BEHAVIORAL RESEARCH OF THE SAIGA ANTELOPE, *SAIGA TATARICA*, IN ITS MAIN REPRODUCTIVE SEASONS IN A SEMI-NATURAL CONDITION

By

Aili Kang

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半散养条件下塞加羚羊（*Saiga Tatarica*）在其主要繁殖季节的行为研究

研究生：康蔼黎

导　　师：张恩迪

研究方向：动物行为学

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Abstract

As one of the famous and important animal species in traditional Chinese medicine (TCM), Saiga antelope once roamed on the semi-arid steppes of Central Asia in more than one million animals. However, the slaughter for its horn, meat and skins has caused the amount of this species decrease 95% in one decade and made destruction of the male saigas. In China, it disappeared from field survey records 30 years ago.

In 1987, a reintroduction project was initiated in Wuwei Endangered Wildlife Breeding Center of Gansu, in order to recover the population of this species in China. From 1993, the saigas were released into an enclosure of 27*ha* area. The various vegetation types and topography was similar to the habitat in the wild. It provided the animals with a semi-natural condition. Scientific study of animals in such a condition may be a kind of transition from captive to wild. It can play important role in the conservation of target species.

Considering that 1) reproductive behavior is vital to the survival and growth of either individual or population, and 2) examination on the variation between individuals in reproductive behavior will be important in understanding influence of environment changes on individual, present study focuses on the behavior patterns of the female saigas in their main reproductive seasons in that semi-natural condition. Following is a summary of the main results and discussion for the study.

A systematic ethogram of 46 behavior patterns is established for those saigas (Chapter 3). The interpretation is composed of a description for action, position, probable function and related patterns. In addition, sex of probable initiator and receiver is given to social behavior pattern. Based on the ethogram, discussion was made on some special behaviors observed. It may provide further behavior study on this species with an important baseline.

In view that analyzing the time structure could be a useful method to follow the living conditions, present study described the time budget and temporal activity patterns of the Saiga antelope in their mating and lactation seasons, and measured the difference between two sexes and among age-classes (Chapter 4). All the behaviors were aggregated into 6 behavioral categories. It was showed that lying and foraging were the principal activity of the saigas and occupied more than half of daytime. Bimodal peaks for

those two behavior patterns in daytime occurred in both sexes. Time budget of saigas changed markedly through those two main reproductive seasons in both sexes. The difference may be caused by the different reproductive strategies of two sexes. In comparison with younger saigas, older ones expended more time in social interactions leading to mating and representing energy expenditure in mating seasons. It was assumed that the saigas in middle age-classes （male:2-3 year old, female: more than 2 year old） may be most active animals in their herds in mating seasons.

Because establishment and development of mother-young relationship within short lactation periods is vital to the survival and growth of calves, present study provides observation on the maternal saigas and their calves in the first 12 weeks of lactation in Chapter 5. Suckling behavior, vocal communication and distance between mother and their calves was analyzed.

The results showed that suckling duration decline through 12 weeks and the first significant decline of suckling duration was between the 3^{rd}-4^{th} weeks. In contrast, the suckling intervals increased in those weeks, and first significant prolonging was between 4^{th}-5^{th} weeks. The calves were observed as suckling initiators firstly in the 3^{rd} week. From the 11^{th} week, the initiation rate of suckling of the calves became more than that of their mothers. It suggested that the period of 4^{th}-6^{th} week, and 11-12^{th} week may be a turn for independency development of the saiga calves.

Meanwhile, most suckling bouts were both initiated and terminated by maternal saigas, which may suggest that mothers were primarily responsible for determining the suckling duration and intervals, which may be according to her secretion of milk.

Mothers kept a long distance from the calves most time in hiding period after parturition. After rejoining other saigas, the distance of young with mothers kept more stable and however, young didn’t keep closer to their mothers than to other members.

The study found that vocal signal may play an important role in communication between mother and their calves. In the first 4 weeks, more than 95% suckling bouts were initiated after maternal females made sounds to the calves. In hiding period, when they accessed hiding sites, the mothers didn’t approach to their calves directly, but bleated near the sites until the calves stood up and walked toward each other. It may be interesting in the further study to find out if the environment with different predator pressure will influence the vocal communication of the maternal saigas to keep contact with their offspring, which may be helpful to understand the role of vocal signal in maternal care.

The saiga antelopes in the wild have hiding strategy for calves when they were born, which may due to predation pressure. If there was no such a pressure in the semi-natural condition, will the saigas do optional choice for birth and hiding sites, or change their hiding behavior? Observation was carried out on the hiding behaviors and the factors that may account for hiding behavior, in addition to predator pressure. The results showed that the birth and hiding sites did not scattered optionally with the enclosure. The saigas like sites with short shrubs as their concealment more than high shrubs or trees. Other factors that may influence hiding strategy of the mothers were disturbance of other saigas, especially adult males, and of human. Meanwhile, the mothers may be the main decision makers for moving routes among hiding sites.

Considered as one of important behavior patterns for detecting predator, vigilance of female saigas in lactation period was also measured in present study. The duration of vigilance during foraging changes from 6 ± 6sec (n=256) in the first week to 1 ± 1sec (n=48) in the twelfth week of lactation, while the frequency changes from 2.98 ± 1.40per min (n=101) to 0.14 ± 0.19per min (n=32). At the same time, those two parameters were also measured in four conditions (feeding lonely, feeding in herd without lamb, walking alone and walking with lambs). The results showed that female saigas changed their vigilance behavior with the growth of calves. Females with active juveniles or walking lonely were more vigilant. The significant difference of duration and frequency were not coincident with each other.

Altogether, this is the first study for saigas’ reproductive behavior patterns in details. It will provide important information for further comparison of saigas’ behavior among captive and natural environment. At the same time, through the study, a systematic observation frame will be established for the further monitoring on saigas’ behavior in reintroduction.

摘　要

塞加羚羊（*Saiga tatarica*）因拥有一对通透竖直的双角，一直是我国传统中医药中著名的物种。它曾广泛地分布在中亚半干旱草原上，数量超过 100 万头。但是，在过去短短的十几年时间中，由于没有节制的猎杀，这种动物的数量下降了 95%以上，并且破坏了种群的自然性比。而在我国，由于捕杀，早在 20 世纪 60 年代之后就没有了该种动物的野外纪录。

考虑到物种多样性保护和国药发展的需求，从 1987 年开始，在国家相关部门的支持下，甘肃武威野生动物繁殖研究中心启动了一个针对塞加羚羊的重引入项目。自 1993 年起，中心所饲养的塞加羚羊放入一个面积为 27 公顷的围栏里。该围栏内的环境取自自然，类似于塞加羚羊的野外生境，为该种动物提供了一个半自然状态的活动空间。这种环境是连接饲养和野外自然环境的中间环节。对生活于其中的塞加羚羊进行行为观察，对于重引入保护项目而言是十分重要的过渡环节。这也是促使本研究实施的初衷。

同时，动物的繁殖行为对于个体和种群的生存和延续至关重要。而且测量个体在繁殖行为上的差异，较之于其他行为，更有助于理解环境变化对于行为的影响。因此，本研究将重点放在塞加羚羊，尤其是雌性个体在主要繁殖季节中的行为表现上。希望通过本研究，从行为学角度初窥塞加羚羊的繁殖策略，了解塞加羚羊在半自然环境中的行为适应。

以下将按照本论文各章节的先后次序，对主要研究结果进行概述。

本研究为塞加羚羊建立了一个系统的行为谱（第三章），共包括了 46 种行为模式。对于每种行为，描述了组成动作，动物所表现的姿势，可能的行为功能，并加入了可能相关的其他行为模式。每个行为都有一组中英文对照名称。此外，在描述社会行为的过程中，加入可能的发起者或接受者的性别。这个行为谱的建立为比较不同环境中塞加羚羊行为的差异建立了一个系统框架。

塞加羚羊在它们主要繁殖季节，即交配和繁殖季节中各类行为的昼间时间分配和活动的时间模式在第四章中加以阐述，并且比较了两性之间和不同年龄个体之间的差异。所有的行为被划分为六大类，包括行走、觅食、站立、卧躺、社会行为、以及其他行为。在产仔季节，

还加入了哺乳行为作为第七类。从时间分配上而言，卧躺和觅食是占用时间最长的两类行为，合计时间超过白昼的一半，而且呈现早晚两个高峰段。雌雄个体在交配和产仔季节的时间分配在上述几类行为上都有明显的差别。两性间不同的繁殖策略可能是产生这种差别的主要原因。在交配季节，年长的塞加羚羊花费在社会行为（争斗、赶群、交配等）上的时间显著多于年幼的个体。本研究推测，在交配季节，处于中间年龄段的塞加羚羊(雄性：2-3 年龄；雌性：2 年龄以上) 可能是他们所在群体中最活跃，同时也最具优势的个体。

母幼关系在哺乳时期的建立和发展对于幼仔的存活和生长有重要的影响，因此也是本研究在繁殖行为观察中的重点部分。第五章中，通过分析哺乳行为、声音联系和母幼间的距离变化，探讨塞加羚羊母幼关系建立和变化。

在幼仔出生后的 12 周内，一次哺乳过程的持续时间逐渐减短。在第 3-4 周间，平均哺乳时间首先出现了显著差异。与之相反，其后两次连续的哺乳过程之间的时间间隔则逐渐拉长，两周之间的显著差异首先出现在第 4-5 周间。幼仔在第 3 周开始有主动要求哺乳的行为，至第 11 周，其启动哺乳过程的比率开始大于母兽。这表明第 4-6 周以及 11-12 周可能是塞加羚羊幼仔独立性发展的重要转折时段。同时，对于哺乳过程的启动者和结束者的分析表明，母兽在决定哺乳时间和时间间隔上起主导作用。这可能与母乳的分泌变化有关。

声音信号可能是塞加羚羊母幼联系的重要途径。在产仔后的 4 周内，有多于 95%的哺乳是由母兽发出声音信号后开始的。在幼仔躲藏期，当母兽接近幼仔躲藏地的时候，它们不是直接走到幼仔卧躺处，而是发出叫声，待幼仔站起后，彼此接近。在此基础上，建议进行进一步的研究，比较在不同的环境压力（比如捕食压力）下母幼间的声音交流行为是否会有区别，从而有助于了解声音信号在塞加羚羊育幼行为中的作用。

在产仔之后，塞加羚羊幼仔会有一段躲藏期，这可能是由捕食压力导致的反捕食策略。那么，在半散养条件下，没有这样的压力存在，塞加羚羊的产仔地是否会具随意性，或者说躲藏行为是否会出现变化？第 6 章阐述了塞加羚羊的躲藏行为，并分析了除捕食以外可能影响该行为的环境因素。研究结果显示，塞加羚羊在半散养条件下的产仔地并不具有随意性。躲藏地主要出现在低矮的灌丛中，而不是高大的灌木和树下，虽然后者植被区的覆盖度也大于前者。此外，躲藏地处其他塞加羚羊个体的出现率少，而且远离围栏外的人类活动区。由此可见，其他同类个体，尤其是雄性个体，以及人类的干扰，也是影响塞加羚羊躲藏地的因

素。同时，研究结果还表明，在躲藏期，母兽可能是躲藏地之间移动路线的主要决定者，而非幼仔。

最后一个章节所涉及的是对雌性塞加羚羊在哺乳季节的警戒行为的研究。这种行为也是主要的反捕食行为。 对于其觅食过程中的警戒行为观察显示，塞加羚羊母兽在幼仔出生后的前 1-3 周内警戒性高。而随着幼仔周龄的增加，母兽的警戒持续时间和每分钟的频率都有显著的下降。其次，对母兽在不同情况下（是否与幼仔同行，是否与其他个体通行）的警戒行为进行比较表明，母兽和幼仔一起活动时，或者独自行走时，警觉性增强。这样的警戒强度和野外的是否相似，或者存在差异，需要进一步的比较研究，从而反应捕食压力的缺少对于半散养状态中塞加羚羊行为的影响。

通过上述的观察分析，本研究第一次对塞加羚羊的繁殖行为，特别是雌性羚羊的行为进行了具体的探讨，反映了塞加羚羊对于特定的半散养环境的行为适应状况。虽然，由于没有相应的野外观察，不能更深入地比较不同环境中的行为变化。但是，本研究为进一步比较塞加羚羊从饲养种群到野外种群的行为变化提供了重要的比较依据。同时，也为重引入工作中监测塞加羚羊的行为建立了一个系统的观察研究框架。

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Table of Contents

Chapter 1. Threats toward Saiga Antelope and Necessity of Research on Reproductive behavior

Antelope horn is as famous and important as muskiness, pilose antler and rhino horn in the traditional Chinese medicine (TCM). The history of using antelope horn may trace back to the '*Shengnong Bencao*' 2000 years ago. Though in China, there are 5 species in subfamily antilopinae, including the Tibetan antelope (*Pantholops hodgsoni*), Tibetan gazelle (*Procapra picticaudata*), Przewalski's Gazelle (*Procapra przewalskii*), Goitered gazelle (*Gazella subgutturosa*) and Saiga antelope (*Saiga tatarica*), the '*Chinese Medicine Dictionary*' designates that the horns for TCM is from the Saiga antelope.

Taxonomic, Morphology and Distribution

The Saiga Antelope (*Saiga tatarica*) was first described by Linnaeus in 1766. *Saiga* is the Russian name for this antelope. Tatary is a region in part of European Russia and *–icus* (Latin) suffix meaning belonging to. It belongs to the order Artiodactyla and the family Bovidae (Nowak, 1991). The single species, *S. tatrica* was found in historical time in the steppe zone from western Ukraine to western Mongolia. In the Pleistocene this species evidently occurred from England to Alaska (Sokolov 1974). It is now placed in the genus of its own and includes the single species *tatarica*, which is further subdivided into two subspecies. The nominate subspecies S. *tatarica tatarica* inhabits the semiarid steppes in the north-west Caspian region in Kalmykia, Russia and throughout much of the Republic of Kazakhstan, while the Mongolian subspecies *S. tatarica mongolica* inhabits two isolated areas in northwest Mongolia.

Saiga Antelope has a compact body and slender leg and the body length ranged from 100 to 140 cm (Nowak 1991). Adult males stand about 70-83cm at the shoulder and weigh up to about 37-60kg in autumns while adult females are about 63-74 cm tall at the shoulder and weight 29-37kg in autumns. The coat is composed of a wooly underlayer and a coarse set of bristly hairs and with a fringe of long hairs extending from the chin to the chest. The upper parts are cinnamon buff in summers, the nose and sides of the face are dark, the crown is grizzled. The winter coat of the saiga is longer and thicker and uniformly whitish so that they look like white at a distance. The underparts, rump patch and tail are always light white. A dark dorsal stripe extends from the mane to the end of the tail, which has a tuft of black short hairs that would erect when alerts or flees. The fronts of the legs have strips of light gray. The most notable features of the Saiga antelopes are its inflatable nose and straight horns. Saiga’s nose contains large nasal chambers that filter out sand and dust and humidify the air inhaled (Teer 1991). Only the males possess the semi-translucent, wax colored horns, which grow 200-225 mm long. Almost vertical, the slightly lyrate horns are ringed on their lower two-thirds. These horns not only make the saiga become famous species in TCM, but also lead it into the lists of endangered animals of IUCN and CITES. China listed it as Class I species in protected animals.

Horn trade and smuggle

There are no less than 30 kinds of traditional medicine composed of antelope horn. In ‘New-Edited Chinese Patent Medicine’ (Song and Guo 2002), antelope horn is the main component of 18 kinds of medicines for detoxification, cold treatment and illness of lung. The manufacturers distribute in Jilin, Heilongjiang, Hunan, Shanghai, Henan and Zhejian, etc. When TCM specialists confect prescription to prevent from SARS in 2003, they chose antelope horn as one component in prescriptions for terminal patients. Besides of medicine, people also buy those horns directly and use as tonic in cooking or drinking.

A survey report (Chan 1995) from Traffic in 1994 documented that Southeast Asia and China have main consumer markets of antelope horn. The mean price of horns in 1994 is about $300/kg. It is estimated that there were probably 30,720 horns, equally from 15,360 male saigas, in Hongkong’s markets in August 1994 (Chan 1995).

State species committee of China conduct a survey on medicine markets of animal products in 1996 (Guo *et al.* 1996). There are 51-62 markets having products of antelope horns. The price in medicine stores was about $730-2421/kg (It is assumed that 1kg = 3 pairs of antelope horns).

In 2002, a survey (Aili Kang 2002, unpublished data) in Bayi Town of Linzhi, Tibet, showed more than 10 stores sale antelope horns to tourists. The length of those horns was about 9-25cm, and the lightest horn is 25g. Many horns were without ridges or only with one ridge. The mean price there was about $360/kg. The mean stock of a store there was about 20 pairs per day.

Though there were dummies in those markets, those data indicated that 1) the high market demand of those horns, and 2) sub-adult saigas may have become hunt targets under high poach pressure.

The high demands could also been indicated by smuggle cases in recent years. During 2000-2003, at least 15 cases of smuggling saiga horns were reported. These cases occurred respectively in Qinghai, Xinjiang, Inner Mongolia, Jilin and Shanxi provinces. Totally amount of confiscated horns was 4955.83kg, which mean more than 14867 male saigas might be killed.

Dramatic crash of wild population

In contrast with the high purchase amount in medicine markets, the population of the Saiga antelope has been facing vital threat. Because of unlimited hunts on this species, the number of this species in four main populations has been crashing from 1998 (Milner-Gulland *et al.* 2001). By 2002, the population in the wild was 5% of that before 10 years (Miler-Gulland *et al*. 2003). Considering about such a sudden plight of this nomadic antelope, the 2002 IUCN Red List of Threatened Species listed it as Critically Endangered, the highest category of threat.

The main cause for such a dramatic crash is poaching, for both horns and meat. Moreover, horns have higher value in medicine than meat. In Kazakhstan, the price of saiga's horn is $100/kg, which is considerable income according to local life level (Lushchekina and Struchkov 2001). Hence, male saigas became the main target in slaughters. Selective poaching caused destruction of the male saiga which may overwhelm the animals' famed fecundity. The sex ratio in rutting seasons reached to 1:30-106 (male:female) (Miller-Gulland 2003). The decrease of males in rutting brought about increasing of intra-female competition. Younger females could not get chance to mate with males, which will influence recruiting in next year.

Historical distribution in China

The historical distribution of Saiga in China ranged from 85°-100 °E and 40°N to 47°N, where covered by arid, semi-arid desert and arid steppes. Based on purchasing amount of antelope horn during 1930-1940 in Xinjiang, it was estimated officially that hunting amount was about 1.5-2.5X10^4 animals per year (Wang *et al*. 1998). During 1950s'-1960s', the population occurred in the area of Junggar basin and Beita Mountains, extending to Mazong Mountain in Gansu province and the west edge of Inner Mongolia near the boundary between China and Mongolia. However, there has been no field record referring to saigas' occurrence from 1970s, indicating that the population of this species has been extinct in China (Liang 1986, Chen 1987).

Reintroduction

In 1987, State Administration of Traditional Medicine of People's Republic of China and State Forestry Administration People's Republic of China (Formerly Ministry of Forestry) conduct a reintroduction project to recover the population of this species. Firstly, 12 animals were introduced from captive generations from the Berlin Taie Zoo, Germany and San Diago Wildlife Zoo, United States, into Wuwei Endangered Wildlife Breeding Center of Gansu, China.

Based on the reintroduction of the saigas, *Introduction and Captivity of the Saiga antelope* research project was carried out during 1988-1993. Behavior observation was carried out on activity rhythm, rutting behavior of male, and estrus and parturition of females (Tan *et al.* 1994a, 1994b, 1994c). At that period, the saigas were kept in 23X30 m enclosure and feed by keepers.

From 1992, the saigas enclosure was enlarged to 30*ha* and the animals were allowed to forage freely. Till 1997, the numbers of the saigas had been up to 33 animals. However, an unexpected decline happened since then and as a consequence there remained 9 animals in the center in 2000. Regrettably, there was no check on the causes of such a decline. Fortunately, until winter of 2003, the number of saigas has been resumed to 25 animals. However, no behavior research was continued from 1992.

Research necessity on behavior of female saiga

The saigas in present study were maintained in enclosure with winter supplement for several generations. The enclosure of 27*ha* area with various vegetation types may provide the animals with a semi-natural condition. The environment in the enclosure is similar to that in the wild (Liu *et al*. 1993, Liu 1996, Liu and Chen 1996). The saigas can choose different sites for resting and concealment. Except keepers regular patrol twice a day, seldom human activities occurred near those animals, which may decrease the interaction between animals and humans in captive condition. Hence, their behavior patterns may express some of the features as those in the wild.

However, some of their behavior patterns may be varied. For instance, in the limited space with plenty of food resource may cause disappearance of seasonal migration behavior pattern. Without predator pressure, vigilance may be less than those animals in the wild. At the same time, predation has probably played a key role in shaping reproductive behavior, such as choice of birth/hiding sites and relationship between mother and young. Therefore, to observe the behavior expression of those saigas, and comparison of them with those in the wild, is a necessary step to monitor behavior changes for reintroduction project.

Optimally, the information on wild animals acts as a baseline for comparison with captive ones during reintroduction procedure. However, Studies of free ranging animals are often hampered by the difficulty of direct observation of the subjects (Emmons, 1988; Law *et al*. 1997). In comparison, scientific study of animals in semi-natural condition is a kind of transition from captive to wild. It can play important role in the conservation of target species.

The success of individuals, in evolutionary terms, depends on their ability both to survive and to reproduce successfully with successful offspring. Reproductive behavior can influence effective population size and the degree of inbreeding and reproductive isolation (Reinhardt and Köhler 2002). Hence, the study on it can be vital for the conservation of species.

In species that only females providing care to offspring, such as the saigas, reproductive behavior of females may all direct towards achieving maximum success in the environment in which the animal evolved (Lindsay 1996). Among those patterns contributing to reproductive success, maternal behaviour may be the most important patterns. Further more, examine the variation between individuals in reproductive behavior, will be important in understanding influence of environment changes on individual in reintroduction projects.

One of the ecological peculiarities of Saiga Antelopes is their high rate of reproduction and recruitment. In years with a favorable climate the population size can increase rapidly, by up to 60% in a single year (Zhirnov 1998). In the wide, usually up to 95% of females produce young in their first year, with twin calves being common, resulting in an average litter size of 1.6 young per breeding females. The high recruitment rate is also encouraged by the high percentage of breeding females in a population, usually not less than 65%. This high reproductive rate provides for a certain resistance to natural and man-made effects (reviewed in Chan, 1995).

As an ungulate species of polygamy mating system, the main features of them for reproduction are: 1) synchronized estrus and parturition time, 2) only females offering parental care to offspring, 3) females first coming into their estrus in the first winter after their birth (8 months around), and 4) males competition for holding harems in rutting seasons.

Therefore, present study focuses on the reproductive behavior, mainly the behavior in lactation and activity patterns in rutting season, of the saigas in the semi-natural condition. The aim of the study is to describe and measure the behavior patterns of the female saigas in their main reproductive seasons. Results of the study will indicate the behavior patterns of the females and males, and the difference among individuals of different sex or age classes. This is the first study for saigas' reproductive behavior patterns in details. It will provide important information for further comparison of saigas' behavior among captive and natural environment. At the same time, through the study, a systematic observation frame will be established for the further monitoring on saigas' behavior in reintroduction.

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Chapter 2. Methodology

Study site

The study was conducted at the Wuwei Endangered Wildlife Breeding Center which locates at approximately 37.9°N, 102.9°E, between the north Qilian Mountain and Southwest fringe of Tengger desert. The area is at an elevation about 1,766m with many sand dunes of 1-15m in height. It is characterized by a continental, dry temperate climate. Annual temperature averages at 7℃, with coldest at -35℃ in January and warmest at 38.5℃ in July, followed by August. Annual precipitation is 176.0mm. The vegetation of this area composes of 116 species of plants that mainly belong to the families of *Graminee, Chenopdiaceae* and *Palilonaceae*, which is listed from the work of Liu (1996).

The enclosure for saiga antelopes in the center is about 27*ha*. *Medicaga sativa* during its growing period from April to October is main food for saigas. The distribution of this species is considered to have an impact on the behavior of the saigas. A map of prime vegetation types (see Chapter 6, Fig 1) was made by Arcview 3.1 with GPS (Garmin 12) location for study on hiding sites of calves.

There are two keepers working for the saigas. They do daily regular patrol twice respectively in the morning and afternoon. Except for those keepers, I was the only person in the enclosure during observation periods. The saigas in the enclosure can forage freely without the limitation of feed at fixed time that occurs in captive condition. From November to next March every year, the saigas were supplied with food in fixed sites twice every day. The food includes hey of *Medicaga Sativa,* slices of carrots and potato.

Animals

The study was conducted in three periods, from November - December 2000, April – August 2001, and October 2003 – January 2004. Totally, there were 29 saigas observed in the study. Table 1 shows the observed animals with code in different periods. Except F1 that was introduced from Kalmykia, Russia in 1997, all other saigas in this study were born in the center.

Table 1. The animals observed in different periods in the present study. The birth and death date of those animals was also listed here.

Animal	Age (in year) in observation period			Birth date	Death date
	November – December 2000	April – August 2001	October 2003 – January 2004		
F1*	3.5	4	--	1997	2003
F2*	2.5	3	5.5	1998	
F3*	1.5	2	4.5	1999	
F4*	0.5	1	3.5	2000	
F5*	0.5	1	3.5	2000	
F6*	0.5	1	--	2000	2002
F7 *(M1, F1)	--	Calf	2.5	2001	
F8 *(M1, F5)	--	Calf	2.5	2001	
F9 (M2, F?)	--	--	1.5	2002	
F10 (M2, F?)	--	--	1.5	2002	
F11 *(M2, F?)	--	--	1.5	2002	
F12 *(M2, F?)	--	--	1.5	2002	
F13	--	--	0.5	2003	
F14	--	--	0.5	2003	
F15	--	--	0.5	2003	
F16	--	--	0.5	2003	
M1*	2.5	3		1998	2001 winter
M2*	1.5	2		1999	
M3*	1.5	2		1999	2002
M4 *(M1, F?)	--	Calf	2.5	2001	
M5 *(M1, F?)	--	Calf	2.5	2001	
M6 *(M1, F?)	--	Calf	2.5	2001	
M7 *(M1, F?)	--	Calf	--	2001	2003 summer
M8 *(M2, F?)	--	--	1.5	2002	
M9 *(M2, F?)	--	--	1.5	2002	
M10	--	--	0.5	2003	
M11	--	--	0.5	2003	
M12	--	--	0.5	2003	
M13	--	--	0.5	2003	

Note: * shows that the animal was identified individually in observation periods.

Behavioral observation

Identification of activities was made through a pair of 20×8 binocular over distance around 50m and 25×2 telescope when the distance is longer than 80m. The bouts of suckling, vigilance and social behavior were recorded and timed using a stopwatch. Behavior data forms and notebooks were used to record frequency of various behavior and other field notes, such as weather and movement of keepers in the enclosure, which might made effect into the animal's behavior and data then should be excluded from the analysis.

The collection of data used for analyses was conducted after preliminary observation on behavior for two weeks before each record period. The pre-observation periods allowed me to fine-tune recording skills, recognized each saiga and allowed the saigas to adapt the presence of mine. Nevertheless, in consideration of shy and alert nature of saigas, I usually kept the distance of more than 50m from them and used plants on the dunes to hide myself to minimize disturbance to the animals.

During the preliminary observation, I recognized each individual animal by earmarks if available, combined with natural markings such as body shape, facial idiosyncrasies and coat coloration. Since only the males bear horns, it is no problem for me to identify saigas of two sexes. All the lambs were marked with ear-tags after their birth.

All the observation was conducted during the daytime. The day-time length recorded in my study was defined as 8:00~18:00 in the winters of 2000 and 2003, and 6:00~20:00 from May to August of 2001. I spent more than 10 minutes in advance of every observation period to locate the targeted animals. Scan sampling (Altmann 1974) was used to assess the proportion of time spent on different activities. I scanned each saiga at 10 minute intervals and recorded its behavior at that instance. Focal-animal sampling (Altmann 1974) was carried out to measure frequency and duration of suckling bouts, vigilance bouts, and interaction. Time sampling and all-occurrence recording methods were used for data record. The records were all timed to the nearest second. The saigas were recorded in turn during the observation period so as to gain the approximate equal data for each animal. Details of record methods and definition on specialized behaviors will be given in the appropriate chapters.

The vegetation measurement was carried out for analysis selection of birth as well as hiding sites by maternal females and will describe in detail in chapter 5.

Statistics analysis

Due to the limited sample size of the target animals, most quantitative aspects of behavior were investigated by using nonparametric tests. Quantitative difference of parameters between independent groups was measured by *Mann-Whitney U-test* or *Kruskal-Wallis H-test. Wilcoxon Signed Ranks Z test* was conducted for analysis between relative samples. *Kruskal-Wallis* ANOVA test was used for a dependent variable by a single factor variable. The degree of correspondence between the observed data from expected values was tested using the nonparametric method of *Chi-square goodness-of-fit test*. Correlation analysis was conducted by *Spearman's rho analyses*.

When the distribution of samples was proved by *Kolmogorove-Smirnov one-sample goodness-of-fit test*, parametric tests were performed to test the difference of variables. *Student's t-test* was used for unequal variables on some of the individual variables. A one-way analysis of variance (ANOVA) was used for a quantitative dependent variable by a single factor (independent) variable, which was linked with pairwise multiple comparisons that can determine which means differ.

Details of statistical tests used are indicated in each chapter. All probability values were two-tailed. Differences were regarded as significant if $p<0.05$ and as highly significant if $p<0.01$. Statistical software package *SPSS* version 10 (SPSS Inc.) was used for all the tests.

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Chapter 3. Ethogram

Abstract

An ethogram of 46 behavior patterns is established in this chapter for the Saiga antelope in the semi-natural condition. The interpretation is composed of a description for action, position, probable function and related patterns. In addition, sex of probable initiator and receiver is given to social behavior pattern. Based on the ethogram, discussion was made on some special behaviors observed. Altogether, this may be the first systematic ethogram for the Saiga antelope, which may provide further behavior study on this species with an important baseline, though it based on the animals in a semi-natural condition.

Introduction

An ethogram is a formal list of a species' repertoire or a major segment of behaviors (Grier 1984). It may be a complete list of all behaviors or it may focus on particular functional classes of behaviors (Grier 1984). The format may be simple alphabetical listing of behaviors by name, or it may be detailed descriptive text and/or line drawings of behavioral elements or sequences. Development of an ethogram is an important step in studies of behaviors of a particular animal species.

In present study, an ethogram of the Saiga antelope in a semi-natural condition was established. To my knowledge, there was no exhausive ethogram having been built for the saiga antelope by now. Tan *et al.* (1994a, 1994b, 1994c) reported saigas' behavior of adults and calves in captive condition, but the description was based only on five maintenance patterns, including foraging, drinking, ruminating, walking/running, resting, defecating and urining. The estrous behavior of female saigas was described by Tan *et al.* (1993) in captivity. Zhirnov *et al.* (1998) gave general description on the behaviors of this species in the wild.

All the behavior patterns in present study are assumed by a population of the saigas in a semi-natural condition. Among them, only one female (F1) was introduced from the field of Kalmykia, Russian Federation. Others were all born in that condition. This is the first systematic ethogram of the Saiga antelope, though it may not represent complete behavior patterns of this species in other condition, such as in the wild. It can be a frame of reference to other behavior studies and comparison for the same species under different conditions.

Methodology

Totally 29 animals of the saiga antelope (Table 2, Chapter 2) were observed in a 27*ha* enclosure. *Ad lib* method (Altman 1974) was used in observation and all occurrences were recorded. The study periods covered most months of one-year cycle, except February, March and September. Photographs and video types were also used for descriptive documentation.

In data collation, the supplement was made according to observation of keepers in the breeding center, and reports of Tan *et al.* (1993, 1994a, 1994b, 1994c) and Zhirnov *et al.* (1998).

The ethogram presented here includes: 1) an English name and a Chinese name for each behavior (generally the most commonly used English/Chinese term in the modern literature, and not necessarily the first name used in the literature), 2) a text description on actions and postures constituting that behavior, 3) probable function (if the function of one behavior pattern could not be defined, a question mark will be used for further discussion). Additionally, 4) mainly relative behavior patterns in present study and 5) the sex of initiator or receiver was given for social behavior patterns.

In the ethogram, all behaviors were divided into two categories: 1) individual and 2) social behavior. In the sub categories, behaviors were listed in alphabetical order, rather than grouped by proposed meaning or temporal association. In addition to these catalog entries, some photographs from this study were included to further illustrate the context.

Ethogram

Individual Behavior

Defecating (排粪): It is the passing of feces in a standing or walking position. The tail is erected while fecal dropped. It usually follows urinating.

Probable function: Elimination.

Drinking (饮水): A saiga takes water into month and swallows it in a standing position.

Probable function: Nutritive.

Foraging/Feeding (觅食/摄食): A saiga is finding, browsing or grazing, and taking food items into the mouth and chewing and swallowing them. When foraging, often, the saiga lowers its head in grass. Sometimes, it lifts its head and grazes leaves of bushes that higher than them. The saiga typically feeds while standing or walking, but occasionally feeds while lying.

Probable function: Nutritive.

Leaping/stotting (腾跃): It is a high jump where a saiga rises almost vertically off the ground/ or a bouncing gait with all four legs hold stiff and straight. While leaping, the saiga keeps its tail in a horizontal level. It occurs at the beginning of running away.

Probable Function: Anti-predator/self-defending

Lying(卧躺): A saiga lies down on the ground, with abdomen or body side touching the ground (in a recumbent position), without any other actions. When the saiga rests its chin either upon its side or on the ground, usually with eyes closed, it may come into a sleeping status. The hind legs may both be under the body, or may be held away from the body. The forelegs can be folded under the sternum, or one or both may be fully extended.

Probable Function: resting.

Moving (移动): For a saiga, it is a form of coordinated quadrupedal locomotion in which all four legs are in motion. The behavior causes moving from one site to anther site. According to the different speed, moving could be specified as **Walking (行走)**,

Trotting（小跑）and **Running**（奔跑）. The saiga often holds its neck lower lightly than the horizontal level of the body back while running.

Probable function: Locomotive

Ruminating(反刍): A saiga is chewing a bolus that is passed up to the buccal cavity. It occurs with standing or lying**.**

Probable Function: nutritive

Selecting and modifying lying site (选饰卧地): Before lying down, a saiga is walking around at certain site, while lowers its head and closes nose toward the ground, until it finds some site and stops moving. Then, it uses forelegs paws the ground to form a shallow hollow (pit) with 15-20cm in depth and 1-1.5m in diameter. Followed, it turns around for 2-5 circles in the hollow, and then lies down.

Probable function: self comfortable

Self-grooming(修整): A saiga licks and combs its fur with its incisors or scratches with its hind hooves. The saiga grooms while standing or lying.

Probable Function: self comfortable.

Standing（站立）**:** A saiga is supported by four limbs without any other action. A standing saiga is considered as inactive. In a prolonged standing period, a saiga closes its eye, while the neck and head are held in a horizontal position.

Probable function: resting(?)

Urinating（排尿）**:** It is the passing of urine in a standing position. The posture of urinating is different between two sexes. Male saigas spread their hind legs while urine is being passed. Females bend hind legs, lowered hindquarter when urine is being passed.

Probable function: eliminative

Vigilance(警戒) (Fig 1): A saiga raises head and gazes to one orientation, with ears erecting and turning forward. It occurs in foraging, walking, standing, or lying.

Probable function: self-defending/anti-predation

Walking with lowered head(低头走动): A saiga is holding its head slightly lower than horizontal level while it is passing an object in a short distance around 10m. The object may be a newly big stack, or the observer. The gaits in this behavior pattern are in low speed.

Probable function: self-defending/anti-predation

Head up-down (上下摆头走动): A saiga makes its head up and down while walking slowly. It occurs when the saiga is approaching some uncertain area or objects, such as an observer. Sometimes, maternal females have such a behavior when they are close to the hiding sites of the calves.

Probable Function: self-defending/anti-predation.

Social interaction

Brushing facial gland (摩擦眶下腺) (Fig 2): A saiga comes to a bush/grass, tilting its head forward, applies its face on the spot and brushes the part below the eyes in cheek very lightly in a forward movement.

Probable function: scent marking or maybe abnormal.

Approaching (接近)：A saiga walks forward another saiga in a straight or curving path without lowering head.

Probable function: dominance/contacting

Aggressive approaching (侵略性接近)(Fig 3): A saiga does forward movement toward another saiga in a straight or curving path. Its head is lowered. The approach is usually in trot, which is separated from **Walking with lowering head**. It is followed immediately by retreating of the receiver being approached, confronting, or fighting. It may also evolve into a chasing. One male may approach aggressively to another male or female.

Probable function: dominance

Avoiding(避开): A saiga moves to maintain or increase its' distance from an approaching saiga. The avoidance is often in a quick walk or trot in a short distance according to the gait of approaching one. It occurs in male-male and male-female pairs.

Probable function: submission

Calling by calf（**幼仔叫**）**:** A saiga calf makes sounds like bleat toward its mother. It occurs usually before **suckling** or is as a response after the call of its mother (**call by maternal female**).

Probable function: communication

Calling by maternal female(母叫): A maternal female makes sounds like bleat exclusively toward calves. It occurs when the mother walks toward the calf, followed by **Suckling** usually, or when the mother begins to move.

Probable Function: communication

Chasing (追逐)(Fig 15)**:** A saiga pursues another, usually at a trot in an apparent attempt to overtake or change route orientation of another one. Chasing is occurring in male-male, male-female, and occasionally in female-female.

Probable function: dominance or sexual

Circling（**绕圈**）**:** Two saigas are closely beside one another head-to-tail pivot in circles with walking slowly. They heads were lowered to the ground while circling. It is followed by more serious fighting patterns (**sparring** or **clashing**) toward each other, or withdraws by one of them. It occurs in male-male or female-female pairs.

Probable function: competition

Clashing（**顶撞**）**:** In a typical sequence, two saigas first backs off for several steps, lowers head, with forward-pointing hors, then having a bump suddenly. It may be the most intensive aggressive behavior in fighting, less frequent and duration than sparring, and cause injuries. It occurs only in males.

Probable function: competition

Copulation(交配)(Fig 3)**:** A female saiga walks slowly in front of a male, holds her tail horizontally and swings it quickly from side to side. The hindquarter of the female is up slightly but distinctively with the deep brown strip on the back. The male follows female close beside or behind her in a trot speed, with head upside and sound made by nose. The female keeps her gait in a slow speed and sometimes halts if the male doesn’t follow. She walks around rather than straightly. When he is close to the rump of the female, he lifts one of the front legs on the side of the female and tries to mount, with tail flicks from side to side quickly. After several mount tries, when the male copulates with a distinctive hindquarter pushing (observed in a distance), the female then bends her hind legs, lowers hindquarter in a urinating position and holds tail down. It can be considered that the mount and copulation is successful and the rut is ended. If the male tries to close her again, the female will avoid in quick gait.

Probable function: sexual behavior

Detouring（绕行）: A saiga changes its route orientation while it is near a dominant one. While following, chasing, or aggressive approaching other ones, the saiga makes a detour when it finds itself is near a dominant saiga. It occurs in male-male or female-male.

Probable function: submission

Flehmen(卷唇): A male saiga, after sniffing the urine or rump region of a female, elevates its head, extends neck, opens its mouth and everts its upper lip in the air. The head roll from side to side. Only male saigas did this behavior in present study.

Probable function: sexual.

Following (跟随)(Fig 4): A saiga moves along the path of another one, usually at the same gait as the latter being followed. In contrast to a chase, there seems to be no attempt to change the movement, initiate attack, or overtake the leading saiga. It could be done by saigas in both sexes and all age classes.

Probable function: dominance or sexual behavior

Head butting (顶头)(Fig 5)**:** A saiga lower its head toward the other, hits or pushes against the head of the other. It occurs in female-female, female-calf, calf-calf pairs.

Probable function: dominance or play

Head down as foraging (低头觅食状)(Fig 6): A saiga suddenly lowers its head and begins to browsing/grazing the grass when another saiga is approaching, but does not move aside. It occurs only in males.

Probable function: submissive

Head on (抬头压状)(Fig 7)**:** A saiga rests its chin or entire head on the dorsal surface of the neck, body or rump of another saiga. It could be done by calf to calf, adult female to calf, or calf to adult female.

Probable function: dominant or playing

Head up-stretch (伸头发声)(Fig 8)**:** A male saiga stretches his neck, lifts his head, with his muzzle toward a female/ or his harem, accompanied by grunts which sounded like Hu-hu-hu. The tail of the male is swaged from side to side quickly. When the muzzle is lifted, the skin on the bridge of nose was pursed obviously and impressively. It occurs frequently after sniffing females' rump region.

Probable function: courtship

Herding (赶群)(Fig 9)**:** It is composed of other behavior patters, including chasing and head up-stretch. The male saiga uses chasing to hold females into one group (harem) and keep them with short distance between each other. The male walk aside, behind or in the harem to prevent females from departure. The head up-stretch occurs after chasing in the harem.

Probable function: sexual behavior

Licking（舔）: A saiga touches another one by tongue on the head, body or anus. It was found only in maternal females to calves.

Probable function: maternal behavior

Mounting (爬跨) (Fig 10)**:** A saiga stands on its hind legs, erects its body and neck behind another saiga, and places it forelegs on either side of the front one. The mounting saiga swags its tail quickly from side to side. Mounts may be male-female, male-male, or female-female; rarely will a female mount a sub-adult male.

Probable function: dominance or sexual behavior

Neck wrestling（扭脖）: Sparring with neck. One saiga tries to put its neck on the other one, presses the other lower its head or rubs the neck by neck. It occurs in female-female, female-calf, calf-calf pairs.

Probable function: dominance or play

Parallel walking（平行走）: Two saigas, moving forward beside one another, with shoulder to shoulder, lowered necks and heads, slow walking. It may follow aggressive approaching. It was found mostly in male-male pair, but occasionally in female-female interaction.

Probable function: competition

Partial mounting (半爬跨): It is typically with lateral rather than rear orientation, and often with just one foreleg across the body of the mounted saiga. In a behavior similar to the initial mount orientation movements, termed head on neck, back or rump, the forelegs will not actually rise off the ground. It occurs in male-female, female-female, calf-calf.

Probable function: dominance or courtship

Rubbing horns（摩角）: An adult male saiga uses one or both its horns to rub shrub branches, vigorously moving its head up and down or sideways.

Probable function: displaying

Sparring (绞角顶头)(Fig 11)**:** Two males carefully join their horn and twist heads and necks, apparently trying to force the opponent off balance. There was a large difference in intensity between sparring and clashing. An intensive sparring may cause serious injuries, no less than clash.

Probable function: competition

Spontaneous ejaculating (阴茎自行伸出)(Fig 12): An adult male saiga bends its hind legs, lowers its hindquarter closed to the ground, penis stretches/ejaculates suddenly in the air. This behavior frequently follows urination. The urine is sprayed onto the pelage under the neck when ejaculation. Sometimes, the males paw the ground with one foreleg before ejaculation.

Probable function: sexual behavior

Suckling (哺乳)(Fig 13)**:** A saiga calf stands in a head to tail or head to head position beside its mother, and puts its head under the abdomen of the mother, takes milk from udder. When suckling, the calf sways its tail from side to side fast, often steps its hind legs, with butting frequently.

Probable function: nutritive (maternal behavior)

Suckling avoidance（拒绝哺乳）: When a calf tries to touch the abdomen of the mother, the mother lifts one of her hind legs on the side that the calf stands. Mothers lifted their hind legs, walks forward or aside quickly.

Probable function: ?

Swinging head（摇头）: A saiga lifts and waves its head from side to side or turning around quickly. It occurs mostly in calves, and sometimes in females.

Probable function: playing or abnormal

Touching by front leg（用前脚触）: A saiga puts one of its front legs on the body side or hindquarter of anther one. It could be done by all saigas.

Probable function: dominance

Touching by nose (用鼻触)(Fig 14): A saiga uses its nose on the face, nose, muzzle, body or rump of another one. It is often accompanied by sniff. It could be done by all saigas.

Probable function: social communication, sexual behavior, or learning

Touching horn（接触角）: when male saigas low head to each other, one of them touch the horns of the other by muzzle without any other apparent signal, mostly occurring in young males. This often occurred with sparring.

Probable function: submission

Withdrawing (撤退)(Fig 15): A saiga lowers its head when anther saiga is approaching. If the approaching saiga doesn't stop, then the first saiga walks or runs away. It occurs in male-male pairs.

Probable function: submission

Discussion

Totally 46 behavior patterns were found and described in present study, including 15 individual behaviors for maintenance and 32 social behaviors for interaction. Following is special discussion on some of those behavior patterns.

Urinating and defecating

Both male and female saigas have distinctive posture when urinating. However, they don't show special posture for defecating, except erecting their tail so as not to block the passing of feces. The defecating occurs after urinating and while walking. These two behaviors are usually linked to each other, but the urine and feces doesn't always in the same place. The saigas in present study don't have latrine, the same as reports from wild (reviewed by Schaller 1998). The feces were found scattered around the enclosure, but they were more in foraging and lying sites than other parts. It is obviously in the feeding sites with supplied food in winters. The explanation may be that the saigas urinated and defecated usually after lying and foraging.

Scanning, walking with head up-down, walking with head lowering, and ***vigilance*** are four patterns of behaviors being of anti-predation function. Scanning is not directly relative to the appearance of danger and occurs usually in foraging. Vigilance is different from the scanning by ear erecting, which indicates that the behaviors may find something strange or danger. However, while they were in lactation, the female saigas kept ear erecting. On one hand, it may because my sense is not as sensitive as those of the saigas. On the other hand, females are more vigilant in breeding seasons than in other ones. Walking with head up-down was used by the saigas when they were approaching to some novel objects, such as a newly placed large stake. Sometimes when the saiga passed me in a short distance of 10m about, they showed 'Walking with lowered head' behavior. In such distance, I found that they were gazing at me without turning their head toward me. An observer from long distance may not find such a gazing action, and could not separate that behavior from common walking. I didn't find any changes of ear position in 'walking with head up-down' and 'walking with lowered head'.

Whether ***brushing facial gland*** is a patter of scent marking behaviors or not is still in question. In present study, all males expressed this behavior mainly in mating seasons. Because Saigas have front and preorbital glands, and the frequency of this behavior was observed more in mating seasons than that in other periods, it may be defined as a scent marking in males. However, some females (n=4), not all, were also found brushing the part below the eyes in cheek. The age of those females ranges from 8 month old to 3 years old. Both males and females did mark around their lying or foraging sites without fixed mark objects. It may be abnormal in females. Since there is no detailed information from wild about it, the definition about this behavior pattern was considered as a uncertain one in this study.

Leaping/stotting is a common behavior in *Antilopinae* (reviewed by Schaller, 1998). In present study, the Saigas did it at the beginning of running away when they found something might be dangerous to them, such as an appearance of a strange man. It is assumed to be associated with alarming (Tcaro *et al.*, 2004). A leaping/stotting by an adult saigas initiated running of other members. Nevertheless, I found that the leaping/stotting by sub-adult saigas (three occasions) did not have the same effect to other members around them. Adult saigas may neglect this kind of alarm by young saigas because they may be less experienced.

Schaller (1998) gave a comparison on neck fight among different species in Bovidae and indicated that Antilopinae do not have that behavior pattern. His description on that behavior is similar to the **neck wrestling that was found** in interaction between females, or sub-adult saigas. The expression of that behavior pattern in sub-adult males, not adult males, may suggest that it may be ancient and have been lost in males after the horns are developed.

Altogether, this may be the first systematic ethogram for the Saiga antelope, which may provide further behavior study on this species with an important baseline, though it based on the animals in a semi-natural condition. Observation from wild and captivity will be necessity to expand the ethogram to a more complete one.

Fig 1. Vigilance of a female saiga antelope (4 years old)

Fig 2. A female saiga (1 year old) in the right was brushing its face with a branch of *Haloxylon ammodendron*.

Fig 3. A male saiga (1 year old) was approaching aggressively to other ones.

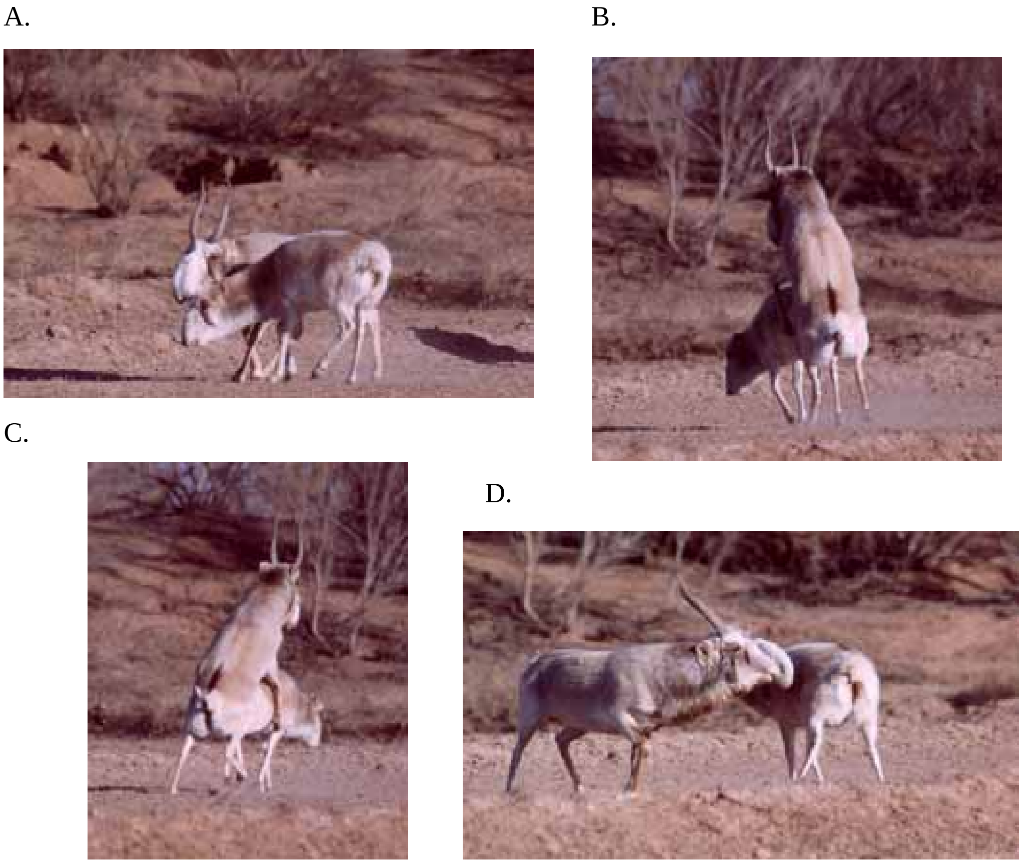

Fig 3. A copulation bout of the saiga antelope. A. the female didn’t avoid approaching of the male. B. the male was stretching its nose toward the female’s rump. The female was standing and swinging its tail. C. and D. The male was mounting the female. The male is 2 years old, and the female is 4 years old.

Fig 4. A male saiga (2 year old) was following a female (8 months old). The left horn of that male was broken in fights with other males.

Fig 5. Two female saigas were butting their heads. The left female was 2 years old, and the right one was 1 year old.

Fig 6. A fight between two male saigas. The male (2 years old, with broken horn) in the right was lowering its snout on the ground and browsing grass.

Fig 7. A male saiga antelope (2 years old) was trying to put his head on the back of a female (3 years old).

Fig 8. A male saiga (3 year old) was doing head up-stretching with grunts toward females.

Fig 9. In a herding bout, a male saiga (2 years old) was chasing a female who was running out of the harem.

Fig 10. A female saiga (1 years old) was mounting another one (2 years old).

Fig. 11. Two male saigas were in sparring. (They were both 2 years old)

Fig 12. A male saiga (2 years old) was doing spontaneous ejaculating.

Fig 13. A suckling bout of the Saiga antelope

Fig 14. A male saiga (2 years old) was using his snout touching the rump area of a lying female

Fig 15. The male saiga (1 year old) in the left was withdrawing after a fight, and the one (2 years old) in the right was chasing the loser.

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Chapter 4. Diurnal Time Budget and Activity Patterns

Abstract

In view that analyzing the time structure could be a useful method to follow the living conditions, present study describes the time budget and temporal activity patterns of the Saiga antelope in their mating and lactation seasons, and measures the difference between two sexes and among age-classes. All the behaviors were aggregated into 6 behavioral categories. It was showed that lying and foraging were the principal activity of the saigas and occupied more than half of daytime. Bimodal peaks for those two behavior patterns in daytime occurred in both sexes. Time that saigas spent on maintenance behaviors changed markedly through those two main reproductive seasons in both sexes. The difference may be caused by the different reproductive strategies of two sexes. In comparison with younger saigas, older ones expended more time in social interactions leading to mating and representing energy expenditure in mating seasons. It was assumed that the saigas in middle age-classes may be most active animals in their herds in mating seasons, which may be corresponding to the body condition of those animals.

Introduction

No matter what condition they are in, animals may choose among behaviors accordingly to the balance between the acquiring sufficient energy to offset the costs of behavioral for maintenance, growth and reproduction (Baras 1995, MaKeegan, 1997, Marcum *et al.* 1998).

Time budget and temporal patterns of behaviors play major roles in species' ecological relationships and are considered as adaptations to environment influences (Aschoff 1958, Duncan 1985, Beltran and Delibes 1994). They can be described for the situation of individuals and groups of animals (Tester and Figala 1990), Moreover, they may provide information on physical parameters, such as the nutritional state (Remmert 1969), social status (Bornett 2000) or stress (Baras 1995, Duchesne 2000, Flannigan 2002). Therefore, these studies can be an important tool to monitor a general status of individuals while their living conditions are transformed or a vital element to effective captive management of a species (Stevens and Hutchins 1993, Kleiman 1994). It is, furthermore, necessary for developing effective conservation strategies for species, for example reintroduction projects being put into conservation schedules (Dierendonck 1996, Berger 1999).

Saiga antelope has been collected in zoos for more than 130 years, while some of them were kept in captivity successfully (Wang 1998). Most part of the general behavior patterns of wide Saiga antelope were studied by Zhirnov (1998). When a group of saiga antelopes were introduced to present study site, relative observation were carried out on activity patterns of this species in captivity (Tan 1994, Tan 1994). However, after 1992 when this population was released into an enclosure with 27 *ha* area, which was considered as a semi-nature condition with free foraging, no detailed research was conducted.

In view that analyzing the time structure could be a useful method to follow the living conditions (Berger 1999), present study describes the time budget and activity patterns of the Saiga antelope in a semi-nature condition, measures the influence between different behavior patterns on time budget, and also considers the sex difference which may show some reproductive strategies of this species.

Methodology

Diurnal observation was carried out in different periods in 2000, 2001 and 2003 (Table 1). The daytime range was defined between sunrise and sunset according to GPS (GARMIN 12) data. Scan sampling procedures (Altmann 1974) was conducted at 10 minute interval. The behavior of every animal was recorded at the end of every 10 minutes.

In 2000 and 2003, pre-observation of two weeks was made to choose sampling intervals. The discrepancy between continuous recording (CR) and recording with different sample intervals (5min, 10min, 15min) was measured (After Martin and Bateson 1993). The percentage difference between CR and recording of each sample interval was calculated for each category of behaviour. Both in 5min and 10min interval， the proportion of categories, where the discrepancy with CR was less than 10%, reaches more than 95%. Hence, considering about reliability and practices, 10min interval was chose for recording in present study on time budget and activity patterns.

All focal animals (Table 1) were individually identified with a combination of ear markers and morphological differences.

Table 1. Observation periods, days per week, period per day, focal animals and total effective scan number of this study.

Observation period	Total hours for observation(h)	Observation period per day	Focal animal		Total Effective Scan Number
			Male	Female	
Dec, 2000	209	7:00-18:00	M1, M2, M3	F1, F2, F3, F4, F5, F6	1818
May-August, 2001	960	6:00-20:00	M1, M2, M3	F1, F2, F3, F4, F5, F6	2685
October,2003 -January, 2004	330	7:00-18:00	M4, M5, M6, M8, M9	F2, F3, F4, F5, F7, F8, F9, F10	1785

To measure behavior changes in different stags of rutting season, observation period in winters of 2000 and 2003 were divided into following three sections: pre-mating period (PrMP), mating period (MP) and post-mating period (PoMP), according to the occurrence and disappearance of herding behavior of male. In 2001, the observation started three weeks before first parturition and ended at the end of the thirteenth week after parturition.

The behaviors studied for time budget and temporal patterns were derived from an ethogram made by present study (see Chapter 3). They were aggregated into following functional behavioral categories:

1. **Foraging**: the finding, biting and chewing of food.

2. **Moving**: including walking and running by an undisturbed animal, Walking with lower head among vegetation for biting and chewing food were categorized into

foraging.

3. **Standing**: remaining motionless or standing with ruminating.
4. **Lying**: all behaviors engaged in while lying down, including ruminating, sleeping and alert postures.
5. **Interaction**: interactions between individuals, including any contact or non-contact action, such as chasing, aggression, backing from aggression or fighting.
6. **Other behavior**: auto-grooming, vigilance, and other behaviors.

In the lactation period, suckling behaviors of maternal females and sucking of lambs were added to the seventh category. However, because adult males didn't have such behaviors, the proportion of suckling behaviors that was exhibited by maternal females was added to the category of interaction when comparison between two sexes of adults was done.

For each animal the time spent in categorized behaviors during the study was transformed into proportion of time calculated as follows: number of observations of a behavior/total number of scan samplings per day. The term time budget was defined as the summed proportions (total 100%) of these behaviors. Temporal behavior patterns were also determined over daytime. Data were divided into 1h-time increments, from 7:00 to 17:59 and calculated as: number of observations of a behavior/total number of scan samplings per hour.

Of every observed animal, data were compared with Kruskal-Wallis *H* test in order to measure individual variance before they were pooled together. Comparisons among weeks and months were made by the Friedman test for related samples. Variation between two sexes or different age classes was measured by Mann-Whitney *U* test. Spearman rank correlation coefficients were used to look for relationships between time budgets of different behavior patterns. All probability values are two-tailed. Differences were regarded as significant if $p<0.05$ and as highly significant if $p<0.01$.

Result

Over all time budget

A total of 6288 scan number observations were analyzed for the selected saigas over the course of the study. All data were firstly pooled into mating or lactation seasons respectively to put a general view of the saigas. Table 2, 3 and 4 gives summaries of saiga diurnal budget in different periods in mating and lactation seasons.

The saigas spent 38 ± 9% time on lying, followed by 28 ± 9% on forage and 19 ± 8% on moving. The interaction occupied 2 ± 7% time. The large standard deviation (S.D.) was assumed caused by the significant difference between male and female, which will be analysis in following sections.

In summer of 2001, it took 50±8% time of saigas for lying, and secondly 26±6% for foraging, 14±9% for moving. The time saigas allocated for interaction is 1±1%, lower than that in winters.

Table 2. Percentage Means of Time Budget of the adult saigas in Pre-mating period (PrMP), mating period (MP), and post-mating period (PoMP) in winter of 2000

	female (n = 6)				male (n = 3)			
	PrMP	MP	PoMP	Dif. (*U*) PrMP & PoMP	PrMP	MP	PoMP	Dif. (*U*) PrMP & PoMP
Lying	35 ± 6	32± 13	41 ±3		36±4	31±11	41±4	
Dif. (*U*)		**189.50***	**252.50***	**193.00****		**187.00***	**36.00****	**48.00***
Moving	17±3	18±5	17±2		19±4	24±11	19±3	
Dif. (*U*)		1082.50	360.50	483.00		202.50	69.00	115.00
Standing	14 ± 6	16 ± 6	10 ±3		11±4	10±5	5±3	
Dif. (*U*)		975.50*	187.00**	**295.50***		238.50	**45.50***	**31.00****
Foraging	32±6	31 ± 9	30± 3		31±4	29±9	29±6	
Dif. (*U*)		1033.50	375.50	383.00		225.00	90.00	94.00
Interaction	1±1	2±1	1 ±1		3±1	4±3	2±2	
Dif. (U)		**1475.00***	**750.50***	400.00		**188.50***	**98.00***	**93.00***
Other	1±1	1±1	1±1		1±1	1±1	2±1	
Dif. (U)		**785.00***	**171.00***	**384.00***		**241.50***	**54.50***	**89.00**

Dif. = difference; *, p < 0.05; **, p < 0.01, all comparison were made by Mann-Whitney *U*-test

Table 3. Percentage Means of Time Budget of adult saigas in Pre-mating period (PrMP), mating period (MP), and post-mating period (PoMP) in winter of 2003

	female (n = 10)				male (n = 5)			
	PrMP	MP	PoMP	Dif. (*U*) PrMP & PoMP	PrMP	MP	PoMP	Dif. (*U*) PrMP & PoMP
Lying	39 ± 5	38 ± 6	35±6		40±5	39±13	38±9	
Dif. (*U*)	2925.50		**1113.50***	**272.50***	3733.00	1926.00		494.50
Moving	19±7	19±6	15±6		20±4	22±12	19±5	
Dif. (*U*)	2924.50		**1031.50***	314.00*	3815.40	1797.00		464.00
Standing	7 ± 3	11 ± 4	13±4		6±12	6±5	11±13	
Dif. (*U*)	**1204.50****		1168.00	**96.00****	3905.00	1765.00		515.00
Foraging	33±6	31 ± 9	35± 2		29±6	23±11	29±7	
Dif. (*U*)	**2300.00***		**912.00****	**234.00****	**2375.50****	**1143.50****		517.00
Interaction	1±1	6±5	3±2		4±3	8±11	3±5	
Dif. (*U*)	**1858.00****		**1191.50***	370.50	**3427.00****	**464.50***		491.00
Other	1±1	1±1	1±1		2±2	1±2	1±2	
Dif. (*U*)	**275.00***		**1045.00***	214.00	3878.00	1173.00		423.00

Dif. = difference; *, p < 0.05; **, p < 0.01, all comparison were made by Mann-Whitney *U*-test

Table 4. Percentage Means of Time Budget of adult saigas in lactation period of 2001

	Female (n = 5)				Male (n = 3)			
	May	June	July	Dif. (*H*)	May	June	July	Dif. (*H*)
Lying	44±7	45±4	43±4		53±5	49±3	51±4	
Dif. (*U*)		117.00	120.50	3.57		16.00	49.00	3.67
Moving	22±7	16±2	21±8		21±4	17±3	13±2	
Dif. (U)		**56.00****	**73.00***	**25.47****		**15.00***	**6.00****	**19.48****
Standing	6±4	9±13	4±1		3±1	6±2	4±1	
Dif. (*U*)		102.00	115.50	2.73		**10.00***	50.00	**8.10***
Foraging	27±8	31±2	31±9		19±1	23±2	29±3	
Dif. (*U*)		**71.00***	122.00	**11.16****		**0.00****	**9.00****	**22.54****
Interaction	4±2	3±1	1±1		0±0a	0±0	0±0	
Dif. (U)		**841.50***	**300.7***	**24.12****		786.50	350.66	4.77
Suck	5±4	4±6	2±2		**---**	**---**	---	
Dif. (U)		1492.00	**2870.00****	**12.64****		---	---	---
Other	0±0	0±0	0±0		0±0	0±0	0±0	
Dif. (U)		**1064.00***	**2156.00***	**29.23***		1023.00	901.00	6.56

a. 0±0 appears in table 4 did not means that there is no such behavior patterns in that season. It is because the percentage of that pattern is lower than 0.5 in means.

b. Kruskal-Wallis *H*-test for left 3 cells; [b]Mann-Whitney *U*-test for 2 cells above; Dif. = difference; *, $p < 0.05$; **, $p < 0.01$.

Female in mating season

In 2001 winter, lying and standing of females differed among PrMP, MP, and PoMP (Kruskal-Wallis test, lying: H=7.07 $p<0.05$; standing: H=18.33 $p<0.01$). Females spent more time on lying in PoMP than in PrMP and MP. The time of standing was increased to 16% in MP and then down to 10% in PoMP. Because of the appearance of sexual behaviors, females spent significantly more time on interaction in MP than that in PrMP or PoMP (Table 2).

The changes of females in 2003 winter varied in all six patterns. The most significant difference occurred in foraging among three periods. From PrMP to MP, females significantly reduced their time on foraging with great increase standing and interaction time. After MP, females not only decreased their time on moving and interaction, but also on lying, while increasing foraging and standing time. Comparison between PrMP and PoMP, showed that females spent more time on standing and foraging in PoMP and decreased their lying and moving time. Their interaction time in PoMP decreased from the level of MP to that of PrMP.

Male in mating seasons

Calculation of pooled data showed that males in 2000 changed their time on lying, standing and interaction significantly among three periods around mating. The time on interaction were increased in MP, while lying and standing declined. After mating, males increased their time on lying significantly, which even more than that in PrMP.

In 2003 winter, males varied their time on foraging and interaction significantly. Males reduced their foraging greatly in MP but resumed in PrMP, while the changes of interaction time was increased significantly in MP and decreased in PoMP. There were no significant changes of lying, moving, stand and other behavior patterns around mating.

Females in breeding season

The females gave birth to their lambs during May 7-14, 2001. In the first two weeks after parturition, the proportion of time that females spent on moving reached 21.76±6.79% which was significantly more than that of June and July (Kruskal-Wallis test, H=25.47, $p<0.01$). During that period, maternal females heading out for herd lonely and spent a large amount of time moving between the areas of forage and hiding sites of lambs. The feeding data also showed a slightly increased during three months (Kruskal-Wallis test, H=11.16, $p<0.01$). In contrast, the time that females spent on suckling decreased from 0.64±0.42% in the first month to 0.14(0.20% in the third month after parturition

(Kruskal-Wallis test, H=9.475, p<0.01).

Males in breeding season

The major proportion of time (50.84±4.06%) was spent on lying by males during May and July (Fig 2). Significant difference also exist in moving, feeding and standing (Kruskal-Wallis test， moving: H=19.48, p<0.01; feeding: H=22.54, p<0.01; standing: H=8.10, p<0.05), especially in July that males spent less time on moving and more time on feeding. The males liked to lie in the afternoon in July when the temperature reached its highest level.

Lambs in breeding season

Lying was the principal activity of lambs during daytime and reached 65±7.00% in May (Kruskal-Wallis test, H=8.45， p<0.05). The lambs began to forage with their mothers from the third week after birth and the time proportion quickly from 15±3% to 29±3% in July (Kruskal-Wallis test, H=14.31， p<0.01). By contraries, the sucking behavior decreases from 1±0.4% to 0.4±0.1% during three months (Kruskal-Wallis test，H=0.004， p<0.01), there is a decrease in moving of lambs between June and July which was possibly due to the high temperature in July.

Temporal behavior patterns

The temporal behavior patterns for males and females are illustrated in Fig1. It showed bimodal peaks for foraging and lying in both sexes. Saigas spent most time around sunrise and sunset on foraging, which was showed by first peak in 7:00-7:59 and second peak in 17:00-17:59 in winters, and first of 6:00-6:59 and second of 19:00-19:59 in summer 2001. It is noted that in the winter of 2003, foraging has a third peak in 11:00-12:00, which was just after keepers put supplied food into enclosure. In summer, females foraging pattern showed the third peak more clearly around 12:00-13:59.

Lying time also appeared two peaks. In 2000 winter, most of time during 9:00-9:59 and 14:00-14:59 is for lying. In 2003 winter, the lying peaks appeared in 10:00-10:59 and 14:00-14:59. Those peaks are correspondent to the minimum percentage of foraging and moving during those hours. In the summer of 2001, the lying time did not show clear peaks in both male and female. It was with little variation among time periods from 7:00 to 19:00. When foraging reached up to its peaks in early morning and later afternoon, lying time dropped to the lowest value.

Neither walk nor standing and interaction showed a clear pattern over the day, except two drops both males and females in the time periods when lying time reached highest.

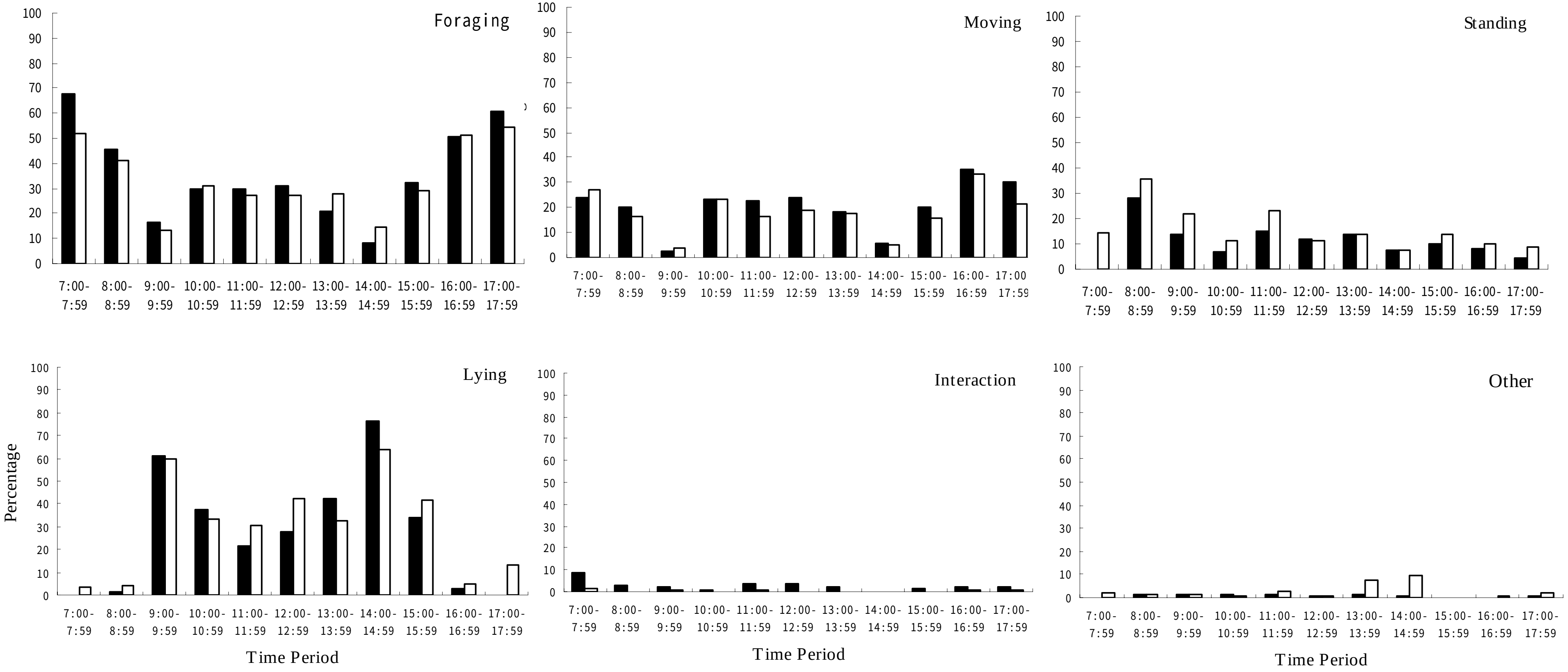

Fig 1a. Temporal Behavior Pattern in Winter 2000. ■ for male, □for female.

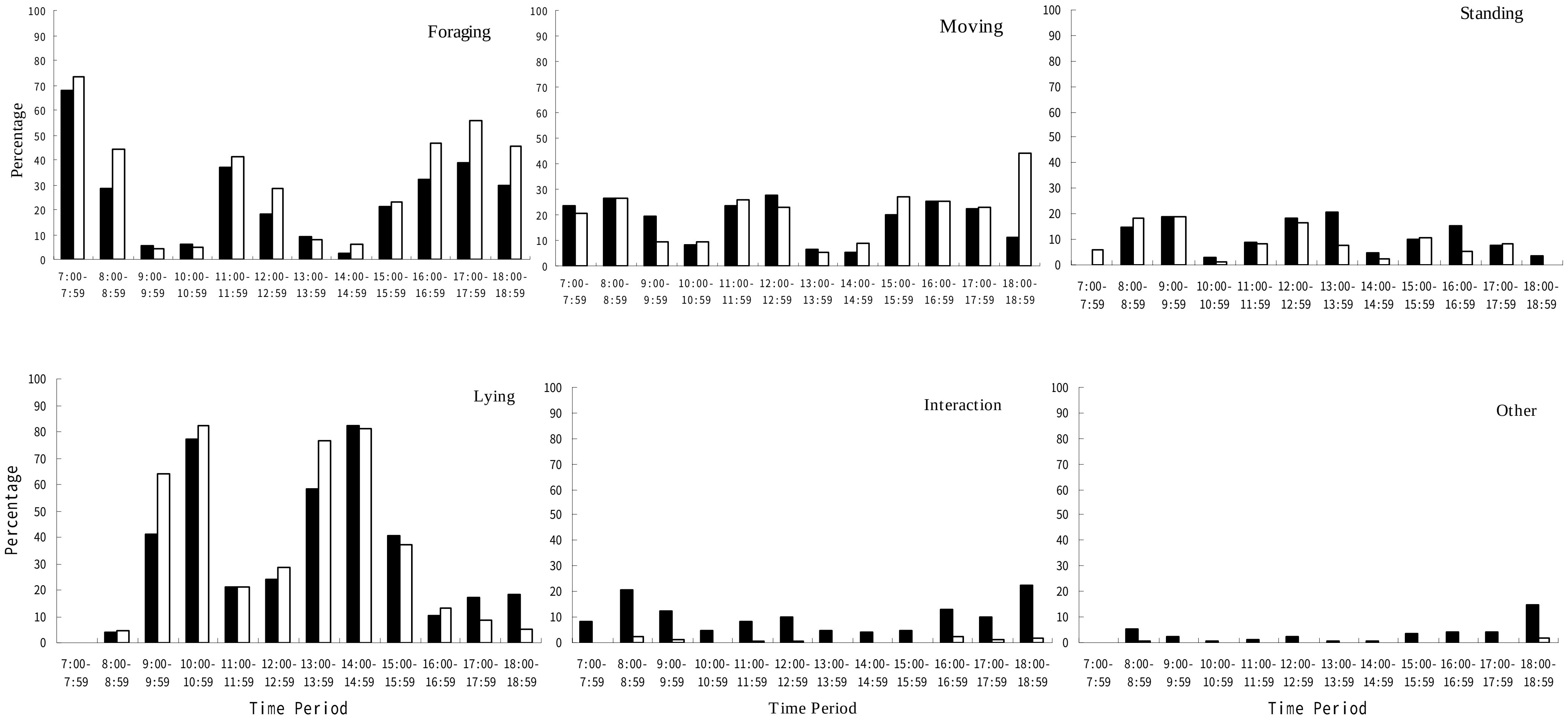

Fig 1b. Temporal Behavior Pattern in Winter 2003. ■ for male, □ for female.

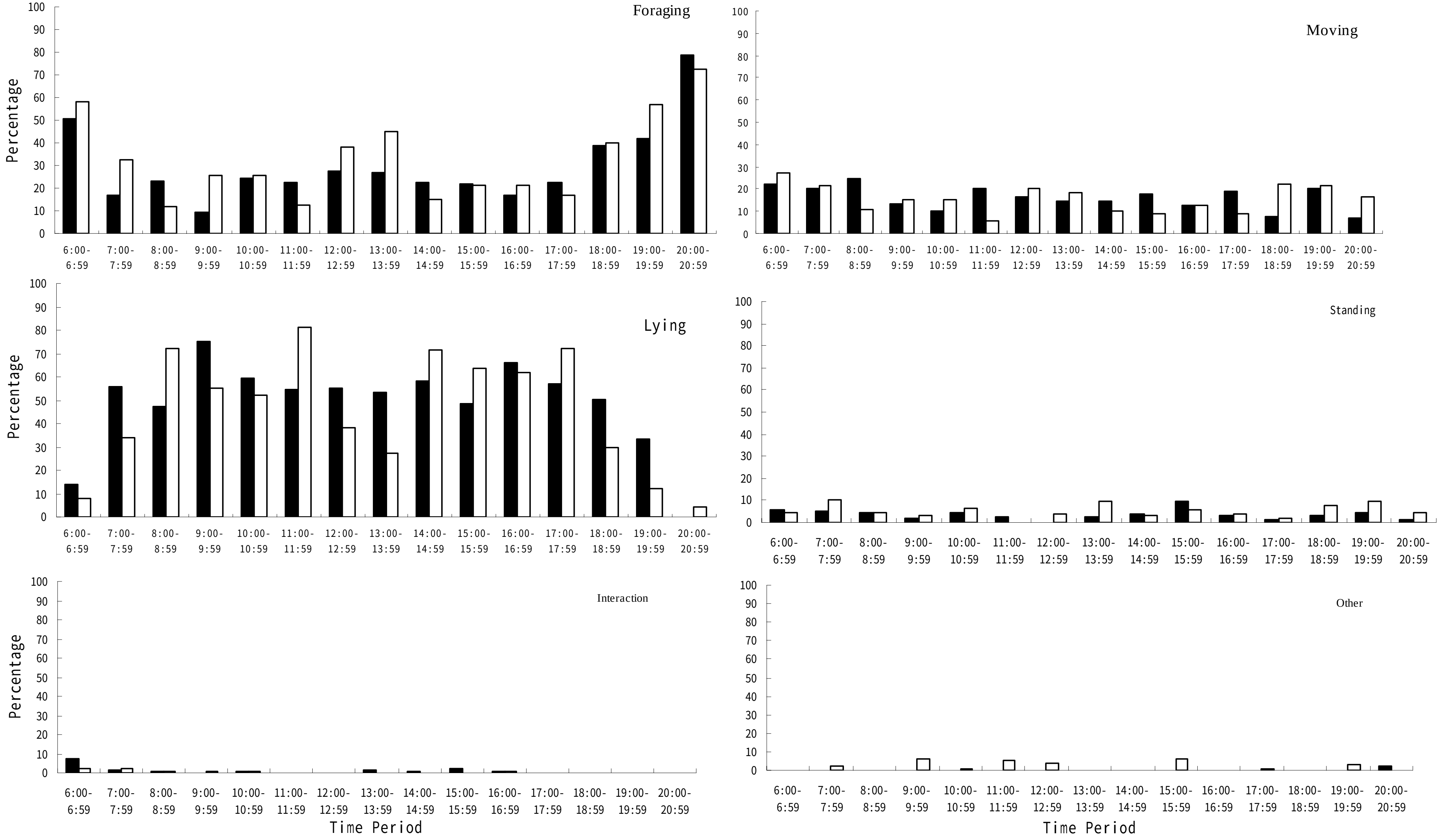

Fig 1c. Temporal Behavior Pattern in lactation season of 2001. ■ for male, □ for female

Sex difference

In 2000, the activity budget of males and females for standing and interaction changes among all three period around mating. Females spent more time than males on stand (Mann-Whitney *U* test, PrMP: U=511.00, p<0.05; MP: U=215.50, p<0.01; PoMP: U=17.50, p<0.01), while their interaction was less than males (Mann-Whitney *U* test, PrMP: U=344.00, p<0.01; MP: U=218.00, p<0.01; PoMP: U=26.00, p<0.01). Males also spent significant more time on walk than females in MP (Mann-Whitney *U* test: U=248.50, p<0.01). The adult male and sub-adult males devoted more time to chasing females and driving other males. When the herd had rest, M1 still walked among and around the herd and interrupt the rest of females, which cut a great amount of time of male on lying. After mating, the time that females spent on lying, moving and foraging also differed significantly from males (Mann-Whitney *U* test, lying: *U*=76.00, p<0.01; moving: *U*=82.00, p<0.01; foraging: *U*=63.00, p<0.01).

In comparison, during the mating season of 2003, two sexes differed their allocation of time on foraging highly significantly (Mann-Whitney *U* test, PrMP: U=626.00, p<0.01; MP: U=7150.00, p<0.01; PoMP: U=97.50, p<0.01) from each other in three periods. Time of males on foraging was always less than females. In PrMp and PoMP, males spent more time on moving than females (Mann-Whitney *U* test, PrMP: *U*=742.50, p<0.05; PoMP: *U*=163.50, p<0.05). But, in mating period, such time on moving is similar to each other. Other than those changes, males also reduced their time on standing which was less than females in MP and PoMP (Mann-Whitney *U* test, MP: *U*=4929.50, p<0.01; PoMP: *U*=116.50, p<0.05). Significantly, the time of males on interaction was more than females in MP.

In the period of lactation, the maternal females had to change her budget now and then because they had their own lambs and should share as well as offer their resource to their babies, while the male did nothing to his offspring. Although the females rejoined into the head with the males, there were significant difference between two sexes that females spent more time feeding (Mann-Whitney *U* test, May: *U*=6.00, p<0.01; June: *U*=4.50, p<0.01; July: *U*=50.00, p<0.01) and less time lying than the male (Mann-Whitney *U* test, May: *U*=18.00, p<0.05; June: *U*=59, p<0.05; July: *U*=66.00, p<0.05).

A comparison made for lamb showed there is no obvious difference on the main activity budget of two sexes. Nevertheless, the male spent more time on social behavior than female and there is a significant difference in June (Mann-Whitney *U* test, *U*=0.00, p<0.05).

At the same time, the proportion of sucking of female is a bit more than male. The lambs in captive weaned at the end of two months (Tang *et al.* 1994).

Age difference

Before doing analysis on age influence toward time budget, saigas were divided into following age classes:

1. Female: A0F (<1 year old), A1F (1 year old), A2F (≥2 year old)
2. Male: A0M (<1 year old), A1M (1 year old), A2M (2 year old)

Female timebudget of different age-classes in mating seasons were illustrated in Fig 2. Significant difference of time budget was of standing in PrMP, with a rank of A2F > A0F > A1F (Kruskal-Wallis test, H=15.86， p<0.01), and in MP with a rank of A2F>A0F>A1F (Kruskal-Wallis test, H=9.97， p<0.05). Interaction of females also varied significantly among age-class in MP, with a rank of A2F>A0F>A1F(Kruskal-Wallis test, H=19.68， p<0.05). After mating, difference among age-classes was not significant.

The time budget of males on different behaviors, comparatively, varied more among age classes (Fig3). In PrMP, interaction time was different with a rank of A2M>A0M>A1M. In MP, difference occurred in foraging (A0M>A1M>A2M, Kruskal-Wallis test, H = 13.74 p<0.01), standing (A2M>A1M>A0M, Kruskal-Wallis test, H=14.21 p<0.01), and interaction (A2M>A1M>A0M, Kruskal-Wallis test, H = 33.28, p<0.01). In PoMP, time of standing and moving was different among age class (standing: A2M>A1M>A0M, Kruskal-Wallis test, H=8.31 p<0.05; moving: A0M>A1M>A2M, Kruskal-Wallis test, H = 9.79, p<0.01).

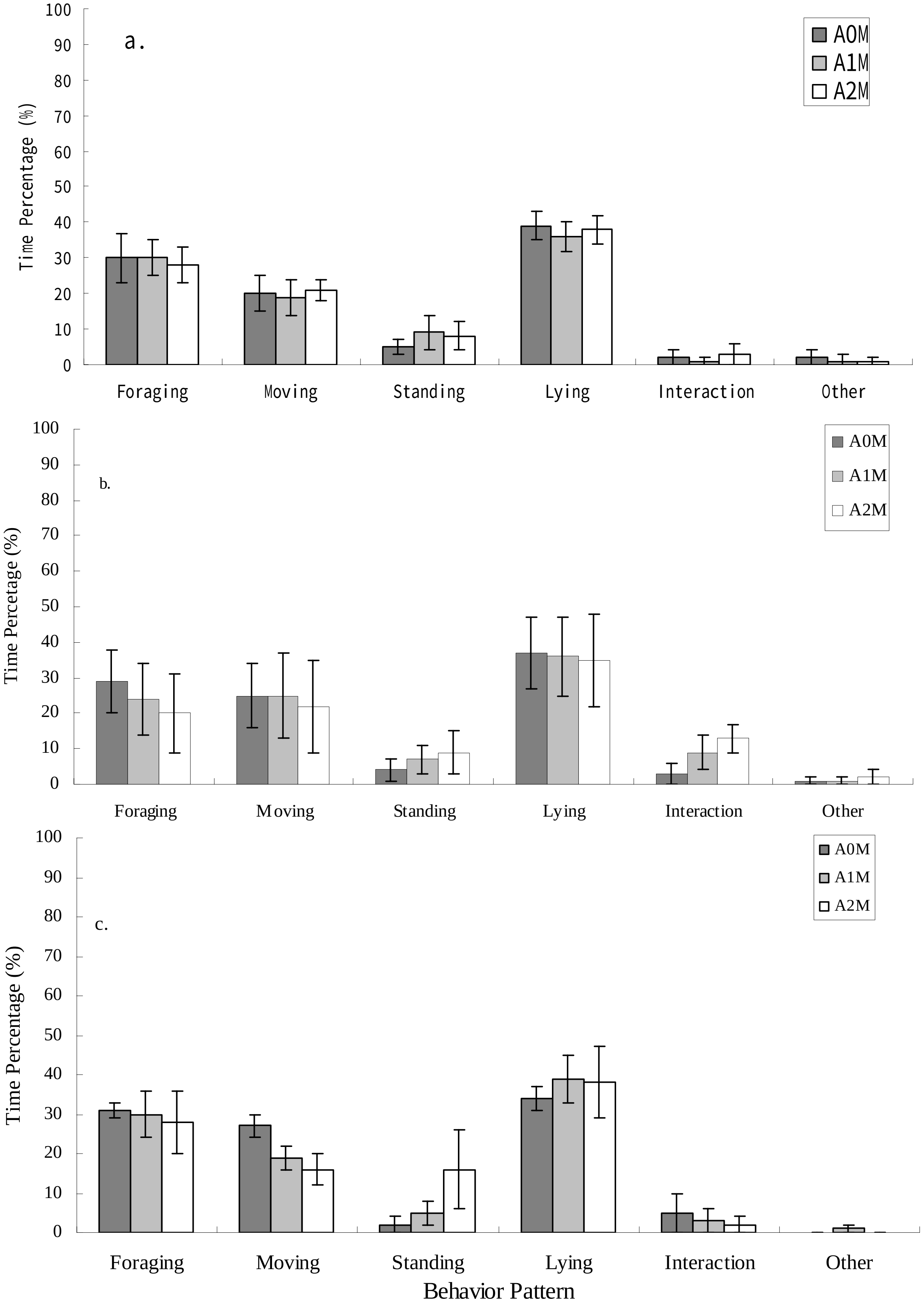

Fig 2. Percentage of time budget of the male saiga antelopes in the semi-natural condition among different age class in a. PrMP, b. MP, c. PoMP.

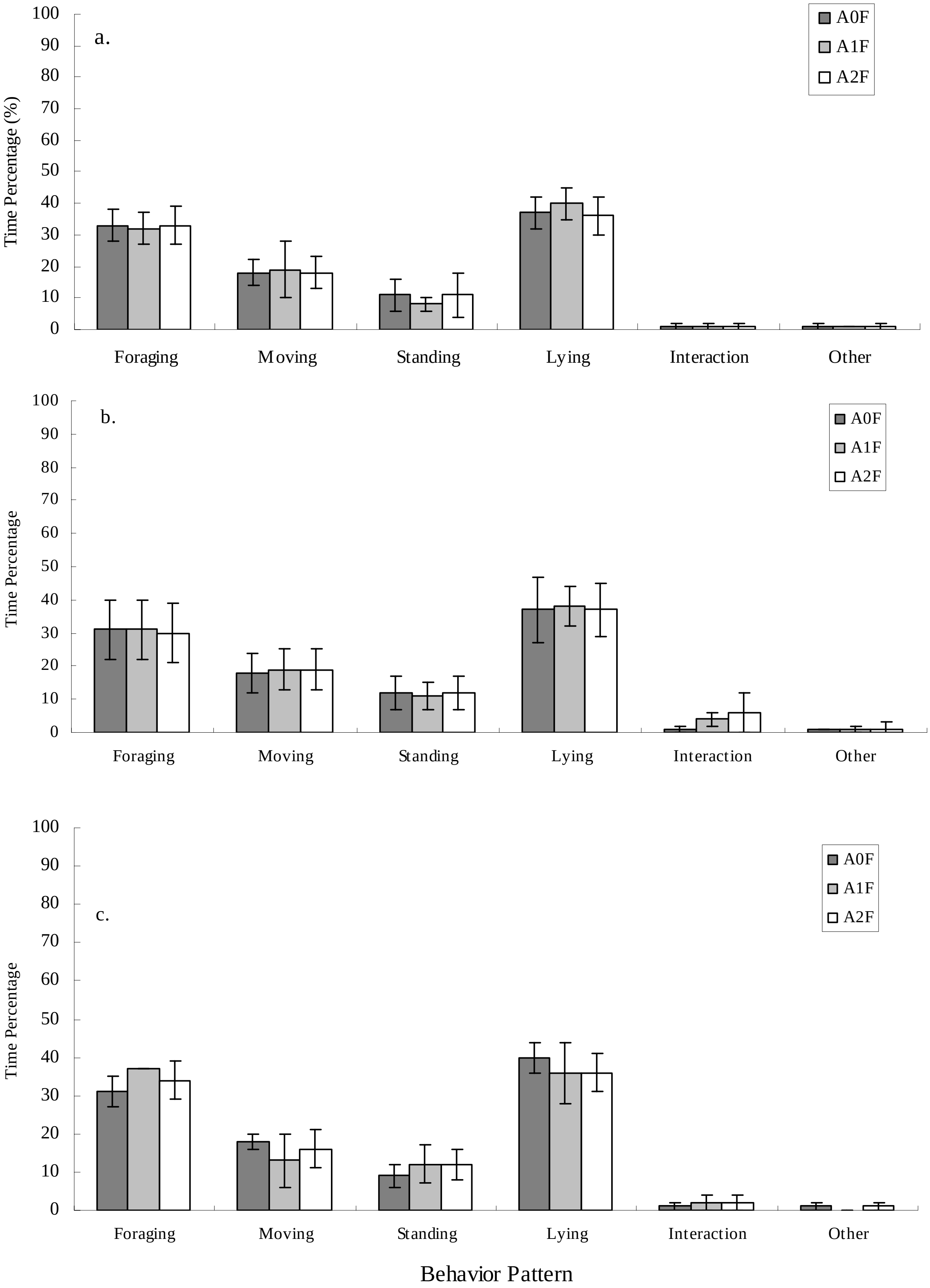

Fig. 3. Percentage of time budget of the female saiga antelopes in the semi-natural condition among different age class in a. PrMP, b. MP, c. PoMP.

Difference in age-sex class

Table 5, 6 and 7 showed means and difference of time budget among age-sex classes in three periods around mating. No comparison was made between age-sex classes in the lactation period because of the small sample size.

Table 5. Percentage of time budget of the saiga antelopes in the semi-natural condition among different age-sex class in PrMP

	A0[a]		A1		A2	
	Male (n=2)	Female (n=4)	Male (n=4)	Female (n=2)	Male (n=4)	Female (n=6)
Foraging	30±7	33±5	30±5	32±5	28±5	33±6
Dif. (*U*)[b]	77.50		79.00		**209.50****	
Moving	20±5	18±4	19±5	19±9	21±3	18±5
Dif. (*U*)	66.00		64.00		**196.00****	
Standing	5±2	11±5	9±5	8±2	8±4	11±7
Dif. (*U*)	**29.00****		78.50		**258.50***	
Lying	39±4	37±5	36±4	40±5	38±4	36±6
Dif. (*U*)	69.50		51.00		**241.00****	
Interaction	2±2	1±1	1±1	1±1	3±3	1±1
Dif. (*U*)	57.00		82.00		**160.00****	
Other	2±2	1±1	1±2	1±0	1±1	1±1
Dif. (*U*)	81.50		79.00		396.50	

a. A0 = younger than one year old, A1 = 1 year old, A2 ≥ 2 year old

b. Sex difference was measured by Mann-Whitney *U*-test, * p<0.05, ** p<0.01

Table 6. Percentage of time budget of the saiga antelopes in the semi-natural condition among different age-sex class in MP

	A0[a]		A1		A2	
	Male	Female	Male	Female	Male	Female
Foraging	29±9	31±9	24±10	31±9	20±11	30±9
Dif. (*U*)	391.50		**346.00****		**870.00****	
Moving	25±9	18±6	25±12	19±6	22±13	19±6
Dif. (*U*)	**232.00****		**415.00***		1806.00	
Standing	4±3	12±5	7±4	11±4	9±6	12±5
Dif. (*U*)	**83.50****		**247.00****		**1254.00****	
Lying	37±10	37±10	36±11	38±6	35±13	37±8
Dif. (*U*)	399.50		552.50		1740.00	
Interaction	3±3	1±1	9±5	4±2	13±4	6±6
Dif. (*U*)	310.00		**525.50***		**1281.50****	
Other	1±1	1±0	1±1	1±1	2±2	1±2
Dif. (*U*)	431.50		525.00		**1357.50***	

a. A0 = younger than 1year old, A1 = 1 year old, A2 ≥ 2 year old

b. Sex difference was measured by Mann-Whitney *U*-test, * p<0.05, ** p<0.01

Table 7. Percentage of time budget of the saiga antelopes in the semi-natural condition among different age-sex class in PoMP.

	A0[a]		A1		A2	
	Male	Female	Male	Female	Male	Female
Foraging	31±2	31±4	30±6	37±0	28±8	34±5
Dif. (*U*)[b]	17.00		8.00		43.00	
Moving	27±3	18±2	19±3	13±7	16±4	16±5
Dif. (*U*)	**0.00****		9.00		65.50	
Standing	2±2	9±3	5±3	12±5	16±10	12±4
Dif. (*U*)	**1.00****		**2.00***		63.50	
Lying	34±3	40±4	39±6	36±8	38±9	36±5
Dif. (*U*)	**3.50***		13.00		51.00	
Interaction	5±5	1±1	3±3	2±2	2±2	2±2
Dif. (*U*)	**6.00***		11.00		54.50	
Other	0±0	1±1	1±1	0±0	0±0	1±1
Dif. (*U*)	6.00		9.00		47.50	

a. A0 = younger than one year old, A1 = 1 year old, A2 ≥ 2 year old

b. Sex difference was measured by Mann-Whitney *U*-test, * $p<0.05$, ** $p<0.01$

Discussion

Over all time budget

Diurnal time budgets and activity patterns of an animal are related to many factors, including environmental conditions (e.g. food abundance, presence of predators, climate), energy requirements for growth, reproduction and homeostasis (e.g. Samson & Raymond 1995).

I found that time that saigas spent on maintenance behaviors changed obviously through different periods around mating in both sexes. On the other hand, female varied their budget on time of foraging and lying among the first 12 weeks of lactation, while males kept relative steady. Occurrence of reproductive behaviors of saigas (sexual and maternal behaviors), which requires additional energy and time, results in the significant changes of time budget.

The results show that lying and foraging were the principal activity of the saigas and occupied more than half of daytime. They are two main kinds of behaviors that increase intake of energy. Craigjead *et al*(1973), by monitoring radio-collared elk (*Cervus elaphus Canadensis*) over a 24-hour period, found that the elk spent 44% of the time on foraging, 46% on lying, and 10% on other activities. Owen-Smith（1998）found female great kudu (*Tragelaphus strepsiceros*) spent 63.1% of time on foraging while males spent 53.8% on the same behavior. The semi-nature condition provide saigas with relatively more food without much selection in limited area, which may cause them spend less time on foraging, while more time on resting. However, the smaller body size of saigas, compared with elk and kudu, may also the reason of less foraging. A study by Lee (1998) on a takh harem stallion (*Equus ferus przewalskii*) showed that takh spent approximately time on grazing and recumbent rest before and after releasing. The saigas in present study spent less time on foraging both in the period of mating and lactation (in mating: 31±6%; in lactation: 28±5%)，while more time on resting in summer (47(5%). The saigas in semi-nature had relatively plenty of food to eat without much selection and the area for them to walk is limited. It may be the reason that the feeding of captive saigas in the farm occupied only one third of time in the daytime.

Temporal pattern

Foraging and other activities generally occur in bouts, interrupted by periods of inactivity and these vary in relative duration over the daily cycle. Accordingly the daytime budgets for foraging and other activities are outcomes of this pattern (Owen-Smith, 1998). Saigas showed bimodal peaks for foraging and lying in both sexes. Foraging peaks occurred respectively around sunrise and sunset, may be a typical activity pattern similar with other ungulate species. It has been reported in axis deer Axis axis (Miura 1981), red deer Cervus elaphus(Clutton Brock *et al*. 1982a), Eld's deer (*Cervus eldi*) (Song 1993), forest musk deer (Moschus moschiferus berezovskii)(Du, 1998). Zeng *et al*. (2001) studied daily active rhythm of golden takin (*Budorcas taxicolor* bedfordi) and found takins have three active peaks in the daytime. Similarly, Przewalski's gazelle had three peaks of feeding, though the time differed among three seasons from spring to autumn (Chen *et al*. 1997).

Difference between two sexes

The difference of time budget between two sexes may be relative to the difference of body size, energy requirement and reproductive investment (Clutton-Brock, 1982). As polygynous species, male saigas attempted to gather harems of 5-15 females in the mating season, herded females and challenges males that approach his area (Nowak, 1991), which makes great changes on time budget of males and cost most of their energy. Whereas, nutritional demands of lactation and maternal care for offspring affect females greatly on their allocation of time and energy.

Saiga Antelopes showed significant differences on time budget between two sexes both in the mating and lactation seasons.

During the period of mating, males spent more time chasing and herding the females. The saigas in my study concentrated their social behaviors before they laid down. When the herd stayed at one place and females was to rest, the males went up to the females with lower neck and head and touched females body by muzzle and forelegs until the females stood up. The females that disturbed by the males had to change their lying site from time to time. Hence, the behavior of males influence females evidently and caused the latter having less time on lying. I assumed that, in consequence, female increased their time on feeding so as to restore their energy since they could not save energy by lying.

The interaction time of male increased during mating period, because of mating competition and harem holding. Those changes, with great consumption of energy for mating caused changes of time budget on other behavior. Male in 2003 decreased their time on foraging markedly, while this change of male in 2001 was not obviously. Such changes may due to individual variance and difference number of males in those two years. Guo *et al.* (2003) suggest that the sexual behavior of males to females of Argali

(*Ovis ammon karelini*) is the important factor to the change of activity budget around mating season. Females increased their time on feeding during mating and on resting after rut. On the other hand, the males spent a great amount of time on resting instead of feeding. For the males that lost most of their energy during rut, resting may be more effective way to resume their constitution, or they were too weak to do activities other than rest.

After parturition, maternal females take responsibility on caring their offspring. They have to share resources of their own to the offspring in order to guarantee the growth of them, which may become a key factor that affect the time budget of females, while males did nothing in lactation for their lambs. Suckling cost much energy of females (Hanwell 1977) and may increase the mortality of females (Clutton-Brock 1989). Therefore, maternal females should adjust their behavior patterns, such as lengthening time of feeding and rest to make up the expense. Females of some species increase their time on feeding as more as 30% in the daytime while decreasing other behaviors (Clutton-Brock 1989). Forest musk deer increased rate of food intake, reduced locomotion and social behavior to keep the balance of cost and intake of energy（Du *et al*. 1998）. Female Chinese water deer spent longer time on feeding in the later period of pregnancy and lactation while their demands of energy reached its maximum（Middleton 1937）. The time budget of saiga antelopes in my study correlated with their maternal behavior in lactation, since hiding lambs, suckling and increasing vigilance cost maternal females much energy. Females may supply their energy by methods of increasing feeding. Females spent significantly more time on feeding than males during May and July.

There were no significant difference of time budget between two sexes of lambs, except social behavior that males takes more time on it than female lambs. In light of obvious sexual dimorphism in body size and behaviors, males may have more demands of energy than females for growth of horn and muscle that would be need for fighting. Why, then, there were no significant difference between two sexes of lambs in present study? Female saigas matured in the age of eight months and could mate with males in the first winter, forasmuch the nutrition and energy intake during the lactation may make vital influence their survival rate in the first winter as well as the rate of success of the first reproduction. Meanwhile, the speed and quantity of growth of male lambs may make effect on their dominant status in intra-sexual competition which influences their rate of successful reproduction directly. The time budget of lactation in my study of one year may be lack of evident to identify and compare the difference between two sexes of lambs.

Difference between old and young individuals

Stallions appeared to spend more time acting socially than did other sex-age classes and they spent less time feeding (Schilder *et al.* 1987). In Spanish ibex, the old males also differ from the adult and subadults in the daily pattern of courtship activity (Alados 1986). Shi *et al.* (2003) reported that in feral goats, adult males spent more time in social activities than did other age–sex classes, and adult males sharply decreased the percentage of daytime that they spent feeding during rutting periods, which may have contributed to their higher mortality over the subsequent autumn and winter.

Present study got some similar results about age influence. In comparison with younger adult males, older males expended more time in activities leading to mating and representing energy expenditure and the less time they use in lying or foraging that representing energy saving or recovery. At the same time, older females also spent more time on social interaction than younger ones in mating seasons.

Nevertheless, it was not the oldest males that spent most time on social interaction in mating seasons. The oldest male in present study was at 3.5 years old. He mostly stayed alone or with a gammy male of 1.5 year old. Their data was excluded into analysis. Hence, it was assumed that the saigas in middle age-classes may be most active animals in their herds in mating seasons, which may be corresponding to the body condition of those animals.

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Chapter 5. Some Features of Mother–young Relationship

Abstract

Because establishment and development of mother-young relationship within short lactation periods is vital to the growth of calves, present study provides observation on the maternal saigas and their calves in the first 12 weeks of lactation. Suckling behavior, vocal communication and distance between mother and their calves was analyzed.

The results showed that suckling duration decline through 12 weeks and the first significant decline of suckling duration was between the 3rd-4th weeks. In contrast, the suckling intervals increased in those weeks. It suggested that the period of 4th-6th week may be a turn for independency development of the saiga calves.

Most suckling bouts were both initiated and terminated by maternal saigas, which may suggest that mothers were primarily responsible for determining the suckling duration and intervals according to her secretion of milk.

Mothers kept a long distance from the calves most time in hiding period after parturition. After rejoining other saigas, the distance of young with mothers kept more stable and young didn’t keep close to their mothers.

In the first four weeks, more than 95% suckling bouts were initiated after maternal females made sounds to the calves. The vocal feature may play an important role in recognition for saigas. Hence, it may be interesting in the further study to find out how the maternal saigas use vocal signal to keep contact with their offspring and the role of vocal signal in maternal care.

Introduction

Because young are often helpless and vulnerable to harsh environment, their survival rely to a large extent on the ability of the parents to provide and adjust their behavior according to the needs of young and environment. Behavior adaptations can be considered as components of a reproductive strategy that result in the successful production of surviving offspring (Stearns 1992, Linnell 1998). A variety of behavioral interactions characterizes the relationship between mothers and their young, and contributes to increase the growth, survival and reproductive success of both the young and the mother. The survival of the neonate depends on integrated expression of appropriate behaviors from both the mother and young.

Studies, such as on the Dall's sheep (Rachlow and Bowyer, 1994), suggest that variability in maternal behavior is an adaptive strategy to variation of environmental conditions. It could be expected that sensitivity of maternal investment to environmental conditions will occur in species with high reproductive effort (Byers and Hogg 1995, Braza *et al.*2000,).

Predation is one of the key factors that influence the maternal behavior and mother-young relationship patterns. Patterns of spatial relations and frequency of association between mother-young of White-tailed deer would be tuned closely to the fawn susceptibility to predation (Schwede *et al.* 1994). Bighorn sheep changed their maternal-care patterns under different predation pressure (Hass 1990). The predation risk on Alaskan moose influenced the maternal females gave birth at sites that helped them minimize risk of predation but exhibited risk-averse behavior with respect to the forage necessary to support the high cost of lactation (Bowyer *et al.* 1999).

As a result, two behavioral strategies between mother and young developed from the pressure of the predation, namely hiding and following (Walther 1965). In the early stage from days, weeks or even months after birth, hiding young remain lying at some distance from their mother and rising only to suckle, walking and play for a short time with mother. Conversely, following young initially stay close to their mother. Following has been viewed as a strategy for avoidance of predators in open habitats and often is associated with migratory habits (Ralls *et al.* 1986). Hiding is usually interpreted for reducing predation in habitats with dense cover (Walther 1965, Lent 1974).

The Saiga Antelope lives in arid or semi-arid grassland, open habitat with less vegetation density. Females aggregate and migrate to north before their delivery in spring, partially because of food distribution (Zhirnov 1998). Calves show hiding behavior for several weeks after birth in the wild (Zhirnov 1998, reviewed by Schaller 1998), and then follow their mother returning to their south habitat. The establishment and development of mother-young relationship within short lactation periods is vital to the quick growth of calves, the new recruitment for their population.

Given that no quantifying study was conduct on the mother-young relationship for this species, present study provides observation on the maternal saigas and their calves in the first 12 weeks of lactation. Suckling behavior, vocal communication, and spatial relationship was quantified between mother and their calves. It firstly documents the changes of early mother-young relationship of this species.

Methodology

Five mother-young pairs of the saiga antelope were observed from April 25 to August 10, 2001. Observation sessions were scheduled between 6:00 and 20:00 every day from May 7 when the first calf was born, to the May 26 when all females with their calves rejoined with males. After that, observation was done from 6:00-12:00 in the first day and from 12:00-20:00 in the second day as an observation day.

Focal sampling (Altmann 1974) was used for observation and behaviors were recorded by all-occurrences recording method (Martin and Bateson 1993) to collect data. Every pair was observed for one day in turn. During each observation period, I record following variables:

1) ***Duration of suckling bout:*** suckling bouts are considered successful suckles that are without interruption by approaching of other members. The duration is recorded from calves touching mother's udders to calves stopping contact and leaving or the mother moving away to stop the suck of calves. The cumulative number of seconds for which a calf sucked was calculated.

2) ***Suckling interval***: the duration between two sequent suckling bouts.

3) Initiator and terminator of every suckling, and their behavior

4) Distance between mother and calves when calves were lying. During those periods, the distance was recorded in female body length (with one body length equaling 1.5m) every

1h.

In data analysis, Wilcoxon signed rank test was applied to measure the weekly difference of variables of suckling bouts and distance. Chi-square test was used for comparison of 1) initiation rate between mother and calves, and 2) frequency among different behavior patterns of suckling initiation.

Result

Because there are only two male calves observed in present study, the sample size is too small to support comparison between two sexes statistically. Hence, all analysis was done by pooling data of two sexes together to give a general description of certain behavior changes during the lactation period.

Duration of suckling bout

The duration of suckling bouts of the saiga calves declined in the first 12 weeks of lactation, illustrated in Fig 1. A marked decline occurs between the 3rd - 4th week.

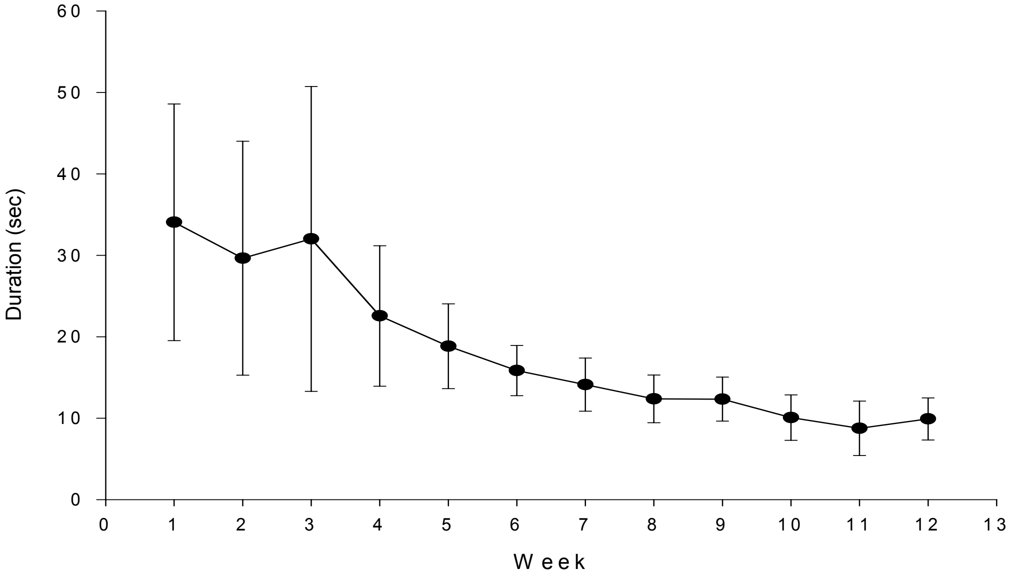

Fig.1 Weekly duration mean of suckling bout of the saiga antelope (n=6) during the 12 weeks in lactation season, 2001.

By Wilcoxon rank test, weekly difference was measured (Table 1). It showed that significance of weekly difference occurred firstly between the 3rd-4th week. Followed, the significance of weekly difference was showed from the 4th to 8th week, and between the 9th-10th week. From the 10th to 12th week, there is no significant difference between each other week.

Table 1. Duration mean of suckling bout of the saiga antelope (n=6) in lactation in 2001.

Week	N	Min(sec)	Max(sec)	Mean±S. D. (sec)	Weekly Dif. (Z)
1	53	10	81	34±14	
					-0.99
2	59	9	62	30±14	
					-1.19
3	78	10	90	32±19	
					-3.66**
4	76	6	54	23±9	
					-2.33*
5	66	11	29	19±5	
					-2.78**
6	57	11	23	16±3	
					-2.65**
7	60	4	24	14±3	
					-2.28*
8	62	8	18	12±3	
					-0.94
9	49	7	18	12±3	
					-2.65**
10	41	5	15	10±3	
					-1.23
11	44	3	16	9±3	
					-1.01
12	32	5	14	10±3	

Weekly difference was measured by Wilcoxon signed rank test. * p<0.05, ** p<0.01.

Suckling interval

Because it was impossible in this study to observe every suckling bout of each calves during daytime, suckling interval is better than the frequency of suckling as an index in this study to show indirectly the suckling rate between sunrise and sunset. The number of suckling intervals in the 12th week is so small that I excluded the data of that week from analysis.

Gradual changes of the suckling interval during the first 12 weeks were illustrated in Fig 2. The weekly difference was significant between the 4th-5th week and 5th-6th week. In the 6th week, suckling interval prolongs to 210±67min. After a fluctuation in the 7th week, the interval was kept more than 200mins from the 8th week.

Table 2. Interval mean (min) between two consecutive suckling bouts of saiga antelope calves from 1st to 11th week after birth.

Week	N	Min(min)	Max(min)	Mean±S.D.(min)	Weekly Dif. (Z)
1	14	36	180	110±41	
					-0.97
2	19	30	222	134±49	
					-0.16
3	37	54	300	128±66	
					-0.40
4	28	60	218	128±43	
					-2.35*
5	23	39	240	154±52	
					-3.16**
6	27	90	300	210±67	
					-1.31
7	17	137	310	188±52	
					-0.77
8	24	60	420	215±100	
					-1.01
9	11	60	390	205±117	
					-0.17
10	12	120	540	258±147	
					-0.94
11	13	120	540	254±152	

Weekly difference was measured by Wilcoxon signed rank test. * $p<0.05$, ** $p<0.01$.

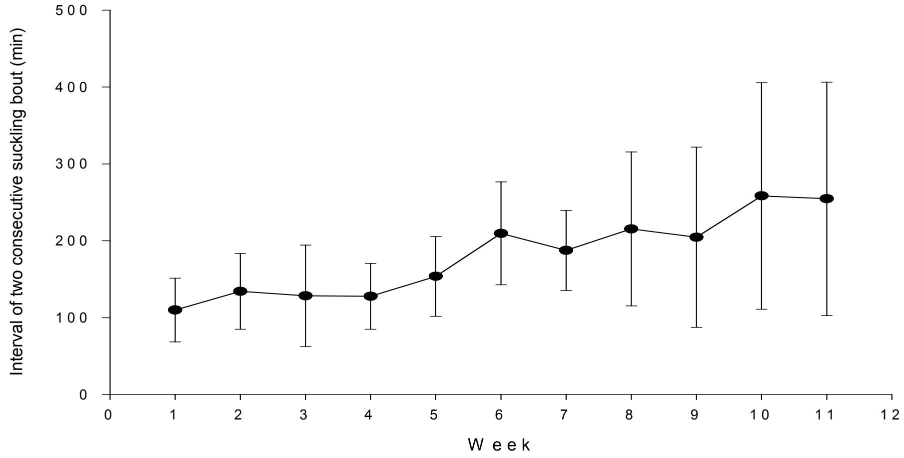

Fig 2. Interval mean of two consecutive suckling bouts of each week in the first 11 weeks of lactation of the saiga antelope (n=6) in a semi-natural condition, 2001

Initiation and termination of suckling

Totally 457 suckling bouts were recorded for the initiator and terminators and their behavior. The calves and their mother usually laid down in a distance from each other in the period of either hiding or aggregation. In first two weeks, calves kept lying lonely for most time, except short periods with mother for suckling, walking and playing. When mothers went back and closed to their calves' hiding sites, they called their calves, then the calves stood up, walked or run to their mother and began suckling. During that period, only mothers were initiators of suckling.

After they rejoined other saigas, both the mothers and the calves could be an initiator of a suckling bout. Mothers were main initiators in the first 10 weeks. In 11th and 12th week, total initiation rate of suckling by calves (68.75% and 58.82%) became more than their mothers (31.25% and 41.18%) (Fig 3).

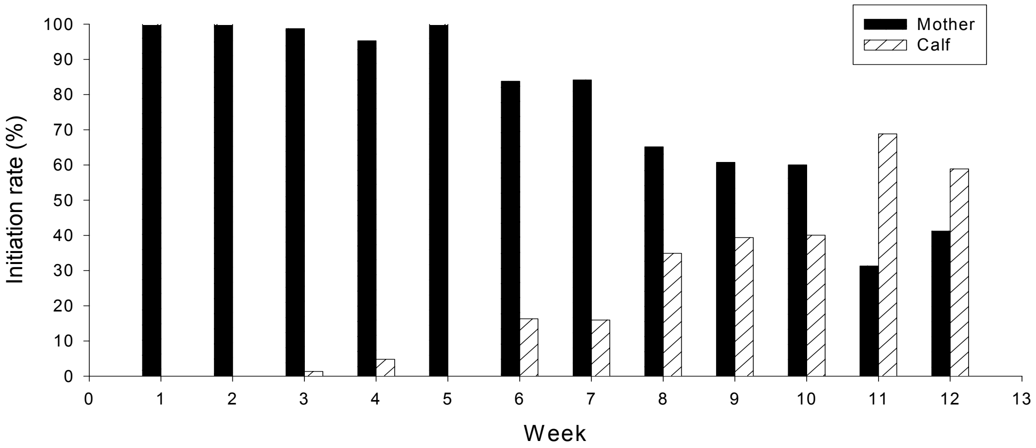

Fig 5. Initiation rate of suckling bouts by mother or calves of the saigas antelope (n=6) in the first 12 weeks of lactation, 2001.

The communication with their offspring or mothers was in several various ways before a suckling bout. The behaviors to initiate a suckling bout that I recorded are defined as following.

Call from mother – The female made sounds of "*mie-mie*" or "*moa-moa*" in the direction to the site that her calf laid. The calf then stood up and walk/run to his/her mother for suckling.

Touch calf's rump – The female walked to her calf and touched its rump by muzzle.

Touch calf's head – The female walked to her calf and touched its head by muzzle.

Touch calf's body – The female walked to her calf and touched its body side or back by muzzle.

Mother walk to her calf – The female walked to the site her calf laid without any another behavior. When the distance is less than 5±2m (n=24), the calf stood up, walked toward the mother and sucked.

Call from calves – The calf stood up and made sounds of "*mie-mie*". The mother then stopped foraging or lying and walked to the calf and started suckling.

Touch mother's belly – The calf walked to its mother and touched her belly for suckling.

Calf walk to its mother – The calf walked to the site that its mother stood or laid without any anther action and began to suck.

Calling from maternal saigas is a main way to the calves as a signal of suckling. When the females and their calves segregated from the herd in the first two weeks, 100% and 97% initiation of a suckling bout was done by mothers using calling. After the females went back to their herd with calves from the 3rd week, in addition to calling, females sometimes walked to the calves and touched them before a suckling bout. However, calling is still the mostly frequent behavior to initiate suckling, above 80% until 9th week. The rate was down to lower than 50% in the 10th-11th week, with no significant difference from other initiation patterns (Chi-square test, $p>0.05$).

In the first five weeks, only 4 suckling bouts were initiated by calves. The rate of requirement for suckling by calves increased from the 6th week by means of making sound to their mothers (from 14% to 50%) or touch mothers' belly (from 36% to 42%). In comparison with the mothers, calves didn't use vocal communication more frequently than touching or walking toward (Chi-square test, $p>0.05$).

Suckling bouts terminated by calves occurred only in the first three weeks of lactation (first week, 24.32%; second week, 4.26%; third week, 2.53%). Then, all suckling was stopped by mothers with walking away.

When the females were in the herd with their calves, other saigas sometimes disturbed their suckling bouts. The disturbance by other calves was observed for 44 times and by adult male saigas for 10 times. Calves approached to the non-mother females that began a suckling and touched her udders, which cause the latter avoided intensively and terminated the suckling for her own calf. Meanwhile, the adult males sometimes walked closely to the females that were suckling with stretching and depressing his neck. The female then avoided body connection with the males by moving away quickly which caused the termination of the suckling.

Vocal communication

During the 12 weeks of lactation, the female used sound of nasal "*mie-mie*" or "*moa-moa*" to communicate with their calves, which is not limited only to occur before suckling bouts. Such sounds, moreover, were not heard of during other observation period.

Maybe caused by different thought about route choice, the herd was separated into two and the eldest female, named Russia, with another three females as well as their children and two adult males, went along an alley over the dune to II-area, while other two female with their calves and the eldest male stayed in I-area. Several minutes later, Russia made sound like "moa-moa" loudly on the other side of the dune. The antelopes in I-area replied with "moa-moa" immediately and began to run along the same alley that Russia used. The sound repeated by two casual teams for three times until they met with each other in II-area. It is the first time that I found the adult females used such sound to communicate with each other. (Observation note taken on July 21, 2001*)*

This was the only time that I found the saigas made vocal communication among adults. In contrast, vocal communication often occurred between the females and their calves. I recorded the situation of individual that made sound and observed that if there were any responds or changes of action by that individual, her calves as well as other adults in order to assume the function of sound made by maternal saigas. Nevertheless, a certain number of vocal communications were too profound to understand and I defined those communications as unknown-communication. Following is the description of those vocal patterns. The words in italic are the status when one was making sound. The sentences after dash are the definition of the status and the response of other saigas to the sounder, and the probable function.

By mother

Moving – Female made sound when the herd was to move. Calves stopping lying, playing or foraging, and followed their mothers. Probable function: moving signal.

Walk toward lambs – After the sound made by female, the calves walked up to the mother and began to suck. Probable function: suckling signal.

Mother beginning to move –The maternal female stopped lying and was to forage lonely out of the herd. No response made by other members. Probable function: uncertain.

Mother return to the site that calves stayed – When the maternal females returned the last site where the calves were rest. Most time, there is no response from other members. Occasionally, lambs stood up, walked close to the mothers, and laid down again. Probable function: uncertain.

Warning – When the females found there was some intruder, e.g. the observer. Lambs and other members stopped their act, and began to move. Probable function: warning signal

By calf

Suckling responding – When the maternal females made suckling signals, calves replied while they walked up to the mother and began to suck. Probable function: suckling response.

Finding their mothers – the calves made sound to find its mother. When mothers responded, a suckling bout often began following the response. Probable function: s*uckling requiring*

Reply – the calves made sound after the sound made by adult females, but no suckling would occur. Probable function: uncertain.

Distance

In the first two weeks of hiding, mother kept a certain distance with their calves for most time, except for reunion periods. Mothers remained a distance of 69±16m (n=40) with their young in the first week. In the 2nd week, the distance decreased to 47±14m (n=37). Difference between those two weeks is significantly (Wilcoxon test, Z=1.97, p<0.001).

In contrast, distance between mother and calf, when reunion, increased with age of calves. The distance increased from 1.5m during the first week after parturition to more than 2.5m in following weeks. When mothers, with calves, returned to their male group from the 3rd week after parturition, the distance increased to 3.4m and didn't vary significantly in following weeks.

The observation also indicated that male calves were found farther away from their mothers than females. They associated more often with other saigas. However, because of the small size of male calves (n=2), no statistical comparison was done for sex-related differences here.

Discussion

Calves made their first attempts to move even in the first week after parturition. Subsequent development was rapid. At the age of 3 weeks, saiga calves had begun to forage. When they were after age of 10 weeks, calves became the main initiators for suckling. Mothers didn't contact with their calves actively.

Suckling Behavior

In mammals, the most obvious parental investment is the resources transferred during lactation, which are more energetically costly than the prenatal costs of gestation (Martin 1984; Clutton-Brock *et al.* 1989).

Lactation is the most obvious way in which the survival of offspring is ensured, since the offspring does not survive if the mother is removed. As reviewed by Clutton-Brock (1991), a close relationship existed between rate of milk intake and survival of young as well as rate of early growth which may affect body size and reproductive success in adulthood. However, lactation increases the energy demands of a female as much as two-fold above normal maintenance needs (Hass, 1990) and may increase their mortality (Clutton-Brock, Albon and Guinness 1989).

The study of Musk deer (Lin *et al*. 1995) showed that average total energy intake of pregnancy female was 50.8% more than unfertilized one, while that of lactation females was about 2.27 (twins) and 1.89 (single) time greater than pregnant female. Hence, the maternal females have to experience a trade-off of maternal care, such as suckling, between the benefit of increasing their reproductive success and cost of reducing the survival or reproductive success in the future.

Estimate of milk obtained by offspring is one of the fundamental measures for parental investment of mammal (Kretzmann *et al* 1993). Because it is difficult to measure milk transferred from mother to offspring in natural or semi-natural situations and consequently behavioral measures of suckling have been used to estimate amount of milk transferred with an assumption that offspring that suckle more obtain more milk (Fletcher 1971). Suckling duration and frequency seem to reflect energy demands of offspring rather than milk transfer from mother to offspring (Birgersson *et al,* 1998). However, such an assumption has recently been questioned and Cameron (1998) in his review of suckling behavior argued that it has inadequate empirical foundation. Every behavior, in general, would cost time and energy of animals, some gain benefit simultaneously, such as feeding while some need executors predict the benefit in the future, such as suckle. The behavior itself seems to be a kind of investment by parents to their offspring. Among the potential benefits of the behavior are higher juvenile growth rates through greater milk availability and shorter intervals between meals (Jensen *et al.* 1999).

In the present study, the correlation between the suckling behavior and actual milk intake of the saigas was not test to measure the maternal investment. The measurement of changes of suckling behavior is intended to indicate changes of relationship between mother and calves.

The first significant difference of suckling duration was between the 3rd-4th week. There were no significant reductions in the first four weeks. The decline became slower from the 10th week. Such a tendency may suggest the gradual adaptation of calves to eating herbage. The earliest browsing/grazing of calves was observed in the second week after birth.

For the Tokara native goats, the mean duration of suckling decreased rapidly from 41s per bout at the 1st week to 20s per bout at the 3rd week, and it was steady at nearly 14s after the 4th week. Bungo (1998) reported the suckling bouts of this species in captivity changed obviously from 27.9s in 1st week to 14.3s in the 3rd week.

Most suckling bouts were both initiated and terminated by maternal saigas, which may suggest that mothers were primarily responsible for determining the suckling duration and intervals according to her secretion of milk. The suckling duration declined obviously from the fourth week, and intervals between two consequent suckling bout enlarged markedly from fifth week after parturition. It suggested that the period of 4th-6th week may be a turn for independency development of the saiga calves.

Clutton-Brock *et al.* (1982) showed in red deer that the proportion of rejection rose from less than 15% during the 2nd week to over 50% by the time the calves were 24 weeks old. Berger (1979) observed that the the proportion of rejection was approximately 58% in the first 100 days. Mothers' rejection and young's attempt to access the udder were considered as one aspect of mother-young conflict.

In present study on the saigas, most rejection by the mothers occurred from the 11th week through the 12th week, which could not represent the conflict obviously. Nevertheless, the decrease of suckling initiation rate by mothers indicated that mothers changed from active to passive for suckling, while calves became more active initiators. This is consistent with Triver's (1974) parent-offspring conflict theory.

Spatial and association variance

In hiders, most behavior of young minimized contact with predators (Geist 1981), as an adaptation. It may most important for mothers to represent a careful arrangement of spatial relations with their young.

In present study, though there is no predation pressure, the saigas still remain their hiding pattern in the first two week postpartum. Mothers associated infrequently with their calves and had short contact periods mostly for suckling. They were primarily responsible for the initiation and maintenance of mother-young proximity. Mothers kept a long distance from the calves most time.

After rejoining other saigas, the distance of young with mothers kept more stable and young didn't keep close to their mothers. Except for suckling, calves preferred to associate and behaviorally coordinate with their peers instead of their mothers or other adult females.

Vocal communication

Vocal communication plays an important role in establishing and maintaining social relationships in many mammalian species (Bradbury and Vehrencamp, 1998 for review). Modalities of communication, including vocal behavior, are particularly important for mediating the strong mother-infant bond during early development in almost all mammalian species. Much vocalization functions to establish and maintain contact between infants and their caregivers, particularly when infants are in need of attention, such as when hungry or vulnerable to harm (Balcombe 1990, 1992, Balcombe and McCracken 1992). Bleat may strengthen bonding between mothers and their lambs (Dwyer *et al.* 1998)

In present study, I recorded the status in which maternal females made sound and the response from calves. In first two weeks calves were separated from their mothers and laid in the hiding sites until the mothers visited them. When maternal females visited their calves, they used sound to call the calves in a distance of 5m around instead of going up to the calves directly. The females continued to use such a kind of communication when they were in the herd with calves. In the first four weeks, more than 95% suckling bouts were initiated after maternal females made sounds to the calves who then walked up to their mother and began sucking. Such initiation pattern was remained at high level until calves reached their age of week 10.

Thompson (1996) found that, in Sable antelope, the presence of maternal vocalizations were also dependent to the age of the calf. Mother vocalized only when her calf could not be located visually. In comparison, this study showed that even when the mother faced to their lambs' lying sites, mother still made sound to initiate the association. This pattern is kept when they rejoined with other saigas.

According to the sound communication occurred in initiating a suckling bout, it was never found that mother or calves made response to the wrong calves or non-mothers. It indicates that the vocal feature may play an important role in recognition for saigas. Vocal communication in particular plays an important role in mediating mother-infant relationships, specifically during contexts of separation, for bovines and more generally ungulate species (reviewed by Albright and Arave, 1997).

In present study, sound was not found made by females in other periods out of lactation season. It indicates an adaptive maternal behavior and a communication pattern to keep relationship of mother and young in saigas. Hence, It may be interesting in the further study to find out if the environment with different predator pressure will influence the vocal communication of the maternal saigas to keep contact with their offspring, which may be helpful to understand the role of vocal signal in maternal care.

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Chapter 6. Hiding Strategy after Birth

Abstract

The saiga antelopes in the wild have hiding strategy for calves when they were born, which may due to predation pressure. If there was no such a pressure in the semi-natural condition, will the saigas do optional choice for birth and hiding sites, or change their hiding behavior? Study was carried out on the hiding behaviors and the factors that may account for hiding behavior, in addition to predator pressure. The results showed that the birth and hiding sites did not scattered with the enclosure. Hiding sites were closer around birth sites in the 1st week after parturition than that in the 2ne week. The saigas like sites with short shrubs as their concealment more than high shrubs or trees. Other factors that may influence hiding strategy of the mothers were disturbance of other saigas, especially adult males, and of human. Meanwhile, the mothers are the main decision makers for moving routes among hiding sites.

Introduction

Form and degree of maternal behaviors in mammals appear to be influenced greatly by habitat conditions and predation (reviewed by Schwede *et al.* 1994). Female ungulates often encounter severe environmental constraints on their ability to conceive, gestate, provision, and rear offspring successfully (Bowyer 1991, Rachlow and Bowyer 1991, 1994). In additional to lactation, another vital care by mothers to their offspring may be in the form of protection from predators, especially in the early growth period that offspring was vulnerable to the predators. It is assumed, in ungulates, that predation has probably played a key role in shaping maternal and social behavior (Lent 1974), resulting in the development of neonatal security strategy for the protection of young: hiding and following (Walther 1965, Geist 1981).

Following young initially stay close to their mother constantly from soon after birth. Hiding young remain lying at some distance from their mother in several days or weeks after birth, and associated with their mother only for suckling and play. Adaptive explanations for the dichotomy in maternal care strategies in ungulates have usually been based on the mode of protecting offspring from predators, assuming a causal link between the ecology of predation and evolution of behavior. Hiding is usually interpreted as a strategy for reducing predation on vulnerable newborns in habitats with dense cover (Lent 1974).

Mothers more often take advantage of the topography or dense cover to hide the infant or lure predators away (Walther 1965). Following has been viewed as a strategy for avoidance of predators in open habitats, because it results in increased infant survival through predator-swamping (Estes and Estes 1979, Rutberg 1987).

In ungulate, 80% species exhibit the hider pattern (Estes 1976). Among them, all species in Antilopini, except Mongolian gazelle, are hiders (Leuthold 1977, reviewed by Schaller 1998). The Saiga antelope is one of those species. The present study area provided us with a condition that there was no predator. Most Saiga Antelopes in this study never met with predator since birth, which means they lived without predator pressure. I hypothesized that maternal saigas under the condition without predators may do optional choice for birth and hiding sites. Hence, this study investigates the hiding behaviors of the saiga antelope in such a specific circumstance and the factors that may account for hiding behavior, in addition to predator pressure. In addition, maternal and young behavior for hiding and reunion is also discussed.

Methodology

Five mother-infant pairs of the saiga antelope at the breeding center were observed from calves' birth to the time they rejoined with other saigas in 2001. Besides, the data of birth sites for five pairs in 2002 were also collected. However, because the enclosure was repaired before the breeding season, those data could not be used into analysis. The herd walked freely in a 27*ha* enclosure and dune covers 27% area in it. A rough vegetation map of the area was constructed in Arcview 3.2 before the observation. The map was gridded, each square representing 10X10m. The area was classified into several categories according to different prime vegetation types (Fig 1).

In 2001, I tracked maternal females and located birth and hiding sites. The distance of birth sites with each hiding sites and of consecutive sites of every mother-infant pair was recorded. The birth and hiding sites were measured by following 4 factors: 1) vegetation height; 2) vegetation coverage; 3) frequency of other antelopes occurring for forage or rest and 4) distance between those sites to the area that human being did activities.

At every birth and hiding site, a circular plot of 1 radius was used with the lying tracks of calves as centers. In a plot, vegetation height was measured at two points respectively along crisscrossed four orientations. Then mean height was calculated for each plot. At the same time, vegetation coverage in those plots was estimated at the height of 0.5m. This height was assumed a bit less than the mean shoulder height of the adult saigas (60-70cm).

I also measured these four factors by using random sampling plots within the enclosure based on the map grids. The number of those samples was decided by using the test of normal distribution.

The behavior of choosing sites and reunion was observed by focal sampling. Every pairs were followed at least for two day time per week after their birth. Because the saigas are vigilant and easy to be affrighted in their hiding periods, it is difficult to follow them all time even in the enclosure. Hence, not all hiding sites were located in the study.

Hiding was defined as a period during which the calf begin to lying down lonely and was spatially separated from their mothers, refer to the definition by Thompson (1996) about the Sable antelope. In each hiding bout, I recorded 1) who stopped first around the lying site, 2) the distance between mother and calf when the calf was lying out (estimated in maternal body lengths, 1 body length = 1.5m). In reunion periods, I recorded 1) what the mother did when she walked close to the lying site of the calves, 2) the posture of the calves when their mothers approach (lying or standing), 3) if the mother approached her calves directly or waited for calves response (to approach) in a distance.

For statistical analysis, T-test was used to compare the difference of vegetation between birth and hiding sites and random sites. At the same time, the degree of correspondence between the observed data and expected values was tested using the *Chi-square goodness-of-fit* test. When measuring difference of distance among birth and hiding sites, Wilcoxon signed rank test was used for comparison between weeks. Individual difference was test by Kruskal-Wallis test.

Result

Behaviors in hiding period

Female Saiga antelope separated from other individuals from one to two days before parturition and rejoined the herd with her calves in two weeks after the birth of calf. The female visited her calf several times during the daytime for suckling. All reunion bouts started from a suckling bout. When the female approached within 10±3m (n=65) of the lying sites of their calves, she stopped, stared in the orientation of the sites, and made sound of “moa-moa” (99%, n=64). As a response, the calves got up in a few seconds, replying its mother with similar but more tender sound and walked or ran up to the female for suckling. The females seldom went straight up to her calf.

After suckling, female walked with her calves away from the last hiding site and walked for a while. On 25 occasions (38%), the calves laid down after the mother stopped at some sites. On rest occasion (62%), the calves stopped at the lying sites before their mothers. After stopped around the lying sites, the calf laid down beside its mother (n=29, 45%) or at a distance of 1-5m from the mother (n=36, 55%). The mother then left her calf and went away. In lying out periods, I found only in two occasions that the calves changed their hiding site around within 50 m.

When lying out, mothers remained longer distance with their young in the first week (69±16m, n=40), and decreased distances in week 2 (47±14m, n=37) (Wilcoxon test, Z=1.97, $p<0.001$).

Choice of birth and hiding site

Totally 5 birth sites and 65 hiding sites were located in the present study (Fig 2). The distance between birth and hiding sites may indicate whether the calves would remain closely around the birth sites in their hiding periods or they would move to other area. It showed that hiding sites located closer around the birth sites in the first week than that in the 2nd week after parturition, except for F2 and her calf.

F2 and her calf had a longest distance from the birth site to all their hiding sites (516±60m in the first week, and 424±92m in the second week). The distance decreased in the second week. According to the Fig2b, it showed that after birth, the calf moved long into another section and then they spent their following hiding periods there. Such long moving distance may be caused by some unobserved disturbance. Given such results, F2’s data didn’t be included when difference was measured between individuals in Table 1.

The hiding-site locations were not the same one between two consecutive hiding periods. Both distance between birth and hiding sites, and between consecutive hiding sites was longer in the 2nd week than that in the 1st week of hiding period (Table 1). However, the significant difference occurs only in distance of birth and hiding sites of F1, F3 and F5 between two weeks. Meanwhile, the difference between individuals was not significant.

Table 1. Mean distance between birth and hiding sites, consecutive hiding sites, and between each birth sites.

Female	Mean distance between birth and hiding sites (m)		Dif. Between two week[a]	Mean distance between consecutive hiding sites (m)		Dif. Between two week[a]	Mean distance between birth site (m)
	Week1	Week2	*Z*	Week1	Week2	*Z*	
F1	57±21	168±59	**-2.20***	25±11	135±73	-1.83	333±168
F2	516±60[c]	424±92 [c]	1.74	45±15	128±52	-1.60	403±231
F3	70±41	258±114	**-2.37***	23±14	108±78	-1.83	357±206
F4	55±28	142±59	-1.82	28±9	153±15	-1.07	333±195
F5	113±27	247±153	**-1.99***	25±11	91±24	-1.60	433±189
Individual Dif.[b]	8.27	4.82		6.32	1.41		1.08

a. Wilcoxon signed rank test (Z)

b. Kruskal Wallis Test (Chi-square)

c. This data set of F2 was not used in comparison between individuals.

* p<0.05, **p<0.01

The twins of F1 did not lie at the same site in hiding periods, but they were usually in the same section. However, the data of them is too small (totally n=15) to make significant comparison in this study.

Between dune and plain, only F5 like to hide in the dune (n=8, 67%) more than in plain (n=4, 33%). Other four pairs chose the sites in the plain over 70% (F1: 86%, F2: 92%, F3: 94%, F4: 72%).

Saigas did not select sites with higher vegetation and coverage for birth or hiding. The height and coverage of hiding sites were lower and less than those of random sites (T-test: coverage, t=-8.123, p=0.000, N_h=100, N_c=100). However, it does not indicate that calves did not need any cover to hide their selves. The calves more often laid beside some low shrub on one side. Maternal females avoided areas that other saigas used to forage and rest though the height and coverage of those areas were higher than other sites (Chi-square =27.95, p<0.01).

In the enclosure, there are 6 vegetation types, named by the Family name that the primary species belongs to. Those types are: 1) Leguminosae, 2) Compositae, 3) Caragana and Stipa, 4) Halloxylon, 5) Stipa and Leguminosae, and 6) Medicago. There was difference between each pair (Fig 3). F1 pair located most in Stipa, followed by Compositae type. F2 pair chose Compositae mostly. F3's calf hided mostly in Compositae and Leguminosae, so did F4. F5 and her calf were special in comparison with others. They chose Halloxylon on dune mostly, and didn't hide in Compositae. When excluding the F5 and her calf, the order of the vegetation types that other four pairs prefer for hiding sites is: Compositae (43%), Leguminosae (17%), Halloxylon and Stipa/Leguminosae (13%), Caragana/Stipa (9%), and last Medicago (4%) (Chi-square = 24.82, p<0.01).

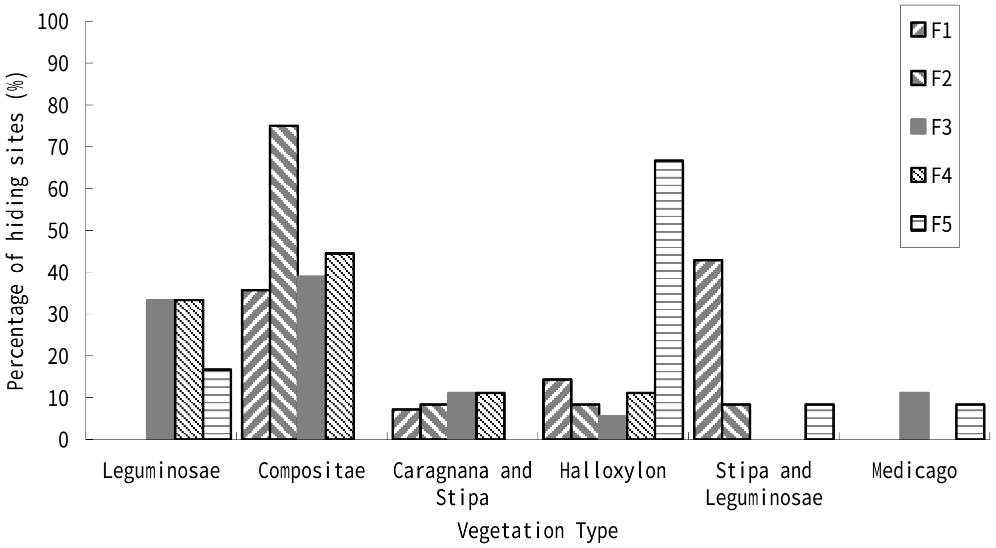


Fig 3. Percentage of hiding sites of every saiga pair in 6 vegetation types in the breeding center in 2001.

71.79% of hiding sites were located in the area that the occurrence of other saiga antelopes during forage or rest was less than 5%. The selected birth or hiding sites were further away from the area human activities existed. Most sites were in the northern or northwestern area near the fringe of the farm, while human activities were mostly in the southern end of the farm (Chi-square =9.37, p<0.05).

While lying, if other animals or people were close to them, the calves kept motionless and did not flee immediately until the ‘intruder’ is within less than 5-10m to it, although the distance probably depends on the running speed and the age of the calves.

For 4 occasions, I appeared near the females with their calves, the mother immediately run away with a high leap at the beginning of a flight while the calf remained lying down quietly. These occasions occurred when they were 1-3 days of age. From the age of more than 3 days, the calves could flight with their mothers.

Discussion

Hiding behavior

In hiders, the survival of young depends on coordinated behavioral patterns between the infant and its mother (Lent 1974). Geist (1981) suggested that all behavioral adaptations of young minimize contact with predators. The infant plays an active role in determining the resting sites by wandering away from its mother and lying down (reviewed by Thompson, 1996). Furthermore, when Schwede *et al.* (1994) reviewed the hiding behavior, they mentioned that the mother may guide the young to new lying sites. The results of this study showed that both the mother and calves could make decision on the lying sites. However, because the calves followed their mothers while walking in reunion periods, it assumed that the mothers are the main decision makers for moving routes among hiding sites.

Though calves separated from mothers for most of the time throughout the day, maternal females seemed to keep at a short distance (less than 50m) from the hiding sites of calves. Females remaining at or near the birth site may represent an anti-predator strategy. Female moose are nearby to defend their young from predators, although such defense is not always successful (Bowyer *et al.* 1998a).

Because vocalizations may risk attracting the attention of nearby predators, it assumed that their use should be reserved for instances when mothers had difficulty finding their infants. The sable antelopes, Thompson (1996) reported that the mothers rarely vocalized if they could locate their calves visually. However, saigas in present study seem to like using vocal communication with their calves, no matter whether they could orient their infants or not. When they accessed hiding sites, the mothers didn’t approach their calves directly, but bleating near the sites until the calves stand up.

Features of birth and hiding sites

Pattern of maternal behavior should be affected by varying environmental conditions. The process of isolation of the female from the herd during parturition has been described for various species of wild and domestic ungulates (review by Langbein *et al*. 1998). And females change their pattern of maternal behavior to cope with different environment (Rachlow *et al*. 1994), such as study on cattles (Lidfors *et al.* 1994). There are large individual differences in calving behavior. In the observation on dairy Finn cattle kept in a 20ha forest area, Lidfors *et al.* (1994) found some (6/7 and 3/7), but not all, of the cows isolated themselves before calving.

Recently, Fisher *et al.* (2002) reviewed the explanations of the dichotomy based on anti-predator adaptations. The traditional hypothesis for this behavior strategy are: 1) following infants in open habitat may mitigate predation pressure or harassment from conspecifics in areas lacking cover, 2) Large-bodied species may favor following strategy because of effective maternal defense in these species, and 3) Following is adaptive in the young of more gregarious species because of increasing group vigilance. In addition, Fisher et al. (2002) also gave the fourth hypothesis that a hiding strategy may allow infant to maximize their growth rate and minimize their age at weaning. Some temperate hider species like fallow deer, *Dama dama*, had rapidly developing young with a short hiding phase and may be able to swamp their predators effectively (Braza, San Jose and Blom, 1988), especially as these species also aggregate.

According to predator pressure, because of the higher vulnerability of the mother in the period of peripartum, and the risk of predation for the calf just after birth, it is advantageous for the female to leave the herd prior to parturition and search for a place which offers shelter from predators and a good view over surrounding areas (red deer Clutton-Brock *et al.* 1982, bighorn sheep – Shackleton & Haywood 1985, ibex – Alados & Escos 1988, Bon *et al.* 1995).

The tendency to withdraw from the herd seems to be more pronounced in ungulates (wild and domestic) living in woody habitats than in animals in open grasslands where special places that offer more shelter are often not available. In these habitats, spatial proximity to other herd members seems to be the best protection for the mother and her new-born kid (reviewed by Langbein 1998). On the other hand, spatial position influences the probability of calf death from predation (through predator-swamping) and disease. It is assumed that aggregation at the time of birth is a predator-swamping mechanism (Milner-Gulland 2001).

Saiga antelopes show both temporal and spatial clustering of births. They gather in spring in areas where there is good pasture, accessible water and minimal disturbance (Bekenov *et al.* 1998). They form large temporary aggregation to migration to the calving sites. However, Zhirnov (1998) reported hiding behavior in the wild. In present study in a semi-natural condition, the saigas also exhibited solitarily after giving birth. Furthermore, their selection of birth and hiding sites is not as optional as the hypothesis at beginning. The hiding sites did not scattered with the enclosure. Both the measurement on concealment height and coverage, and highest percentage of hiding sites in Compositae type indicate that the saigas like land with short shrubs as their concealment more than high shrubs or trees. Meanwhile, saigas may prefer concealment on one side to that all around it. Tall and dense vegetation around the animals may not only block off the predators sight, but the hiders' sight as well.

Saiga antelopes in this farm were usually out of their main foraging area (categorized into Medicago type), when they selected hiding sites for their offspring or when they were with the calves. They seemed to avoid other individuals, especially the adult males. When the adult males met the females by chance in the first two weeks of lactation, they often chased the females or walked up to them with lower head and jerky steps, which caused the females to walk or run aside immediately. In consequence, if the maternal females were suckling their calves, they ceased the course immediately and would not continue suckling in a short time.

Besides avoiding predators, several hypotheses have been proposed to explain why the females isolate themselves from the herd during that time. Just before parturition, the social index of pregnant sheep seems to decrease dramatically. This asocial trend, often accompanied by an increasing level of aggressiveness toward the young from last year and other sheep in the herd (Briedermann 1992), continues during the first week after lambing (Poindron *et al*. 1994, Langbein 1998). The result of this study may support that hypothesis. Other calves may also be a disturbance factor that the females tend to avoid. When a female suckled her own calf, other calf sometimes tried to suck from that female too, and that caused the suckling female to walk forward immediately and cease the suckling. In addition, the recognizing of mother with her calves may be one benefit from separating her calves in the first short period post-partum, before rejoin into her group. Ewes may normally care for only their own calves.

Even in such a predictable environment without the pressure of predation, maternal saigas were apt to select birth and hiding sites out of forage area, though it may cost energy and time walking between those sites. It seems that saigas attempted to avoid disturbance of other member of the herd, especially adult males, and of human, in that most activities of the latter two occurred in the areas covered by *Medicago sativa L.*, main food for saigas. The choice of hiding site may not be a simple response of maternal females to the present environment, but the instinct is inherited from their ancestor that reflected adaptation of previous environment. I suggest that it is necessary to track for more than one generation so as to find out whether the site choices of mothers have more influence than the present environment to the female offspring

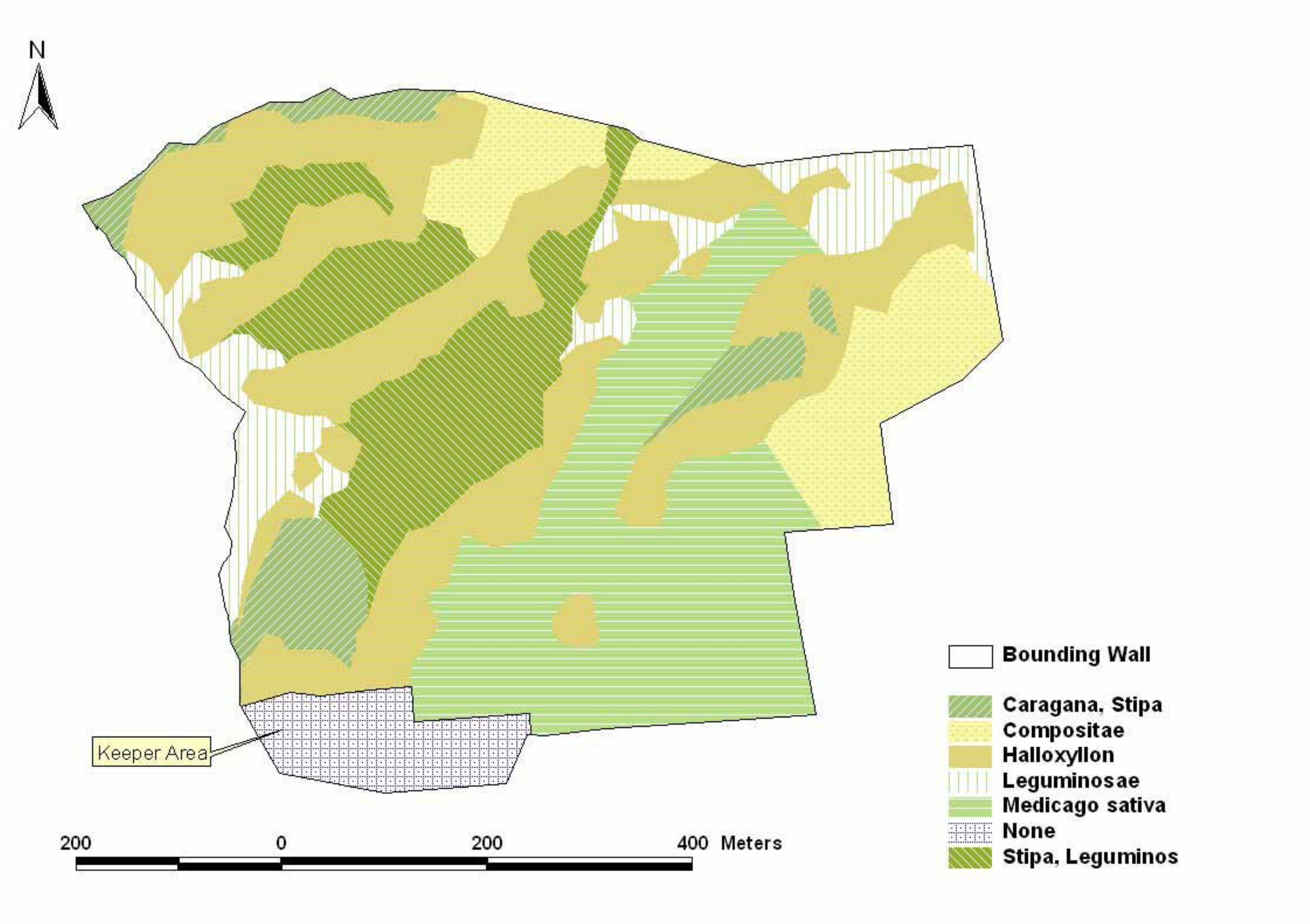
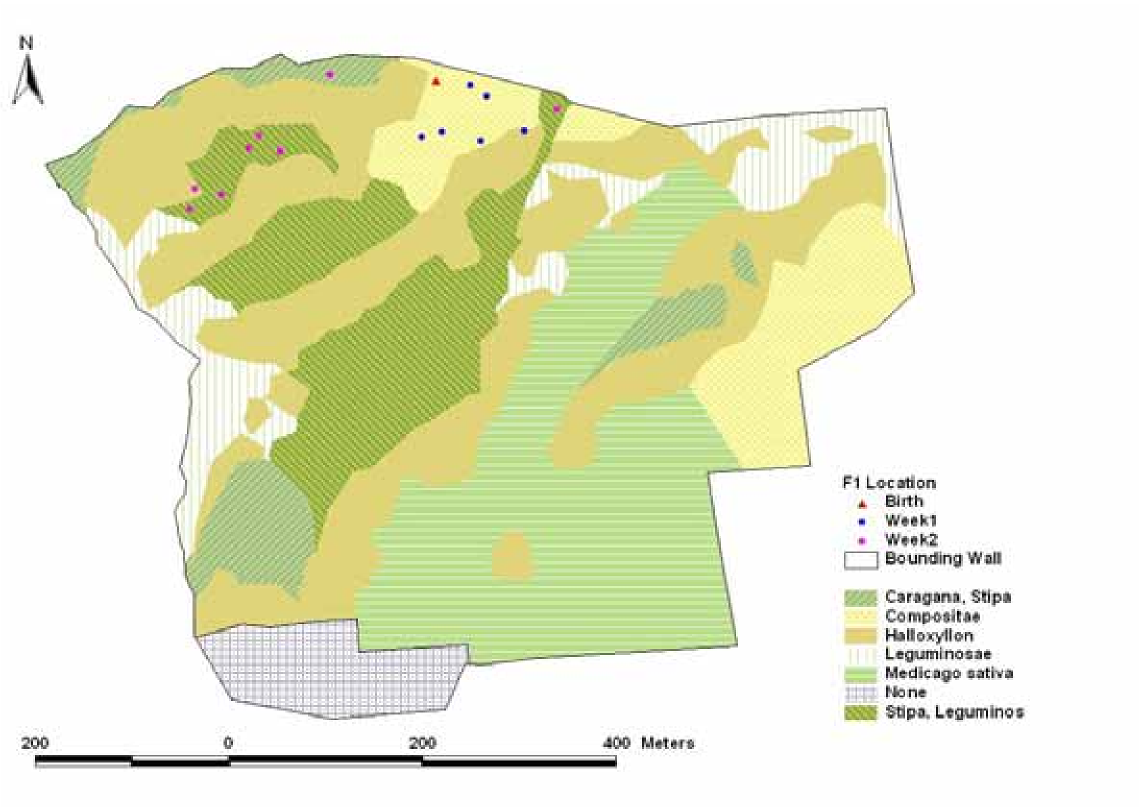
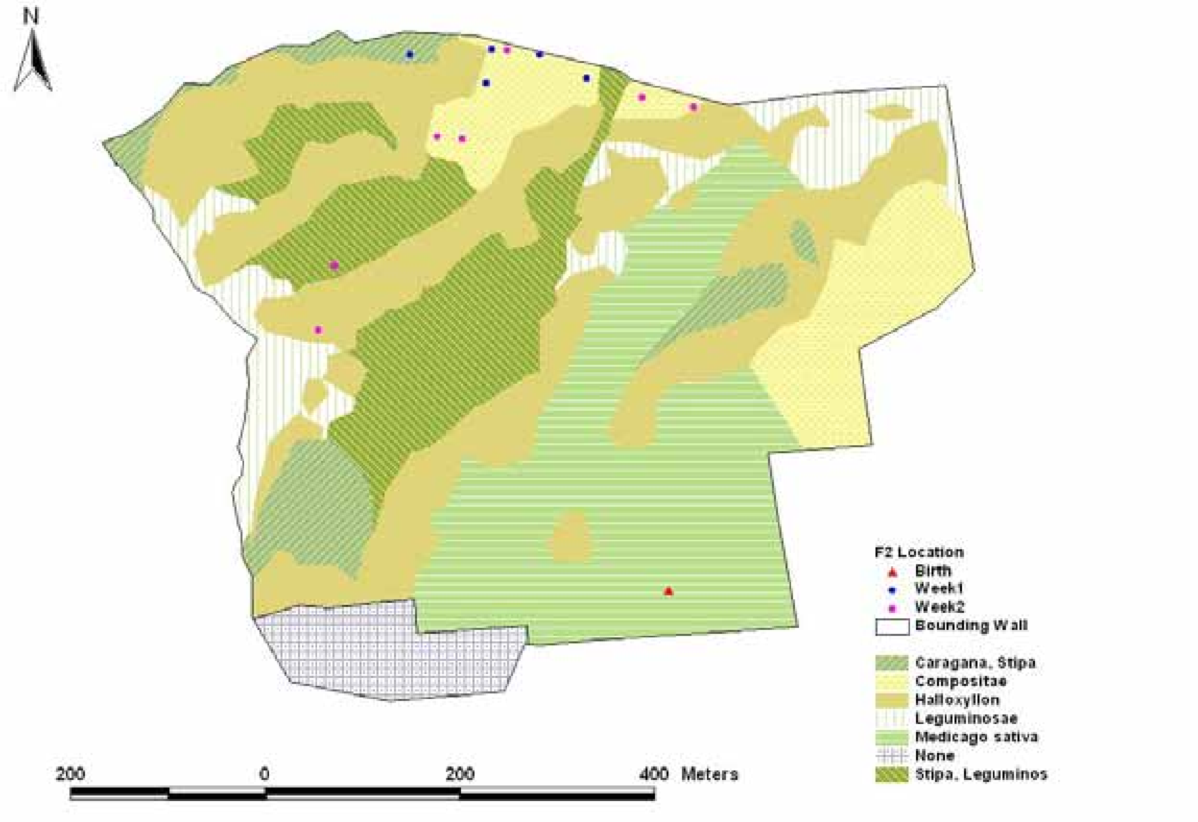


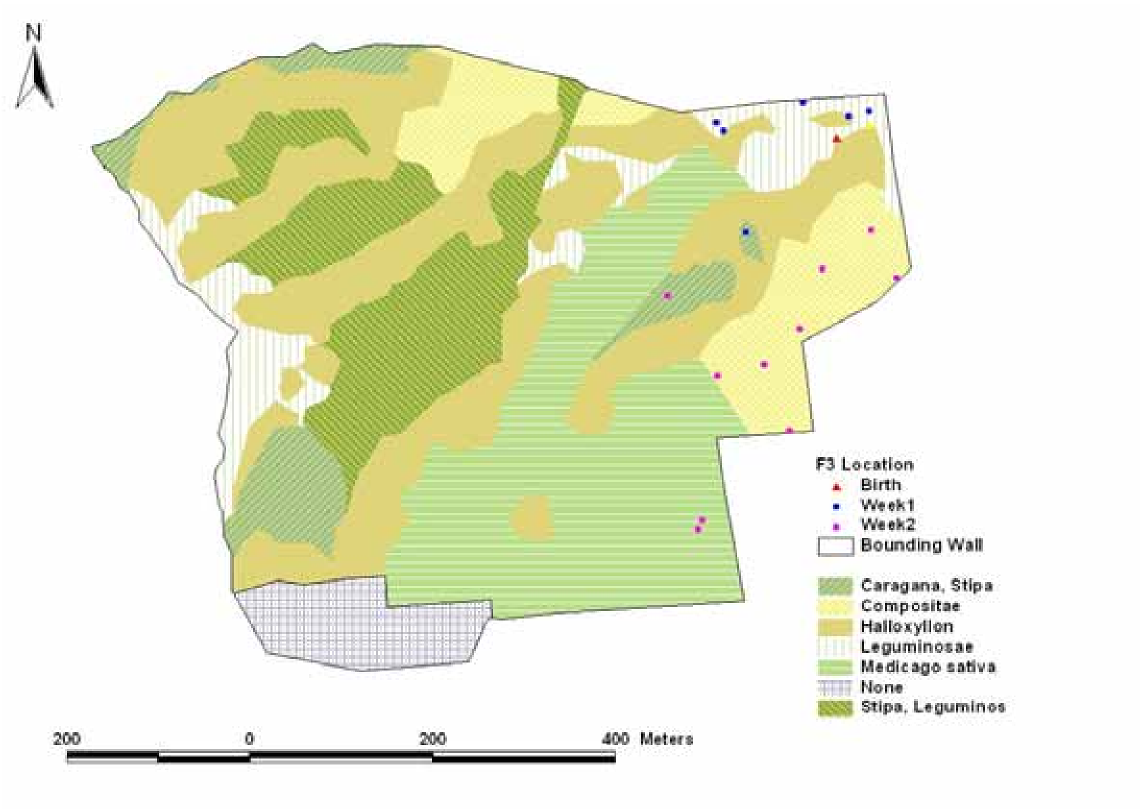
Fig 1. Vegetation map of the Siaga Enclosure in Wuwei Wildlife Breeding Center.



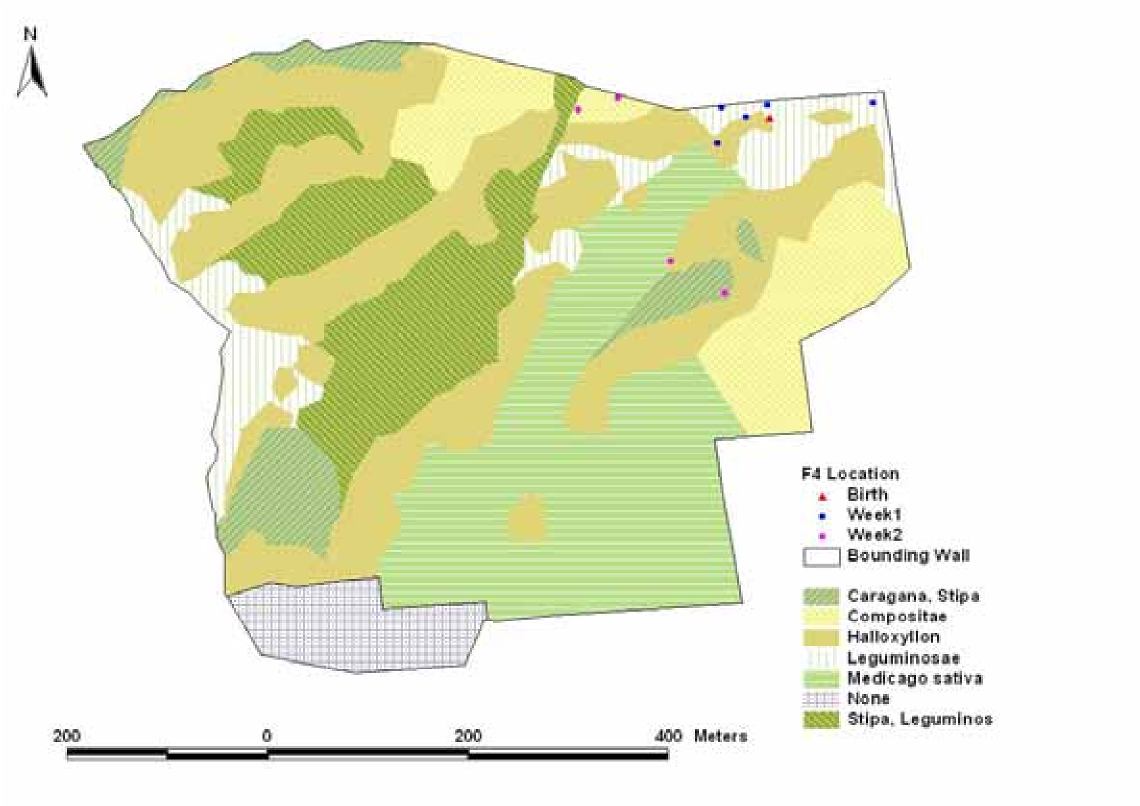
a. The birth and hiding sites of F1 twins (one male and one female).



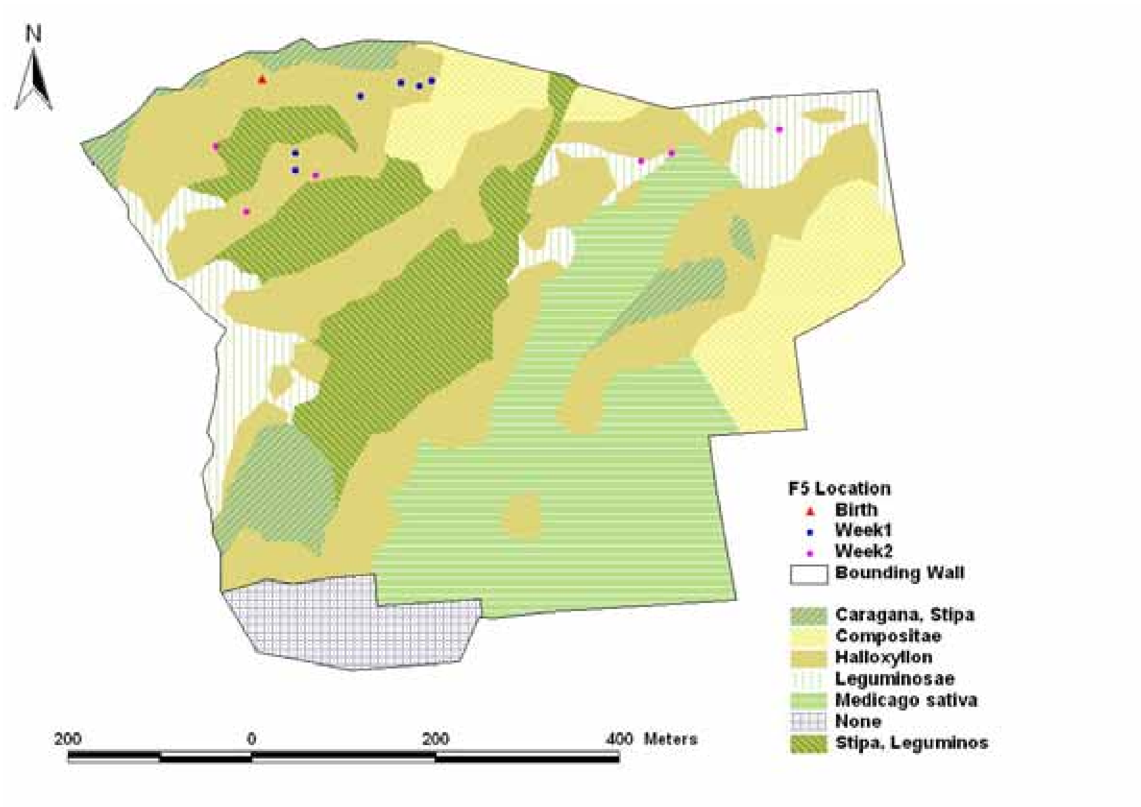
b. The birth and hiding sites of F2 calf.



c. The birth and hiding sites of F3 calf



d. The birth and hiding sites of F4 calf.



e. The birth and hiding sites of F5 calf.

Fig 2. The birth and hiding sites of five saiga pairs in 2001 in Wuwei Wildlife Breeding Center, Gansu.

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Chapter 7. Vigilance Behavior in Maternal Females

Abstract

Considered as one of important behavior patterns for detecting predator, vigilance of female saigas in lactation period was measured in present study. The duration of vigilance during foraging changes from 6 ± 6sec (n=256) in the first week of to 1 ± 1sec (n=48) in the twelfth week of lactation, while the frequency changes from 2.98 ± 1.40per min (n=101) to 0.14 ± 0.19per min (n=32). At the same time, those two parameters were also measured in four conditions (foraging lonely, foraging in herd without lamb, walking alone and walking with lambs). The results showed that female saigas changed their vigilance behavior with the growth of calves. Females with active juveniles or walking lonely were more vigilant. The significant difference of duration and frequency were not coincident with each other.

Introduction

Vigilance is considered as an important means of detecting predator in animals or of regulating social interactions (Zhang 1996). It is not mutually exclusive with foraging, but it generally is with food searching and handling. Illius and FitzGibbon (1994) assumed that herbivores tend to experience a trade-off between vigilance and foraging, unless plant density and biomass are high and food intake is limited only by processing rates. A more vigilant individual may be safer, but excessive vigilance may also bring an unnecessary loss of foraging opportunities (reviewed in Elgar 1989, Frid 1997). Hence, the requirement to balance the requirement of obtaining a nutritious diet and avoiding risk of predation has been well documented for ungulates (Bowyer *et al.* 1999).

As one of the most important means to detect potential threats, vigilance associated with maternal care. Mothers may expend time and energy additionally in being vigilant on potential predators to protect their offspring, which may add to the overall cost of maternal activities since resting/foraging time in particular, may be reduced. The female moose with fawns were more vigilant than those without fawns as well as adult males (Molver *et al.*, 1994). In red deer, the hinds are intensely vigilant when the calves are standing up (Clutton-Brock, 1982). Such increase was also found in Chinese water deer after fawning (Zhang, 1999). Hence, maternal females need, both for themselves and their offspring, to balance the requirement of obtaining a nutritious diet and avoiding risk of predation.

In the present study, I measured the change of vigilance that maternal females spent during foraging from one week before parturition to the 12th week after giving birth. The frequency and duration of vigilance, as two indexes for the change in vigilance behavior of the maternal females, were measured and tested if those two indexes indicated same changes, given that the changes of frequency and duration may be two different patterns for the females to change their vigilance behavior.

Meanwhile, though the maternal saigas separated from the herd in the first two weeks of lactation and locomoted alone, they were with their lambs for suckling several times per day or foraging with other saigas occasionally. Hence, I compared the vigilance behavior of maternal saigas under four conditions, including walking with lamb, walking without lambs, foraging alone and foraging in the herd, to determine when the maternal female would exhibit more alert.

Methodology

In present study, vigilance behavior was defined as: the saiga antelopes were vigilant if they interrupted food searching, food handling or walking to stand with raising head, erecting ears and gazing around.

In the first two week after giving birth, I record the vigilance behavior of saigas under following four conditions:

Forag alone – the female foraged alone without the lambs and out of the herd.
Forag in the herd without lamb – the female foraged in the herd without lamb
Walk without lamb – the females walked from forage site to the site that her lamb laid.
Walk with lamb – the female walked with her lamb from one site to another of hiding.

From the third week, the maternal females rejoined into the herd and most vigilance occurred when they were foraging.

The focal subjects were followed for 5 minutes in each bout, in which duration and frequency of each vigilance bout was recorded. From these records, which were timed to the nearest second, I calculated the proportion of observation time that saigas spent vigilant. In respect that maternal females locomoted alone in the first two weeks after giving birth, I was able to follow one female during each day of observation. Hence, I recorded the vigilance of every female in turn so as to avoid bias among individuals. When observing the vigilance of saigas in herd, I also selected the focal animals in turn. The period that I collected the data of vigilance was from the last week before parturition (named as Week-0 infra, and in figures as well as tables) to the 12th week (named as week1-12) after parturition in 2001. The data from August, Octobet-December 2003 was also used for comparison.

Kruskal-Wallis ANOVA test was used to examine the variation of vigilance in foraging by weeks. Once it is determined that differences exist among the mean, multiple comparison test was used to determine which mean differ from others at an alpha level of 0.05. To compare the difference in the four categorized conditions by pair, I used the *Wilcoxon Signed-rank Z test* of non-parameter.

Result

Vigilance during foraging

Before calving, the females alerted occupied approximately 8.10±9.86% (n=52) time when they were foraging. After calving, the percentage increased to 27.61±16.22% (n=101) in the first week of lactation, then it decreased quickly to 7.13±6.75% (n=19) in the third week of lactation when maternal females rejoined into the herd with their lambs. Until the lambs were at age of twelve weeks, the percentage declined to 0.39±0.58% (n=32), far less than the first week. The proportion of vigilance in forage in the first and second week of lactation is significantly higher than the following weeks.

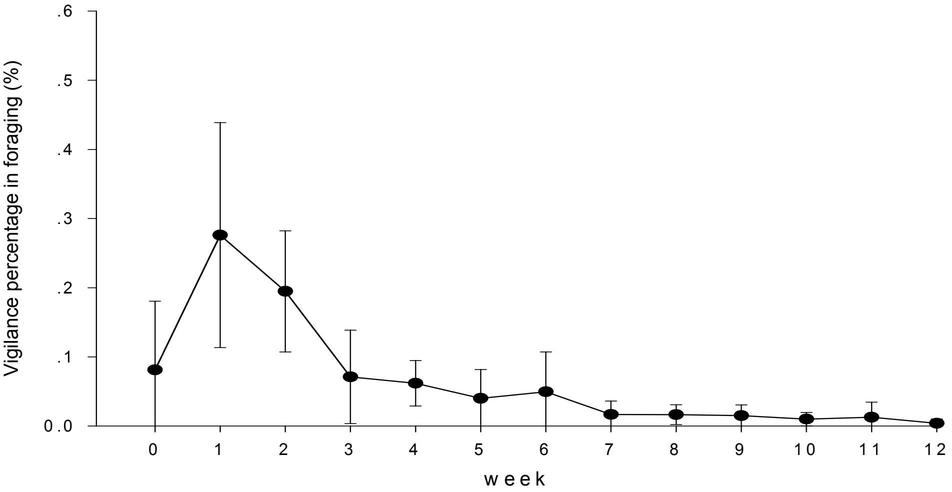

Fig 1. Vigilance proportion of female Saiga Antelopes during forage in the last week before lamb birth and 12 weeks after lamb birth. In the “week” axe, 0 represents the week before lamb birth.

The vigilance duration of maternal saigas in foraging declined significantly from the week before parturition to the 12th week of lactation (Kruskal-Wallis test, chi-square=8.248, d.f.=12, $p<0.01$). The frequency of vigilance of maternal females during foraging indicates a similar fluctuation (Kruskal-Wallis test, chi-square=289.81, d.f.= 12, $p<0.01$) around the parturition to the proportion of time they spent on vigilance. On the other hand, the changes of vigilance frequency (Fig 3) differ from that of vigilance duration of one week before parturition to the third week of lactation.

Though it took longer time for females to detect around warily in a vigilance bout in the week before parturition, the frequency of vigilance (0.50±0.31/min, n=52) is less than that of first 6 weeks of lactation. The frequency of vigilance was more than 2.5 per minute when the lambs were 1 and 2 weeks old, and it decreased rapidly to about once per minute (Table 1).

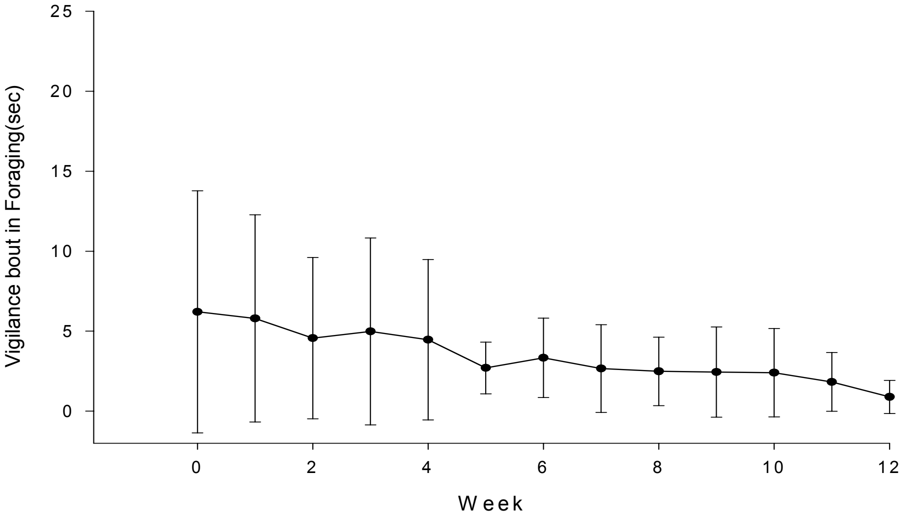

Fig 2. Vigilance duration (sec) of maternal female Saiga Antelopes during forage in the week before lamb birth and 12 weeks after lamb birth. In the "week" axe, 0 represents the week before lamb birth.

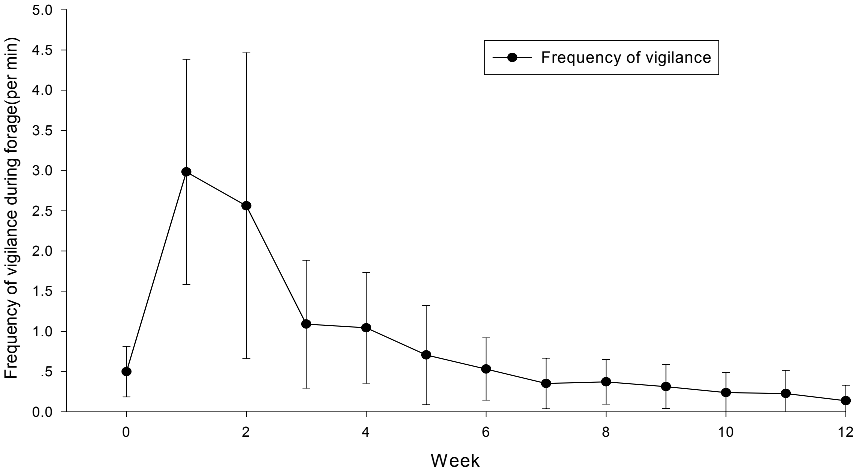

Fig 3. Vigilance frequency (per min) female Saiga Antelopes during forage in the week before lamb birth and 12 weeks after lamb birth. In the "week" axe, 0 represents the week before lamb birth.

Table 1. Mean of vigilance duration and frequency of female Saiga Antelopes during forage in the week before lamb birth (named as Week 0) and 12 weeks after parturition.

	Frequency (per min)			Duration (sec)		
Week	N	Mean	Std.	N	Mean	S.D.
0	52	.50	0.31	175	6**	8
1	101	2.98**	1.40	256	5	6
2	44	2.56**	1.90	149	5	5
3	19	1.09	0.79	182	5	6
4	11	1.04	0.69	91	4	5
5	16	.71	0.61	49	2	2
6	23	.53	0.39	69	3	2
7	46	.35	0.32	96	3	3
8	32	.37	0.28	68	2	2
9	26	.31	0.27	34	2	3
10	21	.24	0.25	32	2	3
11	22	.23	0.28	26	1	2
12	32	.14	0.19	48	1	1

* ** Frequency or duration of the week is significant difference from that of other weeks (Wilcoxon signed-rank test, * $p<0.05$; ** $p<0.01$).

Vigilance difference in various conditions in the first two weeks

In the first two weeks just after giving birth, the females segregated from the herd and locomoted lonely. They visited their lambs several times for suckling and then walked with the lambs for a while until they found other hiding sites. The vigilance occurred mainly under four categorized conditions, including foraging lonely, foraging in herd without lamb, walking alone and walking with lambs, as defined above, during that period.

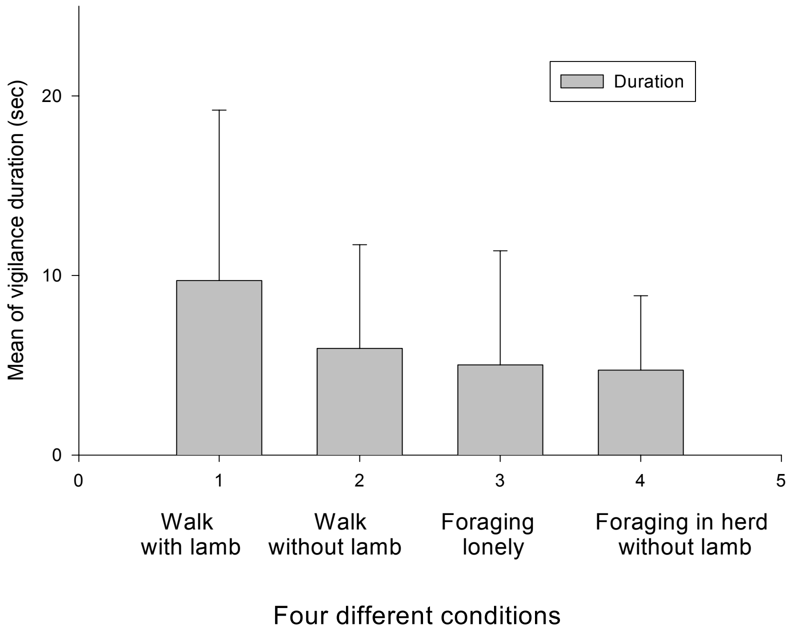

Fig 5. Mean of vigilance duration (sec) of female Saiga Antelopes when they locomoted under four categorized conditions during the first two weeks after birth.

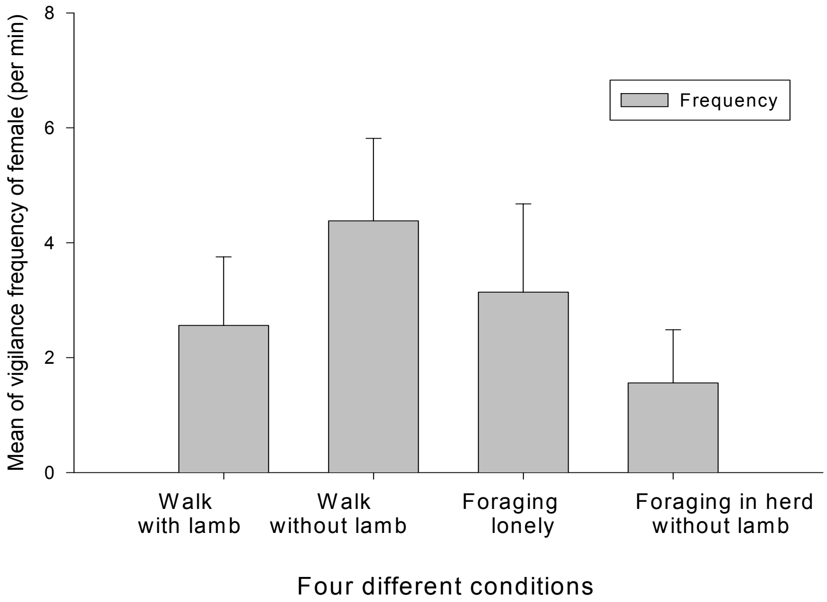

Fig 6. Mean of vigilance frequency (per min) of female Saiga Antelopes when they locomoted under four different conditions during the first two weeks after birth.

On their way reaching their lambs, an action that may expose the hiding site of their lambs under the potential threat, females behaved with great vigilance with frequent stops and gazing around. Under such a condition, the percentage of vigilance was 32±17% with maximum up to 87% (Fig 4). In addition, when they were walking with their lambs and hence exposing their lambs, the maternal females were intensely vigilant and spent 30 ± 20% of time gazing around.

Both the duration and frequency of vigilance that females displayed differed among the four conditions, whereas the significant differences are not coincident with each other (Table 2). Females tended to stop and look around most frequently while she walked lonely to the site that lambs hided (4 ±1/min), and on a lesser degree, while she fed lonely (3 ±1 per min) (Fig 6). By contraries, the time that female spent vigilant while she walked with her lamb was longest (8±8 sec) among the four conditions, followed by that she spent walking lonely (5 ± 6 sec) (Fig 5). The females became comparatively easier while she was in the herd regardless of whether the lamb was with her. As a result, the vigilance duration under that condition was shortest and frequency lowest.

Table 2. Paired-comparison of duration and frequency of vigilance by maternal females under four different conditions (Wilcoxon Signed Ranks *Z* test).

	Frequency (*Z*)	Duration (*Z*)
1. female walked with her lamb - female walked without lamb	-2.134*	-0.741
2. female walked with her lamb – female foraging lonely	-3.059*	-4.790**
3. female walked with her lamb – female foraging in herd without lamb	-1.362	-1.867
4 female walked without lamb – female foraging lonely	-2.666*	-1.348
5. female walked without lamb – female foraging in herd without lamb	-3.139*	-1.610
6. female foraging lonely – female foraging in herd without lamb.	-1.337	-0.152

* p<0.05; ** p<0.01

Discussion

Vigilance is thought to be largely controlled by the threat of predation on foragers, and has been shown to increase with increasing predation risk (Edmunds 1974). As the gut is usually constantly full in ungulates, hunger is probably not an important factor influencing vigilance (Zhang, 1996).

Molvar *et al.* (1994) found that adult female moose with young spend more time in alert-alarm postures than do adult females without young and suggested that predation risk plays an important role in the foraging behavior of moose. In red deer, most females are alert for approximately 20% of time spent foraging before calving. After calving, the percentage increases to about 70% when they are accompanied by standing calves in the first twenty days after birth (Clutton-Brock *et al.* 1982). In present study, the time maternal saigas spent on vigilance while forage in the first week of lactation was three times as much as that in the week before parturition.

I used duration and frequency of vigilance respectively as indexes to measure the changes in vigilance behavior, which, however, did not show coincidence in changes. The duration of a vigilance bout declined gradually from the week before parturition to the 12th week after parturition, while the highest frequency of vigilance appeared in the first and second weeks after the birth of lamb. The difference between those two indexes also appears when comparing vigilance variation of maternal females under four categorized conditions in the first two weeks after parturition.

The percentage of vigilance is calculated using duration per bout timed by frequency during observation, and therefore it combines the frequency and duration to indicate the fluctuation of vigilance proportion maternal saigas spent in forage around the parturition and during 12 weeks of lactation. The higher frequency of vigilance during first two weeks of lactation results in the significantly higher proportion of time females spent on vigilance, though the duration of vigilance in that period does not differ significantly from the following weeks.

I assumed that frequent head up may increase the rate of detecting the surroundings, while it doesn’t occupy much of foraging time. However, it decreases the details that could be detected per vigilance. On the other hand, the animals may detect the environment more clearly during a long vigilance, which may cause decrease of time on forage. Hence, to increase the frequency or lengthen the duration of vigilance is different pattern for maternal females to make effective detection on the surroundings and selection of one pattern may depend on forage quality, activities they did and pressure of predation. In the first two weeks of lactation, the proportion of time that maternal females spent on alert was more than that in the week before parturition by increasing frequency of vigilance while the duration decreased slightly.

Rather than moving continuously through the environment, many animals interrupt their locomotion with frequent brief pauses. One potential benefit of pausing is increased detection of prey, and this form of locomotion is often called pause-travel search, stop-and-go search or salutatory search (Andersson 1981, O'Brien et al. 1990). A second potential benefit of pausing is reduced attack rate by predators. Foraging animals spend as much as 60% of their time with their heads raised to scan for predators (Andrew *et al.* 1998). When the female saiga was about to visit her lamb and close to the hiding site of her lamb, she was very cautious with frequent stop on her way there to look around for predators. In contrary, she left the lamb quickly without hesitation. There existed a conflict for females between approaching her lamb to suckle and avoiding revealing the hiding site of her lamb to predators, and that resulted in frequent vigilance when she approached her lamb.

The analyses revealed that females with active juveniles were more vigilant, and as a consequence spent less time foraging, than those with inactive young; vigilance of females without attendant young was intermediate. These results support that mothers adjust vigilance when young are inactive to compensate for the loss of foraging opportunities during periods of neonate activity, thereby reducing juvenile vulnerability and increasing the overall foraging rate (White and Berger 2001).

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