# IMPACT OF THE INVASIVE PLANT *ALTERNANTHERA PHILOXEROIDES* (MART.) GRISEB ON SOIL MESO- AND MICROFAUNAL COMMUNITY

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**Abstract.** *Alternanthera philoxeroides* (Mart.) Griseb *i*s a plant species which has become one of the most damaging weeds in ecosystems. We examined potential effects of the invasive plant *A. philoxeroides* on soil animal community by considering four levels of plant invasion (including non-invaded, slightly invaded, moderately invaded and heavily invaded ecosystems) in Nanfeihe, Hefei, China. The following conclusions: A total of 2406 individuals of soil animals, belonging to 25 families, 13 orders and 7 classes, and Acarina and Collembola accounted for 64.52% of the total amount of soil animals captured, thus comprising the dominant species; Individual number of soil animals varied with different rate of invasion; the diversity and evenness indices of the soil fauna showed a pattern of non-invaded < heavily invaded < moderately invaded < slightly invaded, however, there were no significant differences between the moderately and slightly invaded plots. The vertical distribution of the species number and individual number of soil fauna had obvious surface segregation with the increased soil depth; The degree of invasion affects the soil physicochemical properties, and the total potassium content is significantly correlated with the number of soil fauna groups.
**Keywords:** *biological invasion, exotic plant invasion, Alternanthera philoxeroides, soil meso- and macrofaunal, community diversity, Nanfeihe*

## Introduction

Biological invasion is a worldwide ecological phenomenon. Invasive species breed, reproduce, spread and form a stable population. Among them, exotic plant invasion, as an important group of invasive organisms, has seriously affected the biodiversity of the invaded land and the quality of the ecological environment, threatening the global ecological environment and economic development and have aroused worldwide concern, becoming one of the hot spots in global change research (Hui et al.2017).

In recent years, with the continuous increase in our understanding of soil ecosystem processes, research has focused on the impact of invasive plants on soil physicochemical properties, soil biodiversity and ecosystem processes, while soil fauna under the effect of invasive mechanisms has not been researched to such an extent (Yu et al., 2012; Pablo et al., 2014; Fernández et al., 2015; Nicola et al., 2015). Most studies have shown that the invasion of plants will increase the species and number of soil animals. Belnap et al. (2001) compared the numbers of invertebrates in early Brome intrusions and native Bromegrass in Utah, and found that species diversity and abundance were significantly reduced. Soil fauna, an important component of the soil ecosystem, can influence the soil environment through physical and chemical activities. Physical activities include plant

debris crushing and decomposition, loosening and mixing of soil; The chemical activities include changing soil texture, crumb structure, aeration, water permeability and other physical properties, and influencing the soil pH, organic matter, carbon and nitrogen content and other chemical elements (Yin, 2000). Soil fauna play an important role in plant community succession and soil nutrient cycling (Shao et al., 2015) and some soil animals can also be used to monitor environmental pollution as indicator organisms (Xiang et al., 2007). The spatial distribution and community diversity of soil fauna are of great significance in assessing ecological health, and are important targets in the study of soil ecosystems (Ding et al., 2017)

The exotic plant invasion of *Alternanthera philoxeroides* (Mart.) Griseb, originated from South America, is now widely distributed in the United States, Australia, New Zealand, China and many other countries by virtue of its adaptability, rapid spread and vegetative reproduction (Van et al., 2002). *A. philoxeroides* in China was first introduced as horse feed in the 1930s and is now widely distributed in most parts of China (Zhou et al., 2017). Through investigating the effect of different rates of invasion by *A. philoxeroides* on soil faunal and soil physicochemical properties, this study aimed to improved our knowledge the impact of this invasive plant on the belowground compartment of terrestrial ecosystem. This would provide a theoretical basis to defend against this highly invasive plant.

## Materials and methods

### *Study site*

The sampling site was located on the north shore of the Nanfei River in Hefei city, Anhui Province (31.88°N, 117.26°E). The site belongs to a subtropical humid monsoon climate with annual average temperature of 15.8 °C and annual average rainfall of 995.3 mm with average annual sunshine of 1902.0 h (Yao et al., 2014). Along the plain of the river banks, the sampling sites are mainly located near the farmland (*Fig. 1*). According to vegetative ground cover rate (Niu et al., 2007; Chen et al., 2017). we established four rates of invasion by *A. philoxeroides*, that is, non-invaded (O, *A. philoxeroides* number is 0), slightly invaded (S, *A. philoxeroides* accounted for 30% of individuals in each plot), moderately invaded (M, *A. philoxeroides* accounted for 60% of individuals in each plot) and heavily invaded (L, *A. philoxeroides* accounted for > 90% of individuals in each plot).

### *Sample collection and processing*

From July to October 2016, soil samples were collected four times. For each rate of invasion 5 quadrats of 50 cm × 50 cm were randomly selected; each sampling interval was more than 10 m, and the natural environment was basically similar. The aboveground vegetation and litter was removed and soil was collected from 4 depths for each quadrat (0–5, 5–10, 10–15 and 15–20 cm) by soil drilling (with a diameter of 7 cm). Soil samples were placed into labelled ziplock bags before being taken back to the laboratory for analysis. At the same time, soil from the top 0–20 cm in each quadrat was collected and mixed well for analysis of soil physical and chemical properties. Identification of soil animals according to relevant literature (Yin, 1998).

Using the Tullgren method (Yin, 2002), soil animals were extracted in the laboratory using a funnel suspended above a 60 W light with continuous irradiation for at least

24 h; the photopathic instinct of the soil animals makes them move away from the light into beakers containing 75% alcohol that are placed underneath the funnel. The soil animals were collected and classified under the optical microscope, and the number of individuals was recorded.
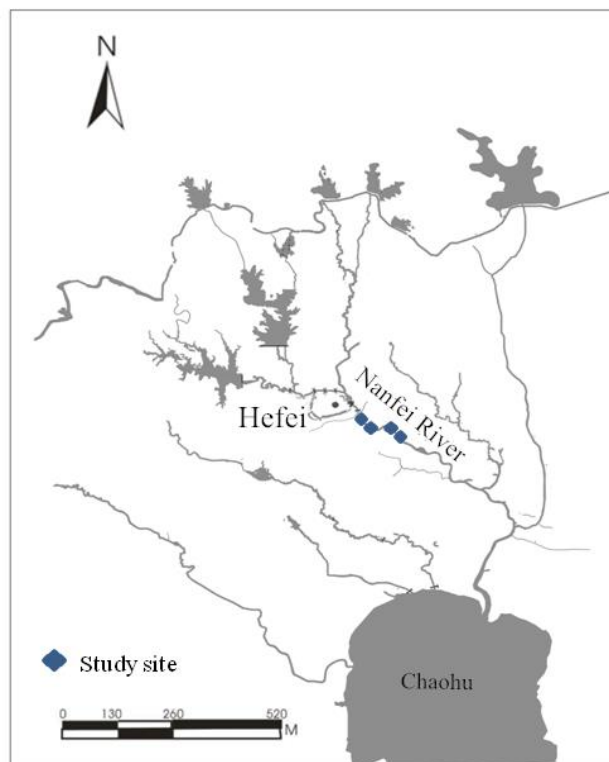


*Figure 1. The sampling site is at Nanfeihe, Hefei, Anhui, China*

Soil samples at depths of 0-5 cm, 5-10 cm, 10-15 cm and 15-20 cm were collected, and roots and stones were removed. Sufficient soil samples were taken by quartering method and air-dried in the room, and then ground through 40-mesh and 100-mesh soil sieves to make soil samples for the analysis of soil physical and chemical properties. Soil organic matter was assessed by potassium dichromate-sulfuric acid oxidation; soil total nitrogen was assessed by the Kjeldahl nitrogen method; soil total phosphorus and available phosphorus was determined by the Mo-Sb colorimetric method; total and available potassium content of soil were determined by flame photometry and soil moisture content measured by conventional drying and weighing method (Bao, 2000).

### Data analyses

Diversity indices are usually used to determine the stability of a community or ecosystem; common indices include the Shannon-Wiener diversity index, Pielou's evenness index, Simpson's dominance diversity index and Margalef's richness index. The Shannon-Wiener index is an integrated indicator to measure richness and evenness. The community diversity of soil animals was analysed using the following indices:

$$H' = -\sum_{i=1}^{s} P_i \ln P_i \qquad \text{(Eq.1)}$$

$$E = H'/\ln S \qquad \text{(Eq.2)}$$

$$C = \sum (P_\mathrm{i})^2 \qquad \text{(Eq.3)}$$

$$D = (S-1)/\ln N \qquad \text{(Eq.4)}$$

where *H'* is the Shannon-Wiener diversity index (*Eq. 1*); *E* is Pielou's evenness index (*Eq. 2*); *C* is the Simpson dominance index (*Eq. 3*); *D* is the Margalef richness index (*Eq. 4*); *S* is the number of species, *N* is the total individual number of soil animals; and *Pi* is the proportion of individuals belonging to species *i* in a sample.

All data were analysed using SPSS for Windows (SPSS, 20.0). Before the analysis, we conducted a diagnostic test of normal distribution and homoscedasticity, and the result is very satisfactory. Statistical analysis was performed by analysis of variance (one-way ANOVA and multiple comparison), and the means were subjected to the Duncan's multiple range test ($p < 0.05$) to obtain the main community differences between the treatments. In addition, to estimate the interaction of soil depth invasion degree among different degree of animal diversity was analyzed by two- way ANOVA analysis. SPSS's correlation analysis was used between soil animals species numbers and soil factors.

## Results

### Impact of plant invasion on soil physicochemical properties

The contents of soil organic carbon, total nitrogen, available potassium and available phosphorus in the heavily invaded areas were significantly higher than those in other plots (*Table 1*), The contents of available potassium and available phosphorus in the non-invaded area and the moderately invaded area were significantly lower than other treatments ($P < 0.05$), There was no significant difference in total phosphorus content between the four rates of invasion. The total potassium content was higher in the heavily and moderately invaded areas than in the other areas ($P < 0.05$), and there was no significant difference in total potassium content between the slightly invaded and non-invaded areas.

### Soil animal composition

From four surveys, 2406 soil micro and meso-fauna were isolated, belonging to 7 classes, 13 orders and 25 families (*Table 2*). Among them, the dominant population (number of individuals accounting for more than 10% of the total number of individuals) consisted of acarina and collembola, accounting for 64.52% of the total amount of soil animals captured; common components of the population (individuals accounting for 1% to 10% of the total individuals) could be classified into nine categories: *Diptera*, *Isopoda, Hymenoptera, Diplura, Psocoptera, nematodes, Haplotaxida, Geophilella* and *Pauropus*, accounting for 32.51% of the total amount of soil animals captured. The rest of the individuals captured were rare populations (individuals accounting for 1% of the total number of individuals), accounting for 2.97% of the total amount of soil animals captured. From slight intrusion area to heavily intrusion area, total individual number of soil animals showed the trend of first increased and then decreased, number of species tends to be stable.

***Table 1.*** *Effects of A. philoxeroides invasion on soil chemical and physical properties*

|   | Organic matter (g/kg) | Total N (g/kg) | Total P (g/kg) | Total K (g/kg) | Available K (mg/kg) | Moisture content (%) | Available P (mg/kg) |
|---|---|---|---|---|---|---|---|
| O | 6.8 ± 0.67d | 0.5 ± 0.03b | 0.2 ± 0.04ab | 16.7 ± 0.36c | 176.0 ± 1.73d | 0.26 ± 0.03b | 10.9 ± 1.47c |
| S | 19.6 ± 0.64c | 1.1 ± 0.11c | 0.2 ± 0.02b | 16.0 ± 0.10c | 188.7 ± 0.58c | 0.23 ± 0.01b | 18.1 ± 2.23b |
| M | 23.4 ± 0.73b | 1.2 ± 0.05b | 0.3 ± 0.03a | 17.8 ± 0.85b | 217.7 ± 7.09b | 0.28 ± 0.01b | 19.5 ± 1.86ab |
| L | 29.0 ± 0.74a | 1.7 ± 0.10a | 0.2 ± 0.06ab | 19.5 ± 0.44a | 300.3 ± 0.58a | 0.39 ± 0.06a | 22.3 ± 2.76a |

Values are mean ± SD. Different letters in the same column indicate that means are significantly different at $P < 0.05$.(a > b > c) O: non-invaded area, S: slight invaded area, M: moderate invaded area, L: heavily invaded area

***Table 2.*** *The richness and abundance of soil fauna in different A. philoxeroides invasion area*

|   | Non-invaded | | Slight invaded | | Moderate invaded | | Heavily invaded | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
|   | N | % | N | % | N | % | N | % | N | % |
| **Parasiformes** | | | | | | | | | | |
| *Ixodidae* | 159 | 6.61 | 132 | 5.49 | 204 | 8.48 | 183 | 7.61 | 678 | 28.18 |
| **Acariformes** | | | | | | | | | | |
| *Chigger mites* | 6 | 0.25 | 12 | 0.5 | 6 | 0.25 | 0 | 0 | 24 | 1 |
| *Oribatulidae* | 78 | 3.24 | 72 | 2.99 | 111 | 4.61 | 102 | 4.24 | 363 | 15.09 |
| **Diptera** | | | | | | | | | | |
| *Muscidae* | 24 | 1 | 36 | 1.5 | 30 | 1.25 | 36 | 1.5 | 126 | 5.24 |
| *Chironomidae* | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0.12 | 3 | 0.12 |
| **Collembola** | | | | | | | | | | |
| *Isotomidae* | 39 | 1.62 | 78 | 3.24 | 105 | 4.36 | 87 | 3.62 | 309 | 12.84 |
| *Folsomides* | 0 | 0 | 0 | 0 | 6 | 0.25 | 3 | 0.12 | 9 | 0.37 |
| *Entomobrya* | 18 | 0.75 | 30 | 1.25 | 48 | 2 | 45 | 1.87 | 141 | 5.86 |
| *Sminthuridae* | 6 | 0.25 | 6 | 0.25 | 9 | 0.37 | 0 | 0 | 21 | 0.87 |
| *Onychiuridae dinghuensis* | 6 | 0.25 | 12 | 0.5 | 15 | 0.62 | 3 | 0.12 | 36 | 1.5 |
| **Isopoda** | | | | | | | | | | |
| *Porcellio* | 3 | 0.12 | 45 | 1.87 | 21 | 0.87 | 24 | 1 | 93 | 3.87 |
| **Hymenoptera** | | | | | | | | | | |
| *Aenictus* | 12 | 0.5 | 57 | 2.37 | 42 | 1.75 | 21 | 0.87 | 132 | 5.49 |
| **Coleoptera** | | | | | | | | | | |
| *Family Nitidulidae* | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0.12 | 3 | 0.12 |
| *Staphylinidae* | 3 | 0.12 | 6 | 0.25 | 3 | 0.12 | 0 | 0 | 12 | 0.5 |
| **Corrodentia** | | | | | | | | | | |
| *Psocidae* | 54 | 0.75 | 54 | 0.37 | 39 | 1.62 | 57 | 2.37 | 123 | 5.11 |
| *Entotrophi* | | | | | | | | | | |
| *Japygidae* | 0 | 0 | 3 | 0.12 | 3 | 0.12 | 0 | 0 | 6 | 0.25 |
| *Thysanoptera* | | | | | | | | | | |
| *Thripidae* | 6 | 0.25 | 18 | 0.75 | 0 | 0 | 0 | 0 | 24 | 1 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Plecoptera** | | | | | | | | | |
| *Perlidae larvae* | 3 | 0.12 | 3 | 0.12 | 3 | 0.12 | 0 | 0 | 9 | 0.37 |
| **Hemiptera** | | | | | | | | | |
| *Pentatomidae* | 0 | 0 | 6 | 0.25 | 0 | 0 | 0 | 0 | 6 | 0.25 |
| **Pseudoscorpionida** | | | | | | | | | |
| *Chthonioidea* | 3 | 0.12 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0.12 |
| ***Strongylida*** | | | | | | | | | |
| *Meloidogynidae* | 0 | 0 | 21 | 0.87 | 45 | 1.87 | 18 | 0.75 | 84 | 3.49 |
| **Araneae** | | | | | | | | | |
| *Arachnid* | 3 | 0.12 | 3 | 0.12 | 12 | 0.5 | 6 | 0.25 | 24 | 1 |
| **Others** | | | | | | | | | |
| *Scolopendrellidae* | 15 | 0.62 | 15 | 0.62 | 36 | 1.5 | 21 | 0.87 | 87 | 3.62 |
| *Haplotaxis* | 0 | 0 | 6 | 0.25 | 9 | 0.37 | 54 | 2.12 | 66 | 2.74 |
| *Pauropus* | 0 | 0 | 6 | 0.25 | 3 | 0.12 | 15 | 0.62 | 24 | 1 |
| Total individuals | 402 | 16.71 | 576 | 23.94 | 750 | 31.17 | 678 | 28.18 | 2406 | |
| Total species | 17 | | 21 | | 21 | | 17 | | 27 | |

N: the number of individuals, %: representing the percentage of the total number of individuals

## *Community diversity of soil fauna under different rates of A. philoxeroides invasion*

In the different degree of invasion of *Alternanthera philoxeroides*, there are some differences in community structure in soil animal (*Fig. 2*). The Margalef richness index was not significantly different ($p < 0.05$) among the four rates of invasion, but the Simpson dominance index ($p < 0.05$) in the non-invaded area was significantly different from those in the other three areas, and Shannon-Wiener diversity index space significant difference $p < 0.05$) In the non-invaded communities, soil animals are less and the number of species are relatively concentrated; In the *A. philoxeroides* invaded communities, There was no significant difference between the slight intrusion to heavily invasion areas, but the Simpson's dominance diversity index increased with the increase of the invasion degree, indicating *A. philoxeroides* invasion may affect to some extent of soil animal community, and in moderate intrusion conditions most suitable soil animal survival.

## *Community diversity of soil fauna at different soil depth*

In the vertical direction, the number of species and individual density of soil animals showed a tendency of obvious aggregation, decreasing with the increase of soil depth. For all treatments, the number of individuals and species of soil animals was highest in the 0–5 cm soil layer and lowest in the 15–20 cm soil layer, although there was no obvious trend in the 5–15 cm soil layer (*Fig. 3*).

The Shannon-Wiener diversity index and Pielou's evenness index showed no significant difference with depth (*Fig. 4*), although they increased with increasing soil depth. The Simpson index was significantly different in the 15–20 cm soil layer when compared with the other soil layers ($P < 0.05$), but the Shannon-Wiener and Margalef indices were the lowest at this depth, indicating that as the soil depth increased, species

diversity decreased, but there were some dominant species that adapted to the deep soil environment and were uniformly distributed.
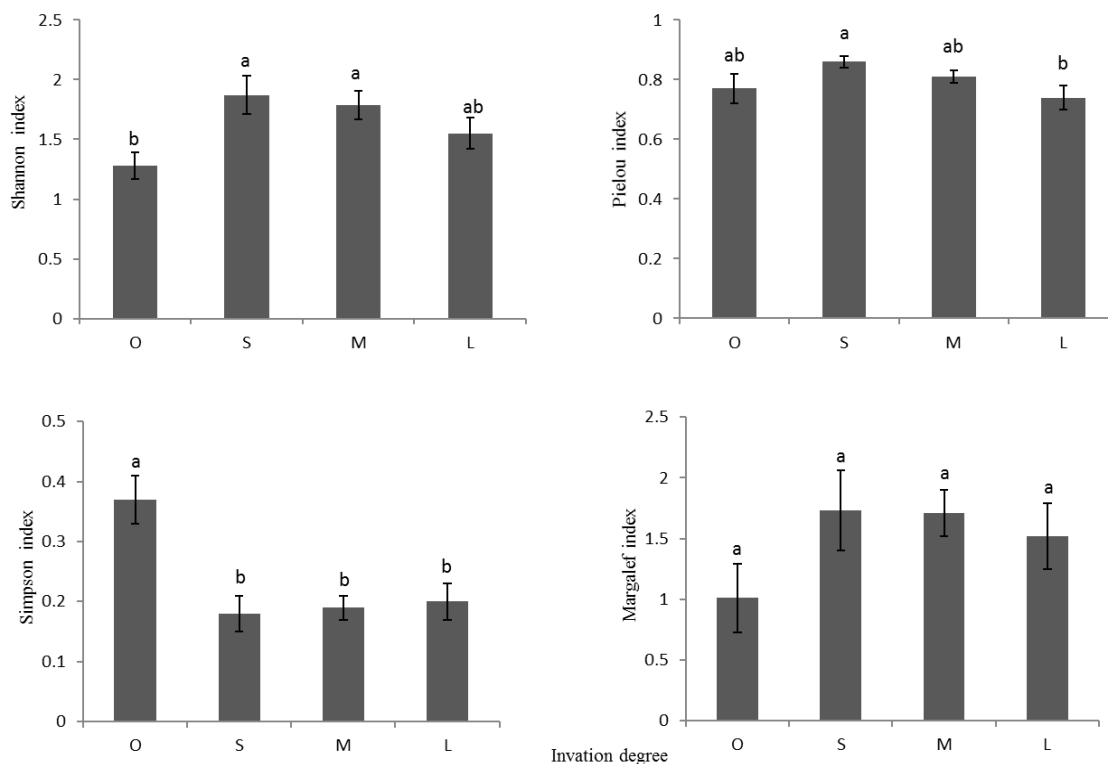


*Figure 2. Diversities of soil fauna community in in different A. philoxeroides invasion area (mean ± SE). (Different letters indicate that means are significantly different at P < 0.05 with a > b > c; O: non-invaded area, S: slight invaded area M: moderate invaded area, L: heavily invaded area)*
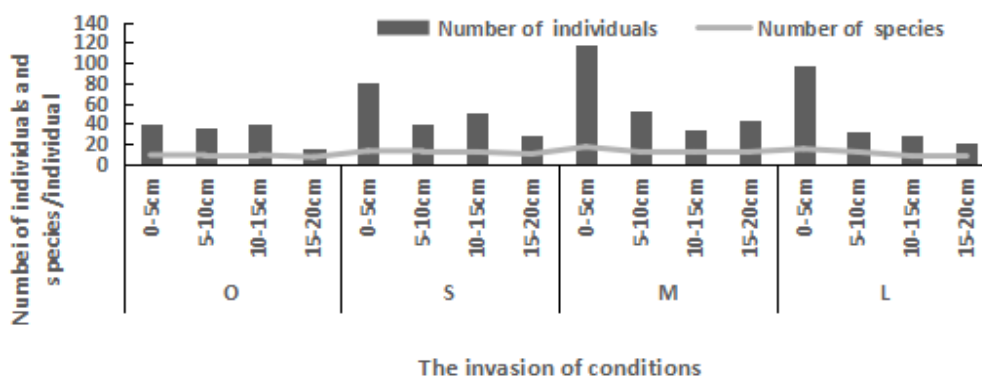


*Figure 3. Vertical distribution of the group number and individual number of soil fauna in different invasion area*

## Different invasion degree and soil depth on soil animals community structure parameters

The two-way analysis of variance of invasion and depth and community showed that the degree of invasion has significant influence on community diversity ($P < 0.05$). Soil

depth of different degree of invasion has significant effects on community diversity ($P < 0.01$), and significant impact on the community dominance index and evenness. he distribution of soil animals was affected by the rate of invasion and soil depth but no significant effect of the two factor interactions on the four community structure indices (*Table 3*). And the rate of invasion and soil depth were respectively affecting four indicators of diversity rather than a common effect.
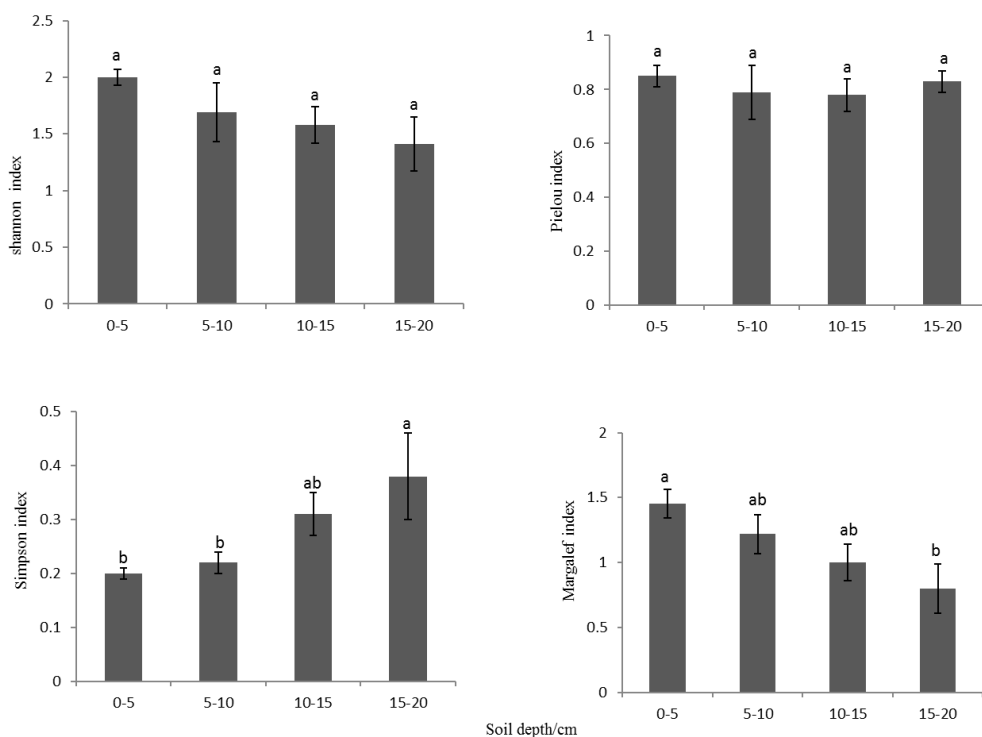


***Figure 4.*** *Diversities of soil fauna community in different soil depth (mean ± SE). (Different letters indicate that means are significantly different at P < 0.05 with a > b > c)*

***Table 3.*** *F-values of a two-way analysis of variance of soil animals community structure parameters in different invasion area and soil depth*

| Variable | DF | Shannon-Wiener | Pielou | Simpson | Margalef |
|---|---|---|---|---|---|
| | | F | F | F | F |
| Invasion degree | 3 | 0.963* | 2.657 | 0.321 | 0.617 |
| Depth | 3 | 5.214** | 1.629 | 13.187* | 24.294* |
| Invasion * depth | 9 | 0.366 | 0.927 | 0.68 | 0.889 |

*Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level

## The relationship between soil physicochemical properties and soil animals in *A. philoxeroides* invaded areas

The correlation of soil animals species and soil physical and chemical properties under different rates of invasion is shown in *Table 4*. Except for the non-invasive area (O area), the number of soil animal species in the invaded area (S, M, L) was significantly negatively correlated with total potassium indicating that the distribution

of soil animals was greatly influenced by total potassium content. The number of species in the slightly invaded area (S) was significantly correlated with total phosphorus ($P < 0.01$), but this relationship was not observed in other treatments (*Table 4*). The total potassium content increased significantly from the non-invaded area to the severely invaded area ($P < 0.05$). When comparing the numbers of individuals and species of soil animals in different invaded areas (*Fig. 3*), it was found that for both moderately and severely invaded areas, the numbers of soil fauna individuals and species were closely aligned with the total potassium distribution, further indicating that the distribution of soil animals might be affected by the total potassium content.

***Table 4.** Correlations between soil animals species numbers and soil factors*

|   | Organic matter | Total N | Total P | Total K | Available P | Available K |
|---|---|---|---|---|---|---|
| O | 0.11 | 0.30 | 0.17 | -0.22 | -0.31 | 0.22 |
| S | 0.05 | 0.32 | 0.71** | -0.43* | -0.24 | 0.02 |
| M | 0.34 | 0.30 | 0.48 | -0.56* | -0.28 | 0.23 |
| L | 0.44 | 0.61 | 0.37 | -0.11* | -0.41 | 0.42 |

**$P < 0.01$; *$P < 0.05$

## Discussion

### *Effect of A. philoxeroides on the soil faunal community*

The present study showed that with the increasing rate of invasion, the total number of individuals and groups of soil meso-and microfauna increased first and then decreased, and the number of individuals and species in some soil animals increased (*Table 2*). These results are consistent with those of several other studies: Gremmen (1998) found that communities dominated by exotic plants the grass *Agrostis stolonifera* have more soil invertebrates and mites at sub-Antarctic Marion Island; Kourtev (2002) found that the number of earthworms in invaded areas was significantly increased when compared with native plant communities; Quan et al. (2011) found that *Mikania micrantha* invasion significantly increased the number of soil nematodes and Acarina individuals, community density and the number of groups in the Huolushan Forest Park of Guangzhou, China; Xie et al. (2011) through found that ragweed invasion significantly increased the density of the community–group numbers of soil fauna, Simpson index and Margalef index by the field plot test method in the suburb of Lishi Town, Shaoguan City, Guangdong Province. These results showed the same results about that invasion by exotic plants can increase the biomass or diversity of soil animals.

*A. philoxeroides* is an amphibious herbaceous plant with strong adaptive and reproductive ability. Chang et al. (2013) research showed that it can quickly form a carpet cover distribution in the invaded area and change the local microclimate environment and soil physical and chemical properties. With the increasing rate of invasion, the soil water content increased and the environmental conditions were more conducive to hygrocoles such as *Nematodes, Mites* and *Collembola*. Soil animals feed on plant humus, radicle and caulicle, Alkemade et al. (2015) showed that after *Spartina anglica* invasion of the European coastal wetland, because of its high net primary productivity, the decomposition of a large number of aging stems provided additional resources into the detritus food web, leading to an increase in the number of soil invertebrates. The development of *A. philoxeroides* roots and stems can provide an

abundant food source for soil animals (Pan et al., 2007). In our study, with the increasing rate of invasion by *A. philoxeroides*, the number of hygrophilous *Acarina* and *Collembola* drastically increased, and the biomass of the moderately invaded area was the highest, with slightly less biomass in the severely invaded area (*Table 2*). It could be due to the high vegetation coverage, environmental conditions are changed, such as increased humidity and poor ventilation, thus resulting in the disappearance of *Thysanoptera, Plecopterodae, Hymenoptera, Hemiptera* and other stomatal breathing soil animals, and a significant increase in the number of hygrophilous animals like *Earthworms*. Siersma et al. (2007) also suggested that invasive plant covers may lead to the changes of soil animals' number, but more research is also necessary to support the major claims of this study.

### Effect of A. philoxeroides invasion on soil fauna diversity indices

It can be found in the study: with increasing rate of invasion, the Shannon-Wiener, Pielou and Margalef indices decreased, while the Simpson index increased, indicating that although invasion increased the biomass of small and medium-sized soil animals, the diversity, in terms of the number of groups, decreased, indicating that the increase in abundance of soil fauna was concentrated within a small number of groups, such as *Parasiforme, Acariformes* and *Collembola* (*Table 2*).

Many studies have shown that the density of soil animals decreases with depth, with the majority of soil fauna distributing in the top 0–5 cm and significant reductions in number and diversity in deeper soil (*Fig. 3*), for example, Chen and Aoki (1998) surveyed the distribution of soil mites in different soil layers in Changchun and found that the amount and type of mites in the soil layer vertical structure was sharply reduced with increasing soil depth, plummeted with the result what Aoki survey mites distribution in the soil layers (0–5) cm highest plummeted down) coincide. Yin et al. (2003a) studied the diversity of soil fauna in the Lesser Khingan forest and found that diversity in vertical direction of soil animals decreased with soil depth and that the surface aggregation of soil meso-and micro arthropods was more obvious than that of large soil animals. Similar results were found in our study, where the vertical distribution of soil fauna in both invaded and non-invaded areas was highest in the 0–5 cm soil layer and decreased with increasing soil depth (*Fig. 3*).

### Effects of soil physicochemical properties on the distribution of soil fauna

There is a close relationship between soil animals and soil environmental factors. Some studies have shown that the soil environmental factors have little effect on the animal groups, just concerning with the number of individual soil animals (Kourtev et al., 1999; Yin et al., 2003b). But in our studies found that *A. philoxeroides* invasion influencing the soil physico-chemical properties, with increasing rate of invasion, soil organic carbon, total nitrogen, available phosphorus, available potassium and total potassium contents increased, there was a significant negative correlation between soil total potassium and the number of soil animal groups (*P < 0.05*), with the increase of total potassium in soil, the soil fauna decreased, it indicated that the regulation of soil potassium content may change the diversity of soil animal communities. Similar results have been found in invasive plants such as *Ambrosia artemisiifolia, Solidago canadensis* and *Ageratina adenophora* (Cruz-Ortega et al., 1998; Tan et al., 2002; Zhang, et al., 2009).

## Conclusion

In summary, changes in the soil faunal diversity indices with different rates of invasion and soil depth showed that *A. philoxeroides* invasion affects the species and quantity distribution of small and medium-sized soil animals. Among the communities invaded by *A. philoxeroides*, the *Acarina* and the *Collembola* were dominant members of the population. Soil animals communities were mainly distributed in the topsoil with high vegetation coverage rate and rich humus and litter, presenting a decreasing trend in abundance in the vertical direction under the common constraints of multiple environmental factors and climate conditions. In the future, comprehensive research on soil animals in *A. philoxeroides* should be strengthened to improve the invasion mechanism. Provide a theoretical basis for better prevention and control of invasive species.

**Conflict of interests.** All of the authors in this paper declare that they have no conflict of interests.

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