Russian J. Theriol. 16(1): 43–46

Breeding under snow cover in Norway rats (*Rattus norvegicus*) on uninhabited islands in Hokkaido, Japan

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ABSTRACT. We analyzed age distribution of Norway rats (*Rattus norvegicus*) on uninhabited islands, Yururi (168 ha) and Moyururi (31 ha) in the subarctic climate zone in Hokkaido, Japan. Age was estimated from eye lens weight. From the age distribution of 73 rats caught in July–August 2013, we found that 10 rats of them were born under the snow cover from December to March.
How to cite this article: Yabe T., Minato Ryu-ichi, Hashimoto T. 2017. Breeding under snow cover in Norway rats (*Rattus norvegicus*) on uninhabited islands in Hokkaido, Japan // Russian J. Theriol. Vol.16. No.1. P.43–46. doi: 10.15298/rusjtheriol.16.1.04

KEY WORDS. Age distribution, breeding, Hokkaido, Japan, *Rattus norvegicus*, snow cover, uninhabited islands.

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Подснежное размножение пасюка (*Rattus norvegicus*) на необитаемых островах близ Хоккайдо, Япония

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РЕЗЮМЕ. Исследован возрастной состав пасюка (*Rattus norvegicus*) на необитаемых островах, Юрури (168 га) и Моюрури (31 га), расположенных в субарктической климатической зоне близ Хоккайдо, Япония. Возраст определяли по весу хрусталика глаза. По возрастному составу выборки из 73 крыс, пойманных в июле–августе 2013 г., мы обнаружили, что 10 из них родились в снежный период, с декабря по март.

КЛЮЧЕВЫЕ СЛОВА: Возрастной состав, размножение, Хоккайдо, Япония, *Rattus norvegicus*, снежный покров, необитаемые острова.

Introduction

Norway rats (*Rattus norvegicus* Berkenhout, 1769) are cosmopolitan and commensal. They are adaptable to cold climate zones, where they thrive even in remote areas from human habitations (Errington, 1935; Inukai, 1939, 1942; Tamanuki, 1944; Schiller, 1956; Paul, 2010). However, coldness is severe to them and cold weather injures them by frost-bite, depresses their reproductive activities, or removes them to human habitations (Errington, 1935; Schiller, 1956; Miyao *et al*., 1964). Then, how do they thrive in areas isolated from human habitations such as uninhabited islands in a cold climate zone? There they have no choice to move to human habitations. We found such a field, small uninhabited islands in the subarctic zone, where Norway rats were prosperous. The growth rate in body weight of Norway rats on these islands was similar to that in a business district in Yokohama (Yabe *et al*., 2017). This suggests that they thrived in these isolated habitations. The aim of the present work is to analyze the affect of snow cover and coldness on reproductive activities of the rats.

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Material and methods

Study sites. We caught Norway rats from two islands, Yururi (168 ha, 43º12′ N, 145º35′ E) and Moyururi (31 ha, 43º13′ N, 145º36′ E) in Hokkaido, northeastern Japan (Fig. 1). These are uninhabited islands separated by 700 m and located 2.5–3.7 km off the Nemuro Peninsula of Hokkaido. They are foggy islands in the subarctic climate zone; they have a mean annual temperature of 6.3ºC, annual precipitation of 1021 mm, and are covered with snow from November to April. Snow depths in November, December, January, February, March, and April are 5 cm, 36 cm, 62 cm, 55 cm, 50 cm, and 14 cm, respectively: data from a meteorological station at Nemuro, a city close to these islands. The center of Yururi is covered with peat bog and moor vegetation, and edged with marine vegetation and alpine plants. Moyururi is covered with low vegetation dominated by Veitch's bamboo (*Sasa veitchii* Rehder, 1919). Several birds of prey such as common buzzards (*Buteo buteo japonicus* Temminck et Schlegel, 1844) are known on these islands (Wild Bird Society of Japan, 2006) and likely prey on rats. They are a bird sanctuary.

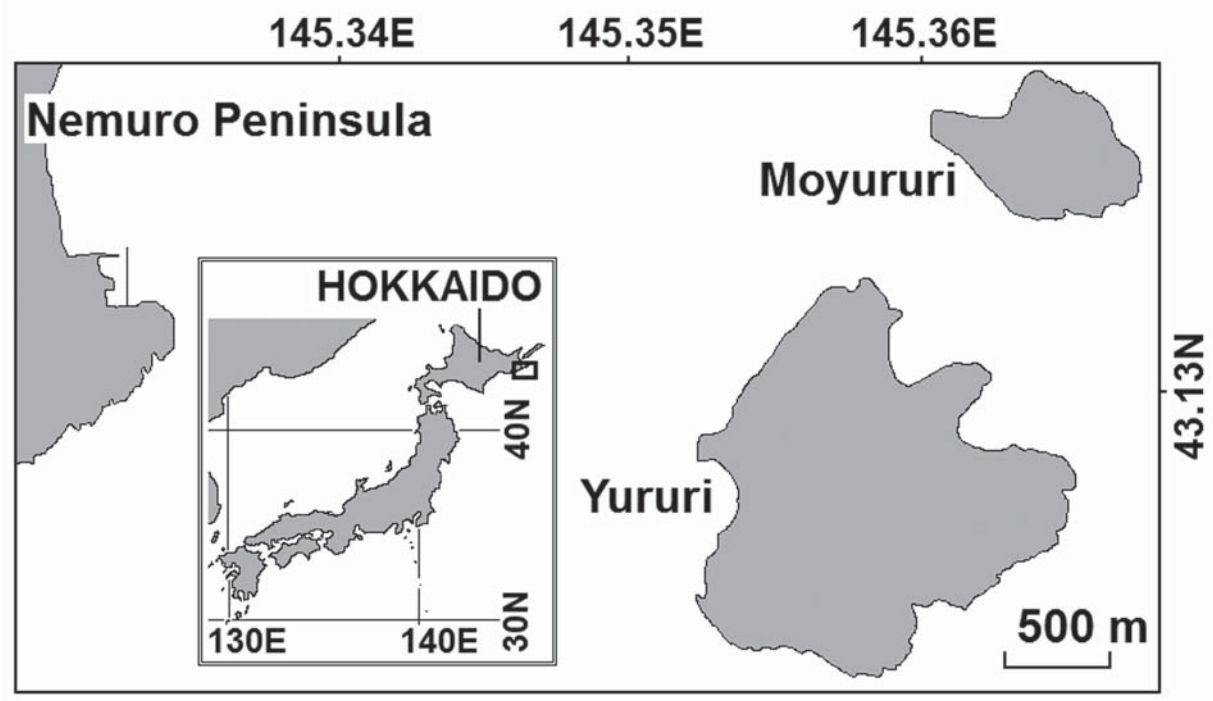

Figure. 1. Map of Yururi and Moyururi islands in Hokkaido, northeastern Japan.

Trapping and analysis. We set cage and snap traps in bushes and grass fields on these islands for four consecutive nights in July–August 2013 after a preliminary trapping on Yururi in October 2012. We collected rats every morning. Eye balls were kept in 10% formalin for research in the laboratory. We modified the following processes from those by Yabe (1979a) as a better method. We excised lens pairs from eye balls, washed them with tap water instead of deionized water and oven-dried them for two hours at 110ºC instead of 80ºC for one night. After drying, lenses were cooled in a desiccator and weighed in pairs to the nearest 0.01 mg. From the lens weight, we estimated rat age using the formulae (Yabe, 1979a), $\hat{x} = 10^{(0.0263Y - 0.377)}$ for males and $\hat{x} = 10^{(0.0278Y - 0.405)}$ for females, where Y is weight of paired lenses in mg and $\hat{x}$ is predicted age in months. The equations for estimating the 95% confidence intervals for the inverse prediction in logarithms were $\log \hat{x} = 0.0263Y - 0.377 \pm 0.825 \times 10^{-3}[(Y - 38.6)^2 + 127.5]^{1/2}$ for males, and $\log \hat{x} = 0.0278Y - 0.405 \pm 0.685 \times 10^{-3}[(Y - 38.0)^2 + 98.7]^{1/2}$ for females. These formulae were modified from those given by Yabe (1979a), who made formulae from one lens weight of 1–13 month-old Wister albinos (63 males and 76 females) by comparing with the data from three strains of Norway rats including captive ones by Donaldson & King (1937). It is suggested that nutrition, genetics, and body size within a species have a minor influence on these formulae (Stump & Anthony, 1983).

Results and discussion

We caught a total of nine rats from Yururi in October 2012 and 77 rats (33 from Yururi and 44 from Moyururi) in July–August 2013. All of them were Norway rats 8 months old or less. From the age distribution of 73 rats (excluding four rats with damaged eyes) caught in July–August 2013, we found that 10 rats of them were born from December to March, apparently under the snow cover, and the other 63 were born in June and July (Tab. 1). The 95% confidence intervals in these 10 rats deviated 0.2 months or less from ages in each age class from 5 to 8 months old, which were ignorable values (Tab. 2). All the nine rats collected in October 2012 were born from June to September. As a result, we found no recruits in April–May, just after the deep snow season, and October–November, just before the deep snow season.

We think that all the Norway rats were born on these islands, and were independent of the mainland population because of the following three reasons. The distance 2.5–3.7 km from the nearest peninsula seems to be too far to know these islands for Norway rats with their visual acuity (52.0 min in visual angle: Bourlière, 1964). It is far from 1 km, which is suggested by Russel *et al*. (2008) to be a swimmable distance by Norway rats. Moreover, it is difficult for rats to be transported by boat because approaching of boats to these islands is restricted.

Yabe *et al*. (2016) stressed a breeding season in winter in Norway rats living outside buildings in a business district in Yokohama. Moreover, we found

Table 1. Age and birth month distribution of Norway rats caught in July–August 2013.

Age in months	Birth month	Number of rats		
		Male	Female	Total
1	July	28	24	52
2	June	10	1	11
3	May	0	0	0
4	April	0	0	0
5	March	3	0	3
6	February	1	3	4
7	January	0	2	2
8	December	1	0	1
Total		43	30	73

Table 2. Age of rats supposed to be born in December-March, predicted age and the 95% confidence intervals (CI).

Age class (in months)	Predicted age in each rat and 95% CI (in parentheses)	95% CI in each age class*
5 (5.0–5.9)	5.5 (5.4–5.7), 5.8 (5.6–5.9), 5.9 (5.8–6.1)	5.4–6.1
6 (6.0–6.9)	6.0 (5.9–6.1), 6.5 (6.4–6.6), 6.6 (6.5–6.7), 6.6 (6.5–6.8)	5.9–6.8
7 (7.0–7.9)	7.5 (7.4–7.7), 7.9 (7.7–8.1)	7.4–8.1
8 (8.0–8.9)	8.4 (8.2–8.7)	8.2–8.7

* minimum and maximum in all rats.

here their breeding under snow cover. Inukai (1942) also suggested breeding and explosion of Norway rats under snow cover after flowering of *Sasa*-bamboo in Sakhalin in 1938. Maeda (1977) observed placental traces and stomach contents of Norway rats just after melting of the snow. Then he concluded that rats bred under snow cover and preyed mainly on rodents such as gray red-backed voles (*Myodes rufocanus* Sundevall, 1846) and *Sasa*-bamboo seeds in Hokkaido.

Snow cover protects Norway rats from the cold air temperature. The temperature at the ground level under the 50 cm snow cover, for example, is kept above –5ºC, even when the air temperature is below –30ºC (Kucera & Fuller, 1978). Inukai (1939) also showed that the temperature at the ground level under the 1 m snow cover was from 0 to –2.8ºC when the air temperature was from –6ºC to –13ºC. Furthermore, deep snow cover stabilizes temperature under snow, and spring melt is a severe time to small mammals (Whitney & Feist, 1984). Thus, snow cover provides probably comfortable breeding conditions for Norway rats.

The snow cover also protects rats from predators. We suppose that birds of prey such as common buzzards had an impact upon the rat population on these islands. We found no other predators or competitors. Probably, active rats on white snow cover and low vegetation were vulnerable to the attacks of birds of prey as was indicated by Errington (1935) and Kucera & Fuller (1978). Accordingly, snow cover protects Norway rats from predators and helps their reproductive activities. There was probably an impact of population densities of rats in June–September and December–March on recruits in the following months. However, we are lacking in data to prove the impact.

For their breeding under snow cover, rats need naturally food supply. Rats on Yururi-Moyururi preyed on animal matter (72.4 ± 39.8% by volume) such as lepidopterous larvae, fish, earthworms, and seabirds in July–August (Yabe *et al*., 2017). Norway rats generally prefer to eat animal matter (Yabe, 1979b). However, because of their imperfect food-hoarding and fat-depositing behavior (Vander Wall, 1990; Yabe, 1994), Norway rats need to gather diet for their active breeding under snow cover. Further investigations are needed into details of the diet.

ACKNOWLEDGMENTS. This study is a part of a project to restore the natural environment of the Yururi-Moyururi area by the Ministry of Environment, Japan. We thank K. Tokida for his help during our survey. The manuscript was critically reviewed by Dr. Y. Fujimaki and Dr. T. Ikeda.

References

Bourlière F. 1964. The Natural History of Mammals. Parshley H. M. (trans.). New York: Alfred A. Knopf. 387 p.

Donaldson H.H. & King H.D. 1937. On the growth of the eye in three strains of the Norway rat // The American Journal of Anatomy. Vol.60. P.203–229.

Errington P.L. 1935. Wintering of field-living Norway rats in south-central Wisconsin // Ecology. Vol.16. P.122–123.

Inukai T. 1939. [Outbreak of Norway rats and damage by the rats in Karafuto (Sakhalin)] // Plants and Animals. Vol.7. P.57–70 [in Japanese].

Inukai T. 1942. [Outbreak of Norway rats in Karafuto (Sakhalin) and review of the control measures] // Journal of Agriculture and Forestry Society of Sapporo. Vol.34. No.3. P.1–13 [in Japanese].

Kucera E. & Fuller W.A. 1978. A winter study of small rodents in aspen parkland // Journal of Mammalogy. Vol.59. P.200–204.

Maeda M. 1977. [Flowering, fruiting and withering of Sasa-bamboo, and rodents] // Sapporo Rin-Yu. No.188. P.43–54 [in Japanese].

Miyao T., Akahane H., Sakai A., Ohishi Y., Nishino T. & Yanagidaira Y. 1964. Small mammals on Shiga Height in Japan, 1. Seasonal differences of capture rate, sex ratio, body weight and reproduction in rat (*Rattus norvegicus*) // Bulletin of Institute of Biology, Shiga Heights (Shinshu University). Vol.3. P.1–10 [in Japanese, with English summary].

Paul E. 2010. The Rat Island eradication project: a critical evaluation of nontarget mortality. Maryland: Ornithological Council. 85 p.

Russell J.C., Towns D.R. & Clout M.N. 2008. Review of rat invasion biology: implications for island biosecurity. Science for Conservation 286. Wellington: Department of Conservation. 53 p.

Schiller E.L. 1956. Ecology and health of *Rattus* at Nome, Alaska // Journal of Mammalogy. Vol.37. P.181–188.

Stump W.Q., Jr. & Anthony R.G. 1983. Use of eye lens protein for estimating age of *Microtus pennsylvanicus* // Journal of Mammalogy. Vol.64. P.697–700.

Tamanuki K. 1944. [Damage by second outbreak of Norway rats in South Karafuto (Sakhalin)] // [Technical Report of Karafuto Central Agricultural Experimental Station]. 20 p. [in Japanese].

Vander Wall S.B. 1990. Food Hoarding in Animals. Chicago and London: University of Chicago Press. 445 p.

Whitney P. & Feist D. 1984. Abundance and survival of *Clethrionomys rutilus* in relation to snow cover in a forested habitat near college, Alaska // Merritt J.F. (ed.). Winter Ecology of Small Mammals. Pittsburgh, Pennsylvania: Carnegie Museum of Natural History. P.113–119.

Wild Bird Society of Japan. 2006. [Important bird area in Japan, Yururi, Moyururi islets]. [in Japanese]. www.wbsj.org/nature/hogo/others/iba/search/sites/hokkaido/14-yururi.htm. Accessed 29 July 2016.

Yabe T. 1979a. Eye lens weight as an age indicator in the Norway rat // Journal of Mammalogical Society of Japan. Vol.8. P.54–55.

Yabe T. 1979b. The relation of food habits to the ecological distributions of the Norway rat (*Rattus norvegicus*) and the roof rat (*R. rattus*) // Japanese Journal of Ecology. Vol.29. P.235–244.

Yabe T. 1994. Fat deposits for wintering in the Norway rat, *Rattus norvegicus* // Journal of Mammalogical Society of Japan. Vol.19. P.129–133.

Yabe T., Otomo T., Harashima T., Shigeoka H. & Yamaguchi K. 2016. Breeding season in urban population of Norway rats in Yokohama estimated from age composition // Medical Entomology and Zoology. Vol.67. P.199–202 [in Japanese, with English abstract].

Yabe T., Horikoshi K. & Hashimoto T. 2017. Small mass of *Rattus norvegicus* (Rodentia: Muridae) on the Ogasawara Islands, Japan // Pacific Science. Vol.71 [in press].