Female sika deer fidelity to migration route and seasonal ranges in eastern Hokkaido, Japan

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Abstract. We examined fidelity to seasonal migration routes and seasonal ranges of 10 migratory female sika deer *Cervus nippon yesoensis* (9 adults and 1 fawn) in eastern Hokkaido, Japan (April 1997–May 2001). Six deer did not change migration routes among years and between fall and spring migrations. Three deer used different routes between fall and spring migrations, but did not change migration routes among years in each season. When some deer changed winter ranges in some years, these ranges were located along the migration routes. These findings do indicate that migratory female sika deer show high fidelity to migration routes.

Key words: *Cervus nippon*, fidelity, migration route, seasonal migration, sika deer.

Many populations of large herbivores migrate seasonally between discrete home ranges (Fryxell and Sinclair 1988). Many studies have reported on seasonal migration and seasonal ranges of ungulate species in temperate ecosystem (Loft et al. 1984; Schoen and Kirchhoff 1985; Kufeld et al. 1989; Servheen and Lyon 1989; Nicholson et al. 1997; Van Deelen et al. 1998). Fidelity to seasonal ranges is common in migratory northern deer (Verme 1973; Nelson and Mech 1981; Tierson et al. 1985; Sweanor and Sandegren 1989; Mysterud 1999). In white-tailed deer (*Odocoileus virginianus*), matrilineal family groups of females and fawns migrate together (Nelson and Mech 1981) and show fidelity to seasonal ranges (Tierson et al. 1985; Aycrigg and Porter 1997). Franklin and Lieb (1979), Clutton-Brock et al. (1982), and Boyce (1991) demonstrated the importance of tradition in the social behavior of many populations of elk or red deer (*Cervus elaphus*). Fidelity to seasonal ranges may be advantageous to deer because of the knowledge which provides regarding seasonal availability of resources (Edge and Marcum 1985; Edge et al. 1985). Fidelity to

seasonal ranges also contributes to stability of social groups in cervids, with attendant benefits in exploiting food resources and reducing predation (Clutton-Brock et al. 1982; Mathews 1989). However, few studies (Smith and Robbins 1994) have investigated actual migration routes and fidelity to them in terrestrial migratory mammals, probably due to the difficulty in collecting telemetry data during the migration periods. The knowledge about migration routes is essential to understand how migratory animals adapt the surrounding environment and/or topography.

Sika deer (*Cervus nippon yesoensis* Heude 1884) migrate seasonally between summer and winter ranges in eastern Hokkaido, Japan (Uno and Kaji 2000; Sakuragi et al. 2003; Igota et al. 2004). What migration routes do these deer use? Do deer show fidelity to migration routes? This approach is also essential for conservation biology because annual range of migratory animals is composed of both seasonal ranges and migration routes and the knowledge of the migration routes should assist managers in determining strategies for habitat manage-

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ment. To examine whether sika deer show fidelity to migration routes, we tracked 10 radio-collared sika deer and then described their movements during several years.

Study area

Our study was carried out in eastern Hokkaido, Japan. Climate is cold and wet with average temperatures range from -10.4°C in February to 17.4°C in August, and an average annual precipitation of 1,200 mm on Akankohan ($144^{\circ}5'E$, $43^{\circ}26'N$) (Igarashi 1986). The Shiranuka Hills, capture site, is one of the largest and most important wintering areas for sika deer, which have been expanding their distributional range in eastern Hokkaido during the last three decades (Kaneko et al. 1998; Kaji et al. 2000). The northern high elevation regions (above 300 m) are primarily composed of coniferous and mixed forests. The eastern low elevation regions (below 300 m) are dominated by urban development and agriculture, but deciduous forests and plantations of Japanese larch (*Larix leptolepis*) persist.

Materials and methods

Ten migratory female sika deer (9 adults and 1 fawn) of 57 deer radio-collared in the Shiranuka Hills (Sakuragi et al. 2003; Igota et al. 2004) were analyzed to examine fidelity to migration route (Table 1, Fig. 1). Since the 10 animals were relocated relatively frequently in spite of difficulty in VHF-tracking during migration, they were chosen out of the 57. We studied only females because behavior of deer generally varies by sexes (Miura 1976; Bowyer 1986; Scarbrough and Krausman 1988; Bowyer et al. 1996) and females are less likely to disperse than males in some cervids (Robinette 1966; Nelson and Mech 1984; Wood et al. 1989). They were located on the ground using standard triangulation procedures (STP; White and Garrott 1990) at least once a week from April 1997 to May 2001. Aerial locations were also conducted with a fixed-wing aircraft when they were lost. Location estimates, dates, and times were plotted on a 1 : 25,000 map.

Winter and summer ranges were defined as those areas within which individual deer remained during winter and summer, respectively. We considered a seasonal range as changed if the seasonal range of one year did not overlap with that of the other year at least once. Fall migration was defined as movement from summer to winter ranges, and spring migration as movement from winter

to summer ranges.

Mean error for ground locations obtained from experimental transmitters for STP was 144.9 m ($n = 60$, $SD = 149.2$). Mano (1994) reported that mean error for aerial locations was 785 m ($n = 10$, $SD = 666$) in eastern Hokkaido. We allowed a 1-km radius circular error for each location based on the location errors because we were interested in annual and seasonal variation of migration routes at a landscape scale, not at a microhabitat scale. We considered migration routes different among years or between seasons if the locations were not distributed within 2-km wide buffer connecting successive locations between seasonal ranges, based on the maximum range of the location error (diameter of 1-km radius circular error).

Most of radio-collared deer migrated between wintering area and different summer ranges (Fig. 1), and their migration routes did not overlap. Although the 2 pairs (Deer Nos. 22, 41 AND 30, 49) used the adjacent summer ranges, respectively, they departed from summer or winter ranges on different days each other in most cases: Deer Nos. 22 and 41 in 5 of 6 migrations; Deer Nos. 30 and 49 in 3 of 4 migrations. They therefore were considered to move independently each other, basically.

Results

We obtained 302 locations for 10 migratory deer during spring and fall migrations. Based on the differences in migration route among years or between seasons, 3 types of deer were recognized in relation to use of migration route (Table 1). Fall and spring migration routes did not vary among years for 9 of 10 deer (Table 1). Migration routes of 6 (Type A) of the 9 deer also did not differ between fall and spring (Fig. 2A), while the migration routes of 3 (Type B) of the 9 deer differed between fall and spring (Fig. 2B).

One deer (No. 12; Type C) used a different spring migration route in 1997 compared to 1998 and 1999, and used a different fall migration route in 1999 compared to 1997 and 1998 (Table 1). However, migration route of deer No.12 did not differ between fall and spring except for the spring of 1997 and fall of 1999, and moreover, the eastern half of the spring migration route in 1997 did not differ from her general route (Fig. 2C). She was killed of hunting in the fall of 1999.

All of 10 deer used the same summer range among years (Table 1). On the other hand, 4 deer changed their winter ranges in some years (Table 1), but alternate

Table 1. Individual profiles (tracking duration and age at capture), fidelity (+, changed; –, not changed) to migration routes and to seasonal ranges, and migration route use type (A, B, and C) of 10 female sika deer tracked by radio telemetry in eastern Hokkaido, Japan. See the text for descriptions of migration route use type assignment.

Deer No.	Tracking duration		Age at capture	Migration route fidelity			Migration route use type	Seasonal range fidelity	
	Capture date	Last date of tracking		Among years		Between Fall and Spring		Summer	Winter
				Fall	Spring				
6	11 April 1997	28 April 2001	≥3	–	–	–	A	–	–
10	12 April 1997	20 May 2000	≥3	–	–	–	A	–	+
18	16 April 1997	1 January 1999	≥3	–	–	–	A	–	–
22	18 March 1998	13 December 2000	≥3	–	–	–	A	–	+
42	21 March 1998	12 January 2000	≥3	–	–	–	A	–	–
55	24 March 1999	21 April 2001	≥3	–	–	–	A	–	–
30	20 March 1998	14 January 2000	≥3	–	–	+	B	–	+
41	19 March 1998	23 April 2001	≥3	–	–	+	B	–	–
49	22 March 1998	17 December 1999	0	–	–	+	B	–	–
12	14 April 1997	8 January 2000	≥3	+	+	+	C	–	+

Fig. 1. Distribution of individual summer ranges (the squares) of radio-collared sika deer in eastern Hokkaido. The numbers indicate ID code of the individual deer. The circle indicates the wintering area (capture site).

winter ranges were located on the way of previously used respective migration routes (see Fig. 2C).

Discussion

Migration routes for most female sika deer did not differ among years and between seasons (Type A). Some deer used different migration routes between fall and

spring, but the fall and spring migration routes did not differ among years, respectively (Type B). Although the migration route for 1 deer seemed to be irregular, it generally did not differ among years or between seasons (Type C). These findings do indicate that migratory female sika deer show high fidelity to migration routes. Fidelity to migration route as well as fidelity to seasonal ranges may be advantageous to sika deer because of the

Fig. 2. Locations of sika deer Nos. 6 (A), 49 (B) and 12 (C) on their migration routes determined by radio telemetry in eastern Hokkaido, Japan. Deer Nos. 6, 49 and 12 represent deer migration route use types A, B and C, respectively. See the text for descriptions of migration route use type. Deer No. 12 also represent deer that changed winter ranges in some years. The lines connect successive locations of a migration route.

knowledge which provides regarding seasonal availability of resources or mortality sources.

Several authors reported that fidelity to a specific winter range was less than for summer range (Tierson et al. 1985; Dusek et al. 1989; Aycrigg and Porter 1997; Van Deelen et al. 1998). Our previous studies also support that fidelity to a specific winter range of sika deer was less than for summer range (Uno and Kaji 2000; Igota et al. 2004). Brown (1992) suggested that traditional use of the winter ranges might be flexible according to yearly differences in winter severity. Our findings further indicate that deer change winter ranges along used migration routes. Some deer changed winter range and yet maintained fidelity to migration routes, suggesting that use of familiar migration routes may be more advantageous to deer than movement into unfamiliar areas. One female (No. 12) in this study moved into probably unfamiliar areas and was killed of hunting. Movement into unfamiliar areas may involve high risk of mortality because of lack of the knowledge of mortality sources, just as dispersers are subjected to high mortality rates

(McCullough 1979).

Understanding of migration routes is also essential for conservation and management of migratory species, but has been rarely done for terrestrial mammals. Our understanding for the migration route of sika deer suggests that managers should pay sufficiently attention to maintain or protect the migration route of deer because deer showed high fidelity to specific migration routes.

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