg of soil up above the surface during the mild climatic period of 89 days (Wang and Fan, 1987). In 2007, the economic damage caused by plateau zokors in Sichuan province was 300 million RMB (around 50 million USD). The total size of damaged grassland mounted up to 5.387×10^3 km^2 of which 3.267×10^3 km^2 with severe damage. Consequently, it is necessary to control the animal. Up to date, several pest control methods are applicated such as rodenticides (*e.g.* D-kreotoxin) (Guoying, 2008; Zhang, 2001), special bows and natural predators such as Eurasian eagles and Upland Buzzards (Cui *et al*., 2008). Arrow traps are frequently used by farmers and scientists with good effects. For example, trapping rate was reported 80-87% with the T-type and the one-arrow type trap (Lihua and Zhang, 2005) and 77.9-96.3% in Zhang's research with homemade arrow traps (Zhang, 2001). One of the main advantages using arrow traps is no negative effect on the environment. Moreover, the technology is very simple and easy to apply under all circumstances. The method of arrow traps can have a great potential to control the zokor in the Qinghai-Tibetan plateau because it lives style with subterranean burrowing activities. Here, we describe the use of four different kinds of arrow traps with different features and costs (Table I) in order to determine the most efficient arrow trap to control plateau zokors.

MATERIALS AND METHODS

Arrow traps

Intelligent (infrared) arrow traps were purchased (Henan Electric Co., Ltd. Falcon, Patent No. ZL201110129567.5). T-arrow traps were purchased from an agricultural cooperative in Qinghai Rimpau (patent No. 200920176465.7). The one-arrow and three-arrow traps were developed by the research team, based on long

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Table I.- Main characteristics of the arrow traps.

Type of arrow trap	Construction	Weight (kg)	Length x width x height (cm)	Force (Nw)	Cost price (RMB Y)
Intelligent (infrared)	three springs/frame/infrared ray/ circuit/three arrows/intelligent switch	1.2	55×30×20	100-110	175
T-type	T-frame/one spring/line/small stick	0.83	50×50×10	130-150	30
One-arrow type	Ladder-shaped frame/line/small stick/one-arrow/rubber band	0.73	60×25×5	60-70	28
Three-arrow type	Ladder-shaped frame/line/small stick/three arrows like fish spear/rubber band	0.95	60×25×15	60-70	35

term experience with elimination of zokors on the Tibetan plateau. Pictures of the different traps are provided in Figure 1. The different characteristics of the arrow traps are presented in Table I. During the experiment, the traps were placed according available information in the literature (Tan *et al.*, 2009).

Test plots

The pastures of the research station of the Southwest University for Nationalities in Hongyuan County (located in the southwest of Sichuan province) functioned as study area with an average elevation of 3600 metres above sea level. It consists of alpine meadow grassland types with grassy weeds as vegetation and meadow soils. Three plots were located between a hill and a river, and each plot has different distances to the hill and river (Table II), the plots had a different soil structure and vegetation composition. Soil near the hill slope contained more sand, with harder parts caused by trampling by yaks .Soil near the river is relatively soft due to the presence of a higher soil moisture content.

Experiment

The experiment was performed in September 2013 and September 2014. Plateau zokors are the most active in the morning (between 8.00 and 10.00 am) and in the afternoon (16.00-18.00 pm). In the morning, the arrow traps were placed. First, we poked with a probe in burrows with recent zokor activity (marked by freshly excavated soil) and then dug out the burrow. Then, we effectively blocked the entrance of each burrow with fresh soil. We registered the total number of burrows present and also the number of burrows that were in use by plateau zokors (“burrows occupied”).

In total, 24 arrow traps were placed near occupied burrows. As some burrows consists of two separate channels, two arrow traps were placed there, but always of the same type. Eight hours after placement, traps were again checked whether they had triggered. However, checking times sometimes varied due to the climatic conditions of the Tibetan plateau (snow, hail and heavy rain). If the arrow traps had eliminated a plateau zokor, traps were relocated to another occupied burrow. Thus, the total number of trapping times slightly differs between the different arrow traps. After another period of 24 h, we checked whether the arrow traps had triggered and recorded the number of triggered traps, the number of traps that did not trigger and the number of plateau zokors that had been eliminated, the number of burrows that were still blocked and the number of burrows that were not blocked any more. The population density data of September 2013 was registered before in smaller plots in the same area and was compared with the 2014 data (Table II).

RESULTS

The population density is 42.14 individuals ha^{-1}in 2014 that slightly higher than in 2013 with 39.7 individuals ha^{-1}, which can be caused by normal population fluctuations.

When focusing on the zokor density of the three investigated plots, we found a relationship between plot structure and zokor density. The closer to the river and the further from the hill, the higher the density of zokors was (Table II), probably also because the different soil structure and vegetation composition.

The different efficacy of different arrow traps were shown in Table III. Traps differed in trigger rates from 83.8% (three-arrow type), 93.8% (infrared type), 93.9% (T-type), to 94.3% (one-arrow type). Capture rates ranged from 84.1 (three-arrow type), 91.8% (infrared type), 93.7% (T-type) to 93.8% (one-arrow type). The capture rates differ slightly. The three-arrow type trap triggers rate less than the three others. The number of burrows that were still occupied after placement of the three- arrow type trap was two times bigger compared to the other three types of arrow traps. This may be caused by the lower triggering rate, which was nearly 10% lower as the others.

Fig. 1. Different arrow traps. From left to right: the intelligent (infrared) type, the T-type, the one-arrow type, the three-arrow type.

Table II.- Population density survey of *Eospalax baileyi* in samples in 2013 and 2014.

Data	Sample	Distance of plot to hill (m)	Distance of plot to river (m)	Plot size (ha)	# of encountered burrows	# of occupied burrows	# of eliminated zokors	Burrow coefficient	Population density	Occupancy rate (%)
Sept 2014	1	330	5	0.25	63	54	15	0.28	60.48	85.71
	2	150	110	0.6	65	54	16	0.30	27	83.08
	3	120	40	1.2	199	146	46	0.32	38.93	73.37
	Avg.	200	52	0.68	109	84.67	25.7	0.30	42.14	77.68
Sept 2013	4	-	-	0.25	35	31	7	0.35	43.4	88.57
	5	-	-	0.25	42	33	7	0.35	46.2	78.57
	6	-	-	0.25	34	21	7	0.35	29.4	61.76
	Avg.	-	-	0.25	37	28.3	7	0.35	39.7	76.49

DISCUSSION

Population density is one of the important indices for monitoring plateau zokor harm degree. The plateau zokor has a higher population density now in the county than the reports of several decades ago (Wang *et al.,* 1995), which mainly caused by its good reproductive success rate. This success rate may be caused by the settlement of herdsmen, grazing of yaks, construction activities and other human disturbances (Tang and Liu, 2014; Yuan *et al.*, 2005;Wei *et al.*, 2014). At about 200 metres far away from the investigated plots, Tibetans have recently settled and there is a lot of yak activity. Moreover, about 500 metres away, a provincial road was constructed. This may also have contributed to the increase in population of the zokors during the last years in our study area. The plateau zokor starts with mating during March to May and give birth to usually 2-4 litters. Young zokors can survive alone after two weeks and leave the burrow in which they were born after about 100 days. Why does the plot nearby river has the highest density of zokors? Firstly, soft and moist soils facilitates the plateau zokor to dig burrows. Moreover, plants near the river are more lush. In our study we found that Chinese cinquefoil herb was frequently consumed by zokors. In the second plot, the vegetation was more scarce (wormwood was one of the main species there). This is bad for zokor survival as there is less food

Table III.- The effect of four kinds of arrow traps on *Eospalax baileyi.*

	Type of arrow trap			
	Intelligent (infrared)	**T- type**	**One-arrow type**	**Three- arrow type**
No. of trapping occasions	100	98	101	99
No. of occupied burrows that were hunted	63	63	64	63
No. of occupied burrows after hunting	5	4	4	10
No. of traps that were triggered when zokor left its hole	61	62	66	57
No. of traps that were not triggered when zokor left its hole	4	4	4	11
No. of traps not triggered when zokor did not leave its hole	35	32	31	31
Trigger rate (%)	93.85	93.94	94.29	83.82
Capture rate (%)	92.65	93.65	93.75	84.13

availability, and also less coverage against their natural enemies.

The single-arrow trap was the most efficient trap during this study. Our test results are in correspondence with the findings of previous researchers (Ma and Sun, 2012; Zhang *et al.*, 2003). The single arrow trap trigger easily as its rubber band is highly sensitive and the vertical launched arrow rarely deflects, and these advantages make it penetrating through the soil quite easily. The T-type arrow easily deflects when triggered, thus leading to a lower elimination percentage. As for the infrared or intelligent arrow trap, it is so sensitive that can eliminate the zokor as soon as its crosses its predetermined detection range. However, due to the climatic conditions of the Tibetan plateau, rain, snow and water may block the sensing probe, making it less efficient. The three-arrow trap has 3 arrows of a large diameter and functions quite heavy, which makes it less efficient. Furthermore, their construction and trigger sensitivity is of vital importance. Concerning force, it has been shown that 60-70 Newton is sufficient to kill a zokor with a small arrow, causing a quick death. However, if the arrows become thicker or more arrows are applied, larger forces are needed because of emerging resistance and traps become more difficult to trigger. Zokors are quick learners and can determine the position of the trunk jam (Kimchi and Terkel, 2003; Ma *et al.*, 2014). When the zokor is not killed but scared by the arrow triggering, it will not return to plug the hole again and results in reducing the efficacy of an arrow trap. Weather conditions can also affect the efficacy of arrow traps in two ways: firstly, snow or ice may block the hole and then reducing the arrow trap's function; secondly, zokor will cut back on activities and remain in their burrow because bad weather makes them feeling uncomfortable. Finally, because of these heavy rains combined with high levels of UV at other times, the rubber band may easily age and should be replaced regularly in order to ensure optimal efficacy of the arrow trap.

In general, arrow traps can contribute to an efficient control of the plateau zokor population when their density becomes problematic in Tibet plateau although the efficacy differs between the different arrow traps. We should improve the traps' efficiency and make it more cheaper as well as more practical in the near future.

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