Control of water hyacinth (*Eichhornia crassipes*) in Rwanda: a survey of local residents' perceptions

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Summary Community support and participation is an important factor to achieving successful results in weed management. This study sought to gain an insight into local residents' perceptions of control of water hyacinth using a face-to-face survey. The results showed that biological control was poorly understood by local residents and was perceived as ineffective by those who did have some understanding. Mechanical removal was clearly perceived to be the most efficient method among those used to control water hyacinth in both Mukungwa floodplain and Bulera Lake basin, though the effect was only short-lived. It is recommended that, in the absence of sustained foreign support, biological control of water hyacinth be reviewed in Rwanda and, perhaps, other least developed countries because in these areas there is lack of sufficient funds for a consistent application and the approach is currently poorly understood by the local population in Rwanda.

Keywords Legal ban, mechanical removal, biological control, aquatic weed.

INTRODUCTION

Water hyacinth (*Eichhornia crassipes* (Mart.) Solms) is one of world's worst aquatic weeds (Villamagna and Murphy 2010). Native to the Amazon basin of South America, water hyacinth has spread globally as an ornamental crop since 1800s and became naturalised in most tropical African countries (Hill *et al.* 2011). In eastern Africa, self-established populations of water hyacinth were first recorded in Egypt towards the end of 19th century (Batanouny and El-Fiky 1975). Half a century later, it was recorded in Sudan (Gay and Berry 1959) and Belgian Congo (now Democratic Republic of Congo) (Evans 1963), which prompted colonial policy makers to ban its cultivation in Rwanda as well [Order No. 51/162 of 4/5/1955]. Unfortunately, this step did not successfully hinder its spread, maybe because, by the time the order was enacted, it had already escaped from cultivation. It was officially reported to have established a self-sustaining population in Mukungwa valley in 1987 (Gashamura 2009), but may have been there since early 1980s or before. During the 1970s, it was still a component of the flora of garden and duck ponds within residential compounds of the European expatriates at ETIRU (Etablissement Industriel du Rwanda) wheat processing plant, Mukungwa hydropower station and SOPYRWA (Société de Pyrèthre au Rwanda) lime factory (V. Uwizeyimana, pers. comm. 2013).

Besides the legal approach, the literature does not mention any other form of water hyacinth control in Rwanda at any time before 1990s, until a Food Agriculture Organization-funded project evaluated its infestation levels and formulated recommendations for both short- and long-term strategies (Labrada and Fornasari 2002). Biological control was attempted during the early 2000s by introducing two species of weevils (*Neochetina eichhorniae* Warner and *Neochetina brunchi* Hustache, Coleoptera: Curculionidae) (Moorhouse *et al.* 2001). However, it is the 2008 and 2010 mechanical removal campaigns that considerably (though temporarily) reduced water hyacinth impact in both Lake Bulera and Mukungwa Valley (J.P. Ndagijimana, pers. comm. 2013). The aim of this study is to gain an insight into local residents' perceptions of control of water hyacinth using a face-to-face survey. The results of this study are discussed in relation to the impact of control methods.

MATERIALS AND METHODS

The study was conducted in Rwanda, between 1°03'–2°50' south latitude and 28°52'–30°54' east longitude, with a special focus on districts that encompass Mukungwa Valley and Bulera Lake. However, its findings are expected to have trans−boundary implications. Because Rwanda is hydrographically connected to countries located downstream, infestations in Bulera Lake and Mukungwa Valley may easily spread to Burundi, Tanzania, Uganda, Kenya, Sudan, Ethiopia and Egypt (Table 1 and Figure 1).

Interviews were conducted with haphazardly selected literate respondents present at the time of interviews in the Mukungwa Valley and Bulera Lake surrounding areas. Data was gathered from potential informants who agreed to participate. They were asked to indicate what they know about water hyacinth infestations and give their rating of the strategies used to keep it under control. In total, 941 respondents (559 in Mukungwa Valley and 382 in Bulera Lake surrounding areas (Figure 2)) were interviewed. Because the information collected was limited to respondents' opinion, only verbal consent was sought and obtained. Personal data such as informant name, address, life experience or profession was not recorded.

The data was analysed by simple scree plotting and table constructs using Microsoft word and Excel applications. Using Origin software, a Paired Sample Wilcoxon Signed Rank Test was used to analyse the differences between residents' perceptions in relation to weed control strategies.

RESULTS

Paired Sample Wilcoxon Signed Rank Test results indicate that, at $\alpha = 0.05$ and all control strategies combined, local residents' perceptions about water hyacinth control strategies did not differ significantly between sites (Table 2). However a clear difference existed between the two sites regarding biological control. Biological control was perceived as the least efficient method among those so far used in Mukungwa valley and almost totally unknown to Bulera Lake Basin respondents (Table 2).

Legal instrument and reduction of nutrient load were found to be unknown by all interviewees in both study sites (Table 2).

Table 1. Lake Victoria catchment area, population density and water hyacinth cover per member country.

Country	Catchment area (%)	Population density (km^{-2})	Weed cover (ha)
Burundi	7	285	200
Rwanda	11	323	800
Uganda	16	180	4000
Kenya	22	257	6000
Tanzania	44	66	2000

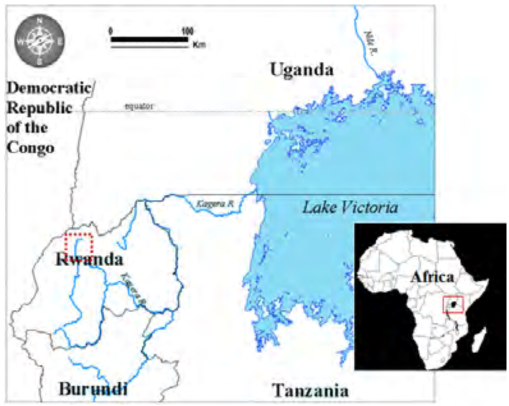

Figure 1. Hydrographic connection between the study area (inside the red-dashed rectangle, left side) and Lake Victoria (right side).

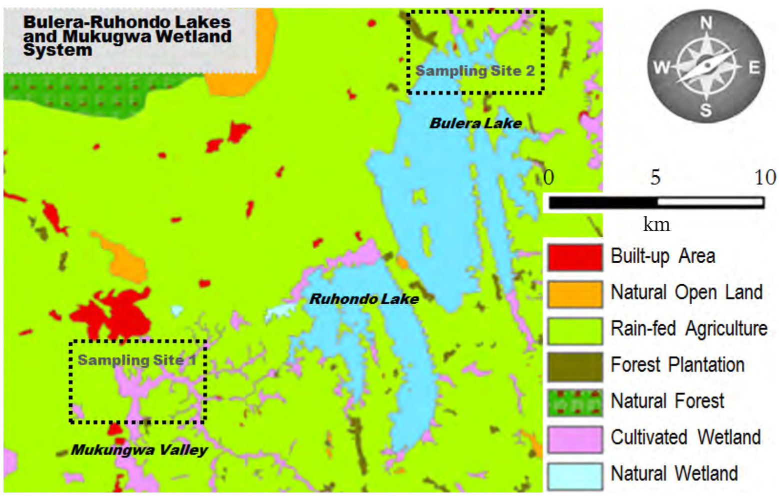

Figure 2. Location of sampling sites (areas inside the black-dashed rectangles).

Mechanical removal was clearly perceived to be the most efficient method among those used to control the water hyacinth in both Mukungwa floodplain and Bulera Lake basin.

Although the majority of respondents were aware that some natural enemies of water hyacinth were released into the area as part of strategies aimed to control the spread of this weed, no one was able to accurately describe the weevils. Those who attempted to do so described

Table 2. Informants' perception of water hyacinth control approaches in Bulera Lake and Mukungwa River basins.

	Efficient (%)		Not efficient (%)		Do not know (%)	
Control approach	BLB[a]	MRB	BLB	MRB	BLB	MRB
Legal ban	0	0	0	0	100	100
Mechanical removal	86.5	90.1	2.4	3.75	7.3	6.15
Biological control	0	0	1.1	95.2	95.3	4.8
Reduction by utilisation	14.1	11.6	59.8	72.7	15.2	15.7
Control by reduction of nutrient load	0	0	0	0	100	100
Statistics (Wilcoxon S. R. Test)	$W = 1, z = 0,$ $P > \|W\| = 0.81$		$W = 0, z = -1.33,$ $P > \|W\| = 0.25$		$W = 5, z = 0.8,$ $P > \|W\| = 0.50$	

[a] BLB = Bulera Lake Basin. MRB = Mukungwa River Basin. P = probability.

or showed a species of crayfish, *Procambarus clarkii*[A] (Figure 3). They even seemed to be unaware that two different species of weevils were released into the valley.

Figure 3. 'Maguru-kotoni' crayfish (*Procambarus clarkii* Girard) falsely considered by local communities as one of the weevil species that were introduced in Mukungwa Valley as a natural enemy of water hyacinth.

[A] Unlike in Kenya where the introduction of *P. clarkii* was meant for animal protein production (Harper and Mavuti 2004), a fraction of respondents believed it was intentionally introduced in Rwanda to biologically control water hyacinth, which according to some of them, was introduced in the study area to improve fish production through enhancement of algae and plankton growth. However, Smart *et al.* (2002) noted that this species does not significantly feed on water hyacinth (Sharshar and Haroom 2009).

DISCUSSION

Local residents' perceptions in relation to biological control of water hyacinth around Mukungwa valley and Bulera Lake align well with evidence from the field (Figure 4) and with findings of other studies, including Ogwang and Molo (2004) who concluded that attempts to biologically keep this plant under control in Lake Victoria has resulted in partial, but not complete, success.

The fact that many local residents are either unaware of biological control or sceptical about effectiveness of biological control of water hyacinth reflects the ambiguity that surrounds the introduction of the weevils in the study area. For instance, the project was short-lived to an extent that the weevil-rearing and research station was no longer operational, only 12 years after the first inoculations.

Figure 4. Full recovery of water hyacinth, only three years after a large-scale removal campaign and 12 years after inoculation of the weevils.

For projects with such long-term impact, a rearing, release and monitoring program should be established. Involvement of the local community in this process is likely to lead to increased chances of agent establishment and distribution and long term persistence (Darby and McLaren 1993, Briese and McLaren 1997). The need to engage local communities also applies to the legal instrument and reduction of nutrient load which were found to be completely unknown by all interviewees.

ISAR (2002) suggests that the overall low impact of biological control of water hyacinth in Rwanda may be attributed to the insufficient amount of weevils released into the ecosystems. Noting that full impacts may take in excess of 20 years to occur, there is a room to remain optimistic for another 5–10 years in order to be able to confirm whether the current partial success was due to the low numbers of weevils deployed or was a sign of inefficacy of the weevils (McFadyen 1998).

It is recommended to policy makers in Rwanda and, perhaps, in other least developed countries that, in the absence of a sustained foreign support, projects of biological control of water hyacinth be reviewed because in these areas there is lack of sufficient funds for a consistent application (independent from the inherent financial instability and technological constraints associated with being a poor country) and the approach is currently poorly understood by the ordinary citizens.

Although it was perceived as most effective, perhaps because the outcome was more obvious to the layman's eye and was quick to achieve (Navarro and Phiri 2000), the impact of mechanical removal was only short-lived because of high growth rates, poor accessibility of areas and high capacity of regeneration as the few propagules that are not removed can quickly restore a viable population. To yield better results, large-scale campaigns should be repeated at least every two years. Unfortunately, mechanical removal is expensive and such regular campaigns are difficult to sustain in a poor country.

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