European Journal of Soil Biology 62 (2014) 39–48

Contents lists available at ScienceDirect

European Journal of Soil Biology

journal homepage: http://www.elsevier.com/locate/ejsobi

Original article

Does the invasion of the exotic tree *Ailanthus altissima* affect the soil arthropod community? The case of a riparian forest of the Henares River (Madrid)

Mónica Gutiérrez-López*, Ester Ranera, Marta Novo [1], Rosa Fernández [2], Dolores Trigo

Departamento Zoología y Antropología Física, Universidad Complutense de Madrid, C/José Antonio Novais s/n, 28040 Madrid, Spain

ARTICLE INFO

Article history:
Received 18 November 2013
Received in revised form
20 February 2014
Accepted 24 February 2014
Available online 12 March 2014
Handling editor: Stefan Schrader

Keywords:
Acari
Ailanthus altissima
Collembola
Litter
Invasive species
Riparian ecosystem

ABSTRACT

Invasive species are a major threat to global biodiversity because they alter the functioning of affected ecosystems by displacing the native vegetation and fauna. This study evaluated the effect of the invasive species *Ailanthus altissima* on soil properties and the microarthropod community, compared to the native species *Populus nigra*. Soil samples were taken in riparian forests, an ecosystem with high risk of colonisation by invasive tree species, on a stretch of the Henares River (Madrid, Spain) under the canopy of both tree species. In addition, controlled laboratory experiments were performed to evaluate the effects of litter on the arthropod community. Some groups of springtails (Entomobryomorpha, Poduromorpha and Symphypleona), mites (Gamasida and some Oribatida) and other arthropods groups (spiders, pseudoscorpionids, isopods and insects) were more abundant under the native species, while Actinedida mites were more abundant under ailanthus. Differences in porosity, pH and organic matter content were also observed between soils. In the laboratory experiments, the Arthropleona springtails and a few Oribatida mites preferred poplar leaf extract, and the Actinedida mites preferred ailanthus leaves. The invasion of *A. altissima* could be influencing soil fauna through their litter and also could be changing several soil properties which consequently affect soil microarthropod communities. This study reveals the clear disturbance of ecosystems that the invasion by exotic species produces at many levels of the soil system.

1. Introduction

Plant species introduction is a common practice in forestry, agricultural and gardening projects. Some of these exotic species are extending, becoming invasive species, displacing native vegetation and disturbing ecosystems; they establish relationships with invaded soil that can strengthen the invasion and hinder the recovery of the original ecosystems [1–4]. Reforestation using exotic species is considered in Portugal the second most important alteration in forests, these species already covering 17% of the Portuguese forest area [5]. Reforestation using exotic species is a tool used in many degraded habitats [6] but involves breaking biotic balances established by evolution, generating an impact on microclimate, soil characteristics and soil biota [7], for example, microarthropod populations [8]. Due to this common phenomenon, the European Commission is developing a specific legislative instrument to identify invasive species and prevent their establishment [9].

One of the ecosystems exposed to a high risk of invasion by invasive tree species are riparian forests, because of their peculiar characteristics [10]. They have been heavily exploited by man because the trees are fast-growing being one of the most productive natural areas, with high biodiversity and important ecological, recreational and landscape values [11]. River banks are therefore areas of high environmental, social and economic value. Naturalisation of some species of exotic trees has been observed in river banks in recent years, such as ailanthus or the tree of heaven (*Ailanthus altissima*), a native of China [12]. This tree grows wild easily and can form numerous shoots with long roots, displacing native vegetation [13,14].

* Corresponding author. Tel.: +34 913945031; fax: +34 913944947.
E-mail address: mogutier@bio.ucm.es (M. Gutiérrez-López).
[1] Current address: Cardiff School of Biosciences, Cardiff University, BIOSI 1, Museum Avenue, Cardiff CF10 3TL, UK.
[2] Current address: Museum of Comparative Zoology, Department of Organismic and Evolutionary Biology, Harvard University, 26 Oxford Street, Cambridge, MA 02138, USA.

http://dx.doi.org/10.1016/j.ejsobi.2014.02.010
1164-5563/

Invasive species can cause large changes in soil fertility and nutrient cycles [1,2], affecting soil biota and other surrounding plant species. Castro-Díez et al. [15] found higher release of nitrogen and rate of litter decomposition under the canopy of exotic species concluding that changes on decomposition processes are owed to differences on the physicochemical substances of the different types of litter. Jonsson et al. [16] showed that litter addition to soil influenced nutrient contents and polyphenols, which can affect the growth of plants and soil microarthropods.

Soil organisms play a key role in the structure and dynamics of plant communities [17], being responsible for important processes as decomposition and nutrient cycling, and forming also different types of associations with roots of several plant species [3,10]. The effect of invasive plant species on ecosystem processes could be a result of their effects on the soil organisms that drive these processes [7]. Several studies show how changes of plant cover can affect soil organisms, such as microorganisms, mycorrhizal fungi, plants and invertebrates (nematodes, arthropods or earthworms) [6–8,16,18–20]. Soil invertebrates can also maintain mutualistic relationships or can be herbivores or plant pathogens, and therefore, they can determine the colonising success of different plant species and play important role in successional changes of the ecosystem [21–23]. Furthermore, the role of ecosystem engineers in soil formation through their bioturbation activity can be critical [19,24,25].

The observed effects of invasive exotic trees on soil fauna are quite variable, depending on the species, the place of study or the method used. However, the different chemical composition of the litter of many exotic species compared to the composition of native species [15,26,27] should induce a change in the composition of the microarthropod community colonising that litter. In this way, Arbea and Jordana [8] found lower species diversity of Collembola in exotic larch forests compared with native ones and Sousa et al. [5] found fewer individuals and lower species diversity of Collembola in recent forests of exotic eucalyptus in Portugal compared to communities under the natives *Quercus ilex* and *Quercus suber*. Moreover, Pinto et al. [10] found that these communities were influenced by physical and chemical characteristics of the soil and the litter, such as organic matter content and nutrient recycling rate. Additionally, Ojala and Huhta [28] showed that populations of many species of Collembola and oribatid mites did not survive after the introduction of an invasive birch. In laboratory experiments, Das and Joy [6] found lower colonisation of the detritivore Collembola *Cyphoderus javanus* on litter of different tropical forest tree species containing more polyphenols, tannins and lignin, concluding that preference for a litter depends on its palatability. However, another study [19] found higher densities of oribatid mites and a richer community in mixed forests of beech (*Fagus sylvatica*) and spruce (*Picea abies*) than in pure forest, most likely due to the high heterogeneity of habitat and structure of mixed forest patches. Also new invasive species could have allelopathic chemicals that might be expected to impact soil communities, for example, some essential oils have allelopathic properties toxic to soil fauna, especially for arthropods [18,20].

The main objective of this study is to evaluate the impact of *A. altissima* (Mill.) Swingle (Simaroubaceae), one of the most common riparian invasive species of the Iberian Peninsula, on soil properties and on the structure of soil arthropod community. We chose black poplar, *Populus nigra* L. (Salicaceae), as a control species, because it is native to the Iberian Peninsula and its natural habitat, the riparian forest, is frequently invaded by *A. altissima*. Sampling was made in autumn and spring under the canopy of both species, in an area of the Henares River. The effects of soil parameters on the distribution of soil microarthropods were also studied. Furthermore, experiments were conducted in controlled laboratory conditions to study whether the effect of the invasion of *A. altissima* could be due to exotic litterfall with different chemical properties from the native one.

2. Material and methods

2.1. Study area

The sampling area (200 m × 50 m) was selected on the riverside of the Henares River near the locality of Chiloeches (Guadalajara, Spain), (616 m above sea level, UTM: 30 T 480450 4491340) with a eutric leptosol soil association [15]. Riparian communities occupy a narrow band along the river forming gallery forests, being their main influencing factor the soil, as they nearly always have abundant water and nutrients. The presence of the ground water table near the surface ensures a steady supply of water [29]. Riparian vegetation usually forms dark forests, but in recent years, some of these areas have been reduced and replaced with several crops. In turn, this has led to invasion by exotic species such as *A. altissima*, *Ulmus pumila* and *Robinia pseudoacacia*. In the study area, riparian vegetation formed a band of large riparian trees, contrasting with the bush and cereal crops around. Specimens of both tree species, *A. altissima* and *P. nigra*, were forming each one two nearby woods close to the river. Ailanthus invasion began approximately in 2005, displacing poplar trees and forming a monoculture type vegetation area. The average diameter of *P. nigra* was 142.10 ± 26.34 cm, while *A. altissima* was 31.31 ± 8.30 cm. The invasion of ailanthus seems to be relatively recent, while poplar woodlots were established for much more time.

Alluvial ecosystems are known to be of a high biodiversity, especially for plants and phytocenoses. Understory vegetation consisted mainly of herbaceous plants, most of them of the Poaceae family, covering the soil completely (plant cover approximately 100%). Some species were common in both areas, such as *Bromus tectorum* (Poaceae), *Rubia peregrina* (Rubiaceae) or *Daucus carota* (Apiaceae), but there were also some unique species under each wood. The area under *P. nigra* was dominated by a high abundance of common reed (*Phragmites australis*) next to the river and other grasses (*B. tectorum*, *Lolium rigidum*, *Elymus repens*, *Hordeum murinum*). Other species of different families were also found, such as *Silybum marianum* (Asteraceae), *Salsola kali* (Amaranthaceae) and a few small shoots of invasive *R. pseudoacacia* (Fabaceae). The area under *A. altissima* showed less abundance of grasses (mainly *B. tectorum* and *Avenula bromoides*) but a greater diversity of species, such as *Cirsium arvense* and *Crepis vesicaria* ssp. *taraxacifolia* (Asteraceae), *Papaver rhoeas* (Papaveraceae), *Biscutella auriculata* (Brassicaceae) and small shoots of *Salix* sp. (Salicaceae). For more detailed information about the vegetation of the study area, see Martínez Martínez [29].

2.2. Sampling design

Samples were collected in October 2010 (autumn) and May 2011 (spring), when optimal conditions of temperature and humidity for sampling microarthropods occur [19]. For each season, six sampling points were selected under the cover of each tree species (one sampling point under each tree), avoiding the area just around the trunk and the edge of the tree cover. The mean distance between specimens of *P. nigra* was 376.75 ± 167.19 cm, while ailanthus trees formed small groups of specimens, most of them outbreaks from one large, central specimen, and the mean distance between these groups was 226.93 ± 93.59 cm. Samples taken under each tree were separate enough, given small microarthropods dispersion ability, to be considered statistically independent. Soil samples were collected under coverage of both tree species to perform