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Study of the Musk Deer Population Structure in Sikhote-Alin Reserve

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ABSTRACT

Research on population structure and behavior of musk deer has been conducted on defined areas within Sikhote-Alin Reserve (Russian Far East) since 1974 using a combination of techniques (snowtracking, visual observation, and radiotracking since 2012). We have acquired previously unknown data on the structure of the overall population and sub-groups, home range size, sex and age-related differences in habitat use, inheritance of home ranges and territories between generations, mechanisms regulating distribution of individuals and population structure. This knowledge is extremely valuable in understanding recent population declines of musk deer associated with habitat destruction, unregulated hunting and natural cycles in population size.

Introduction

The main habitats of musk deer (*Moschus moschiferus*) are confined to mountain taiga forests with notable presence of dark coniferous species. Musk deer feeds on over 150 species of plants; however a significant part of its diet consists of epiphytic foliose lichen of Parmeliceae family (*Usnea*, *Evernia*, *Bryoria* etc.) which influences the distribution of the population (Zaitsev, 1991, 2006). Musk deer is of great importance in the functioning of ecological relationships with predators (lynx *Lynx lynx*, yellow-throated marten *Martes flavigula*), endo- and ectoparasites, and scavengers.

Ecological relationship with mountain taiga determines the decline of musk deer population due to reduction and transformation of coniferous forests by man and also due to extensive fires. Unregulated hunting and illegal trade in derivatives with the Asia–Pacific region countries which intensified since 1990-s have led to a significant downsizing of population (up to 6–10 times) in many hunting grounds. Decrease in number occurs in nature reserves as well (Zaitsev, 2006). The study of the ecology of musk deer was started in the Sikhote-Alin Reserve in 1930-s by Salmin (Salmin, 1972), and continues from 1974 to the present time, providing the basis for the implementation of measures for the preservation of species (Zaitsev, 2006; Zaitsev et al., 2013a; Maksimova et al., 2014b; Slaght et al., 2012). During this time, a number of properties of the population structure and the position of musk deer in the ecosystem were identified, and population density counting methods were developed (Zaitsev, 1991, 2006; Zaitsev et al., 2013b; Maksimova et al., 2015). Nevertheless, musk deer still cannot be attributes to species with well-known

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ecology. Since the beginning of the study we used a complex technique, and a number of significant results of using this technique are presented in this paper.

Research Methods

Since 1970-s a system for keeping track of the size and structure of musk deer population using multiple methods of observation was shaped in the nature reserve. This system involves the study: a) at few key areas, including two main areas (Zimoveinyi — over 10 km^2 in the basin of Serebryanka River; Nechet — over 10 km^2 in the basin of Tayozhnaya River); b) a comprehensive study of different areas using one of the counting methods developed. A promising way to study the population structure and behavior of musk deer at stations involves a combination of techniques including snowtracking (since 1974), radiotracking (since 2012), photo and video observation of individual animals accustomed to the observer (since 1975), registration with trail cameras (since 2011), and counting of hoofprints and abundance of food plants (lichens) at the test areas. Topographical maps, aerial and satellite images, and GPS-navigators are used.

The studies are conducted at controlled home ranges where the routes form a network with the distance between the routes from 200 to 500 m. Prior to the use of GPS-navigators 10 km of regular routes were labeled at the main station at 20 m intervals. Permanent areas of lichen count (30 × 30 m or 20 × 20 m) were labeled.

During multi-day tracking the daily route of an individual musk deer was tracked (from contact to contact), and a part of the daily route was tracked with fragmentary tracking. The paths of animal movement were plotted on the topographic base; and the outlines of habitats and activity centers were laid out at the outermost animal movement paths. Several tracking techniques were used differing in the precision of recording the route of an animal using different measurement tools and devices (Zaitsev, 1991, 2000, 2002). The method of accustoming musk deer (21 individuals in total) to close presence of an observer (up to 1.5–6 m) based on a sort of "breaking" of the defensive range expanded the research opportunities.

During tracking and visual observation 1749 objects were labeled with bright-colored tags, which made it possible to determine the amount of time that passed after marking. These objects were: caudal gland excreta marks, excrement piles, urinary points, and complex marks near beds. In 628 cases (35.8%) these sites were re-visited by musk deer. For this purpose trail cameras were used. More than 10 musk deer behavior reactions to labeling were observed.

Since 2012 radiotracking is used in addition to snowtracking. Musk deer were caught using modified box traps (Shcherbakov, 1953) or by approaching accustomed individuals and immobilizing them. In 2012–2014 six musk deer were captured and tagged with Telonics transmitters, USA (150–152 MHz), of which five animals were males. They were monitored from several months to several years along with tracking and visual observations. Radiotracking allowed the researchers to obtain information on changes in home ranges during snowless period and throughout the year (Maksimova et al., 2014a,2014b). To determine the size of home range the minimum convex polygon method and kernel density estimation method (Powell, 2000; Worton, 1987) were applied. The latter method is based on a statistical model that allows localizing the movement of individuals to contours with 95% (home range) or 50% (core zone or the center of activity of the range) probability of frequency of visits. We have obtained up to date data for comparison of the results of radiotracking and snowtracking for choosing the optimal option to calculate the parameters of animals' home range.

Results

Up until 1970-s the information on spatial and social structure of the population of musk deer was missing (home range was described by Ustinov (1967)) or was contradicting in nature. A difference in the size of home ranges used by musk deer during the same time interval between males (up to 70–380 ha), and females and juveniles (10–60 ha) (Zaitsev, 1978, 1982) was observed in Sikhote-Alin. During the lifetime (up to 7–8 years, rarely more) some males claimed areas of 3.5–6 km^2. Home ranges of females and juveniles are "contained" within vast ranges of adult males (starting from the age class of 2–3 years and older). The sizes of home ranges correlate with the distance of the daily route of musk deer (from 0.9 to 4–5 km for males starting with the second year of life; 0.56–1.5 km and rarely more for females and juveniles); for males — $r = 0.949$, $p < 0.001$. A home range has one or more centers of activity (cores) united by passages. Under various conditions in different seasons the centers of activity reached for males, according to snowtracking data, 20–53% of the size of the range, and the areas with day-time beds — from 1.5 to 15%. According to radio tracking, the home range core (50% probability) where a male was usually resting during the day-time, occupied 3.1–21.2% of the range area.

Overlap areas between home ranges are important in providing contacts between neighboring individuals. Under stable conditions for males ≥2 years old, according to tracking data, these areas covered not more than 10–15% of home range, but in destabilized groups they reached 40–63%, and for males of 1–2 years age group they sometimes reached 90%. The overlap of home ranges of neighboring males, and visits to the same place by different individuals were detected by radiotracking and trail cameras. Under conditions of high population density and limited home range sizes neighboring females had the smallest contact zones.

After a few days of using a home range (7–10 days or more for males) it stabilizes in size; then an abrupt change of the area size and location occurs, which is again followed by a brief stabilization period, etc. (Zaitsev, 2014). During the season, the year and the lifetime of an individual these changes reach significant values up to dislocation of the center of activity by a kilometer or more. As individuals of both sexes settle in the area, a system of home range separated by hundreds of meters or kilometers is formed (Zaitsev, 1991, 2006). According to radiotracking, in case of a stable connection of musk deer to an area, home range