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Winter Ecology of the Pine Marten (*Martes martes* L.) in the Volga Floodplain Opposite Samara

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Abstract—The footprint tracking method has been used to study specific features of winter ecology of pine martens inhabiting the Rozhdestvenskaya Floodplain of the Volga River. Attention has been paid to the size and demographic structure of the population, the distribution of footprints by habitats, home ranges and shelters, features of foraging and territorial behavior, reactions to objects of natural and anthropogenic origin, and interactions with heterospecific animals.

Key words: pine marten, anthropogenic factor, footprint tracking, specific pattern of activity.
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Pine martens have a secretive way of life and prefer mature forest stands, avoiding open spaces, which aggravates the problem of their survival near populated areas (Geptner, 1967). Forest cutting is also detrimental for them (Zakharov and Zhigarev, 2003), especially at the periphery of the species range (Aspisov, 1973). On the other hand, these animals are ecologically flexible, show good knowledge of the terrain, and are skillful in using its protective properties, which implies that forests moderately transformed by human activities may also be suitable for them (Sokolov and Rozhnov, 1979; Grakov, 1981; Mozgovoi et al., 1998). The purpose of this study was to reveal specific ecological features facilitating the survival of pine martens under unfavorable anthropogenic conditions of the Volga floodplain.

STUDY REGION, MATERIAL, AND METHODS

Adaptive activities of pine martens in winter were studied in the Volga floodplain opposite the city of Samara in 1983 to 2008 (Fig. 1). The study area was about 2400 ha in size, 65% covered with forests. Observations and animal tracking were performed from early January to mid-March, at least twice a month, as described (Formozov, 1959). On the whole, the footprints of males and females were tracked dur-

Table 1. Characteristics of field data on pine marten winter ecology in the Rozhdestvenskaya Floodplain of the Volga River

Years	Current population state	Number of encounters with marten footprints	Number of martens observed	Number of tracking sessions	Total distance of tracking, km	Distance of detailed tracking, km
1983–1987	Medium abundance (1–3 ind./1000 ha)	126	14	43	213	108
1988–1998	Low abundance (no footprints in winter or, in some years, 0.3–1 ind./1000 ha)	95	7	22	106	54
1999–2008	Low abundance (no footprints or, in some years, 0.3–1 ind./1000 ha)	52	10	16	78	61
Total		273	31	81	397	223

†Deceased.

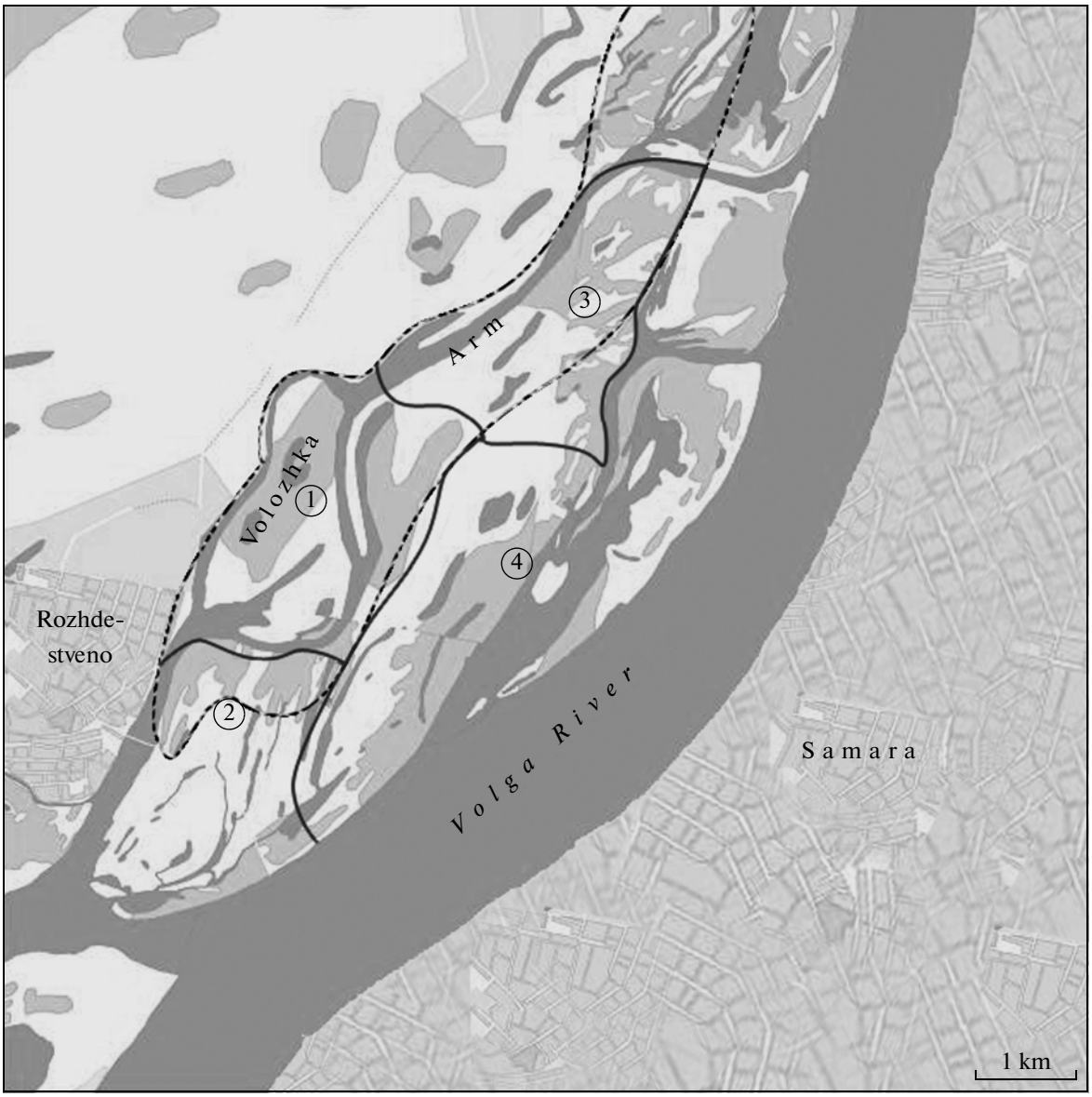

Fig. 1. Left-bank Rozhdestvenskaya Floodplain separated from the city of Samara by the Volga River channel (approximately 2000 m wide) and (*1–4*) plots inhabited by pine martens, with dashed line showing boundaries of the most favorable habitats.

ing 32 and 49 sessions, respectively (Table 1). The sex of pine martens was determined from the location of urine marks; their age, from the size of footprints and general pattern of behavior. In 30% of cases, the footprints were tracked in more detail and mapped.

The study area between 1983 and 2008 was inhabited in winter by one to five animal simultaneously, except for the seasons when no footprints of martens were found; on the whole, there were at least 21 females and 10 males (Fig. 2). The repeated occurrence of pine marten tracks after the "empty" seasons indicated that these animals came to the study area from other biotopes, probably from the Zhiguli Reserve located farther up the Volga River. Eight such cases, with five females and three males, were observed during the 26-year study period.

A high prevalence of adult female tracks at a low frequency of tracks left by mature males and young of the year is indicative of a low population size and overhunting (Grakov, 1981). In the study area, the decline of pine marten population took place against the background of increasing anthropogenic impact: the numbers of campfire spots, roads, wheel tracks, etc. increased by a factor of 5–7, and of fences, by a factor of 15; two to three felling areas and three to four waste dumps appeared. During observations, tracks left by snowmobiles were found two to five times per 3 km of the route.

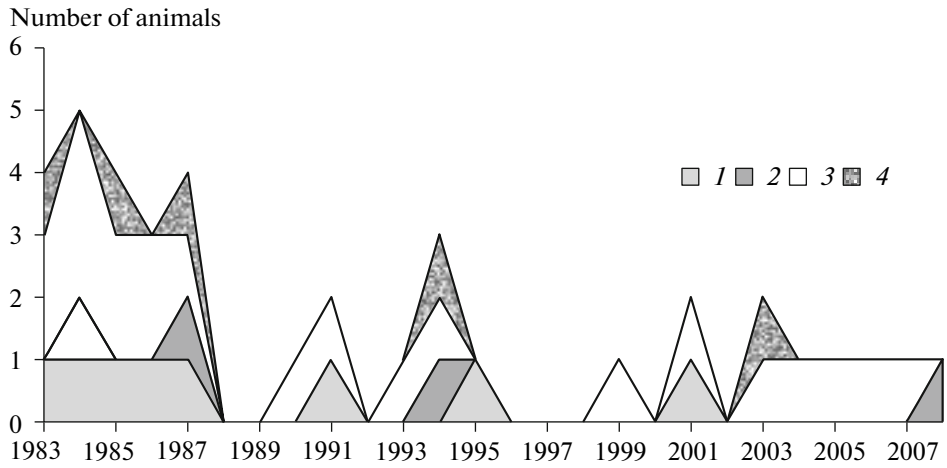

Fig. 2. Demographic characteristics of pine martens recorded in the Volga floodplain opposite Samara in January to March (some animals were observed over 2–4 years): (*1*, *3*) adult males and females; (*2*, *4*) male and female young of the year.

RESULTS AND DISCUSSION

Occurrence of pine marten tracks in different parts of the floodplain. Over the study period, pine marten tracks were observed with different frequencies in all four plots studies in the floodplain (Fig. 3). The highest frequency (63.3%) was recorded in plot 1, which is explained by an abundant food supply, safety, and the diversity of microstations within corresponding habitats (Table 2). There are forested ridges remaining above water level during floods, lakes, channels, an island, bog willow scrub and cattail beds alternating with hummocky marshes, meadows, and aspen thickets. Murine rodents after floods concentrate in elevated areas, providing enough food for martens rearing their offspring. About 0.2–0.4 marten tracks per 10 km of route were recorded there.

Plots 2–4 exposed to anthropogenic impact were less favorable for martens (36.7% of tracks recorded). Plot 2 includes isolated forest areas. In previous years, there were haystacks left for winter, which attracted foxes and, less frequently, female ermines and martens. To date, a power line and a machine and tractor station have been built there. Plot 3 is visited by people less frequently but contains a small amount of forest. Pine marten tracks in plots 2 and 3 occurred with a frequency of 0.1–0.2 per 10 km of route. Plot 4 is overgrown with osier, black poplar, and white willow. Being exposed to heavy recreational load, it is now not habitable for martens, although they occurred there before 1996 (0.05–0.1 tracks per 10 km of route). As anthropogenic impact increased and marten population size decreased, these animals began to make more frequent visits to plots with unfavorable conditions, probably in search for conspecifics (Table 2, Fig. 3).

Specific features of foraging and territorial activities. Pine martens left traces of their foraging (hunting) activity mainly in elevated areas at the margins of pine forests. Routes of their transit movements remained the same over many years. They passed over ravine slopes, between clusters of osier scrub, along fallen trees, shrubs, dense weeds, and even in open areas, with the animals skillfully using protective properties of terrain and vegetation.

We distinguished foraging behavior and transit movements to a different hunting range. In the latter case, martens move straight ahead (with the bends and curves of the route, if any, being determined by topographic (protective) features of the terrain), climbing trees when necessary. When hunting murine rodents,

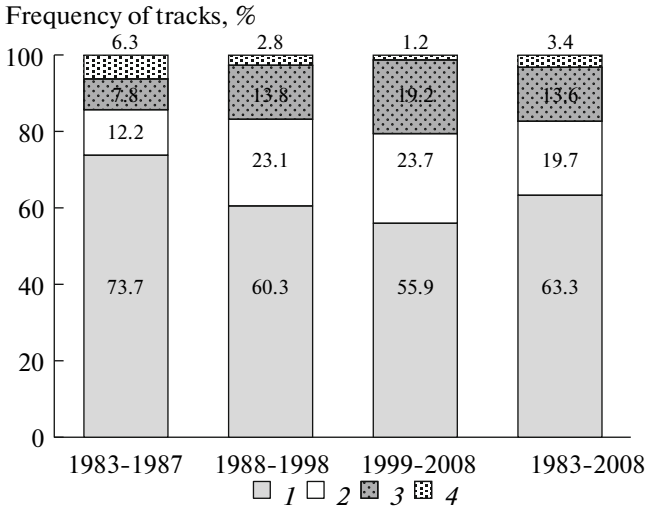

Fig. 3. Occurrence frequencies of pine marten tracks in plots *1–4* of the Rozhdestvenskaya Floodplain in January to March (a total of 273 findings of tracks between 1983 and 2008). For characteristics of plots, see the text.

Table 2. Occurrence of pine marten tracks in different parts of the floodplain: statistical characteristics

Parameters compared	Method of comparison	*N*	Test value	*P*	Evaluation of the result
Occurrence frequencies of tracks in each of the four plots	Kruskal–Wallis *H* test	104	19.4	0.002	The level of the character "occurrence frequency of tracks" changes between the plots
Occurrence frequency of tracks in the first plot versus other plots	Mann–Whitney *U* test	104	587.0	0.001	Occurrence frequency of tracks in plot 1 is significantly higher than in all other plots taken together
Total occurrence frequencies of tracks in plots 2 and 3 over the years with moderate and high anthropogenic load	Mann–Whitney *U* test	18	1.5	0.009	As anthropogenic load increased, martens began to use territories of plots 2 and 3 significantly more frequently

martens move in a zigzag manner, keeping downwind of shrubs and slopes, with the amplitude of movements increasing in flat areas and decreasing in areas with dissected topography. The number of instances when martens climbed trees and the distances they covered by moving from one tree to another (Table 3) are two to four times greater than those reported from other areas (Aspisov, 1973; Grakov, 1981; etc.).

Home range and shelters. The home range consisted of two to three foraging ranges connected by passages. Different foraging sites within the same foraging range were visited in sequence, with breaks for day's rest. When the weather changed, martens usually moved to a different foraging range rather than continued hunting in the same area. In the false rut period (February to March), males foraged and rested during the day in the ranges used by females and followed their permanent routes.

A foraging site was examined once at a time, at night or at dusk, with the marten usually moving along a closed route (Fig. 4). In summer, plots A and B shown in the figure are separated from each other by a channel. Plot A was actively used by the marten in February 19 to 24. After a heavy snowfall followed by a warm spell, the marten moved to the northern site (plot B) and remained there from February 24 to 27. On the night of February 27–28, it returned to plot A and remained there, in the nest shelter, until March 1.

Both males and females rested during the day at forest edges or near separate clusters of trees. Their resting places were diverse: a half-fallen oak tree, a dead poplar tree under snow, a squirrel nest on a standing poplar, a littered cluster of shrubs, a depression covered by tree branches, etc.

In the period of false rut, martens usually move over longer distances, and their home ranges expand (Grakov, 1981). However, home ranges of martens in the Volga floodplain became smaller after an ice road was opened (February–March). Increasing anthropogenic impact made them abandon some foraging sites and reduce their usual daily routes. However, martens remained active in areas inaccessible for motor vehicles.

Foraging behavior and interactions with heterospecific animals. Murine rodents are the main food for pine martens in the Rozhdestvenskaya Floodplain. During one hunt, males covered a distance of up to 5 km. Females were less mobile, but the proportion of foraging activities in their daily time budget was greater (Table 3). High mortality among rodents after a long flood made martens resort to accessory or accidental food items. This resulted in an increased frequency of attempts to hunt birds (by a factor of 2–2.5), tear the bark off tree stumps in search of xylophagous beetle larvae, and climb trees with crow or magpie nests (data of 14 tracking sessions).

Moving to a different foraging area along the forested bank of a river arm, martens examined feeding mounds of muskrats and minks amid the roots of black poplars, where mollusk and crayfish shells remained. In habitats preferred by ermines (a floodplain meadow or cattail bed), martens moved rapidly, making long leaps. The amplitude of zigzag movements of foraging martens was greater than that of least weasels, and transit movements between thoroughly examined microhabitats were shorter than in foxes hunting for small mammals. Therefore, pine martens examine their hunting grounds less thoroughly than least weasels but more thoroughly than foxes.

The decline of pine marten population in the floodplain is also explained by an increase in the abundance of red foxes. Before 1985, no more than one

Table 3. Some features of diel activity of pine martens in the Rozhdestvenskaya Floodplain (January–March 1983–2008)

Parameter of activity	*N*	Mean ± standard error / min–max	Variance / standard deviation	Notes (tendencies)
Daily movement distance, km	31*	3.9 ± 0.3 / 0.9–8.9	3.3 / 1.8	In general, males moved for longer distances. Excess of anthropogenic objects attracting animals attention usually led to a decrease in the daily range of movements
Transit to a different foraging area, m	31*	1272.9 ± 142.1 / 241.0–3060.0	625 999.2 / 791.2	Transit distance increased beginning from late January, especially in males
Number of instances of tree climbing per 3 km covered after rest during the day	31*	12.8 ± 1.9 / 3.0–45.0	107.1 / 10.3	Increased after encountering anthropogenic object, especially in females
Distance covered by moving from one tree to another, m/3 km of daily movement distance	31*	876.8 ± 101.7 / 94.0–2410.0	320 878.4 / 566.4	Being generally longer in females, decreased regardless of animal sex by the end of winter due to snow accumulation on tree branches
Number of urine marks per 3 km of daily movement distance	31*	6.4 ± 0.7 / 2.0–19.0	16.9 / 4.1	Males and adults were leaving more marks, compared to females and young of the year; the frequency of marking increased above the average upon exit from the lair and at the home range periphery
Number of instances of digging per 3 km of daily movement distance	31*	58.9 ± 11.7 / 6.0–195.0	2466.0 / 49.6	Varied depending on the form of behavior (a maximum during foraging, a minimum near the lair), food supply within home range, and success in the previous hunt
Number of orientation reactions in adults per 3 km of daily movement distance	18**	68.8 ± 6.0 / 28.0–113.0	657.4 / 25.6	Traces of such reactions were more frequent on the entryway to the lair; they were also less frequent on transit than on foraging routes, since vectors of movement in the former case were longer
Distance covered along fox tracks, m/3 km of daily movement distance	18**	79.54 ± 12.4 / 20.0–167.0	2782.6 / 52.7	Varied depending on occurrence frequency of fox tracks
Distance covered along ski tracks, m/3 km of daily movement distance	18**	50.2 ± 5.9 / 2.0–129.0	1011.9 / 31.8	Varied depending on snow cover properties and individual feeding habits; martens avoided fresh ski tracks but used older ones
Proportion of foraging activity in daily time budget, %				
females	20	76.9 ± 7.2 / 25.7–100.0	912.1 / 32.7	Females foraged mainly at well-drained margins of oak forest, keeping from year to year in the same areas where nest shelters were located; their individual foraging ranges never overlapped
males	10	56.1 ± 8.9 / 17.3–100.0	493.2 / 22.1	Foraging stations of males were more diverse, and their individual foraging ranges sometimes overlapped slightly

Notes: * Ten males and 21 females.
** Six males and 12 females.

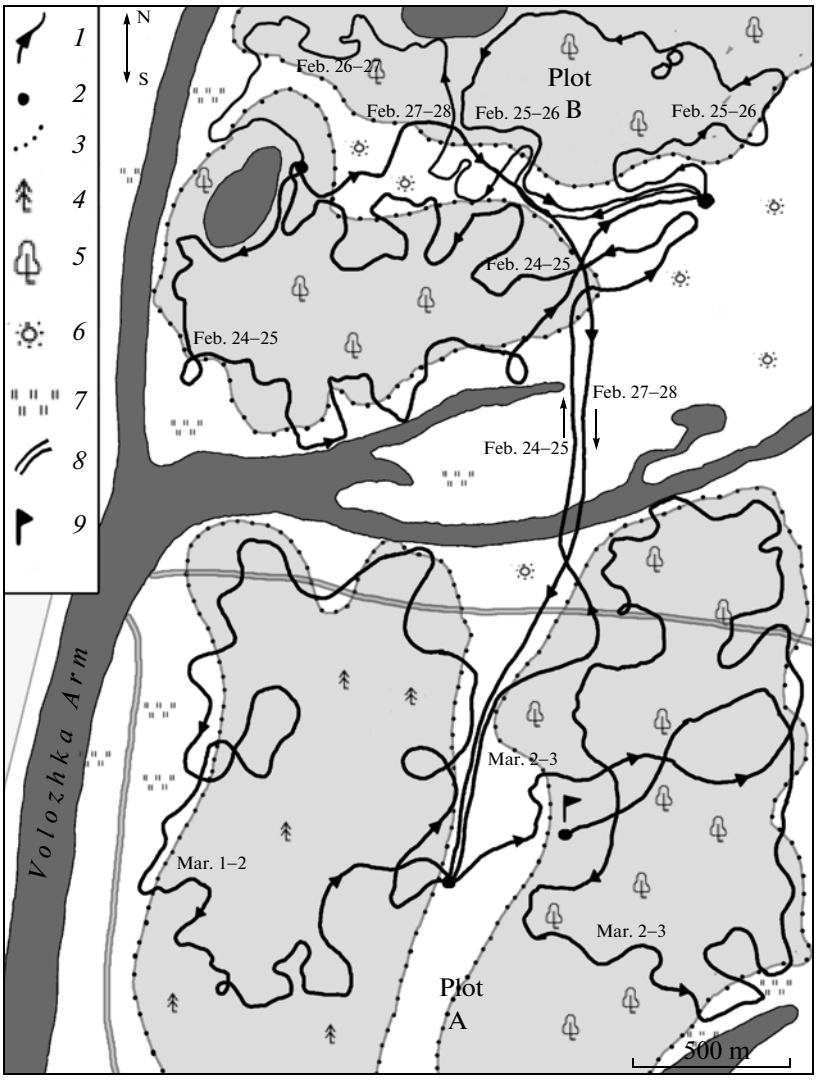

Fig. 4. Scheme of diel movements of an adult female pine marten over the period from February 24 to March 3, 1993: (*1*) route and direction of movement, (*2*) day-rest places, (*3*) boundaries of forest stations, (*4*) pine stands, (*5*) oak forest, (*6*) shrubs, (*7*) meadow, (*8*) road, (*9*) end of tracking.

fresh fox track occurred per 3 km of route in January; beginning from the 1990s, this figure increased to 1–4, being sometimes even greater. The relationships between martens and foxes are ambiguous. Martens move along roads or ski tracks following fox footprints, which allows their definition as "situational commensals" of foxes. In years with a high abundance of foxes, martens showed a negative response to their fresh tracks, especially after encountering them several times in a row: they ceased foraging, rushed about, and sought shelter on trees. The picture observed in the early spring period of activity was different: at a low abundance of males, female martens responded to tracks of male foxes as if to those of conspecific males: they followed these tracks periodically leaving urine marks and dragging the belly over the surface.

Thus, on condition of sufficient food supply and availability of shelters, pine martens can adapt to life in floodplain habitats moderately transformed under the impact of human activities, as was observed in the study area before the mid-1990s. The subsequent decline of pine marten population resulted from increasing anthropogenic impact. Its probable recovery will be evidence for the effectiveness of ecological monitoring

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