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Short Communication

Invasion of alligator weed (*Alternanthera philoxeroides*) in Wular Lake, Kashmir, India

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Editor's note:
This special issue of *Aquatic Invasions* includes papers from the 17th International Conference on Aquatic Invasive Species held in San Diego, California, USA, on August 29 to September 2, 2010. This conference has provided a venue for the exchange of information on various aspects of aquatic invasive species since its inception in 1990. The conference continues to provide an opportunity for dialog between academia, industry and environmental regulators within North America and from abroad.

Abstract

Alligator weed *Alternanthera philoxeroides* (Mart.) Griseb (Amaranthaceae) is being reported for the first time from Kashmir, India. *Alternanthera philoxeroides* was collected in 2008 during the vegetation survey of Wular Lake, a wetland of international importance under Ramsar convention. *Alternanthera philoxeroides* is a noxious invasive weed widespread throughout the world. We suggested that all lakes and wetlands in the Kashmir valley are susceptible to this weed and its growth may assume destructive levels. The morphology and nomenclature of the species is described and illustrated.

Key words: invasive species, new report, Wular Lake, *Alternanthera philoxeroides*

Introduction

Invasive species have earned the distinction as the second greatest cause of species extinction (Drake et al. 1989). Infestations by invasive species may lead to great conservation concern (Wilcove et al. 1998). Invasive non-native species inflict harmful ecological and economic impacts upon ecosystems in non native regions (Pimentel et al. 2005; Meyerson and Mooney 2007). In U.S. alone the total annual economic damages and associated control costs due to invasive alien species have been estimated to be $138 billion (Pimentel et al. 2000). Early detection and timely exclusion are the most cost effective methods of controlling and preventing invasive species. Control measures often come into play only after the alien species has spread to nuisance proportions (Boylen et al. 2006). Early detection, control and eradication yielded a cost to benefit ratio of 17:1 (Anonymous 1993) and 34:1 (Anonymous 2000) in two different studies.

The valley of Kashmir has numerous natural lakes and wetlands, rich in biodiversity. During the past several decades, there has been continuous introduction of non-native species into the region. Of the total flora of the valley, 29% is composed of non native species of which 17% are invasive (Khuroo et al. 2007). Occurrence of alligator weed *Alternanthera philoxeroides* was recorded during the vegetation survey of Wular Lake (Figure 1). Alligator weed is known as an invasive species in many parts of the world (Julien et al. 1995) having a tremendous potential for vegetative reproduction (Julien et al. 1995; Sainty et al. 1998; Clements et al. 2011). In India, the species has been reported from Assam, Bihar, West Bengal, Tripura, Manipur, Andhra Pradesh, Karnataka, Maharashtra, Delhi and Punjab (Pramod et al. 2008).

The purpose of this paper is to note the invasion of *Alternanthera philoxeroides* in Wular Lake and to present some considerations about its potential problems and management.

Figure 1. *Alternanthera philoxeroides* forming floating islands in Wular lake (Photograph by Ather Masoodi).

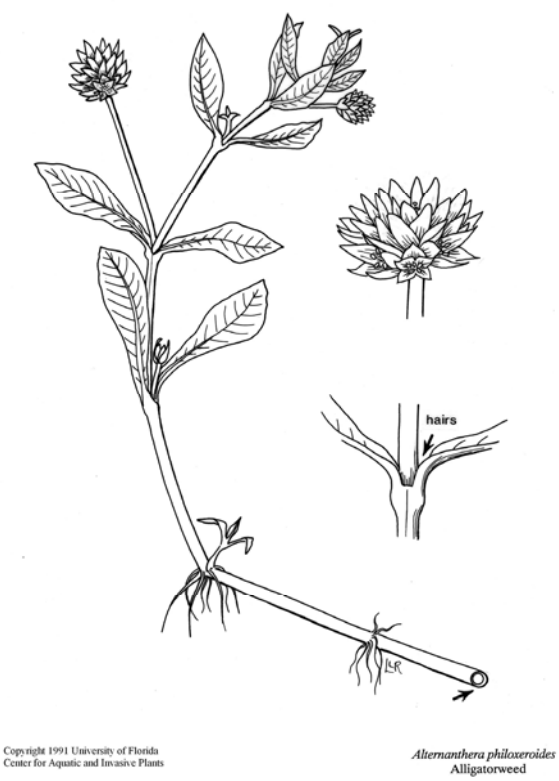

Figure 2. Stolon of *Alternanthera philoxeroides*, inflorescence and swollen internode with opposite leaf (Reproduced with permission from CAIP, university of Florida).

Results and discussion

Wular Lake, the largest freshwater lake in India, is located 34 km northwest of Srinagar at an altitude of 1580m asl. between 34°16′N and 34°25′N latitudes and 74°29′E and 74°40′E longitudes (NWA 2010). It has elliptical shape with a surface area of 112.77 km^2, maximum length 16 km and maximum width 9.6 km (NWA 2010). It is a shallow lake with a maximum depth of 5m and water temperature range from 2°C to 29.5°C during the year. The degraded direct catchment area around the entire Jhelum Basin contributes to heavy load of silt into Wular, decreasing lake width and depth. The lake provides livelihoods to a population of 10,964 households in 31 villages along the shoreline (Anonymous 2007). It also provides important habitats for migratory water birds within Central Asian Flyway. Owing to the importance of the wetland to the biodiversity and socio economic values, the Wular Lake was designated as a Wetland of International Importance under Ramsar Convention in 1990.

Alternanthera philoxeroides (Mart.) Griseb. of the family Amaranthaceae is an invasive weed originally from South America (Vogt et al. 1979) and is now widespread throughout the world (Buckingham 1996). It is a stoloniferous, perennial, mesophytic herb capable of aquatic and terrestrial growth (Figure 2). The stems are prostrate, decumbent or ascending, simple or

Figure 3. *Alternanthera philoxeroides* produces papery white flowers on stalks. (Photograph by Ather Masoodi).

Table 1. Location and size of the *Alternanthera philoxeroides* areas recorded in 2008 in Wular Lake.

Site No	Area size (m^2)	Geographic coordinates	
		Latitude, N	Longitude, E
1	6	34°21′45″	74°32′49″
2	8.5	34°22′59″	74°32′08″
3	12	34°23′07″	74°32′56″
4	4.3	34°23′48″	74°32′49″
5	7	34°23′13″	74°37′26″
6	3.5	34°23′10″	74°33′08″

branched and forming dense mats. At maturity stems are hollow and produce roots at nodes. Leaves are opposite, elliptical-oblanceolate and glabrous measuring 2.5–5.0 cm × 0.6–1.7 cm. The inflorescence consists of head with a solitary peduncle at leaf axils, globose 0.8–2.0 cm in diameter. In Kashmir, the flowering of alligator weed takes place between June-October (Figure 3). Two species of the genus have already been reported from Kashmir viz. *Alternanthera caracasana* Kunth. (Naqshi 1981) and *Alternanthera sessilis* DC. (Kaul 1986). Both species were unintentionally introduced into the region (Khuroo et. al. 2007).

During the vegetation survey of the lake in 2008, *Alternanthera philoxeroides* was observed in six areas. The locations of all areas were recorded using a Garmin Etrex GPS (Table 1). The size of these areas varied from $3.5m^2$ to $12m^2$. Of the six cases of *Alternanthera philoxeroides*, four were present in stands of *Trapa natans*. Alligator weed forms large floating islands in the lake. There are several wetlands adjacent to Wular lakes which are also very susceptible to invasion of this weed. *Alternanthera philoxeroides* forms dense mats and thereby disrupts the aquatic environment by impeding penetration of light and gaseous exchange as well as promoting sedimentation. The weed also provides habitat for mosquitoes.

Alligator weed can be controlled by three principal means; biological, chemical and mechanical. The biological control using the flea beetle *Agasicles hygrophila* has been quite successful in aquatic ecosystems of warm temperate regions (Centre for Weed Management 2003). In Australia the predicted range for alligator weed far exceeds the predicted range of the flea beetle and further biological control programs are under investigation (Julien et.al. 1995; Schooler et. al. 2006). Chemical control using 1% glyphosate for free floating alligator weed was effective, but owing to its weak translocation through roots and stems, it was not effective in terrestrial plants (Ensbey 2005). Mechanical or manual control involves local eradication of the weed at a few locations where infestations are small. In Wular lake, none of these methods to control alligator weed has been attempted as yet. Due to limited areas of *A. philoxeroides* in Wular lake, and since it forms floating islands which settle down on sediment following a decline in water level in

winter, we suggest manual control can be an effective management strategy to eradicate the weed from the lake. The weed is extremely difficult to control once established and eradication is very expensive, especially in developing countries (Sainty et al. 1998). Hundreds of fishermen harvest the fodder plants and other economically important species throughout the year for transportation to other catchment areas and within different regions of the lake. Proactive inspection and surveillance programs should be encouraged to detect the weed before it becomes established. Awareness programs should be a priority for the fishermen who are registered with the fisheries department can be quite helpful. Unfortunately, there is no aquatic weed management strategy in place for the lake despite the evident damage to the ecosystems. It is the time to develop and implement the management plan for alligator weed before it assumes nuisance proportions.

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References

Anonymous (1993) Harmful non-indigenous species in the United States. OTA F–565, Washington, D.C. U.S. Congress Office of Technology Assessment, U.S. Government Printing Office

Anonymous (2000) Economic analysis of containment programs, damages, and production losses from noxious weeds in Oregon (Available from http://www.oregon.gov/ODA/PLANT/docs/pdf/weed_body_a.pdf)

Anonymous (2007) Comprehensive Management Action Plan for Wular Lake, Kashmir. Final report. Prepared for the department of wildlife protection, government of Jammu and Kashmir by Wetlands International-South Asia. (Available from http://www.wetlands.org)

Boylen CW, Eichler LW, Bartkowski JS, Shaver SM (2006) Use of geographic information systems to monitor and predict non-native aquatic plant dispersal through north-eastern North America. *Hydrobiologia* 570: 243–248, http://dx.doi.org/10.1007/s10750-006-0187-z

Buckingham GR (1996) Biological control of alligator weed, *Alternanthera philoxeroides*, the world's first aquatic weed success story. *Castanea* 61: 232–243

Centre for Weed Management (2003) Weed Management Guide: Alligator Weed *Alternanthera philoxeroides*. (Available from http://www.weeds.gov.au/publications/guidelines/wons/pubs/a-philoxero ides.pdf)

Clements D, Dugdale TM, Hunt TD (2011) Growth of aquatic alligator weed (*Alternanthera philoxeroides*) over 5 years in south-east Australia. *Aquatic Invasions* 6: 77–82, http://dx.doi.org/10.3391/ai.2011.6.1.09

Drake JA, Mooney HA, Castri DF, Groves RH, Kruger FJ, Rejmanek M, Williamson M (eds) (1989) Biological invasions: a global perspective. John Wiley and Sons, New York, 525 pp

Ensbey R (2005) Alligator Weed (Agfact P7.6.46). New SouthWales Department of Primary Industries, Orange, NSW, Australia (Available from http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/profiles/alligator/agfact)

Julien MH (1995) *Alternanthera philoxeroides* (Mart.) Griseb. In: Groves RH, Shepherd RCH, Richardson RC (eds), The Biology of Australian Weeds. R.G. and F.J. Richardson, Frankston, pp 1–12

Julien M, Skarratt B, Maywald G (1995) Potential geographical distribution of alligator weed and its biological control by *Agasicles hygrophila*. *Journal of Aquatic Plant Management* 33: 55–60

Kaul MK (1986) Weed flora of Kashmir Valley. Scientific Publishers, Jodhpur, India, 422 pp

Khuroo AA, Irfan R, Reshi Z, Wafai BA (2007) The alien flora of Kashmir Himalayas. *Biological Invasions* 9: 269–292, http://dx.doi.org/10.1007/s10530-006-9032-6

Meyerson LA, Mooney HA (2007) Invasive alien species in an era of globalization. *Frontiers in Ecology and Environment* 5(4): 199–208, http://dx.doi.org/10.1890/1540-9295(2007)5[199:IASIAE]2.0.CO;2

Naqshi AR (1981) *Alternanthera caracasana* Kunth. (Amaranthaceae) from Indian subcontinent. *Journal of Economic and Taxonomic Botany* 2: 249–250

NWA (2010) National Wetland Atlas: Jammu and Kashmir, SAC/RESA/AFEG/NWIA/ATLAS/16/2010, Space Applications Centre, ISRO, Ahmedabad, India, 176 pp

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

Pimentel D, Lach L, Zuniga R, Morrison D (2000) Environmental and economic costs of nonindigenous species in the United States. *BioScience* 50(1): 53–65, http://dx.doi.org/10.1641/0006-3568(2000)050[0053:EAECON]2.3.CO;2

Pramod K, Sanjay M, Satya N (2008) *Alternanthera philoxeroides* (Mart.) Griseb.-An addition to Uttar Pradesh. *Journal of Indian Botanical Society* 87(3/4): 285–286

Sainty G, McCorkelle G, Julien MH (1998) Control and spread of alligator weed, *Alternanthera philoxeroides*, in Australia: lessons for other regions. *Wetlands Ecology and Management* 5: 195–201, http://dx.doi.org/10.1023/A:1008248921849

Schooler SS, Clech-Goods C, Julien MH (2006) Ecological studies to assess the efficacy of biological control on alligator weed and lippia populations. *Australian Journal of Entomology* 45:272–275, http://dx.doi.org/10.1111/j.1440-6055.2006.00 550.x

Vogt GB, McGuire Jr. JU, Cushman AD (1979) Probable evolution and morphological variation in South American Disonychine flea beetles (Coleoptera: Chrysomelidae) and their Amaranthaceous host. USDA Technical Bulletin No. 1593, 148 pp

Wilcove DS, Rothstein D, Dubow J, Phillips A, Losos E (1998) Quantifying threats to imperiled species in the United States. *BioScience* 48: 607–615, http://dx.doi.org/10.2307/1313420