Progress with Biological Control of Water Hyacinth in Malawi

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Abstract

Water hyacinth appeared in southern Malawi during the late 1960s, and spread slowly northwards in the Lower Shire River, but in 1995 it was found in the Upper Shire River, just south of Lake Malawi. It is now present in most parts of the Shire River, and in a number of other locations, including the far north of the country. Biological control was initiated in 1995 under a UK Department for International Development-funded project, and is now being continued through a World Bank-funded project. About 200,000 *Neochetina* have been reared and released, mainly in the Shire River, but recently at other sites outside the Shire. The beetles are well established in the Shire, though establishment and subsequent population build-up has been faster in the Lower Shire than the Upper and Middle Shire. Water hyacinth infestation in the Shire River is now less than it was two years ago, but it is too early to conclude that this is the result of the biological control campaign. As new infestations appear elsewhere in the country, biological control agents will be released to limit build-up of the weed.

FISHERMEN in the southern tip of Malawi report that water hyacinth first appeared there in the Shire River in the 1960s, and suggest that it may have arrived from across the border during floods (Harley 1991; Chimatiro and Mwale 1998), a reasonable hypothesis given that it had been present in Zimbabwe and the Zambezi River for many years before its discovery in Malawi. It subsequently spread slowly northwards, and by 1980 was present at the southern end of Elephant Marsh (Blackmore et al. 1988) (near Makhanga; see Figure 1). By 1991 it had reached the northern end of Elephant Marsh, south of a Chikwawa (Terry 1991). In 1995 it was discovered in the Upper Shire River north of Mangochi, although surveys indicated it was not present between Lake Malombe and Chikwawa at that time (Hill et al. 1999), suggesting that it had been accidentally introduced to the Upper Shire.

The Shire River can be divided into four sections (Table 1), but only the Murchison Rapids section is unsuitable for the weed. As well as occurring throughout the Shire, water hyacinth is now present at a number of locations across the length of Malawi, including Blantyre, Lilongwe River, Salima, Nkhotakota, south of Nkhata Bay, and north of Karonga. There are unconfirmed reports from other locations, including the Songwe River along the northern border with Tanzania, so the weed is clearly now widely distributed. However, in most places outside the Shire River infestations are generally relatively small.

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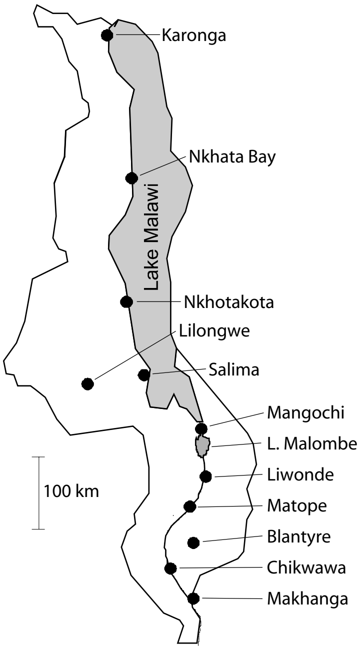

Figure 1. Map of Malawi showing places referred to in the text

A project was commenced in late 1995, funded by the UK Department for International Development (DFID), which focused on the Shire River. The project had four components: biological control, public awareness and community participation, socioeconomic evaluation of the problem, and assessment of the weed's environmental impact, and these were described at a workshop in Harare, Zimbabwe in 1998 (Hill et al. 1999). The project ran for a little over three years, after which there was a hiatus of nearly a year before a new project started, funded by the World Bank. The new project again has several components, but biological control remains the main thrust in the strategy for long-term control. In this paper we provide an update on progress with the biological control of water hyacinth in Malawi.

Methods

Rearing and release of biological control agents

Rearing tanks for *Neochetina* spp. were established at Fisheries Department facilities at Makhanga and rearing was started using *N. bruchi* and *N. eichhorniae* hand-carried from Zimbabwe in September 1996. Part of the initial importation was used to make small-scale releases. Tanks were set up at Mangochi in May 1997 using insects from the first harvest at Makhanga. Initially, both units had 10 tanks, but later 5 were added at Makhanga, and 10 at Mangochi, though the tanks at Mangochi have not been used for *Neochetina* rearing continuously.

Methods used were adapted from those used in South Africa. Rearing tanks were cylindrical, with a diameter of 265 cm and height of 67.5 cm, and so contained approximately 3000 litres of water. Each tank was placed on a concrete plinth, with drainage channels between tanks leading to a soakaway. Water levels were checked daily and topped up as required. Once a fortnight the water was replaced using water pumped from the river. At replacement 500 g of urea and 250 g fertiliser (NPK: 6-18-6 or other as available) were added to each tank. Dead leaves and plants were removed as necessary. Harvesting was undertaken about once a month, and harvested beetles were counted by species and sex then released.

Table 1. Sections of the Shire River (adapted from Crossley 1980, quoted Blackmore et al. 1988)

Section	Between	Gradient mm/km	Features
Upper Shire	Lake Malawi and Lake Malombe	~100	Fisheries
Middle Shire	Lake Malombe and Liwonde	16	Liwonde National Park
	Liwonde and Matope	96	Barrage at Liwonde
Murchison Rapids	Matope and Chikwawa	~5000	Hydroelectric power stations
Lower Shire	Chikwawa and southern border	250	Sucoma sugar plantation Elephant and Ndinde marshes (major fisheries)

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Eccritotarsus catarinensis and *Niphograpta albiguttalis* were imported in May 1997, May 1998, January 1999 and April 2000, hand-carried from South Africa. Initially, imported insects were released, but subsequently a part of each importation was released and part used to set up cultures in tanks at Mangochi.

The mite *Orthogalumna terebrantis* was already present on the weed in the Lower Shire, having accompanied the weed from the Zambezi where it was released in Zambia in the 1970s (Julien and Griffiths 1998). It was redistributed onto water hyacinth in the Upper Shire during 1996 and 1997 and is now well established on the weed throughout its range in the Shire River. Mite-infested leaves are being redistributed on new infestations of the weed as they are discovered.

Monitoring

Currently there are 14 sites at which the impact of biological control is being monitored, 3 in the Upper Shire, 3 in the Middle Shire, 5 in the Lower Shire, 2 on Lake Malawi, and 1 in Blantyre. Monitoring is undertaken once every 2 months, and on each occasion 30 mature plants are selected at random and the parameters listed in Table 2 recorded for each plant.

Results and Discussion

Rearing

Figure 2 plots the *Neochetina* harvested at the two rearing units. By mid 2000 the Makhanga unit had produced over 100,000 and the Mangochi unit about 90,000. Initial harvests at Makhanga were high as the tanks had been running for 8 months before harvesting commenced, so populations had reached high levels. During 1999, production was intermittent as the DFID project had ended and the new project had not yet started.

Table 4 shows that, at both units, there has been a slight excess of females in both species. At Makhanga, where the climate is hotter, slightly more *N. bruchi* have been produced than *N. eichhorniae*, while at Mangochi, almost two-thirds of production has been of *N. eichhorniae*. Rearing of both *Eccritotarsus* and *Niphograpta* has been unsuccessful: after 1–2 generations the populations in the rearing tanks have died out for reasons that are not clear.

Releases

The first releases of *Neochetina* were made in September 1996, from the first importation. The first

Table 2. Parameters recorded during impact monitoring

Parameter	Description
Longest leaf	The length of the longest petiole plus lamina on the plant
Root length	The maximum length of the root system
Lamina length for leaf 2	Leaf 2 is the second youngest/2nd most recently opened leaf.
Lamina width for leaf 2	At widest part of lamina
No. of leaves	Includes sick leaves but not leaves on any daughter plants
No. of ramets	The number of daughter plants attached to the sampled plant
No. of beetles	The numbers of adult weevils of the two species released
Leaf 2 scars	The number of weevil feeding scars on leaf 2
Leaf 2 mites	The mite damage score, using the system in Table 3
Leaf 2 pathogens	Damage caused by pathogens on leaf 2, using the same scale as for mite damage (Table 3)
Leaf 4 mites, pathogens	As for Leaf 2
Leaf 5 mites, pathogens	As for Leaf 2
Other agents	Presence/absence of *Eccritotarsus* and *Niphograpta*

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releases of insects reared in Malawi were made in May 1997, and continued regularly until early 1999. Harvesting and thus releases during 1999 were intermittent, but with the start of the new project in late 1999, harvesting and releases have again continued regularly. Including the first releases, by mid 2000 over 190,000 weevils had been released. Figure 3 shows the proportion of insects released in different areas. Within an area a number of different release sites have been used.

Table 3. Mite and pathogen damage scores

Score	% of leaf occupied/damaged
0	0%
1	<5%
2	6–25%
3	26–50%
4	51–75%
5	75–100%

The rationale for the pattern of releases between the different areas is as follows:

- More releases have been made in the Upper Shire River as it was expected that populations would be carried downstream to the Middle and Lower Shire.
- During 1999, the time between the two projects, all of the weevils rearing at the Mangochi site were released in the Upper Shire.
- Establishment and build-up of populations in the Lower Shire have been faster than in the Upper and Middle Shire, requiring fewer releases.
- The first project focused on the Shire River. Since the start of the current project, releases have been made in Salima, Nkhotakota, and Chiwembe dam, Blantyre. The last site is only about 4 ha, but has large healthy plants due to pollution of the inflow (Limbe River).

Further releases are being made in the Middle Shire where establishment has been slow. No further releases are required elsewhere unless sites are discovered where the beetles are absent.

To date a little over 5000 *Eccritotarsus* have been released at sites in the Upper, Middle and Lower Shire and at Blantyre. About 800 *Niphograpta* have been released in the Upper and Middle Shire.

Table 4. Percentage of *Neochetina* spp. production by sex and species at the two rearing units

Unit	*N. bruchi*			*N. eichhorniae*		
	Male	Female	Total	Male	Female	Total
Makhanga	46.9	53.1	53.7	47.7	52.3	46.3
Mangochi	45.8	54.2	36.3	47.6	52.4	63.7

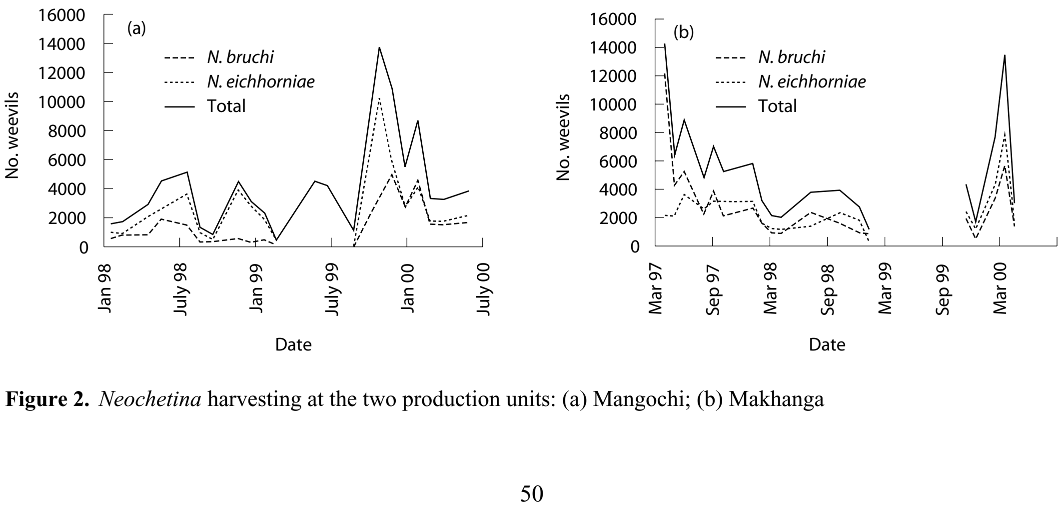

Figure 2. *Neochetina* harvesting at the two production units: (a) Mangochi; (b) Makhanga

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Monitoring

Here we present an example of the data-sets being collected. Figure 4 shows the mean number of weevil feeding scars on leaf 2 for one site each in the Lower, Middle and Upper Shire River.

The beetles are established at all monitoring sites. Damage by the weevils has increased in the Upper Shire in the last two years. In Lake Malombe and the Middle Shire, damage levels have remained low, while in the Lower Shire there has been a build-up to higher levels than in the Upper Shire. In recent months a reduction in weevil damage has been seen at some Lower Shire sites, and this appears to be associated with the reduction in plant height, though it may be a simultaneous response to an environmental variable rather than a causal link.

From 1998 to 2000 there has been some decrease in plant height, but this is not matched by a reduction in laminar area for leaf 2 or leaf number. If biological control is working, we would expect a general reduction in plant vigour and thus size.

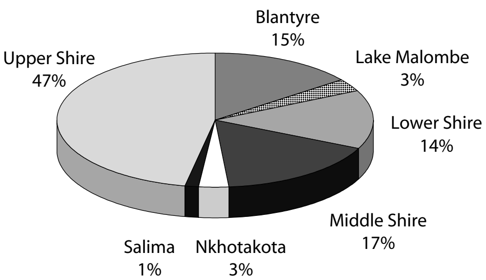

Figure 3. Releases of *Neochetina eichhorniae* and *Neochetina bruchi* in the Shire River.

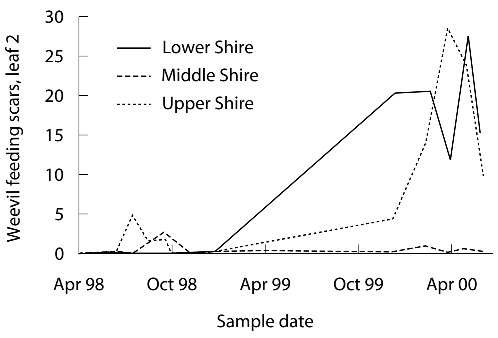

Figure 4. Weevil feeding scars at three monitoring sites in the Shire River.

Mite damage was generally higher in 1998 than subsequently, though there has been some increase in 2000. Interestingly, the same pattern has occurred for damage by pathogens, and this suggests that the mites may be facilitating infection by pathogens. However, both control agents may be responding to the same environmental conditions. No evidence has been found for establishment of either *Eccritotarsus* or *Niphograpta.*

At all the sites on the Shire River there appears to have been a reduction in the infestation of water hyacinth, and at one site in the Lower Shire monitoring has ceased as there is now so little water hyacinth present that monitoring is impractical. In the Upper Shire the reduction of the weed appears to have coincided with an increase in cover by the sedge *Pycreus mundtii*, and Rother and Twongo (1999) have suggested that the water hyacinth is stimulating a succession in which it is being replaced by *Pycreus* and *Ludwigia.*

Conclusion

Neochetina spp. are well established in most parts of the Shire River, and numbers at some sites have built-up to levels at which a significant impact can be expected on water hyacinth infestations. Hill et al. (1999) suggested that impact might become visible by 2000–2001, and certainly the population of water hyacinth in the Shire River is less than it was two years ago. Fishermen in the Lower Shire are crediting the weevils with this reduction, but while this is pleasing, more data need to be collected to confirm this view.

In other parts of Malawi, new infestations can be expected to occur. In some cases it may be possible for local communities to effect control by manual removal—there are already some cases of this reported. At the same time, the long-term strategy remains centred on biological control, and *Neochetina* spp. and *Orthogalumna* will be released on significant new infestations as they are reported. It is hoped that *Eccritotarsus* and *Niphograpta* will also become established.

As Julien and Orapa (1999) concluded, a successful biological program requires expertise, appropriate training and capacity building, staff and resources over an adequate period. We are confident that these ingredients are all present in the Malawi project, and so we are optimistic that the program will be a success.

Acknowledgments

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References

Blackmore, S., Dudley, C.O. and Osborne, P.L. 1988. An annotated checklist of the aquatic macrophytes of the Shire River, Malawi, with reference to potential aquatic weeds. Kirkia, 13, 125–142.

Chimatiro, S. and Mwale, D. 1998. A participatory rural appraisal study on the socio-economic impact of water hyacinth on local communities of the lower shire area, Malawi. Report to Department for International Development Renewable Natural Resources Knowledge Strategy programme. Malawi Fisheries Department and CAB International, Kenya, 101p.

Crossley, R. 1980. High levels of Lake Malawi. University of Malawi Staff Seminar Paper 2.

Harley, K.L.S 1991. Survey report of a project on exotic floating African water weeds. Unpublished report to the Commonwealth Science Council, 151–177.

Hill, G., Day, R., Phiri, G., Lwanda, C., Njaya, F., Chimatiro, S and Hill, M.P. 1999. Water hyacinth biological control in the Shire River, Malawi. In: Hill, M.P., Julien, M.H. and Center, T.D., ed. Proceedings of the First IOBC Global Working Group Meeting for the Biological and Integrated Control of Water Hyacinth. Harare, Zimbabwe, 16–19 November 1998. Plant Protection Research Institute, South Africa, 39–50.

Julien, M.H. and Griffiths, M.W. 1998. Biological control of weeds: a world catalogue of agents and their target weeds, 4th ed. Wallingford, UK, CABI Publishing.

Julien, M.H. and Orapa, W. 1999. Structure and management of a successful biological control project for water hyacinth. In: Hill, M.P., Julien, M.H. and Center, T.D., ed., Proceedings of the First IOBC Global Working Group Meeting for the Biological and Integrated Control of Water Hyacinth. Harare, Zimbabwe, 16–19 November 1998. Plant Protection Research Institute, South Africa, 123–134.

Rother, J.A. and Twongo, T. 1999. Water hyacinth in the Shire River: techniques for monitoring biodiversity impacts and a baseline survey. Unpublished report to DFID/Government of Malawi/CABI for Lower Shire water hyacinth biological control project.

Terry, P.J. 1991. Water hyacinth in the Lower Shire, Malawi, and recommendations for its control. Report of a consultancy for ODA, 18 September–5 November 1991.