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Distribution of ground-dwelling beetle assemblages (Coleoptera) across ecotones between natural oak forests and mature pine plantations in North China

Xiao-Dong Yu · Tian-Hong Luo · Hong-Zhang Zhou

Abstract This paper studied edge effects resulting from logging to reforestation on the distribution of ground-dwelling beetles (Coleoptera) across ecotones between natural oak forests and mature pine plantations established after harvesting of natural forests. Using pitfall traps, ground-dwelling beetles were investigated at three replicated plots (ecotones) with three sampling positions of slope (lower, middle and upper) for each plot. Rarefaction estimates of species richness indicated that traps on natural forests and transition zones had more species than mature plantations did, and traps on the middle slope had more species than on the lower and upper slopes did. Results of an ANOVA analysis, which used forest type and slope position as factors and number of species and individuals as the response variables, showed a significant effect of forest type and slope position, and a significant interaction between forest type and slope position. Multivariate analyses (DCA and CCA) showed that beetles of transition zones were more similar to those of natural forests than to those of mature plantations, and that some environmental characteristics, i.e., proportion of broad-leaved trees, canopy cover and elevation (slope position), significantly affected species abundances. We conclude that the logging of natural oak forests and the reforestation of pine plantations can result in subtle variation in the composition and distribution of beetle assemblages at a local scale and such variation should be taken into account when conservation issues are involved.

Introduction

Studies on spatial population processes in heterogeneous environments, especially in relation to forest fragmentation and reforestation, have increased in the recent decades (Kareiva and Wennergren 1995; Hanski 1999; Bjornstad et al. 2000; Rodeghiero and Battisti 2000; Barbosa and Marquet 2002; Matthysen 2002; Vanbergen et al. 2005; Johansson et al. 2007). Forest edges created by logging have microclimates which are distinctive from the adjacent habitats (Holland et al. 1991; Murcia 1995). Some studies have suggested that the distinctive microclimates of forest edges have significant impacts on insect communities (Kotze and Samways 1999; Heliölä et al. 2001; Taboada et al. 2004; Lövei et al. 2006; Máthé 2006; Phillips et al. 2006; Yu et al. 2006b, 2007, 2009).

Liaodong oak woods, *Quercus liaotungensis* Koidz. (Fagaceae), were the dominant forest type of natural woodlands in North China. Because of extensive deforestation in 1960s and limited natural regeneration, only a few natural oak woods now occur in the region. Knowledge about their functions as ecosystems and the effects of their loss on arthropod communities in this region is scant (Wang et al. 1999; Li and Ma 2003; Li and Zhang 2003; Yu et al. 2003, 2004, 2006c). In some locations pine and larch plantations were established after the logging of natural oak woods. Because the conifer plantations are significantly different from natural oak woods, the transition zone between the conifer plantation and the remnant oak woods forms a unique forest edge ecotone. However, few studies have been conducted on the edge effects on beetle assemblages from the

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transition zones between natural broad-leaved forests and mature conifer plantations established after the logging of natural broad-leaved forest. In this study, we examined edge effects based on natural oak forests, mature pine plantations, and the transition zones (mixed forests) between natural oak forests and mature plantations. The following questions are addressed, (1) What are the differences in beetle assemblages between natural oak forests and mature pine plantations? (2) Are natural oak forest specialists averse to the transition zones and to mature pine plantations? (3) Do the plantation species enter the natural forest interior? (4) What are the effects of spatial heterogeneity in sampling position resulting from slope position on beetle assemblages?

Materials and methods

Study area

This study was conducted at Beijing Forestry Ecosystem Research Station (BFERS, about 114 km west of Beijing) on Dongling Mountain (40°00′N, 115°26′E, 800–2,300 m) which is a part of Taihang Mountain Ranges, North China. This forest grows on a brown mountain soil. The area has a cool-temperature monsoon climate with an average annual temperature of 4.8°C (January −10.1°C, July 18.3°C). Precipitation averages 611.9 mm/year, and 78 percent of annual rainfall occurs from June to August (Chen and Huang 1997). In this region, liaodong oak forest is the most extensive native forest type. In some areas, where the oak forests were logged ca. 40 years ago, conifer plantations of pine (*Pinus tabulaeformis*) and larch (*Larix principis-rup-prechtii*) were established. All these forests have a closed canopy with tree height of 8–15 m (max 20 m). For more detailed description of these forest types, see Yu et al. (2006c).

Transition belts consisting of three forest types were selected for this study. The belt included oak forest, pine plantation, and transition zone as an ecotone formed by the adjacent oak forest and pine plantation. Mature oak trees (50–70 years old) comprised 90% of the canopy in the oak forest, with a moderate canopy (canopy cover, 50%). The understory vegetation coverage was relatively moderate (30–40%), and the leaf litter layer was moderate (ca. 3 cm) and soil moisture was dry-medium. Pine plantation, established after the logging of the natural oak forests ca. 40 years ago, had a dense canopy (canopy cover, 80%) dominated by 90% of pine trees, with 10–20% cover by shrubs and herbs under the canopy. Leaf litter dominated by needles (ca. 4 cm) was moderate and soil moisture was dry. Transition zones dominated by remnant natural oak trees and planted mature pine trees (40–50 years old) had a dense canopy (canopy cover, 70%). The shrub and herb layer covered ca. 40–60% of the ground, and the leaf litter layers were thick (ca. 5 cm) and soil moisture was dry-medium.

Three sites (replicated plots) with similar slopes and elevations (south-facing slope, 20°–25°, 1,200–1,300 m) of more than 40 ha each were selected, and each forest type within each site was more than 5 ha. The distance between sites was more than 500 m.

Sampling

Three transects for each replicated plot including three forest types were set along an elevational gradient, corresponding to three mountain positions (lower slope, middle slope and upper slope; Table 1). Transects were separated by at least 50 m, and the distance for sampling locations between two forest types was over 50 m. Along each transect beetles were captured using pitfall traps. For more details on this method, see Yu et al. (2004, 2006a). Although there may be a bias from using the method of pitfall traps to estimate the absolute density by beetle activity, this trapping method is still useful to monitor and assess the local population changes (Baars 1979; Spence and Niemelä 1994). Sampling was conducted from June to September in 2000. As our previous studies suggested, most beetle species could be found in this period in this region (Yu et al. 2002, 2006c). The traps were serviced every 3 days each month. Each transect included six trapping locations corresponding to three habitats. Two trap locations for each habitat were 15 m apart from each other. Five traps in each location were placed in a cruci-form pattern with a distance of 1 m between the traps. Samples from each location were pooled for data analysis.

Data analysis

To remove the possible the effects of abundance variation among samples, a rarefaction method was used to standardize species richness per number of individuals (Gotelli and Colwell 2001). Rarefaction was performed for each forest type or sampling position, with 500 iterations being conducted independently, using "EstimateS" software

Table 1 Experimental design, indicating number of traps in each habitat × slope position combination [number of traps × number of replicates (sites)]

	Transect		
	Oak forests	Transition zones	Pine plantations
Lower slope	2 × 3	2 × 3	2 × 3
Middle slope	2 × 3	2 × 3	2 × 3
Upper slope	2 × 3	2 × 3	2 × 3

(Colwell 2006). Two-way ANOVA with Tukey test for post-hoc pairwise comparisons was used to assess differences in rarefied richness and abundance of beetle assemblages among forest types and slope positions. Rarefied richness was log transformed and abundance data square-root transformed (Sokal and Rohlf 1981). All analyses were made with SPSS 7.5 (SPSS Inc. 1997).

Beetle-community structure and the relationship between the species and samples in relation to forest type and slope position were studied using detrended correspondence analysis (DCA) (Jongman et al. 1995). The 54 species occurring in two or more stands were included in the analysis. The relationship between the catches of species occurring in at least two samples and environmental structure of the forests was studied by canonical correspondence analysis (CCA; ter Braak 1986; Jongman et al. 1995). Eight environmental variables: the proportion of broad-leaved tree species, elevation (slope position), canopy cover, shrub cover, herb cover, litter cover, litter depth and soil moisture were included in the analysis. The importance of these variables in explaining the abundance and distribution patterns of beetles was studied by performing a partial CCA with Monte Carlo randomizations (ter Braak and Šmilauer 1998). Variables were added one by one into the model, starting from the most important one until the subsequent variable was statistically non-significant. DCA and CCA were done by using CANOCO 4.0 software (ter Braak and Šmilauer 1998).

Results

A total of 1,097 specimens of beetles were captured, corresponding to 92 species in 16 families (Appendix 1). The most species-rich families were: Carabidae (19 spp), Curculionidae (18 spp), and Staphylinidae (16 spp).

Rarefaction estimates of species richness indicated that traps in oak forests and transition zones had more species than pine plantations did, and traps on the mountain position in the middle slope had more species than traps in the lower and upper slopes. For both forest type and for sampling positions, no specific habitat had faster species accumulation rates than found for the two other habitats (Fig. 1).

Results of the ANOVA using forest type and slope position as factors and number of species as the response variable showed a significant effect of forest type and a significant interaction between forest type and slope position (Table 2). However, the species number from samples did not differ significantly among the three positions (Fig. 2a). The ANOVA using number of individuals as response variable showed that forest type and slope position had significant effects, and there was a significant
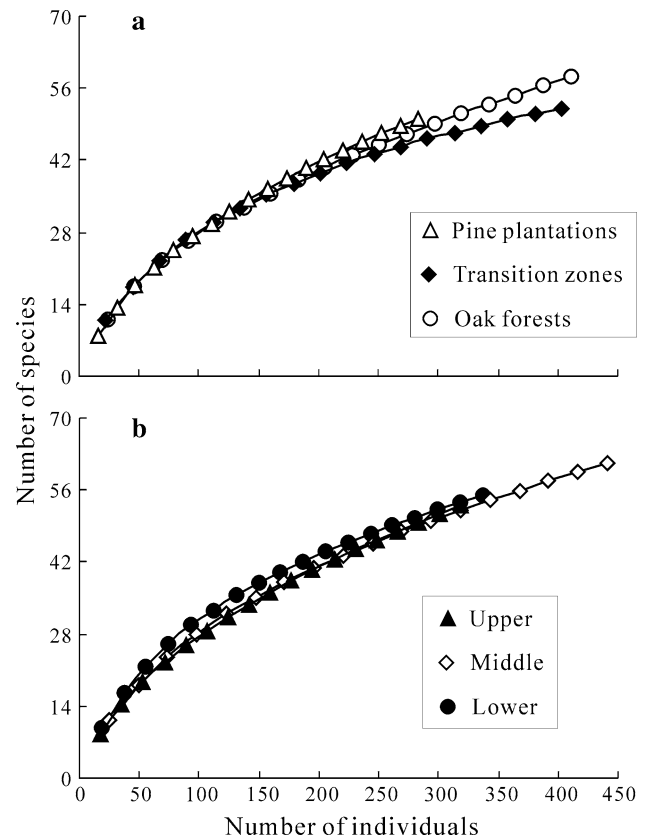

Fig. 1 Rarefaction estimates of species richness in each forest type (**a**) and sampling position (**b**)

Table 2 Results of the two-way ANOVA for the responsive variable; number of species

Source	Sum of squares	Degrees of freedom	Mean squares	F	P
Type	0.170	2	0.085	5.515	0.007
Position	0.072	2	0.036	2.334	0.109
Type × position	0.202	4	0.051	3.274	0.019
Error	0.696	45	0.015		

interaction between forest type and slope position (Table 3). The samples of the middle slopes were more abundant than those of lower and upper slopes in transition zones and pine plantations, but the samples of oak forests showed a significantly decreasing trend from lower slope to upper slope (Fig. 2b).

In the multivariate analyses, beetle catches of different feeding guilds showed different responses to habitat changes, and the species scatters also indicated the importance of environmental characteristics affecting species abundances (Figs. 3, 4). In the DCA, the samples of three slope positions did not show a significant difference for all feeding guilds, but there were significant differences in the composition and distribution of beetle assemblages
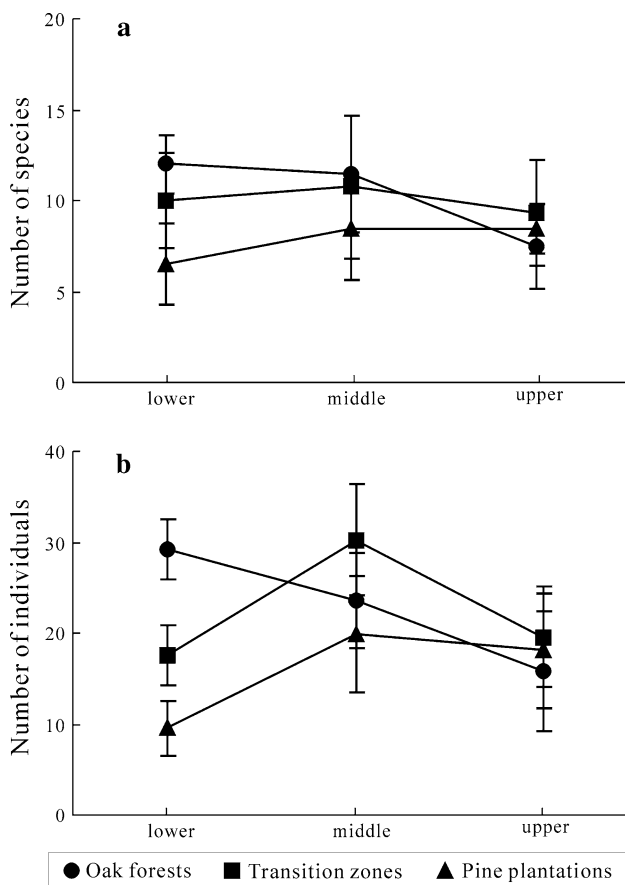
Fig. 2 Mean number of species (**a**) and individuals (**b**) by forest type and slope position

Table 3 Results of the two-way ANOVA for the responsive variable; number of individuals

Source	Sum of squares	Degrees offreedom	Mean squares	F	P
Type	7.597	2	3.799	10.172	0.001
Position	6.013	2	3.006	8.050	0.001
Type × position	12.565	4	3.141	8.411	0.001
Error	16.806	45	0.373		

for all feeding guilds among the three habitats (Fig. 3). The samples of beetle assemblages in the pine plantations were significantly distinct from the samples from the oak forests, and the samples of transition zones were more similar to those of oak forests. Although the ranges of these samples are scattered all over the two-dimensional ordination space, remarkable variations in different feeding guilds were identified.

In the carnivores, many broad-leaved forest species, i.e., *Carabus vladimirskyii*, *Pristosia* sp.3 and *Ontholestes* sp., were to the upper left side of the ordination space; *Carabus manifestus* (associated with conifer forests) was to the

lower right side of the ordination space; and most habitat generalists species were located at the middle of the ordination space (Fig. 3a). In the herbivores, the samples from oak forests were mixed together with those of transition zones and as most species are habitat generalists, they ranged over most of the ordination space. Only *Pissodes nitidus* was in the lower part of the of ordination space, indicating its preference for conifer plantations (Fig. 3b). In scavengers, *Scytosoma* sp.1 and *Scytosoma* sp.2 associated with conifer plantations were at the left side of the ordination space; and other species, as habitat generalists, extended over most of the ordination space (Fig. 3c).

In CCA (Fig. 4), the sum of all the eigenvalues was 4.14 and the eigenvalues of the first two gradients were 0.31 and 0.14, respectively. These axes explained 11.0% of the cumulative variance of the species dataset and 80.0% of the species-environment relationship. The proportion of broad-leaved trees that are part of the native oak forests was greatest at the lower left from the origin of the ordination ($F = 4.22$, $P = 0.002$), and *Anatolica externecostata*, *Carabus sculptipennis*, *Carabus vladimirskyi*, *Pristosia* sp.3 and *Ontholestes* sp. clustered in this direction. The environmental variables indicating conifer forest conditions at high elevation including higher canopy and litter cover, were located to the upper right of the origin. The coverage of canopy trees ($F = 1.98$, $P = 0.002$) and the elevation ($F = 1.98$, $P = 0.002$) were statistically significant, whereas litter cover did not explain the patterns significantly. *Carabus manifestus*, *Pissodes nitidus*, *Scytosoma* sp.1 and *Scytosoma* sp.2 clustered this direction. Four environment variables (litter depth, moisture, herb cover and shrub cover) indicative of the transition zones were above the origin. Most species were associated with this direction. However, these variables did not explain the patterns significantly.

Discussion

Our results indicate that forest type and sampling position could affect ground-dwelling beetle assemblages. Species composition of beetle assemblages drastically changed across the transition zone. In addition, we showed that slope position had a significant effect on beetle communities, and except for oak forests, transition zones and pine plantations had more species and abundance in the middle slope position.

Our result indicate that beetle assemblages in the transition zones (mixed forests) were more similar to the assemblages in the oak forests (natural forest interior) than to those in the pine plantations (plantation interior). Most species in the transition zones (mixed forests) can be found in natural oak forests (35 of 58 species) and pine

plantations (30 of 50 species). These results are consistent
with the previous studies from forest-grassland or forest-
clearcut ecotones (Kotze and Samways 1999; Heliölä et al.
2001; Magura et al. 2001; Magura 2002; Molnár et al.
2001; Baker et al. 2007; Yu et al. 2007, 2009), suggesting
that the forest edge assemblage was a mixture of natural
forests and new structures. As with other studies (Heliölä
et al. 2001; Yu et al. 2009), only a few species were
restricted to or abundant in transition zones (forest edges).
This result differs from studies in central Europe (Molnár
et al. 2001; Magura et al. 2001; Magura 2002). The tran-
sition zones (forest edges) studied by these authors had
abundant bushes and dense herbs, and were significantly
different from the adjacent habitats. However, in our study,
similar to our previous study in southwestern China (Yu
et al. 2009), the vegetation in transition zones originated
from the oak forests and pine plantations, and formed a
transition from the natural oak forests to the conifer plan-
tations. The multivariate analyses also showed that the
proportion of broad-leaved trees and canopy cover were
significant environmental variables determining the com-
position and distribution of ground-dwelling beetles in this
study. A high proportion of broad-leaved trees represented
the characteristics of oak forests, and high coverage of
canopy trees indicated the characteristics of conifer plan-
tation. The transition zones, with the relatively high pro-
portion of broad-leaved trees and high coverage of canopy
trees formed a matrix that contained most species from the
adjacent habitats. Some beetle species (i.e., *Carabus ma-
nifestus*, *Pissodes nitidus*, *Scytosoma* sp.1, *Scytosoma* sp.2)
that preferred the habitats of conifer plantations may not use
the microhabitats and resources in natural broad-leaved
forests, and these species disappeared or decreased in
abundance in the samples from natural broad-leaved forests,
resulting in a decrease of species richness and abundance.
These findings are consistent with previous studies (But-
terfield et al. 1995; Fahy and Gormally 1998; Magura et al.
2000, 2003; Ohsawa 2004; Yu et al. 2004, 2006a, 2008),
which identified that conifer plantations change the com-
position and distribution patterns of beetle assemblages
associated with native broad-leaved forests, and that more
species and individuals of beetle assemblages are found in
natural forests than in regenerating conifer plantations.
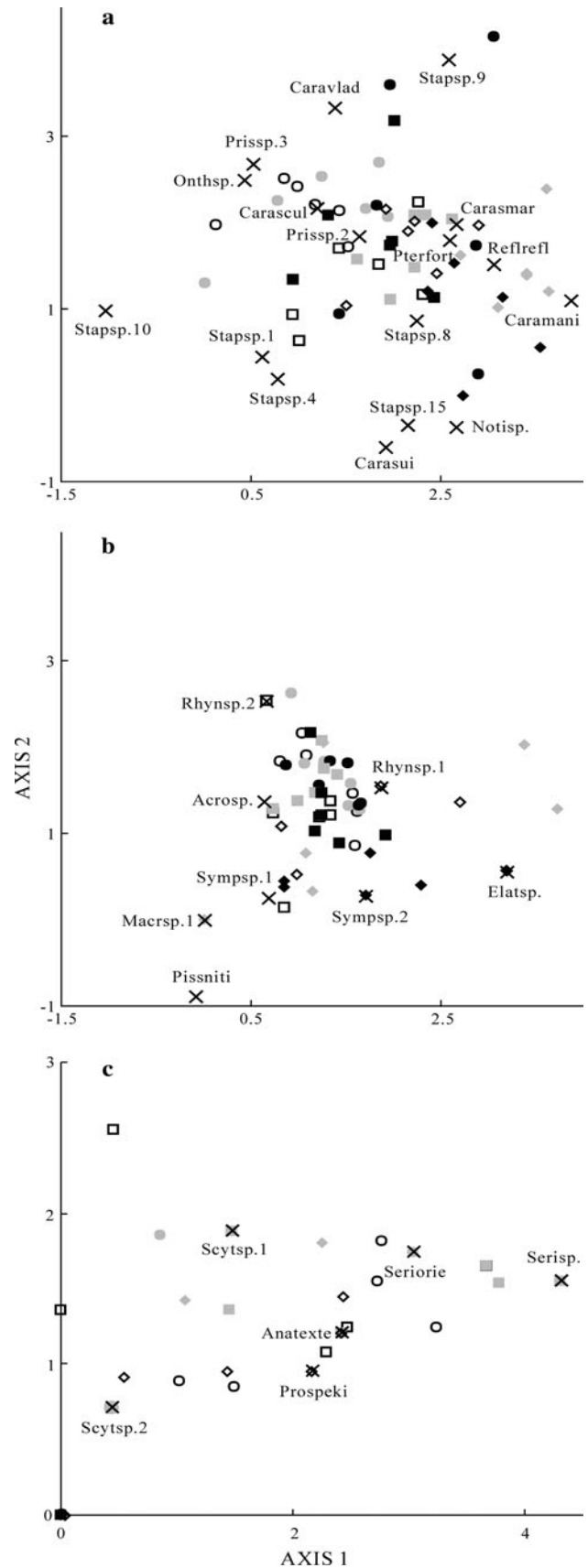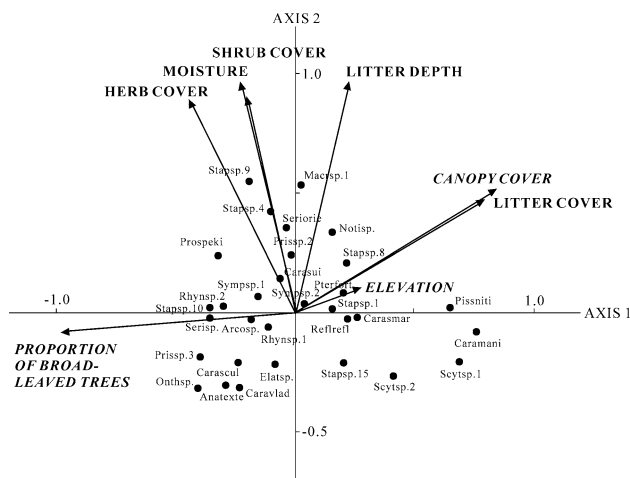
Fig. 4 CCA for beetle species and eight environmental variables which were the most important in shaping the beetle-abundance patterns. Only species with at least five individuals are presented. The environmental variables are given in italics, if statistically significant. The beetle species (*times*) are marked with 4 + 4 letter abbreviations, e.g., *Carabus manifestus* = CARAMANI

The slope position also significantly affected the distribution of beetle assemblages, indicating spatial heterogeneity of beetle distributions. In oak forests, the number of species and individuals of beetle assemblages decreased from the upper, middle to the lower slope. But in transition zones and pine plantations, more species and abundance were found in middle slope positions than in lower and upper slope positions. The differences between the three forest types of slope position on the distribution of beetle assemblages correspond to the characteristics of microhabitats of the three forest types. Compared with the pine plantations and transition zones, the coverage of canopy and understory in the natural oak forests was sparser, and the leaf-litter layer was thinner. In the pine plantations, the coverage of trees and herbs was similar to that of the transition zone, as were the herb-species composition, structure and thickness of leaf litter. Thus, the oak forest ground layer would experience more sunshine and moisture, and as a consequence the changes of microhabitats would be more drastic in oak forests along the slope than those in the two other forest types. Our previous studies in this region suggested that weevils that infested the acorns of oak woods differed in their abundance based on microhabitats associated with slope positions, decreasing from the upper slope to the lower slope (Yu et al. 2003). A study on spider-plant interaction in South America also suggested that the jumping spider *Psecas chapoda* could evaluate, in fine detail, the physical state of its microhabitat, and its spatial and micro-spatial distribution can be readily affected by changes in habitat and microhabitat

structure (i.e., the size and morphology of the host plant; Romero and Vasconcellos-Neto 2005). In our study, the different changes of microhabitat along the slope might be the reason to explain the differences in spatial heterogeneity among the three forest types.

Implications for conservation

As our previous studies suggested (Yu et al. 2004, 2006a, 2008), our present study shows that the composition and distribution of beetle assemblages in natural oak forests are significantly different from regenerating conifer forests, and many forest species in natural broad-leaved forests do not survive or their abundance is reduced in regenerating conifer forests (pine plantations), i.e., *Anatolica externe-costata*, *Ontholestes* sp., *Carabus vladimirskyi*, *Pristosia* sp.3. Other findings also supported this point, suggesting that conifer plantations appear to inadequately supported populations of deciduous forest specialists, even when they are mature and develop in direct contact with mature ancient forests (Niemelä et al. 1993; Niemelä 2001; Heliölä et al. 2001; Koivula et al. 2002; Magura et al. 2003; Koivula and Niemelä 2003; Finch 2005). Therefore, preservation of natural deciduous forests is important for sustaining the existence of deciduous forest specialists.

In addition, our study showed that along the slope, the spatial pattern of the composition and distribution of beetle assemblages in natural oak forests were significantly different from those of regenerating forests, including conifer plantations (pine plantations) and transition zones (mixed forests). So after the implementation of a logging moratorium on all forests, including natural mature deciduous forests, establishment of conifer plantations would affect the distribution of beetle community at a local scale. Therefore, to sustain the species composition and distribution of natural deciduous forests for beetle assemblages in North China, such subtle variation of slope position on beetle communities within one stand should be taken into account when conservation issues are involved.

Appendix 1

See Table 4.

Table 4 Beetle species captured on Dongling Mountain, Beijing, North China, with forest type and position

Family	Species	Oak forests			Transition zones			Pine plantations			Total
		Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	
Alledulidae	*Allecula* sp.1	1	0	0	0	0	0	0	0	0	1
	Allecula sp.2	1	2	0	0	0	0	0	0	0	3
Cantharidae	*Athemus testaceipes*	0	0	0	0	0	0	1	2	0	3
Carabidae	*Agonum nitidum*	0	0	0	0	0	0	0	2	0	2
	Bedimidion sp.1	0	0	0	0	0	0	1	0	0	1
	Bedimidion sp.2	0	0	0	0	0	0	1	0	0	1
	Carabus brandti	0	1	0	0	0	0	0	0	0	1
	Carabus manifestus	0	0	1	1	5	1	0	59	27	94
	Carabus sculptipennis	3	1	1	0	2	0	0	1	0	8
	Carabus smaragdinus	3	3	2	4	5	3	9	9	1	39
	Carabus sui	0	1	1	1	1	1	0	0	1	6
	Carabus vladimirskyi	4	17	3	0	2	2	0	0	4	32
	Harpalus coreanus	0	0	0	0	0	0	1	0	0	1
	Notiophilus sp	0	1	0	4	4	1	0	2	3	15
	Pristosia sp.1	0	0	1	0	0	0	0	1	0	2
	Pristosia sp.2	18	4	5	27	39	31	5	3	21	153
	Pristosia sp.3	4	4	0	0	1	2	0	0	0	11
	Pristosia sp.4	2	0	0	0	0	0	0	0	0	2
	Pterostichus acutidens	0	0	0	1	1	0	0	0	0	2
	Pterostichus fortives	1	0	0	0	2	0	0	2	0	5
	Reflexisphodrus refleximargo	2	4	1	3	4	1	1	5	5	26
	Reflexisphodrus sp.	0	0	1	0	0	0	0	0	0	1
Cerambycidae	*Chlorophorus* sp.1	1	0	0	0	1	0	0	0	0	2
	Chlorophorus sp.2	0	1	0	0	0	0	0	0	0	1
	Pidonia sp.	0	0	0	0	0	0	0	1	0	1
Curculionidae	*Chlorophanus* sp.	0	0	1	0	0	0	0	0	0	1
	Macrocorynus sp.1	0	0	0	6	3	0	0	1	1	11
	Macrocorynus sp.2	0	1	1	0	0	0	0	0	0	2
	Macrocorynus sp.3	0	0	1	0	0	0	0	0	0	1
	Pissodes nitidus	0	0	0	2	1	0	2	2	4	11
	Rhynchaenus sp.1	28	38	36	9	31	17	13	5	4	181
	Rhynchaenus sp.2	23	18	16	9	39	11	1	1	0	118
	Sympiezomias sp.1	4	2	1	2	0	7	1	0	1	18
	Sympiezomias sp.2	8	4	7	6	3	14	1	2	9	54
	sp.1	0	0	1	0	0	0	0	0	0	1
	sp.2	0	0	0	0	0	0	0	1	0	1
	sp.3	0	0	1	0	0	0	0	0	0	1
	sp.4	0	0	1	0	0	0	0	0	0	1
	sp.5	0	0	0	0	0	1	0	0	0	1
	sp.6	0	0	0	0	0	0	0	1	0	1
	sp.7	0	0	1	0	0	0	0	0	0	1
	sp.8	0	0	0	0	0	1	0	0	0	1
	sp.9	0	0	0	0	0	0	2	0	0	2

Table 4 continued

Family	Species	Oak forests			Transition zones			Pine plantations			Total
		Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	
Elateridae	*Agrypnus* sp.1	0	0	0	0	0	1	2	0	0	3
	Agrypnus sp.2	0	0	0	0	1	0	0	0	0	1
	Melanotus sp.1	0	0	0	0	0	0	0	1	0	1
	Melanotus sp.2	0	0	0	0	1	0	0	0	0	1
	sp.	7	5	1	2	2	0	2	1	2	22
Leoididae	*Agathidium* sp.	0	0	0	0	0	1	0	0	0	1
Lucidae	*Serrognathus tittanus*	2	1	0	0	0	0	0	0	0	3
Mordellidae	*Mordellistena* sp.	1	0	0	0	0	1	0	0	0	2
Pselaphidae	sp.	2	0	0	1	0	0	0	0	1	4
Ptiliidae	*Acrotrichis* sp.	8	6	3	1	10	3	0	2	2	35
Scaphidiidae	*Scaphidium* sp.	0	1	0	0	0	0	0	0	0	1
Scarabaeidae	*Anomalophylla korlovi*	0	1	0	0	0	0	0	0	0	1
	Caccobius sibiricus	0	2	0	0	0	0	1	0	0	3
	Cetonia viridiopaca	0	1	0	0	0	0	0	0	0	1
	Clinterocera mandarina	0	1	0	0	0	0	0	0	0	1
	Mimela pekinensis	0	0	0	0	0	0	0	1	0	1
	Onthophagus sinicus	0	0	0	0	0	0	1	1	0	2
	Onthophagus sp.	1	0	0	0	0	0	1	0	0	2
	Oxycetonia jucunda	0	1	0	0	0	0	0	0	0	1
	Serica orientalis	0	0	1	2	2	0	0	0	1	6
	Serica sp.	3	0	1	1	0	2	0	0	0	7
Scolytidae	*Cryphalus* sp.1	0	0	0	0	0	0	1	1	0	2
	Cryphalus sp.2	0	0	0	0	0	0	1	0	0	1
	Xyleborus sp.	0	0	0	0	0	0	1	0	0	1
Staphylinidae	*Ontholestes* sp.	34	5	0	4	2	0	1	0	0	46
	sp.1	0	2	0	0	1	1	1	0	1	6
	sp.2	0	0	0	0	2	1	0	0	0	3
	sp.3	0	0	0	0	0	0	0	0	1	1
	sp.4	0	0	1	5	1	0	1	0	0	8
	sp.5	0	0	0	1	0	0	0	0	3	4
	sp.6	0	1	0	0	0	1	0	0	0	2
	sp.7	0	0	0	0	1	1	1	0	0	3
	sp.8	1	0	0	1	2	2	3	1	0	10
	sp.9	0	0	1	0	5	2	0	0	0	8
	sp.10	1	3	0	2	0	1	0	0	0	7
	sp.11	1	0	0	2	0	1	0	0	0	4
	sp.12	1	0	0	0	0	2	0	0	0	3
	sp.13	0	0	0	0	1	0	0	0	0	1
	sp.14	0	0	0	0	0	1	0	0	0	1
	sp.15	2	0	1	0	0	1	0	0	3	7
Tenebrionidae	*Anatolica externecostata*	3	3	2	2	0	0	0	0	1	11
	Blaps rugosa	0	0	0	0	1	0	0	0	0	1
	Microdera sp.1	0	0	0	0	0	0	1	0	0	1
	Microdera sp.2	0	0	0	0	1	1	0	0	0	2

Table 4 continued

Family	Species	Oak forests			Transition zones			Pine plantations			Total
		Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	
	Microdera sp.3	0	0	0	0	0	1	0	0	0	1
	Prosodes pekiensis	2	2	0	5	3	0	0	0	0	12
	Scytosoma sp.1	2	0	0	0	1	0	0	4	10	17
	Scytosoma sp.2	1	3	0	1	0	0	0	7	2	14
	Scytosoma sp.3	0	1	0	0	0	0	0	0	0	1

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