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Scientific Note

Emergence of the aphid *Hysteroneura setariae* (Thomas, 1878) and ladybird predators *Coccinella septempunctata* L., 1758 (Coleoptera: Coccinellidae) on the grass *Muhlenbergia capillaris* (Lamark) Trinius in central Japan

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Abstract. Pink muhly grass *Muhlenbergia capillaris* (Lamark) Trinius is a perennial, tussock-forming grass that is native to North and Central America. The reddish-purple coloration of the spikes of this species has resulted in this grass becoming popular as an ornamental plant around the world. Interestingly, very few insects have been reported to be associated with this grass. I therefore examined arthropod assemblages on *M. capillaris* in two urban parks in central Japan in autumn and found that the aphid *Hysteroneura setariae* (Thomas, 1878) (Hemiptera: Aphididae) and its natural ladybird predator *Coccinella septempunctata* L., 1758 (Coleoptera: Coccinellidae) occurred at high densities at one of the parks (ca. 9000 vs 3.4 individuals/m^2). Other insect pests, such as the moth *Helicoverpa armigera* (Hübner, 1808) (Lepidoptera: Noctuidae) and mirid bugs were also present, but at markedly lower densities. Since *H. setariae* is not a pest in Japan and *C. septempunctata* is a beneficial predator, *M. capillaris* could be used as a banker plant in agricultural fields as well as in urban green spaces.

Keywords: Aphididae, candidate banker plant, Coccinellidae, ornamental plant.

In their native ranges, exotic ornamental plants are often infested by a variety of herbivorous insects, which are often imported together with the plants (Liebhold et al. 2012; Patoka et al. 2016). Alternately, native pests can be preadapted to infesting the imported plant species by being pests on closely related plant species found at the destination (Meijer et al. 2012; Marsaro Júnior et al. 2020). On the other hand, ornamental plants can provide ecosystem services, such as enhanced pollinator activity (Griffiths-Lee et al. 2020) and play a role in pest control (Parsons et al. 2020; Lopez & Liburd 2022). Given the wide variety of possible outcomes, follow-up studies on insects associated with newly introduced ornamental plants are often required.

Pink muhly grass, *Muhlenbergia capillaris* (Lamark) Trinius (Poaceae) is a perennial, tussock-forming grass that produces reddish-purple, diffusely branching spikes in autumn. The tussocks reach a height of up to ca. 1.5 m and the inflorescences appear similar to a colorful mist when viewed at a distance. This species is native to the south-eastern United States, Mexico, Guatemala and the Caribbean, and while some of the wild populations in these areas are declining, the species is increasingly being cultivated as an ornamental plant around the world (Engstrom 2004; Royal Botanic Gardens, Kew 2022). Although this grass is believed to be pest-free, insects such as aphids, mealybugs, lace bugs and beneficial ladybirds have been reported to be associated with the plant (Kirk & Belt 2010; Carr et al. 2011; Bolles 2016). Except for these fragmentary records, arthropod assemblages on *M. capillaris* have not been reported from both native and introduced areas. As this grass has recently been planted in Japanese public parks and private gardens, I had the opportunity to examine the arthropod assemblages on this species. The aim of this report was therefore to describe the arthropod assemblages on *M. capillaris* in autumn in two Japanese parks, and to clarify the potential costs and benefits of the arthropods.

The arthropod surveys on *M. capillaris* were conducted at two urban sites in Japan; Nagai Park and Expo ’70 Commemorative Park (Nagai and Expo, hereafter) (Fig. 1). The distance between the study sites is 18.5 km. The areas of Nagai and Expo are 65.7 ha and 264 ha, respectively. Both parks are situated in urban areas of Osaka Prefecture, central Japan, where a variety of trees, shrubs and herbs are planted. The Nagai site is located in the Nagai Botanical Garden (24.2 ha), which is within Nagai Park. The flower beds of *M. capillaris* at both sites are similar in shape and size (ca. 50 m × 20 m). The beds at Nagai were planted in the winter of 2021, while those at Expo were planted in the winter of 2020.

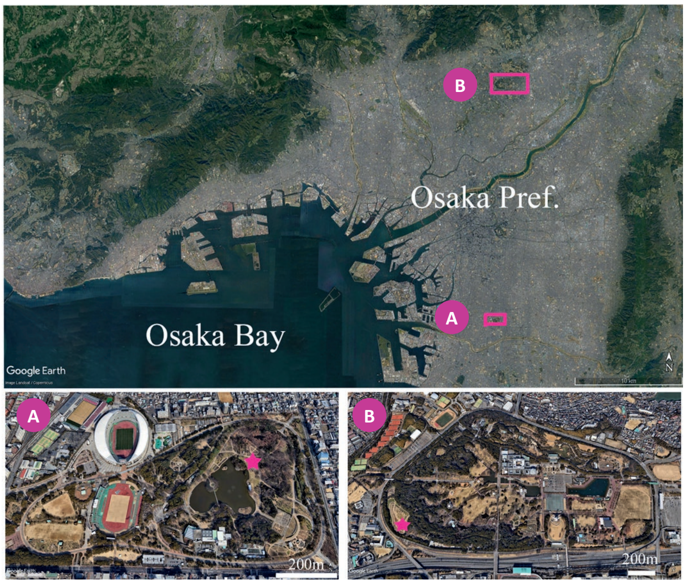

Figure 1. Map of study sites in Osaka, central Japan. (A) Nagai Park; (B) Expo ’70 Commemorative Park. Pink stars show *Muhlenbergia capillaris* flower beds. Reproduced from Google Earth®.

Muhlenbergia capillaris produces long reddish-purple spikes that bear diffuse, airy flowers in autumn, which facilitates arthropod observations (Fig. 2A). At both sites, five 10-m transects were established: three along inner paths and two along the perimeter of the beds. I then searched for, and recorded, arthropod species on *M. capillaris* at a height of 20 cm above the ground to the top of plants along each transect (1 m × 10 m) on November 3 and 13, 2022 at Nagai and November 5, 2022 at Expo. The density of each arthropod species was calculated as the number of individuals /m^2. Because the densities of aphids were too high to enumerate accurately using the transect method, their density was estimated by calculating the product of the mean number of aphids per spike (N = 10) and the mean no. of spikes / m^2 (1-m^2 quadrats, N = 10).

During the field census, at least 17 arthropod species were found on *M. capillaris* (Tab. 1). Aphids were very abundant, with the total number of apterous adults, nymphs and alates numbering 6500-9600 individuals/m^2 at the two sites. Most of the aphids were distributed on spikes, especially between spikelets and developing seeds (i.e., 0-5 individuals/spikelet; Fig. 2B). The aphids were identified as *Hysteroneura setariae* (Thomas, 1878) (Hemiptera: Aphididae) based on their morphology including dark body and siphunculi color, long and pale cauda and single oblique vein on hind wings (Blackman & Eastop 2000; Matsumoto 2008; Fig. 2C). Ants were not observed to tend the aphids.

There were also several aphid predators, including ladybirds, syrphids and spiders. The seven-spotted ladybird beetle *Coccinella septempunctata* L., 1758 (Coleoptera: Coccinellidae) was the most dominant ladybird species (Fig. 2D, E); the density of all developmental stages (i.e., adults, pupae and larvae) was 3.42 individuals/m^2 on November 13, 2022 at Nagai, indicating that ca. 3,500 ladybirds emerged from the 1000-m^2 flower bed at Nagai. The adults and larvae voraciously consumed *H. setariae* aphids by walking swiftly on the very thin spikes. Interestingly, despite the abundance of *H. setariae* aphids at Expo, the density of *C. septempunctata* was very low (0.04 individuals/m^2). Other ladybirds, *Harmonia axyridis* (Pallas, 1773) (Coleoptera: Coccinellidae), *Propylea japonica* (Thunberg, 1781) (Coleoptera: Coccinellidae), syrphids and spiders were much less common than *C. septempunctata*. The katydid *Conocephalus maculatus* (Le Guillou, 1841) (Orthoptera: Tettigoniidae) was widespread at Nagai (Fig. 2F). The population density of pest insects, such as *H. armigera* and mirids [*Stenotus rubrovittatus* (Matsumura, 1913) (Hemiptera: Miridae) and *Trigonotylus* sp.], was low at both sites (<0.04 individuals/m^2, Tab. 1).

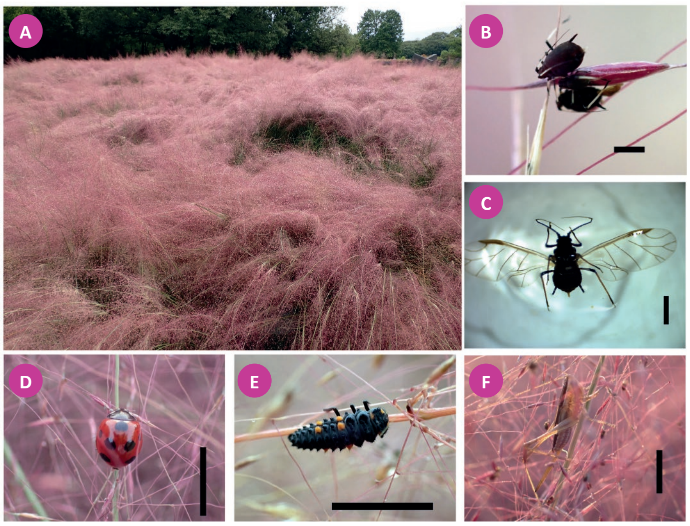

Figure 2. Insects on *Muhlenbergia capillaris*. (A) *M. capillaris* stands; (B) apterous viviparous adults and nymphs of *Hysteroneura setariae*; (C) *H. setariae* alate; (D) *Coccinella septempunctata* adult; (E) *C. septempunctata* larva; (F) *Conocephalus maculatus* nymph. Scale bars: (B), (C) 1 mm; (D) - (F) 10 mm.

Hysteroneura setariae is an alien species in Japan that originates from North America; this species is spreading globally and has been reported in South Africa, Australia, Southeastern and South Asia and South America (Blackman & Eastop 2000; Nasruddin 2013). In North America, this aphid uses *Prunus* trees and Poaceae grasses alternately as host plants, and it is known to be a pest on various Poaceae crops such as rice, wheat, sugarcane and maize (Blackman & Eastop 2000; Nasruddin 2013). However, this species also occurs on spikes or leaves of Poaceae weeds, e.g. *Eleusine* and *Eragrostis*, in Japan without host alteration and is not considered to be an agricultural or horticultural pest (Matsumoto 2008). Interestingly, although the spikelets of *M. capillaris* are airy and interspersed, most park visitors did not notice the presence of aphids at the study sites, even though high densities of *H. setariae* aphids can give the colorful inflorescences a slightly dark tint. Therefore, *H. setariae* aphids on *M. capillaris* might serve as fodder prey for various natural enemies of aphids in horticultural and agricultural settings in the country.

Coccinella septempunctata is a well-known and common ladybird species that was originally distributed in the Palearctic region but has successfully invaded the Nearctic region due to its ability to prey upon a wide range of prey aphids, its high mobility, and life-history plasticity (Hodek & Michaud 2008). This ladybird species typically has two, occasionally more, generations per year in central Japan. The first-generation adults typically aestivate during summer and second-generation adults overwinter in a quiescent state (Sakurai et al. 1983; Ohashi et al. 2005). Thus, the *C. septempunctata* populations on *M. capillaris* corresponded to the second generation. At Nagai, first-generation larvae and adults feed upon the abundant aphids [e.g., *Aphis craccivora craccivora* Koch, 1854, *Rhopalosiphum padi* (L., 1758) (Hemiptera: Aphididae)] that occur on various herbs and grasses (e.g., *Vicia sativa nigra* (L.) Ehrh., *Poa trivialis* L.) in spring, after which numbers decrease markedly in autumn than in spring (Yamazaki *personal observations*). Therefore, extensive planting of *M. capillaris* would have the effect of markedly increasing the population size of the second generation, resulting in an increase in overwintered adults in the following spring. However, the reason why the density of *C. septempunctata* was low at Expo is unclear.

The association of *H. setariae* and *C. septempunctata* on *M. capillaris* may be considered from the viewpoint of pest control using a banker plant system. Banker plants are defined as the plants that typically support non-pest (but occasionally also pest) herbivorous arthropods and their natural enemies, which then attack and control pests on crops or other useful plants (Parolin et al. 2012). Given that banker plant systems have successfully been developed in combination with cereal plants, aphids and parasitoids, particularly in greenhouses and agricultural fields (Frank 2010; Nagasaka et al. 2010), the tripartite association among *M. capillaris, H. setariae and C. septempunctata* could be potentially used as a banker plant system in agricultural fields as well as in urban green spaces. *Coccinella septempunctata* maintained on *M. capillaris* by preying on *H. setariae* could thus be used to regulate other aphid species on useful plants. In Thailand, the agricultural weed *Eleusine indica* (L.) Gaertn. (Poaceae), *H. setariae* and two ladybird species [*Coccinella transversalis* (Fabricius, 1781) and *Menochilus sexmaculatus* Fabricius, 1781 (Coleoptera: Coccinellidae)] have been studied within the context of a banker plant system (Rattanapun 2017).

This report presents a snapshot of the arthropods found on cultivated *M. capillaris* in late autumn in central Japan. Additional field surveys in other seasons and districts combined with laboratory experiments examining, for example, the suitability of *M. capillaris* as a hostplant for aphids and rearing of aphids in search of parasitoids, are required to assess the effectiveness of this ornamental grass for pest control. Since planted *M. capillaris* has been shown to support various arthropods, including aphids and their natural enemies around the world, there is a possibility that enhancing biological control measures using this ornamental grass is potentially viable. However, risk assessments of possible negative ecological effects of such measures are also necessary.

Table 1. Density of arthropods in two stands of *Muhlenbergia capillaris* in parks in central Japan in autumn, 2022. Average number of individuals /m² (without parentheses) and standard errors (in parentheses) are shown for each species and developmental stage. *A: adult; P: pupa, puparium; L: larva, nymph, juvenile. **Only the average no. of individuals/m² is shown as a different estimation method was used. See text for details.

Order/Species	Stage*	Nagai		Expo
		Nov. 3	Nov. 13	Nov. 5
Coleoptera				
***Coccinella septempunctata* L., 1758**	A	0.40 (0.21)	0.56 (0.15)	0.02 (0.02)
	P	0.34 (0.20)	0.38 (0.26)	0
	L	0.94 (0.33)	2.48 (0.77)	0.02 (0.02)
Harmonia axyridis (Pallas, 1773)	A	0.02 (0.02)	0	0
Propylea japonica (Thunberg, 1781)	A	0.04 (0.02)	0	0
Altica sp.	A	0.02 (0.02)	0.04 (0.02)	0
Orthoptera				
Conocephalus maculatus (Le Guillou, 1841)	A	0.14 (0.07)	0.02 (0.02)	0
	L	2.81 (0.21)	0.12 (0.05)	0.02 (0.02)
Tetrix japonica (Boliva, 1887)	A	0	0	0.02 (0.02)
Hemiptera				
Hysteroneura setariae* (Thomas, 1878)*	A, L	9,600	8,632	6,500
Stenotus rubrovittatus (Matsumura, 1913)	A	0	0	0.04 (0.02)
Trigonotylus sp.	A	0	0	0.02 (0.02)
Lepidoptera				
Ancylolomia japonica Zeller, 1877	A	0	0.02 (0.02)	0
Zizeeria maha (Kollar, 1844)	A	0	0	0.02 (0.02)
Helicoverpa armigera (Hübner, 1808)	L	0	0.02 (0.02)	0
Diptera				
Syrphinae undet.	P	0.04 (0.02)	0.04 (0.02)	0
Syrphus dubius Matsumura, 1918	A	0.02 (0.02)	0	0
Sarcophagidae undet.	A	0	0.04 (0.02)	0
Sepedon aenescens (Wiedemann, 1830)	A	0	0.02 (0.02)	0
Araneae				
Oxyopes sertatus L.Koch, 1878	L	0.02 (0.02)	0.02 (0.02)	0

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Conflict of Interest Statement

I declare that there is no conflict of interest regarding the publication of this manuscript.

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