Int. J. Agric. Nat. Resour.50(1):12-22. 2023
www.ijanr.cl

PLANT ENTOMOLOGY

DOI 10.7764/ijanr.50i1.2402

RESEARCH PAPER

Composition, abundance and biodiversity of terrestrial arthropods in pastures and their relationship with landscaping plants

Jinu Eo, Myung-Hyun Kim, Soon-Kun Choi, and Hea-Son Bang
National Institute of Agricultural Sciences, RDA, Wanju, 55365, Republic of Korea

Abstract

J. Eo, M-H. Kim, S-K. Choi, & H-S Bang. 2023. Composition, abundance and biodiversity of terrestrial arthropods in pastures and their relationship with landscaping plants. Int. J. Agric. Nat. Resour. 12-22. We investigated the association of landscaping plants with the communities of ground-dwelling arthropods within pastures and tested the hypothesis that arthropod biodiversity increases with vegetation heterogeneity. The community characterization and biodiversity of arthropods in a pasture were compared with those within communities with landscaping plants, including forest remnants, *Forsythia koreana* and *Prunus serotina*. The total abundance of mites was greater within the forest remnants than within the pasture; however, the abundance of insects and spiders did not differ. Nonmetric multidimensional scaling and the multiresponse permutation procedure revealed that the community composition of insects and spiders differed according to vegetation type. The abundance of *Teleogryllus emma* was highest within the forest remnant community, which suggested the species' dependency on vegetation type. Species richness and the Shannon index of insects increased within *F. koreana* but not within *P. serotina* compared with the pasture. This suggested that belts of shrubs might have a greater promoting effect on insect biodiversity than belts of trees. Species richness of spiders did not differ by vegetation type. The total number of insect and spider species within the study area increased by 2.8 and 3.5 times, respectively, by establishing three types of vegetation. These results suggested that increasing vegetation heterogeneity by establishing landscaping plants is a good option for conserving insect and spider biodiversity in pastures.

Keywords: Diversity, forest remnant, *Forsythia koreana*, heterogeneity, *Prunus serotine*

Introduction

The largest part of deforestation is related to agroindustrial clearing for pastures (Fleischner, 1994; Tyukavina et al., 2017). Deforestation creates environmental problems resulting from the destruction of natural habitat and vegetation, creating ecosystems with poor biodiversity on a local scale (Perry et al., 2016). Changes in habitat heterogeneity also have a negative effect on arthropod diversity (Vasconcellos et al., 2010; Prieto-Benitez & Mendez, 2011), and highly managed forage production might reduce the ecological value of biodiversity; therefore, there are concerns about the sustainable management of pastures in relation to native biodiversity and ecosystem processes (Fleischner, 1994).

Biodiversity conservation is an important component of supporting services appreciated in

---

Received Mar 15, 2022. Accepted Mar 20, 2023
Corresponding author: eojiny@korea.kr

pasture ecosystems (Garrido et al. 2017), and habitat heterogeneity is linked to the promotion of biodiversity on a landscape scale (Janssen et al. 2009). There have been various attempts to conserve biodiversity within pastures by increasing vegetation heterogeneity. Establishing belts of landscaping plants can increase the biological value of the agroecosystem (Mazalova et al. 2015), and reserving the former natural habitat, such as remnant forests, is critical for the persistence of biodiversity within heavily modified pasture ecosystems (Gibson et al. 2011). Heterogeneous forage species and wooded pastures also increase the biodiversity of other organisms within the pasture (Roellig et al. 2016).

Landscaping plants are primarily used to increase aesthetic values for tourism and recreation. Sightseeing and local festivals using flowering plants are popular during spring in the Republic of Korea, and the oriental flowering cherry (*Prunus serotina*) and Korean forsythia (*Forsythia koreana*) are representative of landscaping trees and shrubs, respectively. Many arthropod species provide biological functions, such as pest and weed control (Carter & Rypstra, 1995; Ichihara et al., 2014). Therefore, understanding the effect of pastoral landscaping plants on ground-dwelling arthropod communities will help us recognize their additional value. Vegetation heterogeneity influences the buildup of the ground-dwelling arthropod population by providing various habitats and food sources (Addison et al., 2000; Cruz et al., 2013). Most ground-dwelling insects and spiders show relatively low rates of dispersal, and some species are specific to particular habitat types (Brouwers & Newton, 2009; Perry et al., 2017). Therefore, an examination of their responses is an effective way to test the impact of landscaping plants on biodiversity in restricted planting areas. Moreover, mites are good indicators of land use, and some species are predominantly found in pastures (Gulvik, 2007; Clapperton et al., 2002).

Vegetation types influence both arthropod community characterization and biodiversity by altering habitat heterogeneity (Janssen et al., 2009; Benton et al., 2003). We hypothesized that diversified habitat caused by landscaping plants promotes arthropod diversity and that different arthropod species prefer different vegetation types for habitat. To verify this hypothesis, we compared the abundance, community composition and biodiversity of ground-dwelling arthropods within four vegetation types—pasture, forest remnant, landscaping trees and landscaping shrubs. Trophic associations were also analyzed because arthropod communities can be influenced by both bottom-up and top-down controls (Jacquot et al., 2019).

Materials and Methods

Study site

The surveyed pasture is located on Seosan Ranch in Seosan-Si, Republic of Korea (36°45’50”N, 126°33’39”E), at an altitude between 50 and 80 m. The annual mean temperature is 12.0 °C, and the annual precipitation is 1285.7 mm. The ranch was established in 1969 when the hill area was developed. The pasture is annually seeded with orchard grass (*Dactylis glomerata*), which is periodically harvested for fodder without grazing. Four types of vegetation—pasture, forest remnant, a belt of trees and a belt of shrubs—were selected for investigating the effects of landscaping plants on arthropod biodiversity (Figure 1). A shrub or tree belt denotes linear plantings of woody plants. Figure 2 depicts the heterogeneous characteristics of vegetation composition and structure. Plant diversity was higher in the vegetation types with landscaping plants than in the pasture. A forest remnant (1.3 ha) is located on a hill. *Quercus serrata*, *Pinus densiflora* and *Castanea crenata* are the dominant tree species. *Rubus crataegifolius*, *Ambrosia artemisiifolia* and *Artemisia princeps* are the dominant species in the herb layer of the forest. A belt of shrub *F. koreana* was established in the plain area at 2~3 m high, 3 m wide and 340 m long. *Paederia scandens* is the dominant annual grass in the herb layer of the shrubs. Two arrays of *P. serotina* 260 m long were planted along the hill slope, and *Festuca arundinacea* is the dominant herbal species within the herb layer.

Field sampling

Ten plots were established within each vegetation type. Each plot consisted of two pitfall traps that were arranged within the line. Transects were sampled along a straight line within the pasture. Sampling plots were located every 10 m along the array of trees and shrubs. A forest remnant 3 m wide was sampled along the edge area because the forest margin area effectively reflects the impact of forests by providing heterogeneous habitats (Prieto-Benitez & Mendez, 2011; Downie et al. 1996). Ground-dwelling arthropods were collected using pitfall traps on July 7–8, 2016. The trap was 9 cm in diameter at the top and 9.5 cm high with a volume of 500 mL. A 50-mL solution of ethanol/ethylene glycol/water at a ratio of 66.5:15:18.5 was used as an arthropod attractant in each trap. The collected arthropod samples were sent to the laboratory and preserved in 70% ethanol. Mites and collembolans were classified at the order level. The species of the adult stage insects and spiders were identified under a Leica DE/MZ 7.5 microscope.

Figure 1. Map of the study area. Dotted lines represent areas planted with landscaping plants.

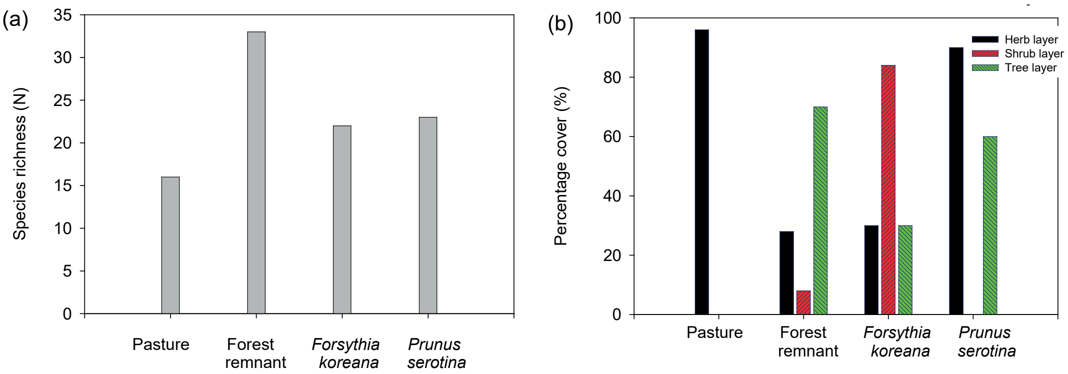

Figure 2. Plant species richness (a) and percentage plant cover (b) within different vegetation types. The percentage cover of plants is measured separately in the herb, shrub and tree layers.

Data analyses

ANOVA with Tukey's post hoc test was conducted for multiple comparisons among the means of the abundance and diversity index of the insects and spiders. The abundance of dominant species (i.e., those representing >1% of the population) and total abundance variables were analysed. A Venn diagram was created to show the shared and unique species within different vegetation types. Pearson's correlation coefficient was used to evaluate the trophic associations among the total abundances of arthropod groups. Biodiversity indices were calculated using Species Diversity and Richness v.4 software (Pisces Conservation). Nonmetric multidimensional scaling (nMDS) ordination was used to demonstrate the relationship between vegetation type and arthropods by grouping samples from all vegetation types. These tests were conducted using SAS v. 9.1 (SAS Institute Inc., Cary, NC, USA). Two-dimensional ordination was plotted using the nMDS results. A multiresponse permutation procedure (MRPP) was conducted to measure the significant differences among community compositions using PC-ORD v. 5 (MjM software design).

Results

Composition of arthropod communities

We identified 437 individual mites belonging to Trombiculidae and Ixodidae and 2,367 individual collembolans belonging to Bourletiellidae, Entomobryidae and Poduridae in all vegetation types. In addition, we identified 1,093 individual insects belonging to 71 species, and three types of landscaping plants harbored 46 species that were not found within the pasture (Figure 3a). We recorded 764 individual spiders belonging to 66 species, and three types of landscaping plants harbored 47 species that were not found within the pasture (Figure 3b). The results of nMDS for the insect community revealed that the plots within the pasture and within *F. koreana* were clearly separated with no overlap (Figure 4). The results of MRPP revealed that the community composition of arthropods within different vegetation types was distributed differently (A=0.180, *P*<0.001) in ordination space. Both nMDS and MRPP (A=0.353, *P*<0.001) also revealed that the spider communities differed by vegetation type.

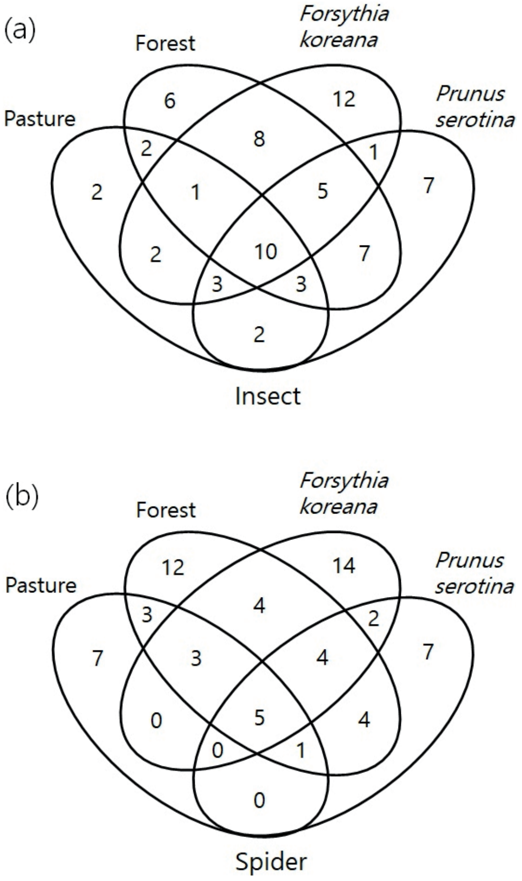

Figure 3. Venn diagrams showing shared and unique species of (a) insects and (b) spiders within different vegetation types.

Abundance of arthropods

The abundances of mites and collembolans exhibited different responses to vegetation type, with mite abundance being 3.3 times greater within the forest remnant than within

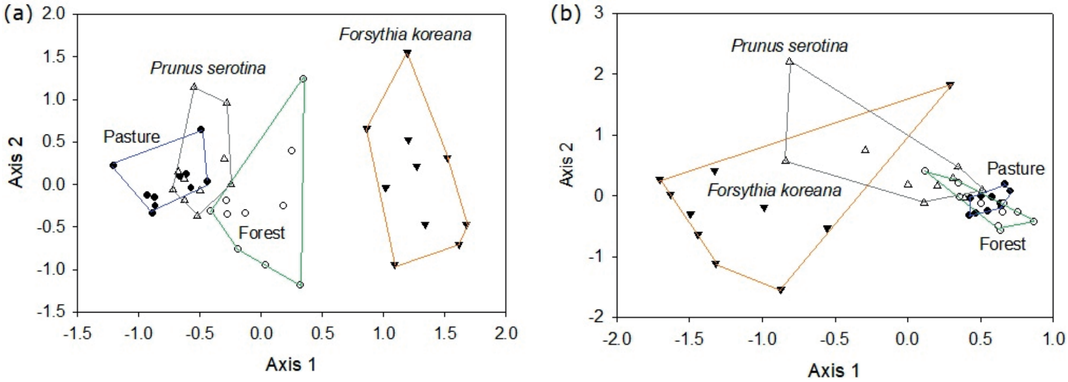

Figure 4. Nonmetric multidimensional scaling (nMDS) analyses for (a) ground-dwelling insects and (b) spiders within different vegetation types.

the pasture; however, collembolan abundance did not significantly differ by vegetation type (Table 1). The total insect abundance was greater within the forest remnant among the landscaping plants (Table 2). The abundance of *Teleogryllus emma* was at least five times greater within the forest remnant than within any other plots. The total spider abundance was great within the forest remnant, a tendency that was similar among insects (Table 3). Some species were observed to be predominant within one type of vegetation. The abundance of *Gnaphosa kompirensis* and *Itatsina praticola* was highest within *F. koreana*, that of *Erigone koshiensis* was highest within the pasture, and that of *Pardosa astrigera* was lowest within the pasture. There was a strong correlation between the abundances of insects and spiders (*r*=0.537, *P*=0.0003). The abundance of collembolans, on the other hand, was not significantly correlated with that of insects (*r*=0.152, *P*=0.348) or spiders (*r=-0.199*, *P*=0.216).

Diversity indices for insects and spiders

The results showed that species richness and the Shannon index were greater within the forest remnant and *F. koreana* than within the pasture (Table 4). The dominance and evenness indices were the greatest within *F. koreana*. There was a trend in the diversity index of spiders that was different from that of insects. The results of species richness determination and the Shannon index were not altered by vegetation type; however, dominance and evenness indices were greatest within *F. koreana*.

Discussion

Vegetation effects on arthropod abundance and trophic reactions

The effects of landscaping plants on the abundance of mites and collembolans differed, which

Table 1. Abundance of mites and collembolans

	Pasture	Forest remnant	*Forsythia koreana*	*Prunus serotina*
	N trap^{-1}			
Mites	6.8 ± 2.0b	21.7 ± 6.3a	10.8 ± 2.5ab	4.4 ± 1.7b
Collembolans	87.3 ± 32.0a	28.5 ± 2.8a	73.2 ± 16.5a	47.7 ± 7.8a

Different letters indicate significant differences (Tukey's test, *P*<0.05).

Table 2. Abundance of dominant insect species (>0.1%)

	Pasture	Forest remnant	*Forsythia koreana*	*Prunus serotina*
	N trap^{-1}			
Teleogryllus emma	0.2 ± 0.1b	17.7 ± 4.2a	3.7 ± 1.1b	0.9 ± 0.6b
Harpalus griseus	28.0 ± 3.7a	15.5 ± 3.7a	0.6 ± 0.3b	22.9 ± 5.2a
Amara congrua	6.7 ± 1.8a	5.4 ± 1.1ab	0.2 ± 0.2b	4.4 ± 1.0ab
Lycoperdina mandarinae	0.2 ± 0.1a	0.8 ± 0.3ab	0.0 ± 0.2b	1.2 ± 0.5a
Crematogaster okakensis	0.8 ± 0.4a	2.9 ± 1.2a	1.7 ± 0.6a	0.7 ± 0.5a
Paratrechina sp.1	3.8 ± 2.5a	3.1 ± 1.2a	0.8 ± 0.5a	3.4 ± 1.2a
Tetramorium sp.1	4.5 ± 2.8a	1.0 ± 0.8a	0.1 ± 0.1a	0.0 ± 0.0a
Solenopsis fugax	0.0 ± 0.0a	3.7 ± 1.8a	2.5 ± 2.2a	0.1 ± 0.1a
Pachycondyla chinensis	0.0 ± 0.0a	4.3 ± 3.6a	0.3 ± 0.2a	3.2 ± 1.1a
Formica lemani	0.0 ± 0.0a	4.6 ± 3.0a	0.0 ± 0.0a	1.1 ± 0.8a
Total (all species)	51.6 ± 5.8ab	75.5 ± 8.0a	26.8 ± 3.6b	45.3 ± 7.8b

Different letters indicate significant differences (Tukey's test, *P*<0.05).

Table 3. Abundance of dominant spider species (>0.1%)

	Pasture	Forest remnant	*Forsythia koreana*	*Prunus serotina*
	N trap^{-1}			
Anahita fauna	0.2 ± 0.2a	0.7 ± 0.2a	0.2 ± 0.2a	0.2 ± 0.1a
Gnaphosa kompirensis	0.6 ± 0.3b	0.1 ± 0.1b	4.9 ± 1.5a	0.4 ± 0.3b
Erigone koshiensis	1.5 ± 0.6a	0.1 ± 0.1b	0.2 ± 0.1b	0.0 ± 0.0b
Pardosa hedini	0.1 ± 0.1a	0.3 ± 0.2a	0.7 ± 0.5a	0.0 ± 0.0a
Pardosa herbosa	0.7 ± 0.2a	0.1 ± 0.1a	0.5 ± 0.4a	0.1 ± 0.1a
Pardosa astrigera	15.5 ± 0.9a	21.0 ± 3.0a	1.1 ± 0.6c	7.8 ± 1.5b
Ozyptila atomaria	0.2 ± 0.1a	0.8 ± 0.2a	0.3 ± 0.2a	0.7 ± 0.2a
Itatsina praticola	0.0 ± 0.0b	0.3 ± 0.2b	1.9 ± 0.4a	0.7 ± 0.3b
Total (all species)	21.7 ± 1.1ab	28.6 ± 3.5a	13.8 ± 3.3bc	12.3 ± 1.8c

Different letters indicate significant differences (Tukey's test, *P*<0.05).

Table 4. Diversity index of arthropod communities within different vegetation types

	Pasture	Forest remnant	Forsythia koreana	Prunus serotina
Insect				
Species richness	6.9 ± 0.5b	11.3 ± 0.6a	10.9 ± 1.1a	10.0 ± 1.0ab
Shannon index (H)	3.8 ± 0.3c	6.3 ± 0.7ab	7.4 ± 0.6a	5.3 ± 0.6bc
Simpson index (D)	3.0 ± 0.4c	5.3 ± 0.8b	7.7 ± 0.9a	4.0 ± 0.6bc
Pielou index (J)	0.7 ± 0.0b	0.7 ± 0.0b	0.9 ± 0.0a	0.7 ± 0.0b
Spider				
Species richness	5.1 ± 0.7a	7.7 ± 1.1a	6.6 ± 1.3a	4.9 ± 0.7a
Shannon index (H)	0.9 ± 0.1b	1.1 ± 0.2ab	1.5 ± 0.1a	1.2 ± 0.2ab
Simpson index (D)	2.1 ± 0.3a	2.2 ± 0.5a	6.0 ± 0.7a	2.6 ± 0.5a
Pielou index (J)	0.6 ± 0.0b	0.5 ± 0.0b	0.9 ± 0.0a	0.7 ± 0.1b

Different letters indicate significant differences (Tukey's test, *P*<0.05).

is consistent with the results of Bokhorst et al. (2018). Plant species influence mites by providing different quantities and qualities of resources (Wissuwa et al., 2012). The lack of a correlation between the abundance of collembolans and the abundance of ground beetles or spiders suggested a weak trophic interaction between them. Ground beetles and spiders have been reported to prey on collembolans but are not specialist predators of them (Bilde et al., 2000; Lawrence & Wise, 2000).

The availability of spider prey is the best predictor of spider abundance (Halaj et al., 1998), and this was exhibited in our results with the strong correlation between the total abundance of insects and spiders. Vegetation composition explains the variation in the abundance of ground-dwelling spiders well (Bowden & Buddle, 2010); their abundance was lower within *P. serotina* than within the pasture. This can be partially explained by the results showing that the physical structure and heterogeneity of vegetation influence spider abundance (Malumbres-Olarte et al., 2013).

Association of insect and spider species with vegetation type

nMDS suggested that landscaping plants contributed significantly to the structure of the insect community and may have influenced the abundances of some dominant species by altering the environmental conditions. The carabid beetle *Harpalus griseus* was found under dry conditions and within sandy grasslands (Lindroth, 1986; Kadar & Szentkiralyi, 1997). Their minimal abundance within *F. koreana* was apparently caused by a dense canopy habitat. The field cricket *T. emma* was reported to have the greatest abundance in agricultural fields with neighboring forest (Yoshio et al., 2009), which is in accordance with our results that indicated that their greatest abundance was within the forest remnant. The wood ant *Formica lemani* was not observed within the pasture, although its abundance was not significantly different between different vegetation types. This result is in accordance with the results of a previous report that indicated that the species' main habitat is forest (Vepsalainen et al., 2008). The total abundance of insects and spiders was greater within the forest remnant than within *F. koreana* or *P. serotina*. Vegetation type might have neutral effects on the total abundance of coleopterans, and specific features of that vegetation influence only a particular group of species (Rieske & Buss 2001).

nMDS suggested that individual species of landscaping plants had a greater effect on the community structure of spiders than the forest remnant. Moreover, some spider species exhibited attraction to a specific vegetation type. *I. praticola* were frequently observed within the litter layer and under dead trees (Namkung et al., 2002), which partially explains their greater abundance within *F. koreana* than within the pasture. *Gnaphosa kompirensis* were suggested to be forest species because of their greater abundance in forests than in the open space (Jung et al., 2008); however, their abundance was greater within *F. koreana* than within the forest remnant. The great abundance of *P. astrigera* both within the pasture and forest appeared to contrast considering the heterogeneity of the two vegetation types. Their great abundance within the forest remnant was expected because the species were more abundant within a complex agricultural landscape than within a simple landscape (Liu et al., 2013). Meanwhile, their large population within the pasture was partially explained by periodic mowing that produces surface straw that could increase their abundance by enhancing their ability to hunt prey (Cheng et al., 2013).

Vegetation heterogeneity and biodiversity of arthropods

It has been suggested that increasing habitat heterogeneity is the key to promoting the biodiversity of insects within agricultural ecosystems (Janssen et al., 2009; Benton et al., 2003). Establishing belts of landscaping plants is a good option to increase habitat heterogeneity within a pasture. Scattered trees and shrubs create high spider biodiversity (Galle et al., 2017). In our study, we found that vegetation type influenced insect biodiversity and that the promoting effect of *F. koreana* on insect biodiversity suggested that a belt of shrubs is more effective than a belt of tall trees. Komonen et al. (2015) have also reported that tree species type influences the biodiversity of ground-dwelling insects, particularly carabid beetles and ants.

The edge of the forest remnant is expected to have a higher spider biodiversity than pasture because the area hosts spider species from both vegetation types. The edge area was reported to have higher spider abundance and biodiversity because of its increased prey availability resulting from more varied nonnative grasses (Prieto-Benitez & Mendez, 2011). Downie et al. (1996) reported that spider species richness was 72% greater at the edge interface than within the pasture, and Jimenez-Valverde and Lobo (2007) reported that spider species richness is positively influenced by vegetation heterogeneity. However, the forest remnant had a minimal influence on the species richness of spiders. The contrasting responses of insects and spiders within the forest remnant can be explained by their different feeding habits; insects include a variety of functional feeding guilds, whereas spiders are only predators.

Changes in arthropod community composition and ecological function

Pasture provides a wide array of cultural and supporting services beyond the production of forage. Many ecosystem services depend on their biological functions, which are related to biodiversity. Landscaping plants can build connections between biodiversity and their ecological function. The results of our study showed that the abundance of some species was high within the landscape plants. For example, *T. emma* feeds on weed seeds (Ichihara et al., 2014); hence, its greater abundance within the forest remnant can promote weed control, and as spiders have a top-down effect on herbivorous pests (Carter & Rypstra, 1995), the greater abundances of *Gnaphosa kompirensis* and *I. praticola* within *F. koreana* suggest a change in the pest control effect. Further research is needed to estimate the changes in the value of these functions resulting from landscape plants.

Conclusions

Three different landscaping plants had different effects on the characterization of the ground-dwelling arthropod community. Species richness differed according to vegetation type for insects but not for spiders; however, our results indicated that the establishment of three different types of landscaping plants increased the total number of insects and spiders 2.8 and 3.5 times, respectively, over the entire study site. Moreover, some species showed habitat specificity, and many arthropod species were observed within only one type of vegetation. These results indicated that establishing various landscaping plants as part of pasture management is helpful for promoting arthropod biodiversity. Our results also showed that the design of the vegetation type may also b be important for conserving insect biodiversity. For example, belts of shrubs can be more effective than belts of trees for increasing the abundance of some species. It is recommended that establishing landscaping plants be considered simultaneously with pasture development and management.

Acknowledgment

This study was conducted with the support of the Research Program for Agricultural Science & Technology Development (Project No. PJ01001301), National Institute of Agricultural Sciences, Rural Development Administration, Republic of Korea.

Resumen

J. Eo, M-H. Kim, S-K. Choi, y H-S Bang. 2023. El papel de las plantas de jardín en la composición, abundancia y biodiversidad de los artrópodos que habitan en el suelo en los pastos. Int. J. Agric. Nat. Resour. 12-22. Hemos investigado la influencia de las plantas de jardín en las comunidades de artrópodos que habitan en el suelo dentro de los pastos y hemos probado la hipótesis de que la biodiversidad de los artrópodos aumenta con la heterogeneidad de la vegetación. La caracterización de la comunidad y la biodiversidad de los artrópodos en un pastizal se compararon con las de las comunidades que tienen plantas de jardín, incluidos los reductos forestales, *Forsythia koreana* y *Prunus serotina*. La abundancia total de ácaros era mayor dentro de los reductos forestales que dentro del pastizal; sin embargo, la abundancia de insectos y arañas no difirió. El escalamiento multidimensional no métrico y el procedimiento de permutación de respuesta múltiple revelaron que la composición de la comunidad de insectos y arañas difería en función del tipo de vegetación. La abundancia de *Teleogryllus emma* fue mayor dentro de la comunidad de reductos forestales, lo que sugiere que la especie depende del tipo de vegetación. La riqueza de especies y el índice de Shannon aumentaron dentro de *F. koreana* pero no dentro de *P. serotina* en comparación con los del pasto. Este dato sugiere que los cinturones de arbustos podrían tener un mayor efecto impulsor sobre la biodiversidad de insectos que los cinturones de árboles. La riqueza de especies y el índice de Shannon en arañas no difirieron por tipo de vegetación. La cantidad total de especies de insectos y de arañas dentro del área de estudio aumentó 2,8 y 3,5 veces, respectivamente, al establecerse tres tipos de vegetación. Estos resultados sugieren que el aumento de la heterogeneidad de la vegetación mediante el establecimiento de plantas de jardín es una buena opción para conservar la biodiversidad de insectos y arañas en los pastos.

Palabras clave: Araña, diversidad, heterogeneidad, insecto, reducto forestal.

References

Addison, J. A., Hardman, J. M., & Walde, S. J. (2000). Pollen availability for predaceous mites on apple: spatial and temporal heterogeneity. *Experimental and Applied Acarology, 24*, 1–18. https://doi.org/10.1023/A:1006329819059

Benton, T. G., Vickery, J. A., & Wilson, J. D. (2003). Farmland biodiversity: is habitat heterogeneity the key? *Trends in Ecology and Evolution, 18*, 182–188. https://doi.org/10.1016/S0169-5347(03)00011-9

Bilde, T., Axelsen, J. A., & Toft, S. (2000). The value of Collembola from agricultural soils as food for a generalist predator. *Journal of Applied Ecology, 37*, 672–683. https://doi.org/10.1046/j.1365-2664.2000.00527.x

Bokhorst, S., Veen, C., Sundqvist, M. K., & Long, J. D. (2018). Contrasting responses of springtails and mites to elevation and vegetation type in the sub-Arctic. *Pedobiologia, 67*, 57–64. https://doi.org/10.1016/j.pedobi.2018.02.004

Bowden, J. J., & Buddle, C. M. (2010). Determinants of ground-dwelling spider assemblages at a regional scale in the Yukon Territory, Canada. *Ecoscience, 17*, 287–297. https://doi.org/10.2980/17-3-3308

Brouwers, N. C., & Newton, A. C. (2009). Movement rates of woodland invertebrates: A systematic review of empirical evidence. *Insect Conservation and Diversity, 2*, 10–22. https://doi.org/10.1111/j.1752-4598.2008.00041.x

Carter, P. E., & Rypstra, A. L. (1995). Top-down effects in soybean agroecosytems: spider density affects herbivore damage. *OIKOS, 72*, 433–439. https://doi.org/10.2307/3546129

Cheng, H., Zhang, C., Hua, R., & Wu, H. (2013). Effects of habitat complexity and fertilization on arthropod community structure in cotton field. *Chinese Journal of Eco-Agriculture, 21*, 1127–1134. https://doi.org/10.3724/SP.J.1011.2013.01127

Clapperton, M. J., Kanashiro, D. A., & Behan-Pelletier, V. M. (2002). Changes in abundance and diversity of microarthropods associated with Fescue Prairie grazing regimes. *Pedobiologia, 46*, 496–511. https://doi.org/10.1078/0031-4056-00155

Cruz, W. P., Sarmento, R. A., Teodoro, A. V., Neto, M. P., & Ignacio, M. (2013). Driving factors for the communities of phytophagous and predatory mites in a physic nut plantation and spontaneous plants associated. *Experimental and Applied Acarology, 60*, 509–519. https://doi.org/10.1007/s10493-013-9663-0

Downie, I. S., Coulson, J. C., & Butterfield, J. E. L. (1996). Distribution and dynamics of surface-dwelling spiders across a pasture-plantation ecotone. *Ecography, 19*, 29–40. https://doi.org/10.1111/j.1600-0587.1996.tb00152.x

Fleischner, T. L. (1994). Ecological costs of livestock grazing in western north America. *Conservation Biology, 8*, 629–644. https://doi.org/10.1046/j.1523-1739.1994.08030629.x

Galle, R., Urak, I., Nikolett, G., & Hartel, T. (2017). Sparse trees and shrubs confers a high biodiversity to pastures: Case study on spiders from Transylvania. *PLOS ONE, 12*, e0183465. https://doi.org/10.1371/journal.pone.0183465

Garrido, P., Elbakidze, M., Angelstam, P., Plieninger, T., Pulido, F., & Moreno, G. (2017). Stakeholder perspectives of wood-pasture ecosystem services: A case study from Iberian dehesas. *Land Use Policy, 60*, 324–333. https://doi.org/10.1016/j.landusepol.2016.10.022

Gibson, L., Lee, T. M., Koh, L. P., Brook, B. W., Gardner, T. A., Barlow, J., Peres, C. A., Bradshaw, C. J. A., Laurance, W. F., Lovejoy, T. E., & Sodhi, N. S. (2011). Primary forests are irreplaceable for sustaining tropical biodiversity. *Nature, 478*, 378–381. https://doi.org/10.1038/nature10425

Gulvik, M. E. (2007). Mites (Acari) as indicators of soil biodiversity and land use monitoring: A review. *Polish Journal of Ecology, 55*, 415–440.

Halaj, J., Ross, D. W., & Moldenke, A. (1998). Habitat structure and prey availability as predictors of the abundance and community organization of spiders in western Oregon forest canopies. *Journal of Arachnology, 26*, 203–220.

Ichihara, M., Uchida, S., Fujii, S., Yamashita, M., Sawada, H., & Inagaki, H. (2014). Weed seedling herbivory by field cricket *Teleogryllus emma* (Orthoptera: Gryllidae) in relation to the depth of seedling emergence. *Weed Biology and Management, 14*, 99–105. https://doi.org/10.1111/wbm.12035

Jacquot, M., Massol, F., Muru, D., Derepas, B., Tixier, P., & Deguine, J. (2019). Arthropod diversity is governed by bottom-up and top-down forces in a tropical agroecosystem. *Agriculture, Ecosystems and Environment, 285*, 106623. https://doi.org/10.1016/j.agee.2019.106623

Janssen, P., Fortin, D., & Hebert, C. (2009). Beetle diversity in a matrix of old-growth boreal forest: influence of habitat heterogeneity at multiple scales. *Ecography, 32*, 423–432. https://doi.org/10.1111/j.1600-0587.2008.05671.x

Jimenez-Valverde, A., & Lobo, J. M. (2007). Determinants of local spider (Araneidae and Thomisidae) species richness on a regional scale: climate and altitude vs. habitat structure. 2007. Determinants of local spider *Ecological Entomology, 32*, 113–122. https://doi.org/10.1111/j.1365-2311.2006.00848.x

Jung, M. P., Kim, S. T., Kim, H., & Lee, J. H. (2008). Biodiversity and community structure of ground-dwelling spiders in four different field margin types of agricultural landscapes in Korea. *Applied Soil Ecology, 38*, 185–195. https://doi.org/10.1016/j.apsoil.2007.10.010

Kadar, F., & Szentkiralyi, F. (1997). Effects of climatic variations on long-term fluctuation patterns of ground beetles (Coleoptera, Carabidae) collected by light trapping in Hungary. *Acta Phytopathologica et Entomologica Hungarica, 32*, 185–203.

Komonen, A., Overmark, E., Hytonen, J., & Halme, P. (2015). Three species influences diversity of ground-dwelling insects in afforested fields. *Forest Ecology and Management, 349*, 12–19. https://doi.org/10.1016/j.foreco.2015.04.014

Lawrence, K. L., & Wise, D. H. (2000). Spider predation on forest-floor Collembola and evidence for indirect effects on decomposition. *Pedobiologia, 44*, 33–39. https://doi.org/10.1078/S0031-4056(04)70026-8

Liu, J., Yu, M., Cui, W., Song, L., Zhao, Z., & Ali, A. (2013). Association between patterns in agricultural landscapes and the abundance of wheat aphids and their natural enemies. *European Journal of Environmental Science, 3*, 101–108.

Lindroth, C. H. (1986.) The Carabidae (Coleoptera) of Fennoscandia and Denmark ii. – *Fauna Entomologica Scandinavica, 15*, 227–497.

Malumbres-Olarte, J., Vink, C. J., Ross, J. G., Cruickshank, R. H., & Paterson, A. M. (2013). The role of habitat complexity on spider communities in native alpine grasslands of New Zealand. *Insect Conservation and Diversity, 6*, 124–134. https://doi.org/10.1111/j.1752-4598.2012.00195.x

Mazalova, M., Sipso, J., Rada, S., Kasak, J., Sarapatka, B., & Kuras, T. (2015). Responses of grassland arthropods to various biodiversity-friendly management practices: Is there a compromise? *European Journal of Entomology, 112*, 734–746. https://doi.org/10.14411/eje.2015.000

Namkung, J., Im, M. S., Kim, S. T., & Lee, J. H. (2002). Spider fauna of Jeju Island in Korea. *Journal of Asia-Pacific Entomology, 5*, 55–74. https://doi.org/10.1016/S1226-8615(08)60133-8

Perry, J., Lojka, B., Ruiz, L. G. Q., Van Damme, P., Houska, J., & Cusimamani, E. F. (2016). How natural forest conversation affects insect biodiversity in the Peruvian Amazon: Can agroforestry help? *Forests, 7*, 82. https://doi.org/10.3390/f7040082

Perry, K. I., Wallin, K. F., Wenzel, J. W., & Herms, D. A. (2017). Characterizing movement of ground-dwelling arthropods with a novel mark-capture method using fluorescent powder. *Journal of Insect Behavior, 30*, 32–47. https://doi.org/10.1007/s10905-017-9598-0

Prieto-Benitez, S., & Mendez, M. (2011). Effects of land management on the abundance and richness of spiders (Araneae): A meta-analysis. *Biological Conservation, 144*, 683–691. https://doi.org/10.1016/j.biocon.2010.11.024

Rieske, L. K., & Buss, L. J. (2001). Influences of site on diversity and abundance of ground- and litter-dwelling Coleoptera in appalachian oak-hickory forests. *Environmental Entomology, 30*, 484–494. https://doi.org/10.1603/0046-225X-30.3.484

Roellig, M., Sutcliffe, L. M. E., Sammul, M., & von Wehrden, H. (2016). Reviving wood-pastures for diversity and people: A case study from western Estonia. *Ambio, 45*, 185–195. https://doi.org/10.1007/s13280-015-0719-8

Tyukavina, A., Hansen, M. C., Potapov, P. V., Stehman, S. V., & Smith-Rodriguez, K. (2017). Types and rates of forest disturbance in Brazilian Legal Amazon, 2000-2013. *Science Advances, 3*, e1601047. https://doi.org/10.1126/sciadv.1601047

Vasconcellos, A., Bandeira, A. G., Moura, F. M. A., Araujo, V. F. P., Gusmao, M. A. B., & Constantino, R. (2010). Termite assemblages in three habitats under different disturbance regimes in the semi-arid Caatinga of NE Brazil. *Journal of Arid Environments, 74*, 298–302. https://doi.org/10.1016/j.jaridenv.2009.07.007

Vepsalainen, K., Ikonen, H., & Koivula, M. (2008). The structure of ant assemblages in an urban area of Helsinki, southern Finland. *Annales Zoologici Fennici, 45*, 109–127. https://doi.org/10.5735/086.045.0203

Wissuwa, J., Salamon, J., & Frank, T. (2012). Effects of habitat age and plant species on predatory mites (Acari, Mesostigmata) in grassy arable fallows in Eastern Austria. *Soil Biology and Biochemistry, 50*, 96–107. https://doi.org/10.1016/j.soilbio.2012.02.025

Yoshio, M., Kato, N., & Miyashit, T. (2009). Landscape and local scale effects on the orthopteran assemblages in the paddy agroecosystems on the Sado Island, Japan with implications for the habitat management for the crested ibis. *Ecology and Civil Engineering, 12*, 99–107. https://doi.org/10.3825/ece.12.99

This work is licensed under a Creative Commons Attribution 4.0 International License.