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Short research contribution

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METHODS FOR LARGE SCALE ASSESSMENT OF SMALL MAMMAL ABUNDANCE IN OPEN HABITATS: PLATEAU PIKA (*OCHOTONA CURZONIAE*) IN ALPINE GRASSLAND

ABSTRACT*:* Quick and accurate estimation of population density in large scale is required in both scientific studies and wildlife management programs. However, effective estimation of small mammal abundance is usually difficult and time-consuming due to the body size and wide distribution of these animals. To test the efficiency of different methods in assessing small mammal densities, population dynamics of plateau pikas (*Ochotona curzoniae*, Hodgson) were studied from April 2005 to August 2009 in alpine grassland (*Kobresia humilis*) at a height of of 3846 m a.s.l. We compared the precision of walked transects method with mark-recapture method using Efford's maximum likelihood spatial estimator (ML). Significant positive correlation was found between walked transects and Efford's ML estimator (r^2 = 0.58, P <0.001). The densities calculated with walked transects were about twice lower than those obtained using the mark-recapture method over the study period (*i.e.*, summer). Nevertheless, the walked transects method remains useful for relative density estimation. Hence, the walked transects method is recommended for use as an index of relative density in large-scale assessment in alpine grassland where most small mammals are active and easily detected in an open habitat.

KEY WORDS: density estimation, walked transects, mark-recapture, plateau pika, small mammals

Estimating the abundance of wildlife population is a central concern in basic and applied ecology; it is also a vital component of any wildlife research. The walked transects method (also called 'line transect') is well known for estimating densities of wildlife populations (Plumptre 2000, Bardsen and Fox 2006). This method is particularly useful, as it requires less time and no interaction with the animals when the species is relatively abundant and easily found. Theoretically, unbiased estimates of density can be obtained using the walked transects method if the following three key assumptions are met (Bunkland *et al*. 2004): (1) objects on the line are always observed, (2) objects are detected at their initial locations before they move in a nonrandom fashion in response to the observer, and (3) distances are measured accurately. The first assumption is the most critical. In the case of mammals with small body sizes and which inhabit open ecosystems, especially those nesting in burrows, estimating their abundance in a precise manner is difficult to conduct.

Though the benefits of walked transects are widely acknowledged, the accuracy of using such for density estimation is under debate and needs to be adjusted (Eguchi and

Gerrodette 2009). Few studies have directly compared the walked transects with other population estimators (Calambokidis and Barlow 2004).

The best approach to compare method accuracies is to know the actual number of animals in an area. When this is not possible, another option is to use Efford's maximum likelihood spatial estimator (ML), a precise measure of population abundance in mark-recapture studies on small mammals (Efford 2004).

Plateau pikas (*Ochotona curzoniae*, Hodgson) are small (females, 120–170 g; males, 150–210 g) diurnal lagomorphs endemic in the Qinghai-Tibetan Plateau in China (Arthur *et al.* 2008). They are active throughout the day but slightly more active during mid-morning and mid-afternoon (Smith and Wang 1991). Plateau pikas prefer to inhabit the wide alpine meadows where they can graze at daytime. They have high reproduction and dispersion rates. These animals are the typical representative of small mammals inhabiting open habitats (Smith and Wang 1991, Pech *et al.* 2007, Arthur *et al.* 2008).

The purposes of this study were: 1) to determine if walked transects method, rather than time-consuming mark-recapture method could be used effectively to monitor the status of pika abundance in large areas (*i.e.*, in large scale); 2) to state whether walked transects method can be used during cloudy days when the visibility of the animals is restricted.

The plateau pika population in the northeast region of Qinghai-Tibetan Plateau, (34°24'N, 100°21'E, elevation of 3 846 m) in Maqin County, Qinghai Province was studied from May to August for years 2005 to 2009. The range of daily temperature is about 25°C and annual mean temperature is below 0°C. Vegetation at the study site is typical of alpine meadows with *Kobresia humilis* C.A. Mey and *Stipa capillata* Keng as dominant plants. The grass cover is grazed year round by livestock, such as yaks and sheep. The common predators in the region include weasels (*Mustela altaica* Pallas) and upland buzzards (*Buteo hemilasius* Temminck and Schlegel).

The study site is located in a basin surrounded by mountains. The 4.0 ha (200 × 200 m) site was divided into a Cartesian coordinate grid system at 10 m intervals using visual-marked stones. The mark-recapture study was concentrated in the 'core' area of 1.0 ha (2005 and 2006) and 2.56 ha (2007 and 2009) near the centre of the site.

Walked transects were conducted at 9:00 to 9:30 a.m. The observer counted all pikas in the 20 m (width; 10 m either side of the centreline) × 1 km (length) belt transect comprising 10 contiguous 100 m long straight sections. Plateau pikas can be observed easily in the relatively flat terrain. In general, vegetation height is less than 3 cm. All pikas active on the surface of the meadow were assumed as counted. Data were collected each morning unless there was rain or windstorm.

The mark-recapture process was conducted after walked transects. All pikas within the study site, including juveniles, were live-trapped, weighed, registered by capture location to the nearest 1 m, examined to determine gender and reproductive condition, and marked by metal ear tags with serial number. Each captured animal revived within 10 min of handling and was released at its capture location.

Using the walked transects data, abundance was calculated according to the standard formula (Bunkland *et al.* 2004),

$$D_{WT} = \frac{n}{2\beta \cdot L \cdot g(x)}$$

where D_{WT} is the density of pikas (pikas ha^{-1}), β is the probability of pikas active on the surface of the meadow in the midmorning (*i.e.* $\beta = 0.74$ for this study) (Smith and Wang 1991), n is the number of pikas observed, L is the total length of the line, and $g(x)$ is the probability of detecting a pika at certain distance x. Since the distance from the line (x) was 10 m and the vegetation was low (average height <3 cm), the pikas could be detected precisely and $g(x) = 1$ was used.

We calculated mark-recapture population densities of pikas using Efford's ML, a precise measure of population abundance for mark-recapture studies for small mammals (Efford 2004, Borchers and Efford 2008) using the program DENSITY 4.4 (http://www.otago.ac.nz/density). Efford's ML uses the location where each animal is captured to fit a spatial model of the detection process. It then obtains the estimates of population density in an unbiased manner using the edge effects despite incomplete detection.

The number of plateau pikas was standardized for observers' influence using a mixed-effects model with observers as random effect. To test the effect of weather condition on the estimates from walked transects, the weather was divided as sunny and cloudy days, and ANOVA was used to detect the differences. The linear mixed-effects model assessed the relationships between abundance estimated by walked transects and Efford's ML estimators.

In total, 290 days were spent measuring pika abundance using the walked transects method, with 47–38 sunny days and 3–30 cloudy days each year. Regardless of variations across years, pika densities were counted monthly using the walked transects method under different weather conditions (*e.g.*, sunny or cloudy). The population densities in sunny days were significantly higher than in cloudy days in May (66.8 ± 3.2 former, 42.2 ± 3.3 latter; t_{57} = 4.039, P <0.001) and July (69.2 ± 2.2 former, 58.0 ± 3.1 latter; t_{83} = 2.958, P = 0.004). No significant differences were detected in June (80.4 ± 2.5 former, 71.1± 4.8 latter; t_{77} = 1.642, P = 0.105) and August (62.2 ± 2.1 former, 57.4 ± 2.2 latter; t_{65} = 1.118, P = 0.268). Given that the densities obtained using walked transects in cloudy days were lower than in sunny days, only the data monitored in sunny days were used to estimate densities. Densities of pikas varied in summer based on the walked transects estimator (Fig. 1). In 2005, no significant differences among different months were observed ($F_{3, 60}$ = 1.771, P = 0.162). However, the density in June was significantly higher than in the other three months from 2006 to 2009 (2006: $F_{3, 53}$ = 4.713, P = 0.005; 2007: $F_{3, 27}$ = 6.680, P = 0.002; 2008: $F_{3, 26}$ = 9.000, P <0.001; 2009: $F_{3, 28}$ = 3.556, P = 0.027).

In the mark-recapture program, 81 to 506 pikas were captured monthly, of which 4 to 185 pikas were recaptured within five years. Pika density varied significantly over the summer, ranging from 80 to 287 pikas per ha (Fig. 1).

Regardless of the differences among months, a strong relationship between the estimated densities from the walked transects and the Efford's ML methods was established ($F_{1, 18}$ = 25.618, P <0.001; Fig. 2). Estimated densities from the walk transects methods was 0.45 times of those based on the Efford's ML estimators. Efford's ML estimators were about 1.8 (May), 2.6 (June), 2.3 (July) and 2.1 (August) times than walked transects estimators when seasonal variation are considered. Unfortunately, these regressions are considered weak indicators, as only five points were taken monthly.

A precise and unbiased estimation of small mammal density has been desired by many ecologists. The mark-recapture meth-

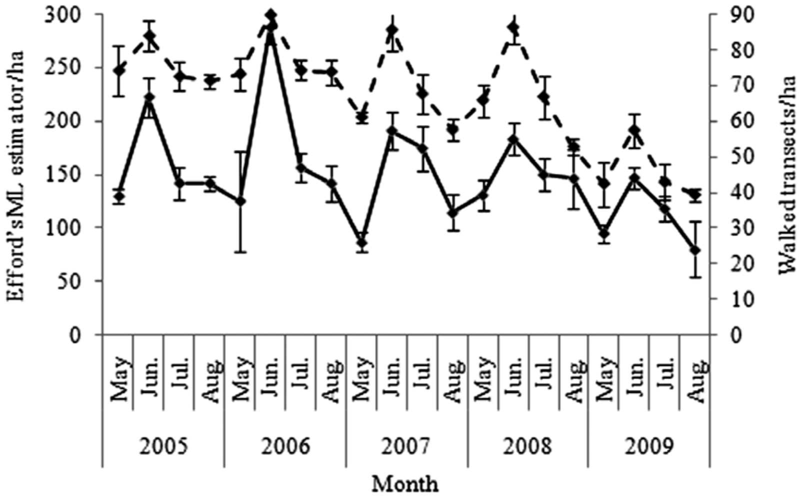

Fig. 1. Population densities of plateau pika (individuals per ha) estimated using the walked transects method (dashed line) and Efford's ML estimator based on mark-recapture data (solid line). Results are expressed as mean ± SE. Error bars represent 95% confidence limits.

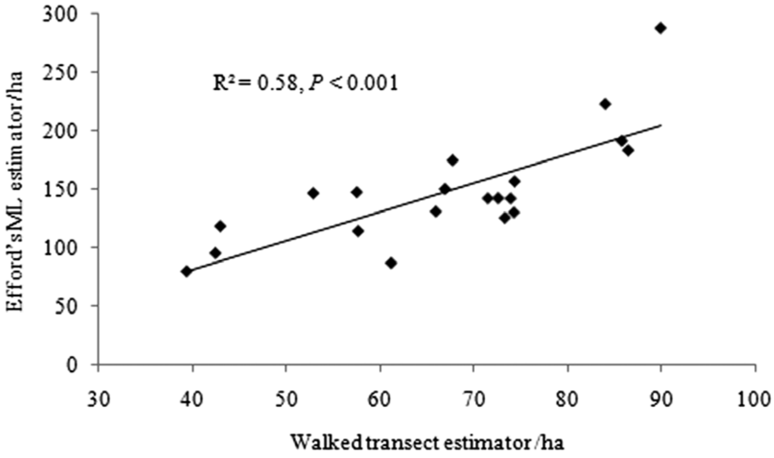

Fig. 2. Correlation between population densities (individuals per ha) of plateau pika estimated by walked transects method and Efford's ML estimators based on mark-recapture data. Densities using Efford's ML estimator are 2.2 times that of densities obtained by the walked transects method.

od is often used in small mammals studies (Bryja *et al.* 2001) and is most accurate when capture probabilities are high (Forys and Humphrey 1997, Ruscoe *et al.* 2001). Efford (2004) and Borchers and Efford (2008) suggested that the 'maximum likelihood method' is the best model to estimate densities based on mark-recapture data.

In this study, results from mark-recapture method were considered as 'true' density. String noose, apart from cage trapping, is often used for capturing because small mammals are very vigilant to strange objects. However, the use of this method is expensive and time-consuming. Typically, capture rate is lower than 10 individuals per 100 nooses. Therefore, the mark-recapture method is not suitable in monitoring the population dynamics or distribution of mammals in large scale (*i.e.* in large areas). Alternatively, many studies have utilized other methods in estimating relative population densities, such as removing sampling, counts of burrows, and walked transects methods. However, removing sampling method is also not suitable in estimating densities in large areas, as it is commonly applied in small scale. Furthermore, capture rate is only typically about 15% and densities obtained using this method is about 6–7 times lower than 'true' densities (Chen *et al.* 2008). As mentioned earlier, another common method in estimating small mammal abundance is counting active burrows. However, even trained persons cannot distinguish in a precise manner the activity status of burrows (Horne *et al.* 1997). Previous studies have suggested that densities estimated by counts of burrows are about 9 times lower than 'true;'densities (Chen *et al.* 2008). In addition, a non-linear relationship between burrows and densities is common for high densities; that is, burrow numbers do not increase further, given the habitat limitation. Thus, counts of burrows are considered weak and potentially misleading indicators of population abundance.

Given the said disadvantages of the three aforementioned methods, most studies have utlized the walked transects in estimating small mammal abundance in large scale (Bardsen and Fox 2006, Pech *et al.* 2007, Arthur *et al.* 2008). In this study, a positive linear relationship between walked transects and 'true' densities was determined. The effect of seasonal variation was similar for small mammals who exhibited stable activity over time on grassland surfaces. The walked transects provided density values that were about twice lower than those obtained by the mark-recapture method. Nevertheless, the density values from the walked transects could offer reasonable indexes on small mammals in relative abundances compared with the other methods.

The estimated densities during cloudy days were lower than those in sunny days because of the lower visibility of small mammals and their less activity on the surface of the meadow. Hence, we recommend that the walked transects method should be conducted in sunny days when mammals are more active and easily detected in an open habitat.

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