

Eurasian red squirrels use woodpiles on the forest floor in eastern Hokkaido

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Dispersal of Manchurian walnut seeds depends mainly on zoochory due to their size. Eurasian red squirrels have a behaviour of caching Manchurian walnuts. This behaviour is scatter-hoarding of large seeds. Snag and dying fallen trees are major resources by themselves in forest ecosystems. Slash or woodpiles after tree felling have the same function as snag and dying fallen trees. The present paper aims to report that Eurasian red squirrels utilize piles of slash, to discuss the importance of slash on the forest floor, and to determine which properties of the piles of slash influence Eurasian red squirrels' access to the slash. Among the woodpile properties, the results showed a negative correlation between the distance to the Manchurian walnut tree and the number of walnuts having feeding marks, and a positive correlation between the number of logs in a woodpile and the number of walnuts having feeding marks. Eurasian red squirrels may use woodpiles as a safe feeding site.

Keywords

Manchurian walnut, dying tree, feeding site

1 Introduction

Trees disperse their seeds in various ways¹⁾. Nuts and pinecones, such as Fagaceae and Juglandaceae seeds and large wingless seeds of Pinaceae, are dispersed using not only gravity (barochory) but also animal vectors (zoochory) such as birds and small rodents. Birds of the Corvidae family and Rodentia mammals are known to transfer and cache seeds^{2–5)}.

Manchurian walnut, *Juglans mandshurica* var. *sieboldiana*, is a deciduous tree species that exhibits punctate or linear distribution in riparian forests along rivers. Its nuts are covered by a hard shell and are relatively large and heavy. Dispersal of the nuts depends more on zoochory than on hydrochory or barochory. Two kinds of Rodentia mammals, Eurasian red squirrel, *Sciurus vulgaris orientis*, and Japanese field mouse, *Apodemus speciosus*, are known to cache Manchurian walnuts in Hokkaido⁶⁾. These animals are scatter-

hoarders of large seeds like nuts and acorns. Animals that scatter-hoard seeds in the ground can contribute to facilitating plant dispersal and seed germination, and therefore are critical for regeneration of forests. Recently, however, habitats of those animals have been decreasing and their populations have been declining as well due to forest fragmentation⁷⁾. It is presumed that changes in the abundance of animals can alter the distribution and abundance of plants in forests on a community-wide basis.

Snag (standing dead trees) and dying fallen trees in a natural forest ecosystem provide a whole new set of habitats for wildlife, and tree death substantially contribute to increasing resources, e.g. light, nutrients, water, and energy, that are available to other organisms in the ecosystem⁸⁾. In forestry operation sites, felling and bucking of trees results in a large amount of slash. Under ordinary circumstances, the slash should be removed for wildfire prevention and easier post-harvest management. Logging slash, however, may provide a habitat for wildlife as is the case with snag and dying fallen trees in a natural forest ecosystem.

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The present paper aims to report that Eurasian red squirrels use woodpiles as a feeding site, and to discuss the importance of leaving logging residues in forests.

2 Methods

2.1 Study area

The study was conducted in the research forest of Tamagawa University located in Teshikaga, eastern Hokkaido (43°23'N, 144°21'E). The vegetation constitutes a mixed forest with Todo fir, *Abies sachalinensis*, Ezo spruce, *Picea jezoensis*, and Japanese oak, *Quercus crispula*, and some pure stands of Sakhalin spruce, *Picea glehnii* or Erman's birch, *Betula ermanii*. Mammals such as Sika deer, *Cervus nippon yesoensis*, and Brown bear, *Ursus arctos yesoensis*, and birds that prefer coniferous forests such as Goldcrest, *Regulus regulus japonensis*, and Coal tit, *Periparus ater insularis*, and also woodpeckers such as Black woodpecker, *Dryocopus martius martius*, and Great spotted woodpecker, *Dendrocopos major hondoensis*, can be found in the forest.

In 2008 through 2017, the mean annual air temperature was 5.4°C, the mean maximum temperature was 31.6°C, and the mean minimum temperature of -21.1°C was recorded in Teshikaga⁹⁾.

2.2. Study methods

There are >150 piles of thinned wood (hereinafter called "woodpiles") in the study area (Fig. 1). Split Manchurian walnut shells having feeding marks of Eurasian red squirrels were observed around 15 woodpiles. Then, those 15 woodpiles were selected as research objects. The width (m), depth (m), and height (m) of each woodpile and its distance to the nearest Walnut tree were measured in order to determine which properties of the woodpiles influence the site usage by Eurasian red squirrels. The number of logs forming each woodpile was also counted.

In order to evaluate the frequency of woodpile usage by Eurasian red squirrels, all split walnut shells around and in each woodpile were collected. One feeding mark was counted with two split nut shells because Eurasian red squirrels divide in half and feed on the walnut.

In order to find out what kinds of wildlife live in the study area and use the woodpiles, motion-sensor



Fig. 1 Landscape view of the study area.
Over 150 piles of slash were left on the forest floor.

cameras (ScoutGuard SG560C) were installed to capture images of animals. Images were captured from May 26 to October 23, 2018.

3 Results

3.1 Configuration of woodpiles

The mean width, depth, and height of the 15 woodpiles were 1.78±0.43 m (0.9 to 2.4 m), 2.26±0.51 m (1.6 to 3.8 m) and 0.55±0.12 m (0.4 to 0.7 m), respectively. The mean number of logs in a woodpile was 49.4±20.9 (21 to 101). The mean distance to the nearest Manchurian walnut tree was 17.36±11.59 (3.0 to 33.6 m). The mean number of feeding marks of Eurasian red squirrels around and in the 15 woodpiles was 19.3±19.7 (2 to 60).

Fig. 2 shows the relationships between the number of walnuts having feeding marks and the woodpile properties. There is a significant negative correlation between the number of walnuts having feeding marks and the distance to the nearest Manchurian walnut tree ($R^2=0.52$, $p=0.003$, Fig. 2B). The number of logs in a woodpile generally, but not significantly, influenced the number of walnuts having feeding marks ($R^2=0.17$, $p=0.13$, Fig. 2A).

3.2 Wildlife

The motion-sensor cameras captured images less frequently in May, June, and July, at an increased frequency in August, and most frequently in October. Images of Eurasian red squirrels were captured in all those months, with many on the top of the woodpile

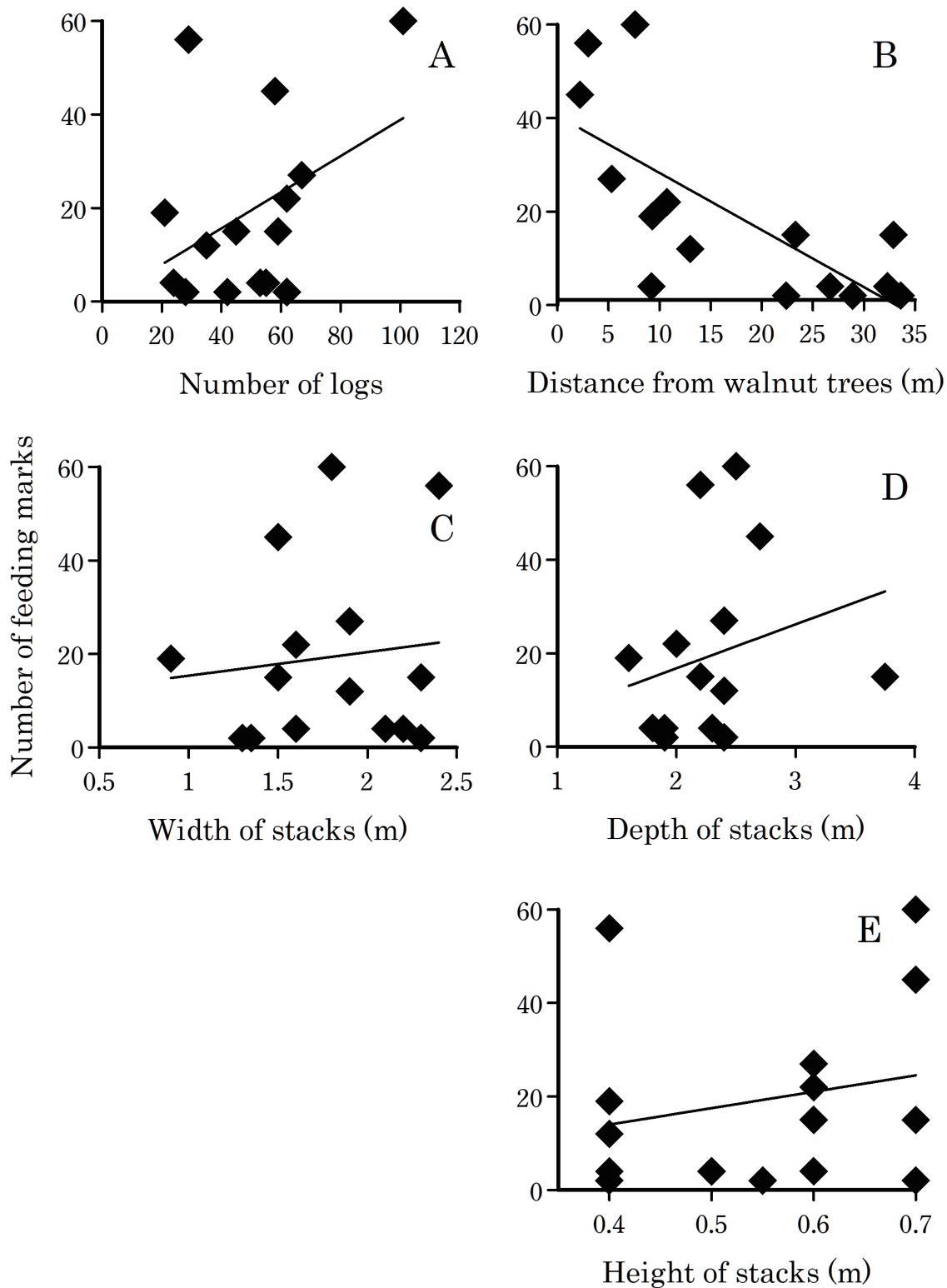


Fig. 2 Relation between number of walnuts having feeding marks and woodpile properties.

A, number of logs, B, distance to walnut tree, C, pile width, D, pile depth, and E, pile height. Coefficients applied to numbers of feeding marks depending on pile properties are A: $R^2=0.17$ ($p=0.13$), B: $R^2=0.52$ ($p=0.003$), C: $R^2=0.01$ ($p=0.69$), D: $R^2=0.06$ ($p=0.38$), and E: $R^2=0.05$ ($p=0.43$).



Fig. 3 A Eurasian red squirrel on a pile of slash in the study area.
The squirrel holds a walnut in its paws.

(Fig. 3). Images of Sika deers, Raccoon dogs, *Nyctereutes procyonoides albus*, Red foxes, *Vulpes vulpes schrencki*, and Brown bears were also captured.

4 Discussion

A negative correlation between the distance to the nearest Manchurian walnut tree and the number of walnuts having feeding marks, and a positive correlation between the number of logs in a woodpile and the number of walnuts having feeding marks were found among the woodpile properties (Fig. 2). Woodpiles may be conspicuous to animals even in snow during winter; therefore, the presence of woodpiles may benefit non-hibernating Eurasian red squirrels as cache sites. Eurasian red squirrels have a scatter-hoarding behaviour, and usually use the bases of branches and caves in tree trunks as well as the ground⁶⁾. The squirrels are highly capable in spatial mnemonics such as chunking, and can remember the cache accurately enough to retrieve it later¹⁰⁾. Walnut shells having feeding marks were found not only around the woodpiles but also within the woodpiles. This may indicate that Eurasian red squirrels may use woodpiles

as a safe feeding site to prevent attacks from predators such as red foxes and raptors like Mountain hawk-eagle, *Nisaetus nipalensis orientalis*^{11, 12)}. A woodpile of larger number of logs provides a larger shelter space. It may be the reason that Eurasian red squirrels preferred woodpiles with more logs.

Many animals, such as Brown bears and Raccoon dogs, and birds were captured with the camera traps during the present study. Yasue et al.¹³⁾ reported that Japanese black bear *Ursus thibetanus*, visits dying trees in coniferous forests to feed on ants nesting in the decomposing tree trunks, and that dying trees provide important food sources to wild animals.

The authors presumed that woodpiles left on forest floors have the important role of serving as a shelter from predators, especially during feeding, in the same way as dying trees do. This study focused on woodpiles with walnuts having feeding marks and no survey was conducted for other woodpiles, which need to be discussed.

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北海道東部における林床に設置された 残材堆積物のエゾリスによる利用

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北海道にはエゾリスおよびアカネズミが生息しており、オニグルミの堅果を貯食する習性をもっている。これらの動物は大型種子を分散貯蔵する。森林生態系における立枯木や倒木はそれ自身が主要な資源である。樹木伐採後の残材は、立枯木や倒木と同様な機能をもつと考えられる。本研究では、エゾリスがいくつかの残材堆積物を利用していることを報告し、林床における残材堆積物の重要性を議論することを目的とし、残材堆積物のどの属性がエゾリスの利用に影響しているかを検討した。その結果、エゾリス食痕数に対して残材堆積物のオニグルミ母樹からの距離で負の関係が、残材堆積物を構成する材の本数で正の関係がみられた。エゾリスは残材堆積物を安全な採餌場所として利用していると考えられる。

キーワード

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