New agents for biological control of water hyacinth

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Additional agents are needed to complement the action of *Neochetina* and other agents currently used worldwide in order to provide predictable and sustainable reductions of water hyacinth. In South America, where water hyacinth originated, about 17 species of arthropods have been identified, each of which provides different scope for biological control. Four of these species are in use worldwide (*Neochetina eichhorniae, N. bruchi*, *Niphograpta* and *Orthogalumna*), six have received renewed interest (*Eccritotarsus*, *Xubida*, *Cornops*, *Paracles* and *Thrypticus*), and seven are poorly known. Two species from the second group, *Eccritotarsus* in South Africa and *Xubida* in Australia, have recently been liberated, and others are being investigated in South Africa (PPRI) and Argentina (USDA). Recent explorations in Argentina revealed that the petiole-mining fly *Thrypticus* sp., once thought to be a single species, is actually a complex of species highly specialized on the water hyacinth family. Similarly, the sap-feeding delphacid, *Megamelus* sp. is more specialized than previously thought. Both appear promising as candidate agents for biocontrol. These findings, with the curious highly localized distribution of E*ccritotarsus* (extremely rare in Brazil and absent in Argentina), suggests that the likelihood of finding new organisms in South America is great. Unexplored areas of Brazil, especially Amazona and Pantanal, Paraguay, Bolivia and Peru should be carefully surveyed.

Need for integrated control

The increasing worldwide problem caused by water hyacinth requires both short- and long-term control or the integration of several techniques in which biological control is an essential component. Experience gained in biological control of water hyacinth in different regions around the world, suggests that the “silver bullet” approach will not solve the problem and several agents working together would be the best alternative. If the need for several agents is accepted, several questions follow: How many agents are currently available for biological control of water hyacinth? Do we need additional agents? Is it possible to find new agents? In the following pages I will try to provide answers to these questions.

Agents in use worldwide

Since the early 70's, when the USDA released *Neochetina eichhorniae*, *N. bruchi* and later *Niphograpta (Sameodes) albiguttalis*, these three agents became available for other countries wishing to control water hyacinth. The mite *Orthogalumna terebrantis*, although not intentionally introduced into the US, also proved to be specific enough to be used in other countries. Thus, these four agents are currently in use in many countries in the tropical and sub-tropical regions of the world in which water hyacinth was introduced (Table 1).

Need for additional agents

Many countries have initiated biological control programmes against water hyacinth and successes have been reported worldwide (Julien & Griffiths 1998). All four agents are important although the weevils seem more successful on the average than the other two in the many sites and countries where the agents were liberated. However, in many situations, the control achieved is not sufficient. In some instances the biological control collides with management practices which are not compatible with the relatively slow action of the bioagents. In others, the explosive overgrowth of water hyacinth boosted by high levels of nutrients, creates a tough enemy to defy. Whatever the reasons to explain the lack of effectivity of the current agents, it seems that additional organisms could enhance the level of control now realized. It is therefore necessary to develop and use management practices fully compatible with biological control and to seek new biological control agents, particularly those with capabilities for rapid population increase.

Arthropods that attack water hyacinth in its native range

The arthropods collected from water hyacinth in its native range of distribution constitute a list of about 43 different species (Perkins 1974). Half of them hardly cause noticeable damage or have a wide range of food plants so they have no value as biocontrol agents. In the other half, however, there are about 19 species that were thought to have potential either because of the damage observed or because of their predictable specificity. In table 1, I have listed these species ordered according to priorities for biological control. The categories arbitrarily classify the arthropods into three priority groups. In the first priority group, agents in use worldwide, I included species that were initially seriously considered as first priority candidates for the screening tests: *N. eichhorniae, N. bruchi, N.*

albiguttalis and *O. terebrantis*. The second priority group includes candidates recently released or under testing: *E. catarinensis*, *X. infusella, C. aquaticum, B. densa*, *P. tenuis* and *Thrypticus* spp. In the third priority group, there are candidates poorly known or of questionable specificity: *Brachinus* sp*, A. subornata, M. acuminata, T. inexacta, M. electrae, E. setigena, C. falvipilus, Hydrellia* sp. and *F. eichhorniae*. Since attributes, limitations and current status of research of these species, as well as field and laboratory host plants, are included in the table, I will restrict my comments to a selected number of key candidates. They are *Eccritotarsus*, *Thrypticus* and *Megamelus* and their importance relies in that they are examples of recently found promising candidates. They show that there are plenty of opportunities to find new agents among those already known and yet to be discovered.

- ***Eccritotarsus catarinensis:*** This mirid remained as an obscure citation in the literature until it was found by Dr. Neser, PPRI, in Brazil, brought to South Africa, found specific for the Pontederiaceae and was released in 1996. Despite its intriguing distribution in its native range and its low initial priority for biological control, the insect proved its value to become a new agent.
- ***Thrypticus*** spp**.**: Since the beginning of the investigations on natural enemies of water hyacinth, *Thrypticus* has been mentioned among the top seven candidates for biological control. However, because of the uncertain taxonomic status of the fly, other candidates were given priority, and *Thrypticus* was put aside. In 1995, a revived interest for new agents for water hyacinth directed the investigations to second priority candidates. Among these, Cordo (1996) recommended studying *Cornops*, *Palustra* and *Thrypticus* in merit of their predicted narrow host range. Due to the failure of *Palustra*, the research on water hyacinth at SABCL focused on *Thrypticus.* Although the effect of its damage on the demography of water hyacinth is obscure, other attributes of the fly like the presumed specificity, ubiquity and abundance appear promising. The tiny tunnels produced by the larvae, often very abundantly, were judged trivial by some authors and auspicious by others. Despite this polarity, whatever degree of damage *Thrypticus* inflicts to the plant, it will possibly enhance the overall stress produced by other agents. Through coloration traits of adults and mining patterns, four different species were characterized that attack *E. crassipes, E. azurea, P. cordata* and *Reussia subovata*. This high specialization virtually assures that *Thrypticus* will soon become a new agent for biocontrol of water hyacinth.
- ***Megamelus*:** Detailed observations on the Homoptera associated with Pontederiaceae were

accomplished for the first time at SABCL and revealed that the Delphacidae *Megamelus* sp. is probably a complex of species perhaps more specific than formerly presumed. Two species were identified so far, *Megamelus* "*pontederiae*" that attacks several Pontederiaceae and *M.* "*eichhorniae*" found only on *E. crassipes* and *E. azurea*. Thus, the prospects for this species look interesting and well worth initiating screening studies.

As mentioned above, these three insects exemplify the many opportunities still available to find new agents among poorly know candidates and to discover new organisms associated with water hyacinth in South America.

Explorations in South America

Although several expeditions were made in South America for surveying natural enemies of water hyacinth, most of them were limited in scope, and many failed to encompass the upper Amazon basin where water hyacinth is thought to originate. Perhaps the most comprehensive survey in South America was undertaken by Bennett and Zwolfer in 1967. However, they restricted their exploration to the northernmost range of the plant, i.e., northern Brazil (Manaus, Belem), Surinam, Guyana and Trinidad. Other authors also explored South America but most of their trips were in the eastern side of the plant distribution, eastern Brazil, Uruguay and Argentina. The occidental part of the water hyacinth range in South America was seldom visited. This region includes the upper basin of the Amazona river in Brazil and around Iquitos in Peru, the Pantanal region in Matto Grosso, Brazil and eastern Bolivia; the Chaco region of Bolivia, Paraguay and northeastern Argentina and the eastern humid side of Paraguay. The chances for discovering new organisms associated with water hyacinth in these regions were thought very small because of the apparently long list of natural enemies put together during a period of nearly 20 years of surveys in SA. However, the recent findings of *Eccritotarsus*, *Thrypticus* and *Megamelus*, suggest that the possibility of finding new organisms are greater than believed so far. Thus, I have the strong belief that new surveys to the mentioned regions could be highly rewarding in terms of finding new candidates and, perhaps more important, to gather vital information on poorly known candidates

Table 1. Characterization of major arthropods associated to water hyacinth.

Species	**Field and Laboratory Host Plants**	**Attributes, Limitations and Current Status of Research**
FIRST PRIORITY – AGENTS IN USE WORLDWIDE		
1. *Neochetina eichhorniae* Warner (Col.: Curculionidae)	*Eichhornia crassipes*	In use in North America, Africa and Asia (Julien & Griffiths 1998)
2. Neochetina bruchi Hustache (Col.: Curculionidae)	*E. crassipes*	In use in North America, Africa and Asia (Julien & Griffiths 1998)
3. *Niphograpta albiguttalis* (Warren) (Lep.: Pyralidae)	*E. crassipes*	In use in North America, Africa and Asia (Julien & Griffiths 1998)
4. *Orthogalumna terebrantis* Wall. (Acarina: Galumnidae)	*E. crassipes, E. azurea, Pontederia cordata, Reussia subovata*	In use in North America and Africa (Julien & Griffiths 1998)
SECOND PRIORITY – CANDIDATES RECENTLY RELEASED OR UNDER TESTING		
5. *Eccritotarsus catarinensis* (Carvalho) (Heter.: Miridae)	Field: *E. crassipes*, other? Lab.: *E. crassipes, E. natans, P. cordata, Heteranthera, Monochoria*	Heavy attack at Belem, Brazil (B. & Z. 1968) Tested in South Africa. Liberated in 1996. Established (Hill *et al* 1999)
6. *Xubida (=Acigona) infusella* (Walker) (Lep.: Pyralidae)	Field: *E. crassipes, E. azurea, P. cordata, P. rotundifolia*	Liberated in Australia September 1981; not established. Reimported in 1995 and liberated in 1996 (Julien unpubl. reports)
7. *Cornops aquaticum* (Bruner) (Orth.: Acrididae, Leptysminae)	Field: *E. crassipes, E. azurea, P. cordata*	Testing undergoing in quarantine at PPRI, South Africa (Hill unpubl. reports)
8. *Bellura densa* (Lep.: Noctuidae)	Field: *P. cordata, E. crassipes, Colocasia esculenta*	Testing undergoing in quarantine at PPRI, South Africa. Release rejected because of its menace to Colocasia esculenta (Hill unpubl. reports)
9. *Paracles (=Palustra) tenuis* (Berg) (Lep.: Arctiidae)	Field: *E.azurea, P. cordata, E. crassipes* Lab.: Various pls. in different families	Polyphagous in lab. testing. It developed readily on *P. rotundifolia, Alternanthera, Canna, Limnobium, Sagittaria*. Rejected for further studies (Cordo, unp. rep.)
10. *Thrypticus* spp.- Four species- (Dip.: Dolichopodidae)	Field: *E. crassipes (T. "eichhorniae"), E. azurea (T. "azureae"), P. cordata (T. "pontederiae")* and *Reussia subovata (T. "reussiae*")	Under study at SABCL. Species *T. "eichhorniae*" apparently strictly monophagous on water hyacinth. Very promising (Cordo, unp. rep.)

THIRD PRIORITY - CANDIDATES POORLY KNOWN OR OF QUESTIONABLE SPECIFICITY		
11. *Brachinus* sp. (Col.: Carabidae)	Field: *E. crassipes*, *E. azurea*, *P. cordata*, other hosts?	Feeding on flowers (Silveira Guido 1965). Same as *Callida* sp. found in Argentina? (Center, Hill and Cordo, unpubl.)
12. *Argyractis subornata* Hampson (Lep.: Pyralidae)	Field: *E. crassipes*, other hosts? Lab: *E. crassipes* and *Pistia stratiotes*	Life history and biology studied by Forno (1983)
13. *Macocephala acuminata* Dallas (Heter.: Pentatomidae)	Field: *E. crassipes*, other hosts?	Feeding on roots. Apparently pest of rice (Silveira Guido 1995)
14. *Taosa inexacta* Walk. (Hom.: Dictyopharidae)	Field: *E. crassipes*, *P. rotundifolia*, other hosts?	Under Lab condit. feeding weakens pls. and hasten deterioration. Prelim. feeding test indicated good degree of specificity (Cruttwell 1973)
15. *Megamelus electrae* Muir (Hom.: Delphacidae)	Field: *E. crassipes*, *E. azurea*, *P. cordata*, other hosts?	Trinidad to Argentina. No visible damage caused to pls. (Cruttwell 1973). Heavy attack in Rio Janeiro in 1967 (Bennett 1967). Under study at SABCL
16. *Eugaurax setigena* Sabrosky (Dip.: Chloropidae)	Field: *E. crassipes. E. paniculata*, other hosts?	Little known on food habits of *Eugaurax* spp. *E. floridensi* ex *Sagittaria falcata*. *E. quadrilineata* ex egg plant (Sabrosky 1974)
17. *Chironomus falvipilus* Rempel (Dip.: Chironomidae)	Field: *E. crassipes*, other hosts?	In stems in Surinam and Brazil. Mentions of undetermined spp. of the family for Uruguay (S. Guido 1965)
18. *Hydrellia* sp. (Dip.: Ephydridae)	Field: *E. crassipes*, *P. lanceolata*, other hosts?	Common in Uruguay (S. Guido 1965)
19. *Flechtmannia eichhorniae* Keifer (Acarina: Eriophydae)	Field: *E. crassipes*, other hosts?	Described for Brazil (Kiefer 1979). Mentioned for Uruguay (S. Guido 1965). Being "Gen. and sp. novum", specificity looks promising

Recommendations

There is a need for additional agents for biocontrol of water hyacinth. There are a considerable number of known candidates with different degrees of potential which need to be screened to determine their suitability for biological control. In addition to this, there is evidence to believe that new organisms could be found in poorly explored regions of South America. Both strategies, screening of known organisms and exploring for new ones, could be easily undertaken by SABCL. This laboratory has the expertise to accomplish both objectives provided that funds are allocated for the purpose. Since SABCL has an operational base structure supported by USDA, ARS, specific funds for water hyacinth will be used for hiring of technicians and for explorations. Estimated funds per year range $30 000 to 60 000 for minimal and optimal approaches and the granted period should be not less than five years. The total amount involved in this estimate, $150 000 to $300 000, should be weighed against the millions of dollars spent annually in the battle against water hyacinth.

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