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Occurrence of Kariba weed on selected water bodies in Uganda

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Abstract. Kariba weed (*Salvinia molesta* D.S. Mitch.) is a floating aquatic fern that has devastated aquatic production systems worldwide. The objective of this study was to establish the status of occurrence and infestations levels of the weed on the water bodies in Uganda. The study was conducted on purposefully selected water bodies in Uganda, over a period of 2018 to 2022. Kariba weed occurred at varying infestation levels on all water bodies in the country, except on Lake Bisina. The highest number of daughter plants (732 plants per 0.25 m^2 quadrant) was registered at Kajjansi, along Lake Victoria. The main impacts of the weed on the water bodies were obstruction of fishing and water transport; and reduced water quality. Given that Kariba weed is dispersed by water currents and vegetatively spread by boats and fishing gears, a catasptrophe in terms of dysfunction of the productivity of the country's water resources is eminent. Biological control of Kariba weed using *Cyrtobagous salviniae* weevils is recommended to sustainably manage this devastating water weed.

Key words: *Cyrtobagous salviniae*, infestation level, Lake Victoria, *Salvinia molesta*

Introduction

Kariba weed (*Salvinia molesta* D.S. Mitch.) is an invasive aquatic fern, native to South America which is rapidly spreading in water bodies of the world (Room *et al*., 1981; Cilliers *et al*., 2003). The wide geographical distribution of Kariba weed, just like other invasive species, is believed to have resulted from accidental or unintentional human actions as a result of rapid growth in global trade, travel and transport (Masters and Norgrove, 2010). Kariba weed dispersal is facilitated by water flow or wind currents; while spread to other water bodies is majorly through viable fragments that attach to boats, fishing gear and the feet of water birds (Coetzee and Hill, 2020).

Currently, the weed has been reported in over 50 countries worldwide (Chapman *et al*., 2017), including Uganda where it was first reported in 2013 as small plantlets in the bays of Lake Kyoga (Wanda *et al*., 2016; Andama *et al*., 2017). Outside its natural range, Kariba weed is one of the world's worst aquatic weeds listed among the most aggressive 100 invasive alien species (Thomas and Room, 1986; Luque *et al*., 2014).

Kariba weed is a free-floating fern capable of rapid proliferation, thereby doubling its biomass and area coverage in 3 to 10 days, to produce thick mats over water surfaces (Mitchell and Tur, 1975; Oliver, 1993). The weed is known to cause enormous socio-ecological impacts, economic losses and

decrease in density and diversity of aquatic species (Julien *et al*., 2002). In Uganda, Kariba weed has caused great disruptions to the productivity of the country's water resources, resulting into annual fish revenue loss of an estimated 20.4 million Uganda shillings (equivalent to US$5,649.1) per fisherman, water transport interferences and reduced quality of water for both domestic and livestock use (Wanda *et al*., 2020).

A survey in 2017 revealed that Kariba weed had covered about 13,688 ha of Lakes Kyoga and Kwania (Wanda *et al*., 2020). Since then, the weed reportedly infested different water bodies, including Lake Victoria, a regional treasure that is one of the world's large tropical fresh water lake, which supports the largest fresh water fishery globally (Kayombo and Jorgensen, 2006).

Although the first invasion of the weed dates to 12 years back, the occurrence and distribution of Kariba weed in Uganda are not fully understood. The objective of this study was to establish the status of Kariba weed occurrence and levels of infestations on water bodies in Uganda.

Materials and methods

A survey was carried out during November 2018 to June, 2022 on various sites along Lakes, rivers, dams and associated wetlands in Uganda. At each site where Kariba weed was present, the area under weed infestation was determined according to Wanda *et al*. (2020). Additionally, weed infestation severity at each site was scored on a scale of 1-5; where the numerical figures denote:

1 = Kariba weed absence;
2 = Kariba weed cover (up to 25% of the water surface covered by Kariba weed) is negligible;
3 = Kariba weed cover (25 to 50% of the water surface covered by Kariba weed) is moderate;
4 = High Kariba weed cover (50 to 75% of the water surface covered by Kariba weed); and
5 = Severe Kariba weed cover (75 to 100% of the water surface covered by Kariba weed).

To determine Kariba weed infestation level at each site, a wooden 0.25 m^2 quadrant was dropped randomly at four points over the weed mat. The total number of plants (mature plants) and daughter plants (young plants) within the enclosed mat were counted and recorded separately per quadrant. The distance between quadrants depended upon the area under Kariba weed infestation; with greater distances left between the quadrants at sites with large Kariba weed area infestation. Every site was geo-referenced, using a handheld GPS (Garmin eTrex–10) to locate the coordinates.

Data analysis

A weed baseline inventory and spatial distribution map for Kariba weed was produced using the ArcGIS software (Version 9.1) (Parra-Quijano *et al*., 2012). All data were subjected to analysis of variance using the R statistical software (v4.1.2; R Core Team, 2021). All data were tested for normality and where skewness occurred, data were subjected to the Box Cox procedure (Venables and Ripley, 2002) in order to determine the most appropriate transformation based on the lambda value. Means were separated using the Least Significant Difference (LSD) test at 5% probability level.

The data were then subjected to a nested model ANOVA (Bates *et al*., 2015) for water body and site effects on the total number of plants and number of young weed plants (herein referred to as daughter plants) per 0.25 m^2. Sites were nested within water body and means were separated using the Least Significant Difference (LSD) test at 5% probability level.

Results

Occurrence of Kariba weed

Apart from Lake Bisina, where no Kariba weed was recorded, all the water bodies surveyed exhibited different levels of Kariba weed infestation (Fig. 1). Weed infestation was low to moderate on Lakes Albert and Victoria, and was severe on Lake Nakuwa and Kibimba dam (Plate 1). Kariba weed infestation was over 75% on Lake Nakuwa and Kibimba dam, where heavy weed mats were observed. There was nearly total loss of productivity as a result of a decline in fish catches, obstructed water transport and reduced water quality.

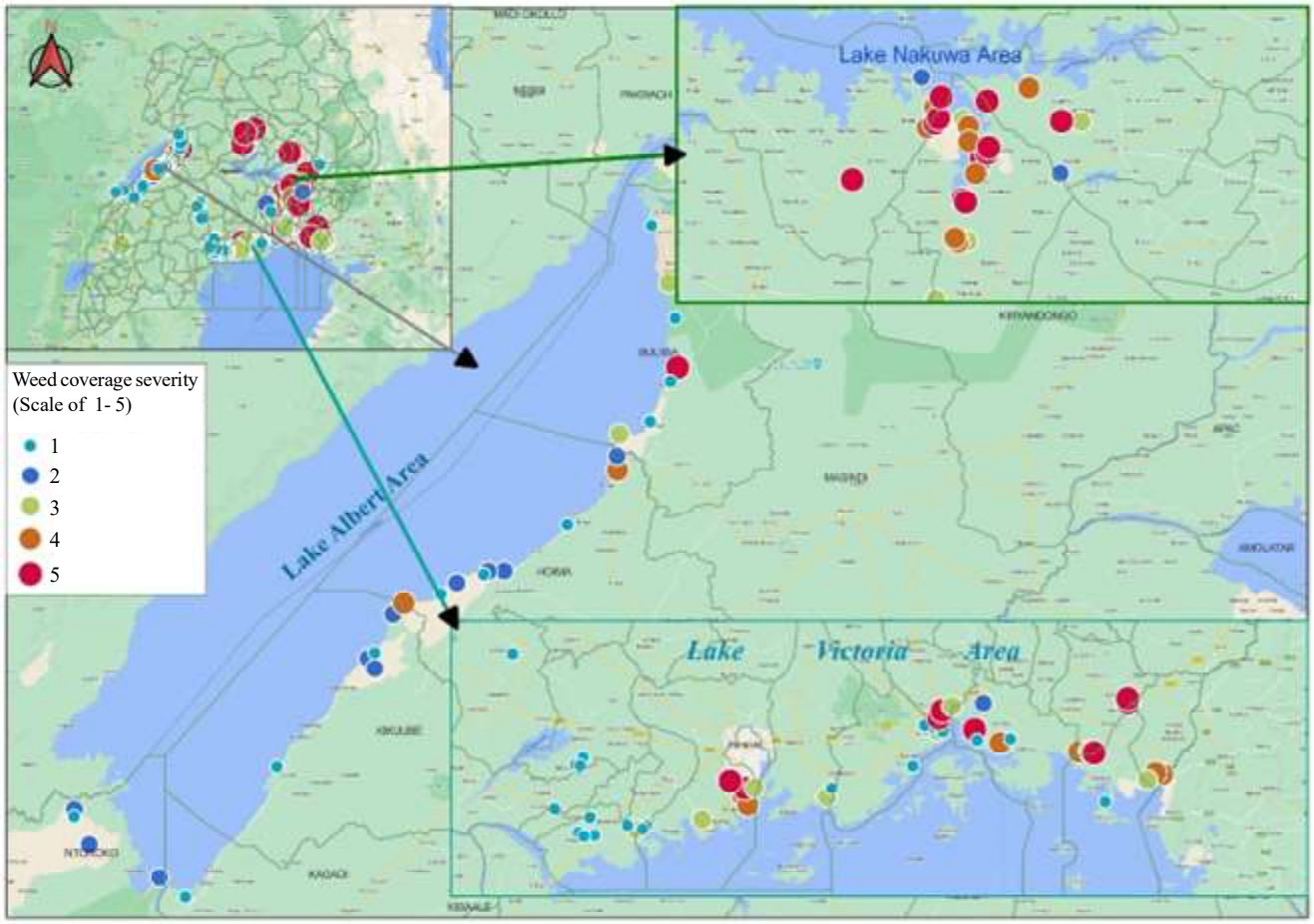

Figure 1. Kariba weed infestation levels and distribution on selected water bodies and associated wetlands in Uganda.

Infestation of Kariba weed

From the ANOVA results, the main factor (water body) and the nested factor (site) had significant effects ($p < 0.001$) on the number of Kariba weed plants per 0.25 m^2 quadrant. The highest number of total and daughter Kariba weed plants was observed at Kajjansi site (732 plants) along Lake Victoria; followed by Rwentale landing site (434 plants) along Lake Albert (Figs. 2-4). Across all water bodies, varying Kariba weed infestation levels were recorded on the different sites, with some registering no Kariba weed infestations (Figs. 2-4).

Plate 1. Kariba weed water surface infestation of selected water bodies in Uganda.

Discussion

Occurrence of Kariba weed

Kariba weed occurred in varying intensities across the water bodies that were involved in the study (Fig. 1). Although no Kariba weed infestation was observed on Lake Bisina, it is a matter of time before the entire water surfaces will be covered up by the weed. This is because the of fast vegetative multiplication rate of the weed, which is enhanced by high water temperatures and nutrient content (Room and Thomas, 1986; Oliver, 1993). Additionally, the fact that Kariba weed is dispersed for long distances within a waterbody by water currents and between waterbodies by animals and contaminated equipment (such as boats and fishing gear) (Julien *et al.*, 2009; Coetzee and Hill, 2020), unprecedented spread within these water bodies and the entire water body system of Uganda is predictable.

Infestation of Kariba weed

Over Lakes Victoria, Albert, Nakuwa and Kibimba dam where moderate to heavy weed infestations were observed (Figs. 2 - 4), the riparian communities reported severe negative impacts of weed invasion. This observation is in agreement with the findings of several other researchers (Julien *et al.*, 2009*;* Wanda *et al*., 2020; Coetzee and Hill 2020). These impacts raise the urgent need to effectively control this weed in order to safe-guard the country's water resources.

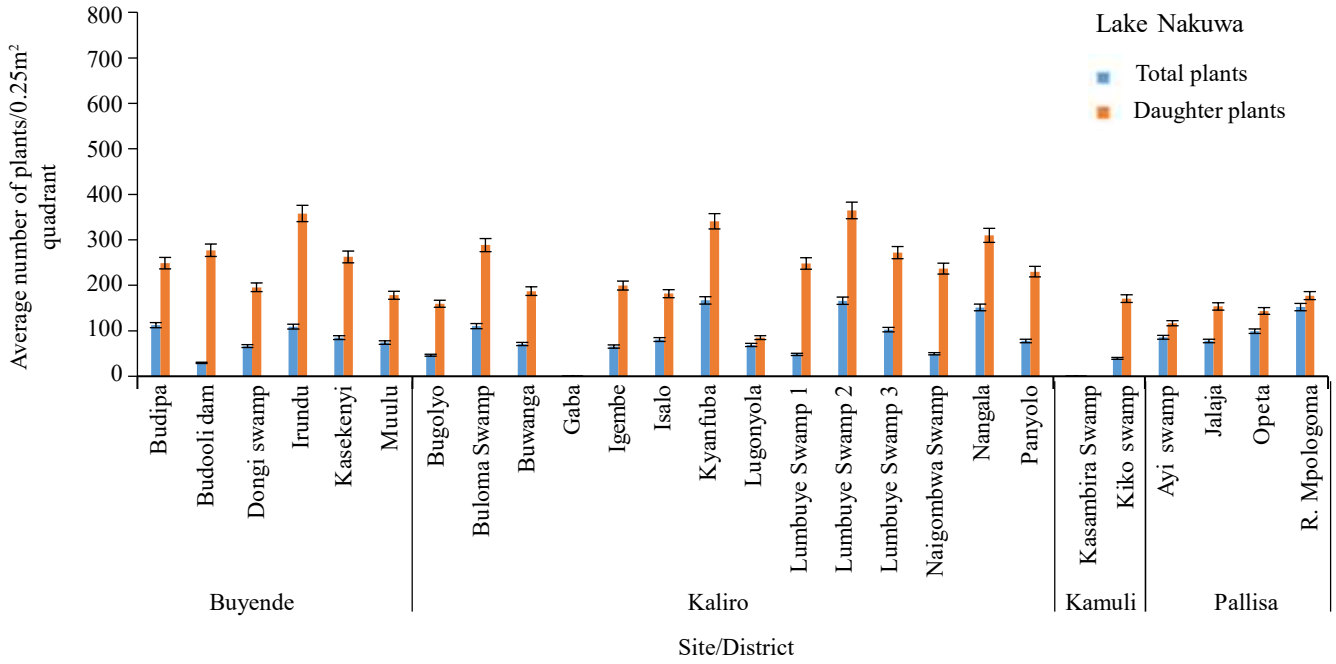

Figure 2. Number of Kariba weed plants per quadrant at 26 sites in various districts around Lake Nakuwa.

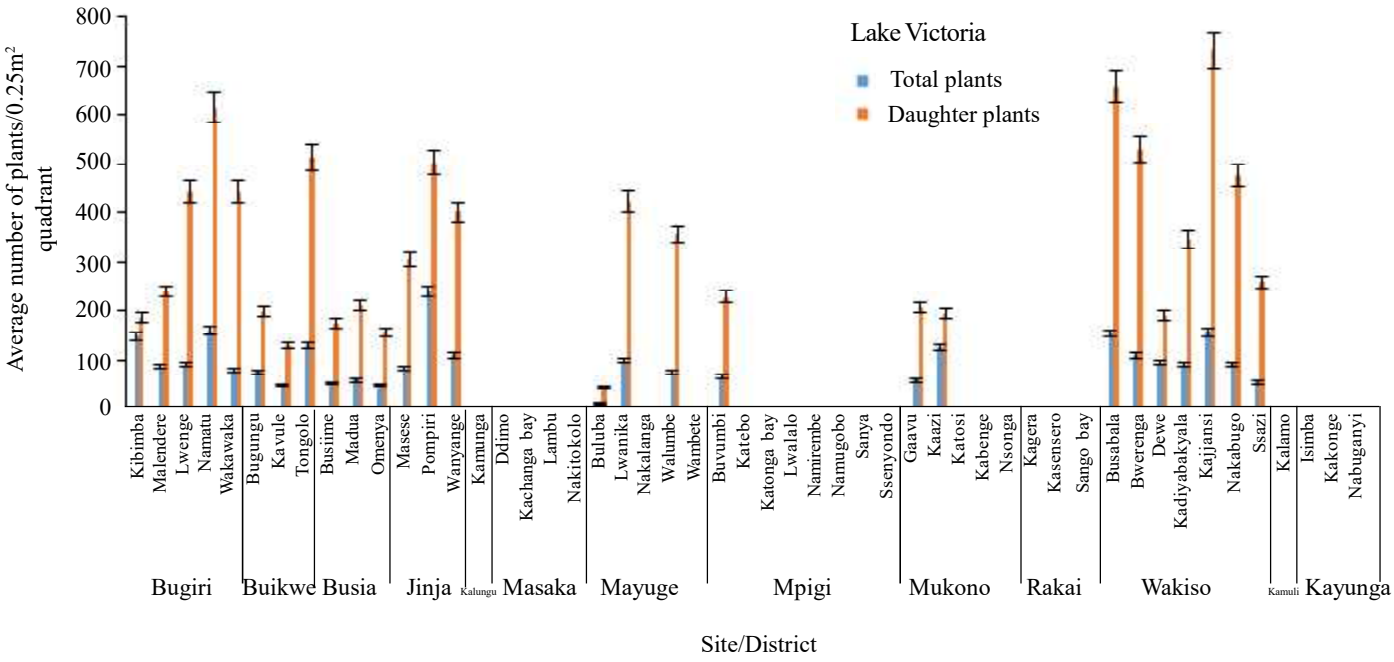

Figure 3. Number of Kariba weed plants per quadrant at 51 sites in various districts around Lake Victoria.

Conclusion

This study highlights the prevalence of Kariba weed across various water bodies in Uganda. The assessment has confirmed varying infestation intensities, with heavy concentrations observed in Lake Nakuwa and Kibimba dam; and the lightest occurrence and infestation on Lake Albert. Given the weed's invasive nature and spread mechanisms, urgent management strategies for this devastating floating fern are needed to avert its growing negative impacts on Uganda's aquatic ecosystems.

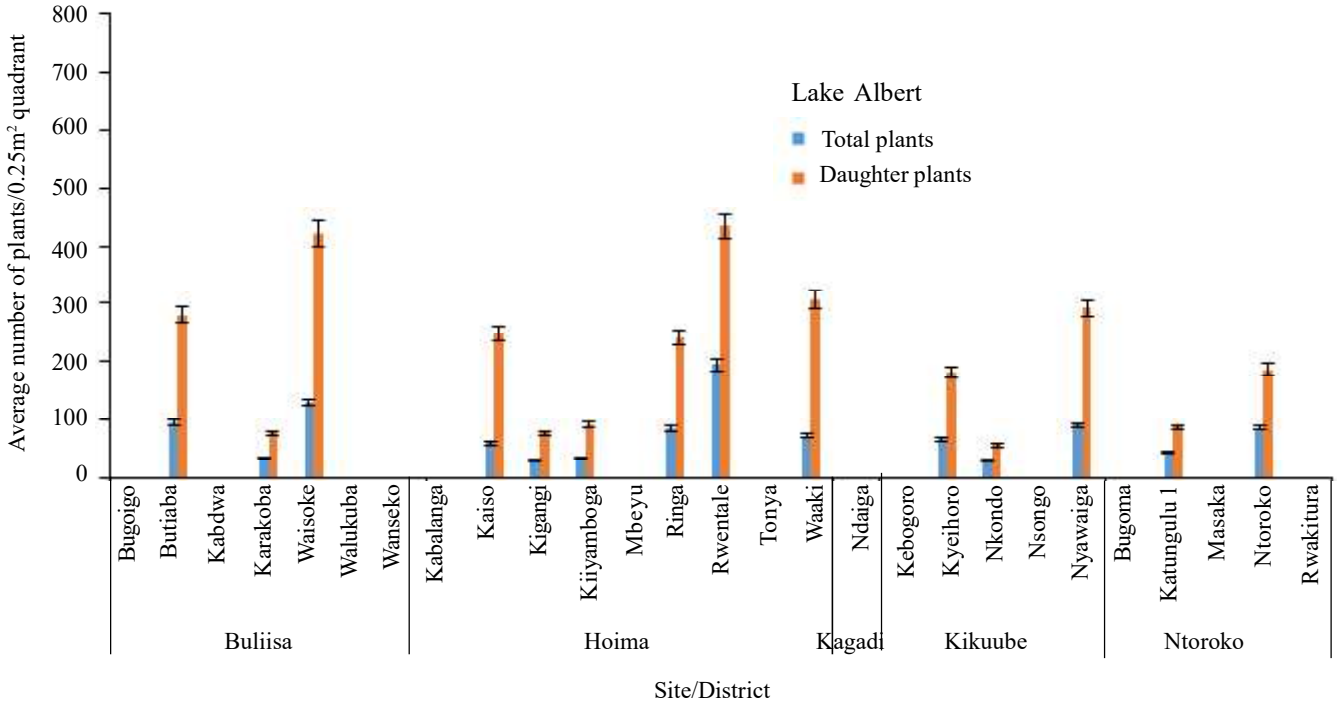

Figure 4. Number of Kariba weed plants per quadrant at 27 sites in various districts around Lake Albert.

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