Acta Botanica Hungarica 67(4), pp. 361–380, 2025
DOI: 10.1556/034.67.2025.4.1

MIND EVEN THE FIRST STEPS: COLONIZATION BY AN ALIEN PERENNIAL GRASS, *PASPALUM DISTICHUM* POSES A THREAT TO THE NATIVE FLOODPLAIN VEGETATION IN HUNGARY

A. Kelemen[1,2,a]*, O. Kiss[3,4,a]* and O. Valkó[2,3]

[1]*Department of Ecology, University of Szeged, H-6726 Szeged, Közép fasor 52, Hungary; E-mail: kelemen.andras12@gmail.com (*corresponding author)*
[2]*'Lendület' Seed Ecology Research Group, Institute of Ecology and Botany, HUN-REN Centre for Ecological Research, H-2163 Vácrátót, Alkotmány út 2–4, Hungary; E-mail: valkoorsi@gmail.com*
[3]*National Laboratory for Health Security, HUN-REN Centre for Ecological Research, H-1113 Budapest, Karolina út 29, Hungary; E-mail: orsolyakiss22@gmail.com (*corresponding author)*
[4]*Institute of Animal Sciences and Wildlife Management, Faculty of Agriculture, University of Szeged, H-6800 Hódmezővásárhely, Andrássy út 15, Hungary*

(Received: 7 November 2024; Accepted: 12 February 2025)

At the advanced stages of invasion, the control of invasive alien species (IAS) often exceeds the capacity of the agencies responsible for it, so early detection is vital for success. This is particularly urgent when perennial grass species become established in wetlands. Here we present a case study on knotgrass (*Paspalum distichum* L.), an alien perennial grass species first detected in Hungary in 2020, in a floodplain of the Danube River at Dunavecse. The study aims to make predictions about the invasion behaviour of knotgrass by combining trait-based approaches and risk assessment tools. In the place of its first detection in Hungary, we compared the species richness, biomass, and seed production of the native and the invaded vegetation. We found that knotgrass formed monodominant stands characterized by extremely high above-ground living biomass with a mean dry weight of 3,670 g/m^2. The invaded stands were characterised by significantly lower plant diversity compared to the non-invaded controls. The above-ground biomass was almost three times higher in invaded plots than in native vegetation. There were no significant differences between the seed yield of knotgrass and the dominant species of native vegetation. All three risk assessment systems classified knotgrass into the highest risk category implying high possibility of its future invasive spreading and becoming a transformer species in Hungary. There are a lot of further potentially suitable habitats for the knotgrass connected with the already occupied site, and the high propagule pressure and strong competitive ability also suggest a high probability of future expansion.

Key words: biomass, diversity, invasion risk assessment, invasive alien species, perennial grass, propagule pressure, seed production, wetland

[a] The first two authors contributed equally to this paper.

INTRODUCTION

The spread of invasive alien species (IAS) is recognized as a major and increasingly relevant threat to biodiversity in the Anthropocene (Bellard *et al.* 2022, Poland *et al.* 2021). There is almost no region of the Earth without invasive species; for example, there is one alien out of the three persistent vascular plant species in Antarctica (Chwedorzewska *et al.* 2015). IAS have a negative impact on the ecosystems, as they are one of the most important causes of species extinction, the decrease of biodiversity, and the collapse or fundamental change of ecosystems (Pyšek and Hulme 2011, Vilà *et al.* 2011, Zhang *et al.* 2023). Moreover, they have caused and will continue to cause enormous direct and indirect economic damages, via decreasing agricultural production, reducing the forage quality of pastures, causing mechanical damages to infrastructure or putting large pressure on the health care systems (Bodey *et al.* 2022, Connelly *et al.* 2007, Diagne *et al.* 2021, Pimentel *et al.* 2005). In the near future, the acceleration of these processes is predicted because of climate change and increasing human mobility, presenting new challenges for invasion ecological research and intervention actions (Bullock *et al.* 2019, IPBES 2023, Sala *et al.* 2000, Valkó *et al.* 2020).

At the advanced stages of invasion, the control of IAS might exceed the capacity of the agencies responsible for their control. Examples of this are mounting in Central Europe, such as in the case of *Asclepias syriaca*, *Solidago* spp., *Ailanthus altissima*, *Amorpha fruticosa* (Mihály and Botta-Dukát 2004). In the case of these IAS, usually the only option is to protect the most vulnerable native species and habitats from these rapidly spreading and aggressive competitors. Since IAS control in the advanced stages is a challenging task and requires substantial resources from nature conservation, prevention and control of potential IAS in the early stages can be a more effective tool (Diagne *et al.* 2021, IPBES 2023, Lodge *et al.* 2006, Mehta *et al.* 2007). Intervention at the early stages has the lowest cost (Cuthbert *et al.* 2022) and the lowest adverse impacts on the other elements of wildlife (Lodge *et al.* 2006, Mehta *et al.* 2007). Therefore, it is important to start defensive actions against the dangerous alien species immediately after their first detection in a certain region. For this purpose, invasion risk assessment is necessary when a new population of a potential IAS appears in a new country or biogeographical region.

Invasion risk assessments of newly established alien species are particularly urgent in wetlands, where newly established alien species have the potential to spread via hydrochory and they can rapidly colonize the entire watershed (Nilsson *et al.* 2010). Also particularly important for perennial grasses, which often become dominant, transforming native communities and generally posing greater difficulties in management compared to annual herbaceous plants (Hábenczyus *et al.* 2022). Guerilla-type clonal plants are among the most successful invaders (Song *et al.* 2013, Wang *et al.* 2019).

Here, we provide a case study about the knotgrass (*Paspalum distichum L.*), which is an alien perennial grass species first detected in Hungary in 2020 by the authors of this paper. The study aims to make predictions about the invasion behaviour of knotgrass in Hungary by combining trait-based approaches and risk assessment tools. We compared the diversity of the vegetation in native and invaded stands, and with trait-based analyses, we compared the performance (biomass) and reproductive success (seed yield) of the native vegetation and the vegetation invaded by knotgrass. During the risk assessment process, we applied three assessment protocols to make our results as robust as possible: 1) the EPPO (European and Mediterranean Plant Protection Organization) prioritization process, whose theoretical basis follows the rules of the International Plant Protection Convention (IPPC) and 2) the Harmonia[+] (Invasive species in Belgium). Both methods fulfil most of the criteria of the quality assurance standards that could be expected from an assessment tool (Roy *et al.* 2018). We also adapted the 3) Australian Weed Risk Assessment (A-WRA) system (the weed term in the Australian literature often means alien plants), also a reliable and complex tool, which is one of the most widely applied and tested protocols for plants that is widely adapted globally (Kumschick and Richardson 2013, Pheloung *et al.* 1999). As a result of these assessments, it is possible to classify the focal species into risk categories (i.e., high, medium, and low risk).

To fulfil these aims we tested the following hypotheses: (i) The diversity of the native vegetation is lower in plots invaded by knotgrass compared to non-invaded control plots. (ii) There are higher above-ground biomass and seed yield in the monodominant knotgrass stands compared to the native vegetation. (iii) Based on its species characteristics, knotgrass is classified into the highest risk category by the risk assessment systems.

METHODS

Characteristics of the focal species

Paspalum distichum is a fast-growing competitor grass characterized by a thick canopy, effective clonal spread and seed dispersal ability. *P. distichum* is a fast-growing, stoloniferous, creeping perennial usually forming dense mats and thick canopy on the mud surface. The nodes of its shoots are capable of rooting and its horizontal growth rate can be as fast as 15–20 cm per week (Noda and Obayashi 1971). Besides this powerful clonal spreading ability, it is characterized by prolific seed production and effective seed dispersal ability. Its buoyant propagules can effectively spread with the floating water, moreover, they are also capable of being dispersed by birds with endozoochory (Middleton *et al.* 1991). As a C4 species, it prefers high temperatures and it is sensitive to shade (CABI 2023, Mesléard *et al.* 1993).

Knotgrass is adapted to semi-aquatic environments and occurs in still or running water, primarily on freshwater bodies e.g. wetlands, ponds, streams, and ditches typically to the depth of one meter (De Datta *et al.* 1979, Häfliger and Scholz 1980, Leithead *et al.* 1971). Besides these characteristics, there are further reasons explaining its success, such as it is also used as a forage crop (Bor 1960, Ikeda *et al.* 1983), and partly due to its disturbance tolerance it occurs as a weed worldwide in rice fields and other types of irrigated croplands (Fajardo and Moody 1990, Kadono 1985, Vasconcelos *et al.* 1998). This species is widely distributed in tropical and subtropical areas worldwide, and it is not entirely clear where it is actually native similarly to other plant species, which are weeds in crops cultivated over a long time (Aguiar *et al.* 2005, Anđelković *et al.* 2016). However, it is generally accepted that its native range is situated in America. Initially introduced as a cultivated forage plant to Europe, it had already been under cultivation as early as 1802 in the southwest part of France (Le Floc'h 1991). Nowadays knotgrass established in several European countries (Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, France, Greece, Italy, Malta, Montenegro, Portugal, Romania, Russia, Serbia, Slovenia, Spain, Turkey, Ukraine, and the United Kingdom) (Anđelković *et al.* 2016, CABI 2023). Based on this known European distribution and its occurrence in six neighbouring countries, it was to be expected to appear also in Hungary.

Several adverse effects of *Paspalum distichum* have been already reported on the native biota as it competes with native plants, forms monodominant stands (Anđelković *et al.* 2016), and reduces fish populations (Kumar and Mittal 1993). Knotgrass can provide optimal habitat for mosquito larvae and therefore can increase mosquito populations (Lawler *et al.* 2007), which effect, coupled with the spreading of the warm-adapted, potent virus vector mosquitos in Central Europe, may increase the risk of diseases (Garamszegi *et al.* 2023, Schaffner *et al.* 2013). Knotgrass can be infected by the fungus *Claviceps paspali* which can cause ergotism in livestock (CABI 2023). It has also negative economic impacts because it can cause the loss of crop yield, for example, in rice fields, and can hamper water regulation activities (Vasconcelos *et al.* 1998).

Study area

We (A.K. and O.K) detected the occurrence of *Paspalum distichum* in the floodplain of the river Danube (GPS coordinates: 46° 55′ 4.99″ N, 18° 58′ 6.50″ E) at Dunavecse on 27 September 2020, which was its first occurrence record in Hungary. Up to our knowledge, the species has not been detected in other sites in the country since then. The environment of the ancient floodplain had been modified at the end of the 19th century, a small-sized clay pit with approx. 0.8 ha area has been dug because of the construction of the river embankments during the river regulation. The habitat formed in this way is characterized by permanent water cover for a long time. In summertime, the water depth is usually approximately 1 m, while in autumn it is typically less than 50 cm, but this largely depends on the water level of the Danube. However, in the last four years, it dried out in summer and early autumn for one- or two-month-long periods, because of the droughts and the incision of the Danube. Still, the water body of this pothole is connected with the riverbed of the Danube for several months every year. The study area has a continental climate with a mild sub-mediterranean influence, the mean annual temperature is 10.2–10.3 °C, and both the mean annual temperature and the mean temperature in autumn are increasing nowadays as a consequence of climate change (HungaroMet 2023). The mean annual precipitation is 530–550 mm and a dry period is typical in summer.

The habitat is characterized by repeated disturbance events due to the flash floodings, and therefore, typically covered with pioneer vegetation formed by annual plants. The native vegetation on the nutrient-rich silty soil of the pothole belonged to the Bidention tripartitae alliance (Borhidi 1995). The vegetation was dominated by *Persicaria dubia*, and the further characteristic species were *Barbarea vulgaris*, *Bidens tripartita*, *Chenopodium rubrum*, and *Persicaria lapathifolia* (Table 1). The vegetation height was typically 100–120 cm. During the field surveys, we noted that approximately half of the whole area of the pothole was invaded by *Paspalum distichum*, where it formed monodominant stands. There were no notable differences in the abiotic factors (such as geomorphology, soil properties, and hydrological conditions) between the area covered by native vegetation and the invaded area.

Sampling and data processing

We compared the species richness, above-ground biomass, and seed production of the original native and the invaded vegetation. The vegetation sampling and biomass collection were performed at the end of September 2022, at the peak of biomass production in this habitat. In both vegetation types, we randomly placed ten 2 × 2 m plots where the percentage cover of each vascular plant species was estimated. Besides this, we collected one above-ground biomass sample (20 × 20 cm) from each plot (altogether 20 samples), and then, their fresh and dry mass (after drying at 65 °C for 24 h to a constant mass) were measured with 0.1 g accuracy. The above-ground biomass composed of living biomass; there was no standing dead or litter layer. The numbers of inflorescences of the dominant species were counted in one 1 × 1 m subplot in each plot. Moreover, five inflorescences of the dominant species were collected (one hundred altogether) from the plots on 2 November 2022 and afterwards, we counted the healthy seeds per inflorescence. Based on these data we estimated the seed production of the dominant species of the native vegetation and also the seed production of the knotgrass. We compared the species numbers (no. of species/4 m^2), the dry weight of above-ground biomass values (g/m^2), and the seed numbers (seed number/m^2) between the native and the invaded vegetation using t-tests.

We performed the invasion risk assessment of *Paspalum distichum* using three different assessment protocols (EPPO, Harmonia$^+$, A-WRA). Up to our knowledge, no invasion risk assessments have been performed for this species before. We went through the EPPO protocol which uses decision trees and considers both the spread potential and the negative impact of species to reach the final classification (Brunel *et al.* 2010, EPPO 2012). We answered the 41 questions of Harmonia$^+$ protocol (https://ias.biodiversity.be/protocols/form/show/83077cae-c6a7-4352-bf24-a27eb00b8424) that refers to various components of invasion covering the stages of introduction, establishment, spread, and multiple kinds of impacts (D'hondt *et al.* 2015). This system operates with ordinal answers and converts them into scores. We also answered the 49 questions of A-WRA scoring system (Pheloung *et al.* 1999) which uses information on a taxon's invasive status in other parts of the world, climate and environmental preferences, and biological attributes. The answers to the questions of the three assessment systems are shown in Appendix.

RESULTS

We found that in the study site, *Paspalum distichum* covers 0.4 ha forming monodominant stands with extremely high biomass, with a mean fresh biomass of more than 25 kg/m^2 (25,040 g/m^2). The creeping and rooting shoots of knotgrass formed a dense, more than 20 cm tangled mat on the mud surface. At the end of September, *Paspalum* was in flowering stage and most of the seeds ripened in the first half of November. The native vegetation was dominated by the annual ruderal forb *Persicaria dubia* (mean cover of 78.9%), and the cover of perennials was negligible (Table 1). The knotgrass altered the vegetation of the invaded site, we detected a significantly lower species richness in invaded plots compared to the native vegetation ($|$t-value$|$ = 7.83; $p < 0.001$; Fig. 1).

The dry weight of above-ground biomass was significantly higher in the invaded plots (3,670 g/m^2) than in the native vegetation (1,292 g/m^2) ($|$t-value$|$ = 15.36; $p < 0.001$; Fig. 2A). There were no significant differences between the seed yield of the dominant species of invaded plots (*Paspalum distichum*: 33,270.4±3,899.8 seed/m^2) and the dominant species of native vegetation (*Persicaria dubia*: 36,460.6 ± 6,158.0 seed/m^2) ($|$t-value$|$ = 1.55; p = 0.14; Fig. 2). We found that the mean number of inflorescences of knotgrass was 158.4 per square metre, while that of *Persicaria dubia* was 384.2. The average number of seeds per inflorescence was 206.6 in the case of knotgrass and 94.9 in the case of *Persicaria dubia*.

Table 1

Percentage cover of the vascular plant species in the studied plots (N1–N10: plots in the native vegetation, I1–I10: plots in the invaded vegetation)

	Native vegetation										Invaded vegetation									
	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
Amaranthus blitum	8	4	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Aster lanceolatus agg.	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbarea vulgaris	8	2	1	0	3	15	10	8	0.5	5	0	0	0	0	0	0	0	0	0	0
Bidens tripartita	1	0.5	0	3	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Carex acutiformis	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chenopodium rubrum	0	4	5	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0
Echinochloa crus-galli	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lycopus europaeus	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paspalum distichum	0	0	0	0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100
Persicaria dubia	70	80	90	78	70	70	75	80	96	80	0	0	0	0	0	0	0	0	0	0
Persicaria lapathifolia	0	0	0	8	20	0	12	0	0	5	0	2	0	0	0	0	0	0	0	0
Typha angustifolia	0	0	0	0	3	1	0	0	4	0	0	0	0	0	0	0	1	0	0	0
Urtica dioica	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2
The results of the risk assessments of *Paspalum distichum*. For more details see Appendix

Risk assessment protocol	Result
EPPO	List of invasive alien plants
	Priority for pest risk analysis
Harmonia+	invasion: 0.630
	impact: 0.650
	overall risk score: 0.410
A-WRA	overall score: 32
	outcome: reject

Two risk assessment systems (EPPO and A-WRA) classified knotgrass into the highest possible risk category (Table 2; Suppl. 1). Although the Harmonia+ system does not assign categories, the values obtained in this system also indicated that the knotgrass poses a high risk (Table 2; Suppl. 2) (D'hondt *et al.* 2015).

DISCUSSION

Plant traits are usually good predictors of invasion success, as they are often associated with invasiveness (Pyšek and Richardson 2007). Several studies revealed positive relationships between size-related performance traits

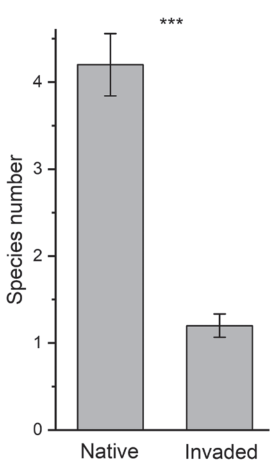

Fig. 1. The species number of the native and invaded vegetation detected in the 2 × 2 m plots (mean ± SE)

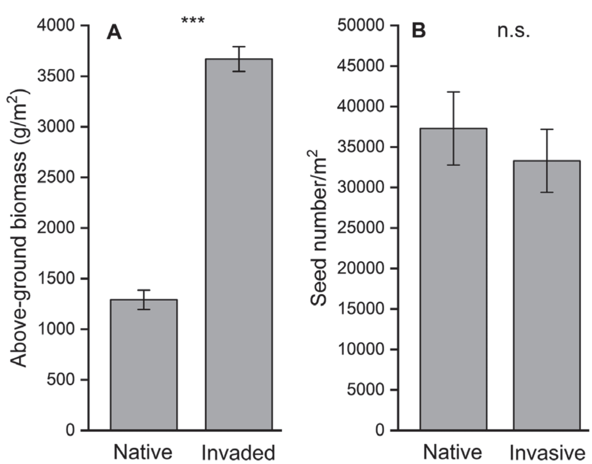

Fig. 2. A = Dry weight of above-ground biomass of the native and invaded vegetation (mean ± SE). B = Seed yield of the dominant species of native and invaded vegetation (mean ± SE)

such as above-ground biomass and the successful invasion (see Rejmánek *et al.* 2005, van Kleunen *et al.* 2010). Not only the existing above-ground biomass but also the high growth rate (which is also typical for knotgrass according to CABI 2023) increases the probability of becoming a successful invader (Theoharides and Dukes 2007). Large-sized species with fast growth rates can effectively acquire the available resources and outcompete the smaller plants due to the size-asymmetric competition for light (Grace 1993, Kelemen *et al.* 2015). We found that the biomass of knotgrass was nearly three times higher than that measured in the control, and comparable high values have not been reported from temperate marshes and floodplain meadows (e.g., Balogh *et al.* 2021, Deák *et al.* 2015, Heinsoo *et al.* 2010, Kelemen *et al.* 2013). Similar above-ground biomass values were obtained in an Indian wetland under subtropical climate, where the *Paspalum*-dominated patches had a maximum biomass of 3 400 g/m^2, and in other vegetation types, the maximum value was 1,400 g/m^2 (van der Valk *et al.* 1993).

Seed yield is another trait that typically also supports invasion success (Daehler 2003, Moravcová *et al.* 2010). We did not detect differences between the seed yield of the knotgrass and that of the dominant species of the native vegetation (*Persicaria dubia*), and both species were characterised by high seed production. The native annual vegetation has to re-establish every year from the seed bank and its species are adapted to the fluctuating water regime and the disturbance, therefore they typically produce a vast number of seeds similarly to a successful invader. However, in the areas invaded by knotgrass, the native species are not able to re-establish from the seeds because of the dense and thick tissue of the knotgrass shoots on the surface. Although, knotgrass still produced a high number of seeds which is particularly important for the invasive spreading and for the successful establishment because of the mass effect (Rouget and Richardson 2003). Later, in the stabilized population of knotgrass, the persistence traits and the competitive ability become more important and result in the alternation of the invaded vegetation (Theoharides and Dukes 2007). Based on these considerations, our results imply that the knotgrass is capable of invasive spreading and can become transformer species very likely.

The results of all three classifications imply that there is a high risk that knotgrass will initiate invasive spread and become a transformer species in Hungary. The completion of these assessments in the case of the recent establishment of a potential IAS in a certain region is important not just because of the complex analyses of the risks but also because the implementation of a field study is possible only in a few (in our case only one) invaded stands at the early stages of the colonization. The risk assessments revealed that we need to consider knotgrass as a dangerous future invader because of its ability for effective spreading and establishment, and because of its adverse environmental effects. In this study, one aspect of its negative effect was revealed as the invasion of knotgrass decreased the diversity of the vegetation at the invaded habitats, by competitively excluding almost all native species. It outcompeted a set of species with insect-pollinated plants which can affect negatively the pollinator assemblages. Besides this, there is a probable adverse effect: as a result of the high productivity of knotgrass, it can increase the sediment load, which decreases the water storage capacity of the invaded habitats. This process is unfavourable if we would like to preserve the water in the landscape for ecological or agricultural purposes.

The effective control of knotgrass poses a challenge for conservation. Knotgrass is characterized by resistance to multiple herbicides, and its ability for vegetative propagation makes its mechanical control difficult, moreover, there are no known natural enemies suitable for biological control, which also contributes to its success (Alcantara *et al.* 2016, CABI 2023). Despite this, in theory, some chemicals might provide effective control in some cases, however, chemical control requires serious caution and is usually prohibited in wetlands (CABI 2023). Ecological restoration methods can be effective to control and prevent its invasion, as complex riparian zones with well-established woody vegetation may efficiently prevent the spread of IAS along the rivers floodplains (Zelnik *et al.* 2015, 2020).

There are a lot of further potentially suitable habitats for the knotgrass connected with the already occupied site. The floodplain habitats are connected by each other by seasonal flooding, which also periodically reloads the nutrient supplies resulting in a high level of available resources (Rejmánek *et al.* 2013). One of the main factors which determine the invasibility of plant communities is the actual amount of available resources, so the floodplains are particularly endangered by the invasion of such good competitor plants as the knotgrass (see also Chytrý *et al.* 2009, Rejmánek *et al.* 2013). Also, floods can transport a huge amount of the propagules of knotgrass which poses a large propagule pressure on the yet not colonized areas. Moreover, the climate of the focal region is predicted to become warmer and thus more favourable for the knotgrass in the future according to the climate change scenarios (Bartholy and Gelybó 2007, Dullinger *et al.* 2017). Because of the above-mentioned considerations, monitoring the potentially suitable habitats for the species is an important task, even though there have been no new populations found in recent years.

*

Acknowledgements – This research was supported by the National Research, Development and Innovation Office within the framework of the National Laboratory for Health Security program (RRF-2.3.1-21- 2022-00006). The work of O.V. was supported by the Hungarian National Research, Development and Innovation Office (grant number: KKP 144096).

REFERENCES

Aguiar, F. C., Ferreira, M. T., Albuquerque, A. and Bernez, I. (2005): Invasibility patterns of knotgrass (Paspalum distichum) in Portuguese riparian habitats. – *Weed Technol.* **19**: 509–516. https://doi.org/10.1614/WT04-080R.1

Alcantara, R., Fernandez, P., Smeda, R. J., Alves, P. L. and De Prado, R. (2016): Response of Eleusine indica and Paspalum distichum to glyphosate following repeated use in citrus groves. – *Crop Prot.* **79**: 1–7. https://doi.org/10.1016/j.cropro.2015.09.027

Anđelković, A., Zivković, M. M., Cvijanović, D. L., Novković, M., Marisavljević, D., Pavlović, D. and Radulović, S. (2016): The contemporary records of aquatic plants invasion through the Danubian floodplain corridor in Serbia. – *Aquat. Invasions* **11**: 381–395. https://doi.org/10.3391/ai.2016.11.4.04.

Balogh, N., Tóthmérész, B., Valkó, O., Deák, B., Tóth, K., Molnár, Z., Vadász, C., Tóth, E., Kiss, R., Sonkoly, J., Antal, K., Tüdősné Budai, J., Miglécz, T. and Kelemen, A. (2021): Consumption rate and dietary choice of cattle in species-rich mesic grasslands. – *Tuexenia* **41**: 395–410. https://doi.org/10.1101/2020.01.23.916635

Bartholy, J. and Gelybó, R. P. G. (2007): Regional climate change expected in Hungary for 2071–2100. – *Appl. Ecol. Env. Res.* **5**: 1–17. https://doi.org/10.15666/aeer/0501_001017

Bellard, C., Marino, C. and Courchamp, F. (2022): Ranking threats to biodiversity and why it doesn't matter. – *Nat. Commun.* **13**(1): 2616. https://doi.org/10.1038/s41467-022-30339-y

Bodey, T. W., Carter, Z. T., Haubrock, P. J., Cuthbert, R. N., Welsh, M. J., Diagne, C. and Courchamp, F. (2022): Building a synthesis of economic costs of biological invasions in New Zealand. – *PeerJ* **10**, e13580. https://doi.org/10.7717/peerj.13580

Bor, N. L. (1960): *The grasses of Burma, Ceylon, India and Pakistan (excluding Bambusae)*. – Pergamon Press, Oxford.

Borhidi, A. (1995): Social behaviour types, the naturalness and relative ecological indicator values of the higher plants in the Hungarian flora. – *Acta Bot. Hung.* **39**(1–2): 97–181.

Brunel, S., Branquart, E., Fried, G., Van Valkenburg, J., Brundu, G., Starfinger, U., Buholzer, S., Uludag, A., Joseffson, M. and Baker, R. (2010): The EPPO prioritization process for invasive alien plants. – *EPPO Bull.* **40**: 407–422. https://doi.org/10.1111/j.1365-2338.2010.02423.x

Bullock, J. M., Bonte, D., Pufal, G., da Silva Carvalho, C., Chapman, D. S., García, C. and Delgado, M. M. (2019): Human-mediated dispersal and the rewiring of spatial networks. – *Trends Ecol. Evol.* **33**: 958–970. https://doi.org/10.1016/j.tree.2018.09.008

CABI (2023): *Paspalum distichum* [original text by Chris Parke]. – In: Invasive species compendium. Wallingford, UK, CAB International. (accessed 17 January 2023) Available at https://doi.org/10.1079/cabicompendium.38952

Chwedorzewska, K. J., Giełwanowska, I., Olech, M., Molina-Montenegro, M. A., Wódkiewicz, M. and Galera, H. (2015): Poa annua L. in the maritime Antarctic: an overview. – *Polar Rec.* **51**: 637–643. https://doi.org/10.1017/S0032247414000916

Chytrý, M., Pyšek, P., Wild, J., Pino, J., Maskell, L. C. and Vilà, M. (2009): European map of alien plant invasions based on the quantitative assessment across habitats. – *Divers. Distrib.* **15**: 98–107. https://doi.org/10.1111/j.1472-4642.2008.00515.x

Connelly, N. A., O'Neill, C. R., Knuth, B. A. and Brown, T. L. (2007): Economic impacts of zebra mussels on drinking water treatment and electric power generation facilities. – *Environ. Manage.* **40**: 105–112. https://doi.org/10.1007/s00267-006-0296-5

Cuthbert, R. N., Diagne, C., Hudgins, E. J., Turbelin, A., Ahmed, D. A., Albert, C., Bodey, T. W., Briski, E., Essl, F., Haubrock, P. J., Gozlan, R. E., Kirichenko, N., Kourantidou, M., Kramer, A. M. and Courchamp, F. (2022): Biological invasion costs reveal

insufficient proactive management worldwide. – *Sci. Total Environ.* **819**, 153404. https://doi.org/10.1016/j.scitotenv.2022.153404
D'hondt, B., Vanderhoeven, S., Roelandt, S., Mayer, F., Versteirt, V., Adriaens, T., Ducheyne, E., San Martin, G., Grégoire, J. C., Stiers, I. and Quoilin, S. (2015): Harmonia+ and Pandora+: risk screening tools for potentially invasive plants, animals and their pathogens. – *Biol. Invasions* **17**: 1869–1883. https://doi.org/10.1007/s10530-015-0843-1
Daehler, C. C. (2003): Performance comparisons of co-occurring native and alien invasive plants: implications for conservation and restoration. – *Annu. Rev. Ecol. Evol. S.* **34**: 183–211. https://doi.org/10.1146/annurev.ecolsys.34.011802.132403
De Datta, S. K., Bolton, F. R. and Lin, W. L. (1979): Prospects for using minimum and zero tillage in tropical lowland rice. – *Weed Res*. **19**: 9–15. https://doi.org/10.1111/j.13653180.1979.tb01511.x
Deák, B., Valkó, O., Török, P., Kelemen, A., Tóth, K., Miglécz, T. and Tóthmérész, B. (2015): Reed cut, habitat diversity and productivity in wetlands. – *Ecol. Complex.* **22**: 121–125. https://doi.org/10.1016/j.ecocom.2015.02.010
Diagne, C., Leroy, B., Vaissière, A. C., Gozlan, R. E., Roiz, D., Jarić, I., Salles, J. M., Bradshaw, C. J. and Courchamp, F. (2021): High and rising economic costs of biological invasions worldwide. – *Nature* **592**(7855): 571–576. https://doi.org/10.1038/s41586-021-03405-6
Dullinger, I., Wessely, J., Bossdorf, O., Dawson, W., Essl, F., Gattringer, A., Klonner, G., Kreft, H., Kuttner, M., Moser, D. and Pergl, J. (2017): Climate change will increase the naturalization risk from garden plants in Europe. – *Global Ecol. Biogeogr.* **26**: 43–53. https://doi.org/10.1111/geb.12512
EPPO (2012): EPPO prioritization process for invasive alien plants. – *EPPO Bull.* **42**: 463–474. https://doi.org/10.1111/epp.2592
Fajardo, F. F. and Moody, K. (1990): Weed control and related cultural practices for wet-seeded rice (Oryza sativa L.) in Guimba, Nueva Ecija. – *Philip. J. Weed Sci.* **17**: 51–64.
Garamszegi, L. Z., Kurucz, K. and Soltész, Z. (2023): Validating a surveillance program of invasive mosquitoes based on citizen science in Hungary. – *J. Appl. Ecol.* **60**: 1481–1494. https://doi.org/10.1111/1365-2664.14417
Grace, J. B. (1993): The effects of habitat productivity on competition intensity. – *Trends Ecol. Evol.* **8**: 229–230. https://doi.org/10.1016/0169-5347(93)90194-T
Hábenczyus, A. A., Tölgyesi, C., Pál, R., Kelemen, A., Aradi, E., Bátori, Z., Sonkoly, J., Tóth, E., Balogh, N. and Török, P. (2022): Increasing abundance of an invasive C_4 grass is associated with larger community changes away than at home. – *Appl. Veg. Sci.* **25**(2): 1–11. https://doi.org/10.1111/avsc.12659
Häfliger, E. and Scholz, H. (1980): *Weeds of the subfamily Panicoideae, Paspalum paspalodes*. – In: Grass Weeds 1. Documenta CIBA-GEIGY, Basel, Switzerland, 103 pp.
Heinsoo, K., Melts, I., Sammul, M. and Holm, B. (2010): The potential of Estonian semi-natural grasslands for bioenergy production. – *Agr. Ecosyst. Environ.* **137**: 86–92. https://doi.org/10.1016/j.agee.2010.01.003
HungaroMet (2023): https://odp.met.hu/climate/station_data_series/daily/ (accessed 17 January 2023)
Ikeda, H., Oyamada, M. and Yamada, N. (1983): Control of knotgrass (Paspalum distichum L.) in the paddy field. – *Bull. Fac. Agric., Miyazaki Univ.* **30**: 51–55.
IPBES (2023): Roy, H. E., Pauchard, A., Stoett, P., Renard Truong, T., Bacher, S., Galil, B. S., Hulme, P. E., Ikeda, T., Sankaran, K. V., McGeoch, M. A., Meyerson, L. A., Nuñez, M. A., Ordonez, A., Rahlao, S. J., Schwindt, E., Seebens, H., Sheppard, A. W. and Vandvik, V. (eds): Summary for policymakers of the thematic assessment report

on invasive alien species and their control of the intergovernmental science-policy platform on biodiversity and ecosystem services. IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.7430692

Kadono, Y. (1985): Distribution of tetraploids of Paspalum distichum L. ('Chikugo-suzumenohie') in irrigation reservoirs in the east Harima area, Hyogo Prefecture, southwestern Japan comparison with three aquatic grasses with a similar ecological niche. – *Weed Res., Japan* **30**: 47–50.

Kelemen, A., Török, P., Valkó, O., Miglécz, T. and Tóthmérész, B. (2013): Mechanisms shaping plant biomass and species richness: plant strategies and litter effect in alkali and loess grasslands. – *J. Veg. Sci.* **24**: 1195–1203. https://doi.org/10.1111/jvs.12027

Kelemen, A., Lazzaro, L., Besnyői, V., Albert, Á. J., Konečná, M., Dobay, G., Memelink, I., Adamec, V., Goetzenberger, L., de Bello, F., Le Bagousse-Pinguet, Y. and Leps, J. (2015): Net outcome of competition and facilitation in a wet meadow changes with plant's life stage and community productivity. – *Preslia* **87**: 347–361.

Kumar, C. R. A. and Mittal, D. D. (1993): Habitat preference of fishes in wetlands in relation to aquatic vegetation and water chemistry. – *J. Bombay Nat. Hist. Soc.* **90**: 181–192.

Kumschick, S. and Richardson, D. M. (2013): Species-based risk assessments for biological invasions: advances and challenges. – *Divers. Distrib.* **19**: 1095–1105. https://doi.org/10.1111/ddi.12110

Lawler, S. P., Reimer, L., Thiemann, T., Fritz, J., Parise, K., Feliz, D. and Elnaiem, D. E. (2007): Effects of vegetation control on mosquitoes in seasonal freshwater wetlands. – *J. Am. Mosquito Contr.* **23**: 66–70. https://doi.org/10.2987/8756-971X(2007)23[66:EOVCOM]2.0.CO;2

Le Floc'h, E. (1991): *Invasive plants of the Mediterranean basin*. – In: Groves, R. H. and Di Castri, F. (eds): Biogeography of Mediterranean invasions. Cambridge University Press, Cambridge, pp. 67–80.

Leithead, H. L., Yarlett, L. L. and Shiflet, T. N. (1971): *100 native forage grasses in 11 southern States*. – Agriculture Handbook No. 389. Soil Conservation Service U.S., Department of Agriculture, Washington, D. C.

Lodge, D. M., Williams, S., MacIsaac, H. J., Hayes, K. R., Leung, B., Reichard, S., Mack, R. N., Moyle, P. B., Smith, M., Andow, D. A. and Carlton, J. T. (2006): Biological invasions: recommendations for US policy and management. – *Ecol. Appl.* **16**: 2035–2054. https://doi.org/10.1890/1051-0761(2006)016[2035:birfup]2.0.co;2

Mehta, S. V., Haight, R. G., Homans, F. R., Polasky, S. and Venette, R. C. (2007): Optimal detection and control strategies for invasive species management. – *Ecol. Econ.* **61**: 237–245. https://doi.org/10.1016/j.ecolecon.2006.10.024

Mesléard, F., Ham, L. T., Boy, V., van Wijck, C. and Grillas, P. (1993): Competition between an introduced and an indigenous species: the case of Paspalum paspalodes (Michx) Schribner and Aeluropus littoralis (Gouan) in the Camargue (southern France). – *Oecologia* **94**: 204–209. https://doi.org/10.1007/BF00341318

Middleton, B. A., van der Valk, A. G., Mason, D. H., Williams, R. L. and Davis, C. B. (1991): Vegetation dynamics and seed banks of a monsoonal wetland overgrown with Paspalum distichum L. in northern India. – *Aquat. Bot.* **40**(3): 239–259. https://doi.org/10.1016/0304-3770(91)90061-9

Mihály, B. and Botta-Dukát, Z. (eds) (2004): *Özönnövények I.* – TermészetBÚVÁR Alapítvány Kiadó, Budapest.

Moravcová, L., Pyšek, P., Jarošík, V., Havlíčková, V. and Zákravský, P. (2010): Reproductive characteristics of neophytes in the Czech Republic: traits of invasive and non-invasive species. – *Preslia* **82**: 365–390.

Nilsson, C., Brown, R. L., Jansson, R. and Merritt, D. M. (2010): The role of hydrochory in structuring riparian and wetland vegetation. – *Biol. Rev.* **85**(4): 837–858. https://doi.org/10.1111/j.1469-185x.2010.00129.x

Noda, K. and Obayashi, H. (1971): Ecology and control of knotgrass (Paspalum distichum). – *Weed Res., Japan* **11**: 35–39.

Pheloung, P. C., Williams, P. A. and Halloy, S. R. (1999): A weed risk assessment model for use as a biosecurity tool evaluating plant introductions. – *J. Environ. Manage.* **57**: 239–251. https://doi.org/10.1006/jema.1999.0297

Pimentel, D., Zuniga, R. and Morrison, D. (2005): Update on the environmental and economic costs associated with alien-invasive species in the United States. – *Ecol. Econ.* **52**: 273–288. https://doi.org/10.1016/j.ecolecon.2004.10.002

Poland, T. M., Patel-Weynand, T., Finch, D. M., Miniat, C. F., Hayes, D. C. and Lopez, V. M. (eds) (2021): *Invasive species in forests and rangelands of the United States: a comprehensive science synthesis for the United States forest sector*. – Springer Nature Switzerland AG, Cham.

Pyšek, P. and Hulme, P. E. (2011): *Biological invasions in Europe 50 years after Elton: time to sound the ALARM*. – In: Richardson, D. M. (ed.): Fifty years of invasion ecology: the legacy of Charles Elton. Blackwell, Oxford, pp. 73–88.

Pyšek, P. and Richardson, D. M. (2007): *Traits associated with invasiveness in alien plants: where do we stand?* – In: Nentwig, W. (ed.): Biological invasions. Springer, New York, pp. 97–125.

Rejmánek, M., Richardson, D. M., Higgins, S. I., Pitcairn, M. J. and Grotkopp, E. (2005): *Ecology of invasive plants: state of the art*. – In: Mooney, H. A., Mack, R. N., McNeely, J. A., Neville, L. E., Schei, P. J. and Waage, J. K. (eds): Invasive alien species: a new synthesis. Island Press, Washington, D.C., pp. 104–161.

Rejmánek, M., Richardson, D. M. and Pyšek, P. (2013): *Plant invasions and invasibility of plant communities*. – In: van der Maarel, E. and Franklin, J. (eds): Vegetation ecology. Wiley-Blackwell, Oxford, pp. 387–424. https://doi.org/10.1002/9781118452592.ch13

Rouget, M. and Richardson, D. M. (2003): Inferring process from pattern in plant invasions: a semimechanistic model incorporating propagule pressure and environmental factors. – *Am. Nat.* **162**: 713–724. https://doi.org/10.1086/379204

Roy, H. E., Rabitsch, W., Scalera, R., Stewart, A., Gallardo, B., Genovesi, P., Essl, F., Adriaens, T., Bacher, S., Booy, O. and Branquart, E. (2018): Developing a framework of minimum standards for the risk assessment of alien species. – *J. Appl. Ecol.* **55**: 526–538. https://doi.org/10.1111/1365-2664.13025

Sala, O. E., Chapin, F. S., Armesto, J. J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L. F., Jackson, R. B., Kinzig, A. and Leemans, R. (2000): Global biodiversity scenarios for the year 2100. – *Science* **287**: 1770–1774. https://doi.org/10.1126/science.287.5459.1770

Schaffner, F., Medlock, J. M. and Van Bortel, A. W. (2013): Public health significance of invasive mosquitoes in Europe. – *Clin. Microbiol. Infec.* **19**: 685–692. https://doi.org/10.1111/1469-0691.12189

Shipley, B. and Vu, T. T. (2002): Dry matter content as a measure of dry matter concentration in plants and their parts. – *New Phytol.* **153**: 359–364. https://doi.org/10.1046/j.0028-646X.2001.00320.x

Song, Y. B., Yu, F. H., Keser, L. H., Dawson, W., Fischer, M., Dong, M. and van Kleunen, M. (2013): United we stand, divided we fall: a meta-analysis of experiments on clonal integration and its relationship to invasiveness. – *Oecologia* **171**: 317–327. https://doi.org/10.1007/s00442-012-2430-9

Theoharides, K. A. and Dukes, J. S. (2007): Plant invasion across space and time: factors affecting nonindigenous species success during four stages of invasion. – *New Phytol.* **176**: 256–273. https://doi.org/10.1111/j.1469-8137.2007.02207.x

Valkó, O., Lukács, K., Deák, B., Kiss, R., Miglécz, T., Tóth, K., Tóth, Á., Godó, L., Radócz, S., Sonkoly, J., Kelemen, A. and Tóthmérész, B. (2020): Laundry washing increases dispersal efficiency of cloth-dispersed propagules. – *NeoBiota* **61**: 1–16. https://doi.org/10.3897/neobiota.61.53730

Van der Valk, A. G., Middleton, B. A., Williams, R. L., Mason, D. H. and Davis, C. B. (1993): The biomass of an Indian monsoonal wetland before and after being overgrown with Paspalum distichum L. – *Vegetatio* **109**: 81–90. https://doi.org/10.1007/bf00149547

Van Kleunen, M., Weber, E. and Fischer, M. (2010): A meta-analysis of trait differences between invasive and non-invasive plant species. – *Ecol. Lett.* **13**: 235–245. https://doi.org/10.1111/j.1461-0248.2009.01418.x

Vasconcelos, T., Tavares, M. and Gaspar, N. (1998): *Aquatic plants in the rice fields of the Tagus Valley, Portugal*. – In: Monteiro, A., Vasconcelos, T. and Catarino, L. (eds): Management and ecology of aquatic plants. Proceedings of the 10th EWRS International Symposium on Aquatic Weeds, Lisbon, Portugal, 21–25 September 1998, European Weed Research Society, Doorwerth, Netherlands, pp. 143–146.

Vilà, M., Espinar, J. L., Hejda, M., Hulme, P. E., Jarošík, V., Maron, J. L., Pergl, J., Schaffner, U., Sun, Y. and Pyšek, P. (2011): Ecological impacts of invasive alien plants: a meta-analysis of their effects on species, communities and ecosystems. – *Ecol. Lett.* **14**: 702–708. https://doi.org/10.1111/j.1461-0248.2011.01628.x

Wang, Y. J., Chen, D., Yan, R., Yu, F. H. and van Kleunen, M. (2019): Invasive alien clonal plants are competitively superior over co-occurring native clonal plants. – *Persp. Plant Ecol. Evol. Syst.* **40**: 125484. https://doi.org/10.1016/j.ppees.2019.125484

Zelnik, I., Haler, M. and Gaberščik, A. (2015): Vulnerability of a riparian zone towards invasion by alien plants depends on its structure. – *Biologia* **70**: 869–878. https://doi.org/10.1515/biolog-2015-0110

Zelnik, I., Mavrič Klenovšek, V. and Gaberščik, A. (2020): Complex undisturbed riparian zones are resistant to colonisation by invasive alien plant species. – *Water* **12**(2): 345. https://doi.org/10.3390/w12020345

Zhang, X., Wang, G., Peng, P., Zhou, Y., Chen, Z., Feng, Y., Wang, Y., Shi, S. and Li, J. (2023): Influences of environment, human activity, and climate on the invasion of Ageratina adenophora (Spreng.) in Southwest China. – *PeerJ* **11**(3), e14902. https://doi.org/10.7717/peerj.149

APPENDIX

Answers to the questions of three risk assessment protocols (EPPO, A-WRA, Harmonia+)

EPPO prioritization process

A.1. Is the plant species known to be alien in all, or a significant part, of the area under assessment? – <u>yes,</u> no

A.2. Is the plant species established in at least a part of the area under assessment? – <u>yes,</u> no

A.3. Is the plant species known to be invasive outside the area under assessment? – <u>yes</u>, no

A.4. Based on ecoclimatic conditions, could the species establish in the area under assessment? – <u>yes</u>, no

A.5. How high is the spread potential of the plant in the area under assessment? – low, medium, <u>high</u>

A.6. How high is the potential negative impact of the plant on native species, habitats and ecosystems in the area under assessment? – low, medium, <u>high</u>

A.7. How high is the potential negative impact of the plant on agriculture, horticulture or forestry in the area under assessment? – low, <u>medium</u>, high

A.8. How high are the potential additional impacts (e.g. on animal and human health, on infrastructures, on recreational activities, other trade related impacts such as market losses)? – <u>low</u>, medium, high

B.1. Is the plant species internationally traded or are there other existing or potential international pathways? – <u>yes</u>, no

B.2. Is the risk of introduction by these international pathways identified to be superior to natural spread? – <u>yes</u>, no

B.3. Does the plant species still have a significant area suitable for further spread in the area under assessment? – small, medium, <u>large</u>

A-WRA system

1.01. Is the species highly domesticated? – yes, <u>no</u>

1.02. Has the species become naturalised where grown? – irrelevant (only score this if you answered yes to 1.01)

1.03. Does the species have weedy races? – irrelevant (only score this if you answered yes to 1.01)

2.01. Species suited to Hungarian climates – 0-low, 1-intermediate, <u>2-high</u>

2.02. Quality of climate match data – 0-low, 1-intermediate, <u>2-high</u>

2.03. Broad climate suitability (environmental versatility) – <u>yes</u>, no

2.04. Native or naturalised in regions with extended dry periods – yes, <u>no</u>

2.05. Does the species have a history of repeated introductions outside its natural range? – <u>yes</u>, no

3.01. Naturalised beyond native range – <u>yes</u>, no

3.02. Garden/amenity/disturbance weed – yes, <u>no</u>

3.03. Weed of agriculture/horticulture/forestry – <u>yes</u>, no

3.04. Environmental weed – <u>yes</u>, no

3.05. Congeneric weed – <u>yes</u>, no

4.01. Produces spines, thorns or burrs – yes, <u>no</u>

4.02. Allelopathic – yes, <u>no</u>

4.03. Parasitic – yes, <u>no</u>
4.04. Unpalatable to grazing animals – yes, <u>no</u>
4.05. Toxic to animals – yes, <u>no</u>
4.06. Host for recognised pests and pathogens – <u>yes</u>, no
4.07. Causes allergies or is otherwise toxic to humans – yes, <u>no</u>
4.08. Creates a fire hazard in natural ecosystems – yes, <u>no</u>
4.09. Is a shade tolerant plant at some stage of its life cycle – yes, <u>no</u>
4.10. Grows on infertile soils – yes, <u>no</u>
4.11. Climbing or smothering growth habit – yes, <u>no</u>
4.12. Forms dense thickets – <u>yes</u>, no
5.01. Aquatic – <u>yes</u>, no
5.02. Grass – <u>yes</u>, no
5.03. Nitrogen fixing woody plant – yes, <u>no</u>
5.04. Geophyte – <u>yes</u>, no
6.01. Evidence of substantial reproductive failure in native habitat – yes, <u>no</u>
6.02. Produces viable seed – <u>yes</u>, no
6.03. Hybridises naturally – yes, <u>no</u>
6.04. Self-fertilisation – <u>not known</u>
6.05. Requires specialist pollinators – yes, <u>no</u>
6.06. Reproduction by vegetative propagation – <u>yes</u>, no
6.07. Minimum generative time (years) – <u>1</u>
7.01. Propagules likely to be dispersed unintentionally – <u>yes</u>, no
7.02. Propagules dispersed intentionally by people – yes, <u>no</u>
7.03. Propagules likely to disperse as contaminants of produce – <u>yes</u>, no
7.04. Propagules adapted to wind dispersal – yes, <u>no</u>
7.05. Propagules buoyant – <u>yes</u>, no
7.06. Propagules bird dispersed – <u>yes</u>, no
7.07. Propagules dispersed by other animals (externally) – yes, <u>no</u>
7.08. Propagules dispersed by other animals (internally) – <u>yes</u>, no
8.01. Prolific seed production – <u>yes</u>, no
8.02. Evidence that a persistent propagule bank is formed (>1 yr) – <u>yes</u>, no
8.03. Well controlled by herbicides – yes, <u>no</u>
8.04. Tolerates or benefits from mutilation, cultivation or fire – <u>yes</u>, no
8.05. Effective natural enemies present in Hungary – yes, <u>no</u>

Harmonia+

a01. Provide the name(s) of the assessors: András Kelemen
a02. Provide the name of the organism under assessment: Paspalum distichum
a03. Define the area under assessment: Hungary
a04. The Organism is: <u>alien to, and established within The Area's wild;</u> alien to, and present within The Area, but not established in the wild; alien to, and absent from The Area; native to the Area
Answer provided with a low, medium, <u>high</u> level of confidence.
a05. This assessment is considering potential impacts within the following domains: <u>the environmental domain</u>
a06. The probability for The Organism to be introduced into The Area's wild by natural means is: high, <u>medium</u>, low
Answer provided with a low, <u>medium</u>, high level of confidence.

a07. The probability for The Organism to be introduced into The Area's wild by unintentional human actions is: high, <u>medium</u>, low
Answer provided with a low, <u>medium</u>, high level of confidence.
a08. The probability for The Organism to be introduced into The Area's wild by intentional human actions is: high, medium, <u>low</u>
Answer provided with a low, medium, <u>high</u> level of confidence.
a09. The Area provides ... climate for establishment of The Organism. <u>optimal</u>, sub-optimal, non-optimal
Answer provided with a low, <u>medium</u>, high level of confidence.
a10. The Area provides ... habitat for establishment of The Organism. <u>optimal</u>, sub-optimal, non-optimal
Answer provided with a low, medium, <u>high</u> level of confidence.
a11. The Organism's capacity to disperse within The Area by natural means is: <u>very high</u>, high, medium, low, very low
Answer provided with a low, medium, <u>high</u> level of confidence.
a12. The Organism's frequency of dispersal within The Area by human actions is: low, <u>medium</u>, high
Answer provided with a low, <u>medium</u>, high level of confidence.
a13. The Organism has a(n) ... effect on native species, through predation, parasitism or herbivory: <u>inaplicable</u>, low, medium, high
Answer provided with a low, medium, <u>high</u> level of confidence.
a14. The Organism has a (...) effect on native species, through competition: <u>high</u>, medium, low
Answer provided with a low, medium, <u>high</u> level of confidence.
a15. The Organism has a(n) (...) effect on native species, through interbreeding: very high, high, medium, low, <u>no/very low</u>
Answer provided with a low, <u>medium</u>, high level of confidence.
a16. The Organism has a (...) effect on native species, by hosting pathogens or parasites that are harmful to them. very high, high, medium, <u>low</u>, very low
Answer provided with a low, <u>medium</u>, high level of confidence.
a17. The Organism has a (...) effect on ecosystem integrity, by affecting its abiotic properties. <u>high</u>, medium, low
Answer provided with a low, medium, <u>high</u> level of confidence.
a18. The Organism has a (...) effect on ecosystem integrity, by affecting its biotic properties. <u>high</u>, medium, low
Answer provided with a low, medium, <u>high</u> level of confidence.
a19. The Organism has a(n) (...) effect on plant targets, through herbivory or parasitism. <u>inapplicable</u>, very high, high, medium, low, very low
Answer provided with a low, medium, <u>high</u> level of confidence.
a20. The Organism has a(n) (...) effect on plant targets, through competition. inapplicable, <u>very high</u>, high, medium, low, very low
Answer provided with a low, medium, <u>high</u> level of confidence.
a21. The Organism has a(n) (...) effect on plant targets, by interbreeding with related organisms or with the target itself. inapplicable, very high, high, medium, low, <u>no/very low</u>
Answer provided with a low, <u>medium</u>, high level of confidence.

a22. The Organism has a (...) effect on plant targets, by affecting the cultivation system's integrity. very high, high, medium, low, very low
Answer provided with a low, medium, high level of confidence.
a23. The Organism has a(n) (...) effect on plant targets, by hosting pathogens or parasites that are harmful to them: inapplicable, very high, high, medium, low, very low
Answer provided with a low, medium, high level of confidence.
a24. The Organism has a(n) (...) effect on individual animal health or animal production, through predation or parasitism. inapplicable, very high, high, medium, low, very low
Answer provided with a low, medium, high level of confidence.
a25. The Organism has a (...) effect on individual animal health or animal production, by having properties that are hazardous upon contact. very high, high, medium, low, very low
Answer provided with a low, medium, high level of confidence.
a26. The Organism has a(n) (...) effect on individual animal health or animal production, by hosting pathogens or parasites that are harmful to them. inapplicable, very high, high, medium, low, very low
Answer provided with a low, medium, high level of confidence.
a27. The Organism has a(n) (...) effect on human health, through parasitism. inapplicable, very high, high, medium, low, very low
Answer provided with a low, medium, high level of confidence.
a28. The Organism has a (...) effect on human health, by having properties that are hazardous upon contact. very high, high, medium, low, very low
Answer provided with a low, medium, high level of confidence.
a29. The Organism has a(n) (...) effect on the health of human targets, by hosting pathogens or parasites that are harmful to them. inapplicable, very high, high, medium, low, very low
Answer provided with a low, medium, high level of confidence.
a30. The Organism has a (...) effect on causing damage to infrastructure. very high, high, medium, low, very low
Answer provided with a low, medium, high level of confidence.
a31. The Organism has a (…) effect on provisioning services. significantly negative, moderately negative, neutral, significantly positive, moderately positive
Answer provided with a low, medium, high level of confidence.
a32. The Organism has a (…) effect on regulation and maintenance services. significantly negative, moderately negative, neutral, significantly positive, moderately positive
Answer provided with a low, medium, high level of confidence.
a33. The Organism has a (…) effect on cultural services. significantly negative, moderately negative, neutral, significantly positive, moderately positive
Answer provided with a low, medium, high level of confidence.
a34. INTRODUCTION – Due to climate change, the risk for The Organism to overcome geographical barriers and -if applicable- subsequent barriers of captivity or cultivation will (…). decrease significantly, decrease moderately, not change, increase moderately, increase significantly
Answer provided with a low, medium, high level of confidence.
a35. ESTABLISHMENT – Due to climate change, the likelihood for The Organism to overcome survival & reproduction barriers will (…). decrease significantly, decrease moderately, not change, increase moderately, increase significantly
Answer provided with a low, medium, high level of confidence.

a36. SPREAD – Due to climate change, the risk of The Organism to overcome dispersal barriers & (new) environmental barriers within The Area will (…). decrease significantly, decrease moderately, not change, increase moderately, increase significantly
Answer provided with a low, medium, high level of confidence.
a37. IMPACTS: ENVIRONMENTAL TARGETS – Due to climate change, the consequences of The Organism on wild animals and plants, habitats and ecosystems will (…). decrease significantly, decrease moderately, not change, increase moderately, increase significantly
Answer provided with a low, medium, high level of confidence.
a38. IMPACTS: PLANT TARGETS – Due to climate change, the consequences of The Organism on cultivated plants (e.g. crops, pastures, horticultural stock) will (…). decrease significantly, decrease moderately, not change, increase moderately, increase significantly
Answer provided with a low, medium, high level of confidence.
a39. IMPACTS: ANIMAL TARGETS – Due to climate change, the consequences of The Organism on domesticated animals (e.g. production animals, companion animals) will (…). decrease significantly, decrease moderately, not change, increase moderately, increase significantly
Answer provided with a low, medium, high level of confidence.
a40. IMPACTS: HUMAN TARGETS – Due to climate change, the consequences of The Organism on humans will (…). decrease significantly, decrease moderately, not change, increase moderately, increase significantly
Answer provided with a low, medium, high level of confidence.
a41. IMPACTS: OTHER TARGETS – Due to climate change, the consequences of The Organism on targets not considered in previous modules will (…). decrease significantly, decrease moderately, not change, increase moderately, increase significantly
Answer provided with a low, medium, high level of confidence.
Comments: by decreasing the water reservoir capacity