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Original Investigation

Sexual difference in seasonal patterns of salt lick use by south China sika deer *Cervus nippon*

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ABSTRACT

Many ungulate species around the world have been reported to use natural lick, and most have shown seasonal patterns of lick use. However few researches focused on sexual differences in seasonal patterns of salt lick use. From January 2006 to December 2008, we used remote video cameras to record the uses of artificial salt licks by wild sika deer (*Cervus nippon*) in Taohongling Nature Reserve, China. We compared sex differences of artificial salt lick use by sika deer assessing both lick use frequency and time spent licking. Our results showed that: (1) there were significant differences in monthly lick use frequency and monthly time spent licking between the two sexes. Females tended to use licks frequently during lactation while the uses of licks by males peaked during the rut; (2) both females and males used salt licks frequently during the period of pelage change; (3) no significant differences were recorded between the individuals of two sexes in terms of staying time, time spent licking per visit and lick duration. We suggest that sika deer could adjust their using of salt licks based on their sodium requirements in different physiological stages. Implications of this study for reserve managers are that more sodium should be supplemented during the rut and lactation.

Introduction

Places where wild animals actively ingest soils are called natural or mineral licks. Many studies have noted that the primary role of licks is the provision of sodium (Weeks and Kirkpatrick 1976; Fraser and Reardon 1980; Moe 1993; Rick et al. 2003; Ayotte et al. 2008). Since 20th century, both managers and researchers have begun to establish artificial mineral or salt licks in areas where natural licks are absent or uncommon and this has been proved very helpful for herbivores to overcome the Na deficiency (Schultz and Johnson 1992).

Many ungulate species are found to eat soil (geophagy) from natural or mineral licks and most of these have clear seasonal patterns in usage (Weeks and Kirkpatrick 1976; Tankersley and Gasaway 1983; Krishnamani and Mahaney 2000; Atwood and Weeks 2002; Montenegro 2004; Dussault et al. 2007). There are two hypotheses to explain the seasonal uses of licks: (1) more minerals are needed in spring or wet season when the forage chemistry changed and the loss of sodium from sweat or urine is much more than other times of year (Langman 1978; Jones and Hanson 1985; Kreulen 1985; Heymann and Hartmann 1991). (2) The mineral requirements are different in different life-history stages. More salt is needed for lactation (Tracy and McNaughton, 1995), and growth of bones, antlers or tusks (Henshaw and Ayeni 1971). And some researchers thought that both the forage change and life-history had influence on the seasonal use of mineral licks (Fraser and Reardon 1980; Tankersley and Gasaway 1983; Moe 1993; Atwood and Weeks 2002).

Numerous works have mentioned that female and male individuals come to licks in different periods (Fraser and Reardon 1980; Tankersley and Gasaway 1983; Moe 1993), but few studies focus specifically on the sex differences in lick use. Atwood and Weeks (2002) explored the sex and age pattern of mineral lick uses of white-tailed deer (*Odocoileus Virginianus*) and found that females came to licks very often during lactation and males visited licks consistently over the study period. Ayotte et al. (2008) compared lick use differences between two sexes of moose (*Alces alces*) and wapiti (*Cervus canadensis*) and found that attendance by female wapiti coincided with lactation demand while no clear differences in patterns of licking activity existed between the two sexes of moose.

Frequency and duration are two important indexes to evaluate use intensity. Most studies on lick use have considered the lick use frequency (Moe 1993; Atwood and Weeks 2002; Matsubayashi et al. 2007), however, few studies integrate time spent licking per visit into their measurements. When comparing lick use differences among four ungulate species, Ayotte et al. (2008) analyzed both

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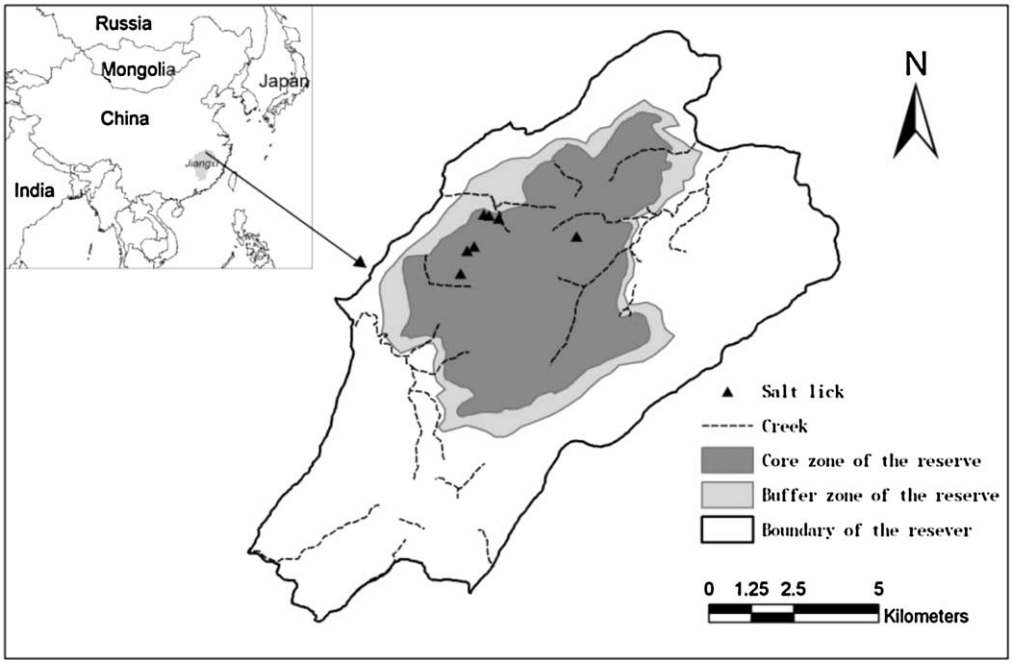

Fig. 1. Location of study area, Taohongling Nature Reserve in Pengze County, Jiangxi Province, China.

overall time spent licking and proportion of total visit time spent licking. Holdo et al. (2002) used number of mouthfuls of soil consumed by African elephant (*Loxodonta africana*) to assess amount of lick use. Several studies use simple visit length, instead of time spent licking to measure lick use (Clayton and MacDonald 1999; Lizcano and Cavelier 2000), which might give misleading results since different individuals have different activity budgets at salt licks (Couturier and Barrete 1987).

In this paper, both lick use frequency and time spent licking per visit were analyzed. We compared differences in lick use especially the seasonal rhythm of lick use by adult male and female sika deer, and sought to determine if lick use was modulated by physiological demands. We predicted that females should use licks frequently during lactation while males should go to licks the most during the period of antler mineralization. We tested these predictions by comparing monthly distributions of lick use frequency and time spent licking by the two sexes.

Material and methods

Study area

Wild sika deer are native to Eastern Asia. About 150 years ago, sika deer was introduced to Europe, North America and New Zealand, and now, farmed and feral sika deer are seen in many parts of the world (McCullough et al. 2009a). There are three extant subspecies of sika deer in mainland China. Our study subject was the southern subspecies (*C. n. kopschi*) with a population size of about 1580 deer scattering in Jingxian, Jinde, Yixian and Ningguo Counties of Anhui Province, Pengze County of Jiangxi Province and Lin'an County of Zhejiang Province (Guo and Zheng, 2000; Liu et al. 2003; Lü et al. 2006; McCullough et al. 2009b). Our study was carried out at Taohongling Sika Deer National Nature Reserve (29°42′–29°53′N, 116°32′–116°43′E) in Pengze County, Jiangxi Province, China (Fig. 1).

The reserve is 125 km^2 in area with altitude ranging from 30 m to 536 m. Climate of this area belongs to subtropical humid type. Average annual temperature is 15.1 °C and annual precipitation is 1300 mm (Jiang 2009). Four seasons are defined as spring: March–May, summer: June–August, autumn: September–November and winter: December–February (Natural Geography Chronicles Compiling Committee of Jiangxi Province 2003). Vegetations are composed of tall grasses, forbs, and secondary growth of shrub species. Besides these, there are small patches of deciduous broadleaved and evergreen-deciduous mixed forests inside the reserve (Liu 2007). Predators of sika deer in our study area include wolf (*Canis lupus*), Asian wild dog (*Cuon alpinus*) and leopard (*Panthera pardus*, Wang 1999).

Artificial salt licks

In August 2003, seven sites where sika deer was frequently sighted were chosen in which to place artificial salt licks. The licks were four to nine square meters in area, with distance of about 1 km from each other. After clearing the above ground vegetation, 10 kg of sodium salts were mixed evenly with the surface soil. Salts were supplemented every 6 months. Animals began to visit salt licks from September 2003 and from then on, deer used the salt licks frequently.

Remote monitoring system

In order to monitor the utilization of salt licks by wild animals, remote monitor video cameras were placed in waterproof boxes and mounted on poles about 16 m high and 60–80 m away from salt licks at each of the sites, at the same time as the artificial salt licks were established. Solar-powered batteries were placed on one side of poles and supplied power (12 V) to the cameras. Cameras were controlled by computer and could scan around and record behaviors of sika deer of about 500 m away. Optical signal was sent to receivers by fiber optic cables and videos were recorded in hard disks of a computer in the Ecological Station of the nature reserve. The recorder was programmed in real-time mode and could record date, time and salt licking place on the disks. The export files were *.MPG format. The cameras were routinely checked every fortnight.

Video recording and replaying

We collected data 1 day every 5 days as the time elapsed from the time animals entered into the area of the salt licks to when they departed during the daylight (05:00–19:00 in spring and summer, 06:00–18:00 in autumn and winter) from January 2006 to December 2008. The videos were replayed on computer in the laboratory, and software named Timer (programmed by a colleague in Institute of Zoology, Chinese Academy of Sciences) was used to record frequency and duration of every behavior of focal individuals.

All the videos were reviewed by the same person. We defined licking behavior when individuals lowered their heads below shoulders and licked soils. We focused on one focal individual each time during replaying of video records. In situations where two or more individuals used the same salt lick together, we replayed the videos to record the behavioral data of every individual.

Data analyses

We classified individual deer as: adult males, adult females, calves and yearlings. Adult males were defined as male deer with two to four antler branches. Adult females were distinguished on the basis of body size. Yearlings were smaller females and males with only simple unbranched antlers. In practice, yearlings were seldom recorded by videos. Visit by the calves were not included in our analysis since the Na need of nursing calves were mainly supplied by milk and they were not observed using licks. Thus, only data of adult individuals were analyzed. We used all-occurrence sampling to record the beginning time, finishing time and duration of all the behaviors and took note of group size and composition for each focal individual. Since it was almost impossible to identify individual in the field, we may have observed the same individual more than once. However, this probability would not likely to bias our conclusion for the population size (about 300) was large in our study.

We ascribed day time into five periods: time before 7:00, 7:00–9:00, 9:00–15:00, 15:00–17:00, and time after 17:00. Time before 7:00 and after 17:00 were dawn and dusk. We defined time spent licking as the time assigned to lick soils in one visit and lick duration was defined as lasting time of each licking bout for focal individual. Staying time was entire period of occupancy of the salt licks area for focal individual in one visit. We grouped all observations into monthly periods. Monthly lick use frequency was got by adding the visit times during 1 month together and monthly time spent licking was calculated by putting the time spent licking during 1 month together.

All statistical analyses were done with SPSS for Windows version 15.0 (SPSS Inc., Chicago). We used Kolmogorov–Smirnov test to check the normality of data. Staying time, time spent licking and lick duration were transformed with *ln*-transformation to meet assumptions of normality and homogeneity of variances. Independent *t*-test was used to compare difference in two sexes on staying time, time spent licking and lick duration. We used χ^2-test to compare differences between the sexes in distribution of time spent at licks during a day, lick use frequency and time spent licking. All values were presented as untransformed means ± SE. All statistical tests were two-tailed and a value of $P < 0.05$ was considered statistically significant.

Results

Group composition of lick users

One hundred and fifty two video records of 227 individuals were seen to use salt licks. Mean group size was 1.49 ± 0.07 with numbers varying from one to seven. Single individual group comprised 69.72% of lick users and single female group was the most frequently sighted group (Fig. 2).

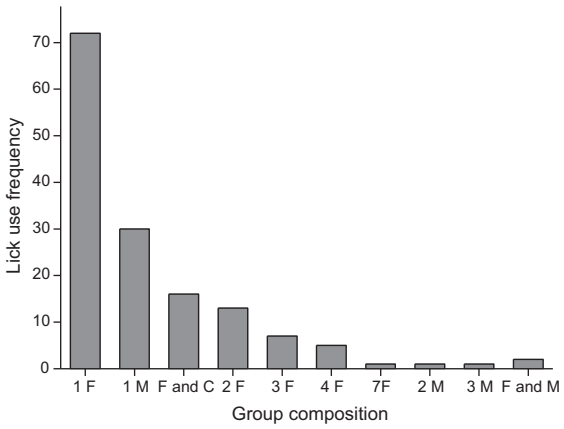

Fig. 2. Group composition of lick users of sika deer in Taohongling Nature Reserve, China from January 2006 to December 2008. M, means male; F, means female and C, means calf.

Time spent at licks during a day

There was a significant difference in time spent at licks during a day between the two sexes ($\chi^2 = 19.989$, $df = 3$, $P < 0.001$). Females used salt licks the most before 7:00 and after 17:00, while the distribution of time spent at licks during a day of males was more even (Fig. 3).

Staying time, time spent licking and lick duration

Staying times of adult females and adult males were 18.39 ± 2.88 min/visit and 21.76 ± 1.68 min/visit respectively. Times spent licking of adult females and adult males were 11.01 ± 0.84 min/visit and 10.33 ± 2.06 min/visit respectively. Lick durations of adult females and adult males were 0.72 ± 0.061 min/lick and 0.77 ± 0.123 min/lick respectively. There was no significant difference in staying time ($t = -1.665$, $df = 170$, $P = 0.171$), time spent licking ($t = -1.311$, $df = 170$, $P = 0.192$) or lick duration ($t = 0.029$, $df = 170$, $P = 0.977$) between the two sexes.

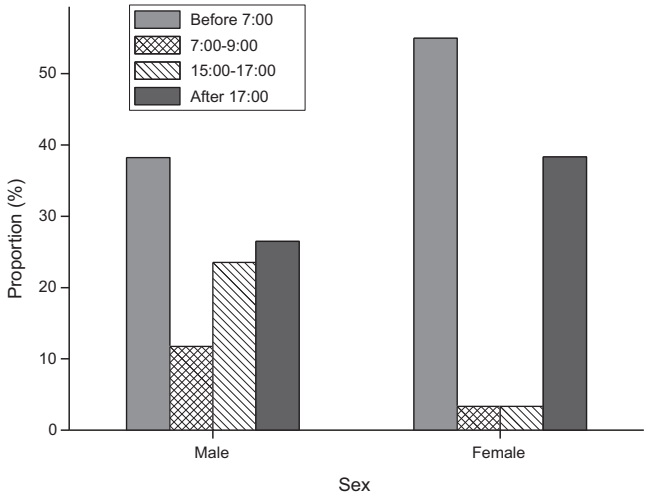

Fig. 3. The distribution of time spent at licks during a day by two sexes of sika deer in Taohongling Nature Reserve, China from January 2006 to December 2008.

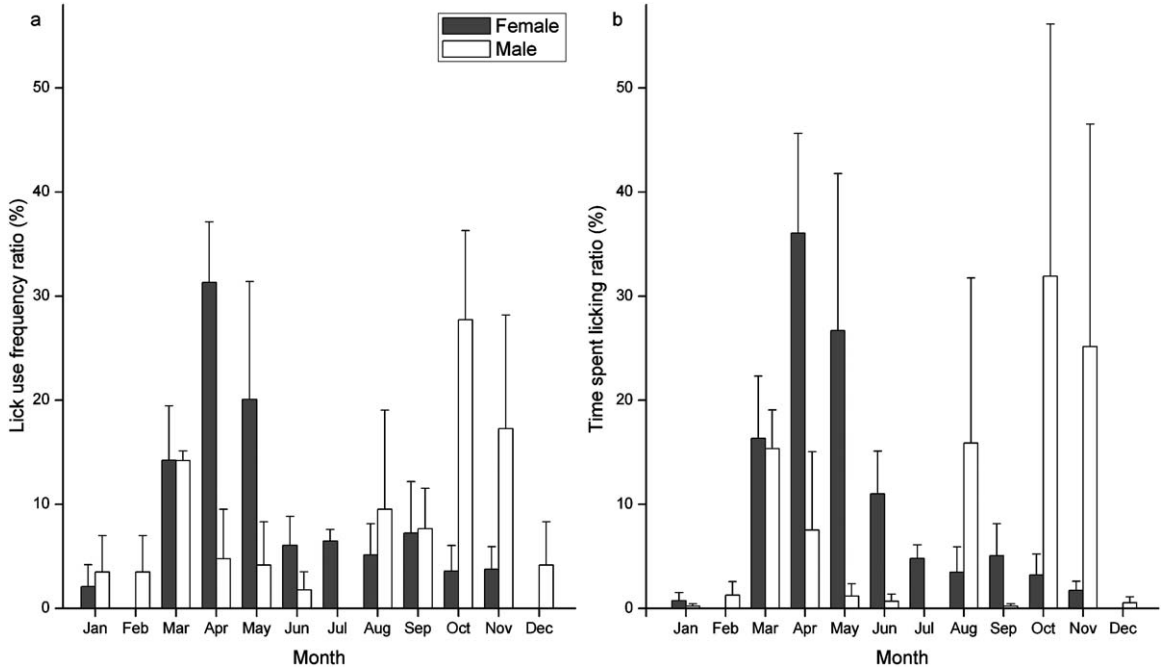

Fig. 4. The distribution of lick use frequency ratio ($\bar{X}$ + SE) (a) and time spent licking ratio ($\bar{X}$ + SE); (b) by two sexes of sika deer in Taohongling Nature Reserve, China from January 2006 to December 2008. Lick use frequency ratio was calculated as lick use frequency in 1 month over lick use frequency in 1 year and time spent licking ratio was calculated as time spent licking in 1 month over time spent licking in 1 year. There were significant differences in distribution of monthly lick use frequency (χ^2 = 49.135, df = 11, P < 0.001) and monthly time spent licking (χ^2 = 949.594, df = 11, P < 0.001) between male and female deer.

Seasonal patterns of lick use

One hundred and seventy one visits by female sika deer and 37 visits by males were recorded. Male and female deer differed significantly in distribution of monthly lick use frequency (χ^2 = 49.135, df = 11, P < 0.001) and monthly time spent licking (χ^2 = 949.594, df = 11, P < 0.001). Peak lick-use time of two sexes was distinct. In terms of lick use frequency and time spent licking, males went to licks the most in October while for females, lick use peaked in April (Fig. 4).

Discussion

Sodium drive is related to physiological demands (Weeks and Kirkpatrick 1976). Belovsky (1978) first reported that ungulate selected diet according to sodium balance. Valk and Kogut (1998) found that cows fed on low salt content forage licked salt licks more than those fed on high salt content forage, and Ceacero et al. (2009) reported that red deer offered meals that contained enough mineral elements except Na and Co consumed high percentage of Na and Co but not other minerals. Thus, ungulate evolve the ability to detect mineral contents in their diets and modify their behaviors to regulate consumption of some minerals to meet different physiological requirements (Chladek and Zapletal 2007; Villalba et al. 2008). Depending on their mineral requirements in different physiological stages, sika deer in our study were able to adjust their activity budgets to lick salty soils. Mineral requirements in different physiological stages by the two sexes might be the main reason for the sex difference in seasonal lick uses.

No significant differences were recorded between individuals of the two sexes in terms of staying time, time spent licking per visit and lick duration, but temporal patterns of licks visiting were different both in time of day and in season of year. Females tended to use licks more intensively at dawn and dusk than males.

Female animals are found to use mineral or natural licks frequently during the period of lactation since milk production need more sodium (Fraser and Reardon 1980; Tankersley and Gasaway 1983; Kennedy et al. 1995). Staaland et al. (1980) reported that sodium demands increased by 40% during early lactation. April and May coincide with the period of later gestation and early lactation for sika deer in our study area, so frequent uses of licks by female sika deer during this period might be driven by sodium requirement for lactation.

Males are commonly reported to use licks frequently during growth of bones, antlers or tusks and the time of antler mineralization (Henshaw and Ayeni 1971; Fraser and Reardon 1980; Tankersley and Gasaway 1983). Muir et al. (1987) found that major mineral deposition in antlers occurred during latter half of growth phase. In our study, male sika deer did not show any preference for sodium in the time of antler mineralization in July, which was consistent with the research by Atwood and Weeks (2002) that, no increase of lick use by male white-tailed deer was found in the time of antlerogenesis.

Peak use of salt licks by male sika deer during October, at the time of rut was against our expectation. Like other male deer, male sika deer spend more time on social behaviors than on feeding during rut (Koga and Ono 1994). Thus, the mineral intake from forage inevitably declined at this time and might be not enough to meet sodium requirement, so that males were required to visit licks more often to get enough sodium. On the other hand, animal bones are in fact highly plastic with minerals being drawn from them and redeposited constantly. Deer actually mobilize minerals from skeletal bones at times of high mineral requirement and replenish the bone reserves when mineral are more available (Rackham 1994). Male red deer also use mineral licks during the late autumn and then after the main period of antler growth is complete. Thus, the peak use of licks by male sika deer in October might be loading the mineral reserves of bones which could then be drawn upon as a mobile resource during the period of intense antler growth.

Apart from the notable separation of peak uses by the two sexes, both male and female sika deer visited licks frequently in March and August, the periods with the least difference in lick use between

the two sexes in a year. These two periods coincide with pelage change of sika deer in spring and autumn. Sika deer begin to grow winter pelage in August and change into summer coat in March. So pelage change might be another factor that influences the lick use. Frequent use of licks in September could also be found in white-tailed deer and growth of winter pelage is thought to be the main reason (Atwood and Weeks 2002).

By comparing salt lick uses between the two sexes, we did not mean to give definitive answers but more as a mechanism of trying to find the possible reason for seasonal patterns of lick use. We only focused on lick use during daytime but deer also used licks overnight because we saw fresh deer tracks at salt licks in the morning. More researches and experiments should be done in future to uncover the underlying mechanism of biological mineral need in wildlife.

Sodium is an important cation in the body fluids of terrestrial animals. In places where sodium concentration is below dietary requirement, artificial salt licks can help animals to ameliorate the negative impact of Na deficiency and improve their nutritional conditions. However, as Klaus and Schmid (1998) demonstrated, presence of salt licks might influence population densities and structure. Thus, when establishing artificial salt licks, possible benefits and costs should be balanced carefully. Once artificial licks have been provided, the managers should be clear of the peak use periods of wild animals, and give proper supplemented values. Based on our results here, more salts should be supplemented during the rut and the period of lactation.

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