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S39-2 The impact of herbivory by deer on forest bird communities in Japan

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Abstract Deer overabundance has become a worldwide phenomenon. Herbivory (browsing, grazing, and bark-stripping) by deer has had a great impact on forest bird communities by changing vegetation structure. My study in central Japan compared breeding-bird communities and vegetation characteristics along a gradient of deer densities. Reduction of the understory and forest midstage by deer decreased the number of species and abundance of birds nesting and foraging on these substrates but increased those of birds preferring open habitats. The increase in density of dead trees increased the number of tree-hole-nesting and bark-foraging birds. The results indicate that the responses of vegetation and bird species to deer pressure are nonlinear because of a combination of positive and negative effects from deer herbivory. Comparative studies across gradients of deer density can yield useful information for deer population management, but most studies have only compared grazed and ungrazed plots.

Key words Deer population management, Forest bird community, Forest ecosystem, Herbivory, Vegetation structure

1 Introduction

Overabundance of deer has become a worldwide phenomenon (McShea et al., 1997; Fuller and Gill, 2001). The increase in numbers has been attributed to several factors, according to region. Fuller and Gill (2001) listed six diverse reasons for deer increase in British woodlands. In North America, the recent explosion is thought to result partly from management intended to restore deer populations that had declined to near-extinction in the nineteen century (Rooney, 2001). In Japan, one of the most important reasons for the abrupt increase in numbers is the increase in food resources from large-scale afforestation in the early 1960s (Takatsuki, 1996).

As a consequence, grazing, browsing, and bark-stripping by overabundant deer is having widespread impact on woodland vegetation (Putman et al., 1989; Gill, 1992; Yokoyama et al., 2001). Bird communities in woodlands and forests have often been correlated with vegetation structure associated with foraging and nesting sites (MacArthur and MacArthur, 1966; James and Wamer, 1982; Hino, 1985), so deer impacts should have an indirect effect on the diversity and abundance of forest birds through vegetation change. The present paper focuses on this effect and then considers the management of deer populations favorable not only for conservation of diverse avian communities but also for health in forest ecosystems.

2 Impact on Japanese forest bird communities

Three kinds of vegetational change can be expected from deer herbivory. The first is a depletion of the understory due to direct grazing and browsing, reducing the height and density of the undergrowth. The second is a thinning of the forest midstage that results from cropping of seedlings and saplings to depress regeneration of woody plants. The third is an increase in dead trees resulting from bark-stripping. Changes develop fastest in the understory and slowest in the forest midstage, although that is advanced by bark-stripping.

These three types of change occurred in my study area in a natural mixed forest, dominated by *Fagus crenata*, *Acer shirasawanum* and *Abies homolepis*, in Ohdaigahara, central Japan (Hino, 2000, unpublished data). In my sampling, I distinguished among three groups of plots using cluster analysis of vegetational characteristics surveyed by belt-transect method on 12 study plots. The groups of plots differed in their densities of Sika deer (*Cervus nippon*) as a result of slope. Steep plots harbored few deer (7.3 ± 2.2 deer/km^2, n = 6), plots on gentle slopes held moderate densities (12.0 ± 3.3 deer/km^2, n = 3), and plots on flat ground supported the highest numbers (24.0 ± 8.2 deer/km^2, n = 3). As expected, dry mass and height of dwarf bamboo (*Sasa nipponica* and *Sasamorpha borealis*), which are predominant plants in the understory, were 10 and 8 times higher on the plots with few and moderate numbers of deer, and forest midstage cover was also twice as dense. In contrast, the basal area of dead trees was 7 times higher on the plots where deer were most abundant.

Censused by the point-count method, the composition of breeding birds on the study plots differed in accord with structural differences in the forest understory (Fig. 1). Species richness and abundance in birds that foraged or nested in the understory or on the ground, such as bush

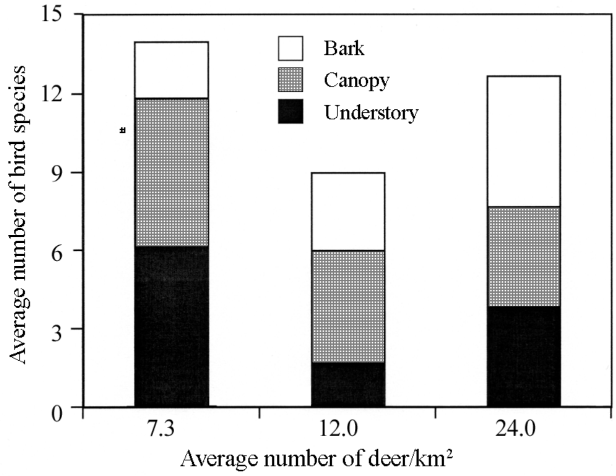

Fig. 1 Comparison of average number of bird species foraging in the understory, in the canopy, and on bark in plots with different deer densities

warblers (*Cettia diphone*) and robins, was highest on plots with fewest deer. Some bird species that foraged preferentially in the forest midstage, such as long-tailed tits (*Aegithalos caudatus*) and willow tits (*Parus montanus*), were found only these plots. In contrast, tree-hole-nesting and bark-foraging birds, such as woodpeckers, nuthatches, and creepers, were most diverse and abundant on the plots where deer were also most abundant. Moreover, birds preferring open habitats, such as pipits and large thrushes, were only observed on these plots. Overall, the number of bird species and individuals on plots where deer were least and most abundant differed little; and they were lowest on plots of intermediate deer density.

Table 1 summarizes the results of my study and four others in the USA that have examined the impacts of deer on forest bird communities. All these studies documented negative effects on understory- and forest midstage- birds. Yet, although paid less attention, positive effects were also found. Casey and Hein (1983) reported that bark-foraging birds increased in response to abundant larger trees and dead standing timber in an area protected for deer. McShea and Rappole (2000) showed that some understory birds also benefited from deer grazing because of their preference for successional stages in understory vegetation. At sites where deer were abundant, however, DeCalesta (1994) attributed declines in both total bird species richness and abundance to the negative impact of deer herbivory on forest midstage birds.

Yet the other studies, including mine, did not find such clear effects. This result is explained by two factors. First, the negative and positive effects of deer herbivory offset one another. DeGraaf et al. (1991), who examined the effects of both deer browsing and thinning on avian communities, reported that thinning produced a high density of shrubs and seedlings despite the browsing. Secondly, thinning and selective felling aimed at stimulating natural regeneration often fail in areas of high deer pressure, leading to structurally impoverished stands (Fuller, 2001)

3 Management of deer populations for birds

What densities of deer are needed to maintain the most diverse avian community? Most studies have shown that total numbers of species and individuals are not affected by deer herbivory despite large shifts in species composition. Such results may nevertheless reflect simple comparisons between ungrazed and grazed plots (Table 1). Because the numerical response of birds to deer pressure can be nonlinear, the effects of different densities of deer need to be investigated (Fuller, 2001). In my study of the effects of three different deer densities, the number of bird species decreased between 7.3 and 12.0 deer/km^2 and increased between 12.0 and 24.0 deer/km^2 (Fig. 1). If I had studied only two plots with 7.3 and 24.0 deer/km^2, I might have concluded that deer had no effect. And had I selected two plots of densities each below or above 12.0 deer/km^2, moreover, I would have deduced nega-

Table 1 Summary of studies on the effects of deer herbivory on forest bird species diversity in forest understory, canopy, and on bark

References	Country	Deer/km^2	Changes in number of bird species			
			Understory	Canopy	Bark	Total
Casey and Hein, 1983	USA	10–20 83	↓	↓	↑	→
DeGraaf et al., 1991	USA	1–3 13–23	(↓)	(↓)	–	→
McShea and Rappole, 2000	USA	0 25 <	↓↑	↓	–	→
DeCalesta, 1994	USA	3.7	→	→		→
		7.9	→	↓	–	↓
		14.9				
		24.9	→	→	→	
Hino (unpublished)	Japan	7.3 12	↓	(↓)	→	↓

tive and positive impacts respectively.

The most valuable approach is one that takes account of how bird species are distributed and how deer affect the availability of resources or vegetation critical for birds across a gradient of deer densities within the same habitat type. DeCalesta (1994) studied four plots with different deer densities (3.7, 7.9, 14.9, 24.9 deer/km^2). He showed that the number of bird species declined abruptly between 7.9 and 14.9 deer/km^2, but did not change between 3.7 and 7.9 deer/km^2 or between 14.9 and 24.9 deer/km^2 (Table 1). This result indicates that changes in the avian community may occur abruptly along a gradient of deer densities, corresponding to changes in vegetation.

Abrupt change was also found in my study. That is, the number of species of understory-nesting birds diminished with decreasing biomass of dwarf bamboo between 7. 3 and 12.0 deer/km^2, and that of tree-hole-nesting birds increased in accord with increasing frequency of dead trees between 12.0 and 24.0 deer/km^2 (Fig.1). DeCalesta (1994) found no such correlations for bark-foraging and open-habitat birds (Table 1), perhaps because the forest area that he studied may comprise tree species not bark-stripped by deer (Sekine and Sato, 1992).

DeCalesta (1994) recommended a deer density of between 7.9 and 14.9 deer/km^2, at the threshold for change in the number of bird species. In my study, it is not easy to determine a recommended density because both species richness and abundance in birds were lowest at intermediate deer density (12 deer/km^2). If the present high density of deer (24.0 deer/km^2) were maintained, the number of dead trees would continue to increase rapidly in forest on the flat areas, breaking up the canopy and making the habitat unsuitable for forest birds. Moreover, overabundant deer might intrude on and reduce the biomass of understory vegetation even in the steep areas. This behavior has already been observed.

On the other hand, if deer numbers drop to a low density (7.3 deer/km^2) in all areas, large woodpeckers, thrushes, and pipits would be lost. I would recommend a deer density that can produce dead trees constantly but much more slowly than at present. This density would be between 12 and 24 deer/km^2. At that density, the overall diversity of birds in Ohdaigahara, central Japan, would be maintained because those birds using the understory could survive on steep slopes and those using tree trunks would have ample habitat in flat terrain. Such a management plan would be applicable wherever deer densities are moderated by topographic features.

4 Management of deer populations for the forest ecosystem

Deer are a keystone species in the forest ecosystem. Research has examined the striking impacts of deer herbivory not only on birds but also on many other animals and plants in forests (McShea et al., 1997; Flowerdew and Ellwood, 2001; Rooney, 2001; Stewart, 2001). Deer may affect forest birds through the interactive network among organisms in general. For example, McShea (2000) demonstrated that deer decreased the survival of rodents by eating acorns, thereby increasing the number of birds as a result of a drop in nest predation by rodents. Therefore, deer herbivory has both positive and negative effects on forest ecosystems, just as it has on forest bird communities. Determining the number of deer that would maintain the most diverse forest ecosystem is a complicated but challenging problem.

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References

Casey D, Hein D, 1983. Effects of heavy browsing on a bird community in deciduous forest. J. Wildl. Manage. 47: 829–836.
DeCalesta DS, 1994. Effect of white-tailed deer on songbirds within managed forests in Pennsylvania. J. Wildl. Manage 58: 711–718.
DeGraaf RM, Healy WM, Brooks RT, 1991. Effects of thinning and deer browsing on breeding birds in New England oak woodland. For. Ecol. Manage. 41: 179–191.
Flowerdew JR, Ellwood SA, 2001. Impacts of deer on small mammal ecology. Forestry 74: 277–288.
Fuller RJ, 2001. Responses of woodland birds to increasing numbers of deer: a review of evidence and mechanisms. Forestry 74: 289–298.
Fuller RJ, Gill RMA, 2001. Ecological impacts of increasing numbers of deer in British woodland. Forestry 74: 193–200.
Gill RMA, 1992. A review of damage by mammals in north temperate forests: 1. Deer. Forestry 65: 145–169.
Hino T, 1985. Relationships between bird community and habitat structure in shelterbelts of Hokkaido, Japan. Oecologia 65: 442–448.
Hino T, 2000. Bird community and vegetation structure in a forest with a high density of sika deer. Jpn. J. Ornithol. 48: 197–204.
James FC, Wamer NO, 1982. Relationships between temperate forest bird communities and vegetation structure. Ecology 63: 159–171.
MacArthur RH, MacArthur JW, 1966. On bird species diversity. Ecology 42: 594–598.
McShea WJ, 2000. The influence of acorn crops on annual variation in rodent and bird populations. Ecology 81: 228–238.
McShea WJ, Rappole JH, 2000. Managing the abundance and diversity of breeding bird populations through manipulation of deer populations. Conserv. Biol. 14: 1 161–1 170.
McShea WJ, Underwood HB, Rappole JH, 1997. The Science of Overabundance: Deer Ecology and Population Management. Washington: Smithonian Institution Press.
Putman RJ edwards PJ, Mann JCE, How RC, Hill SD, 1989. Vegetational and faunal changes in an area of heavily grazed woodland following relief of grazing. Biol. Conserv. 47: 13–32.
Rooney TP, 2001. Deer impacts on forest ecosystems: a North American perspective. Forestry 74: 201–209.
Sekine T, Sato H, 1992. Tree barking by sika deer, *Cervus nippon* Temminck, on Mt.Odaigahara. Jpn. J. Ecol. 42: 241–248 (in Japanese with English summary).
Stewart AJA, 2001. The impact of deer on lowland woodland invertebrates: a review of the evidence and priorities for future research. Forestry 74: 259–270.
Takatsuki S, 1996. Deer in North Japan. Tokyo: Doubutsu-sha (in Japanese).
Yokoyama S, Maeji I, Ueda T, Ando M, Shibata E, 2001. Impact of bark stripping by sika deer, *Cervus nippon*, on subalpine coniferous forests in central Japan. For. Ecol. Manag. 140: 93–99.