How Safe Is the Grasshopper *Cornops aquaticum* for Release on Water Hyacinth in South Africa?

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Abstract

The grasshopper *Cornops aquaticum* is currently being considered as a natural enemy for water hyacinth in South Africa. Both the adults and the nymphs are very damaging to water hyacinth plants. The laboratory host range was determined through nymphal and adult no-choice trials. The test plants were selected on relatedness to water hyacinth, similarity in habitat and on economic importance. Full nymphal development was recorded on *Heteranthera callifolia, Pontederia cordata* (pickerelweed) and *Canna indica* (canna) under quarantine laboratory conditions. Pickerelweed and canna are introduced species and are potentially invasive in South Africa, and are therefore of no conservation concern. Of the other native African Pontederiaceae, *Eichhornia natans* supported development of the grasshopper nymphs, but the lack of emergent leaf material suggests that the plant will not sustain a population, and *Monochoria africana* did not support full development of the nymphs. The adult females were not able to oviposit on the thin petioles of *Heteranthera callifolia* and only one eggpacket was recorded on *Monochoria africana,* suggesting these two species are not at risk. Results from the region of origin show that *C. aquaticum* is an oligophagous insect on the Pontederiaceae family of plants, with a strong preference for water hyacinth. In South Africa we intend to conduct further nymphal and adult choice trials which will better represent the field situation to further quantify the risk to native Pontederiaceae.

WATER hyacinth is considered to be the most important aquatic weed in the world (Center 1994; Wright and Purcell 1995). In South Africa, it was first recorded in the early 1900s. Since then the weed has become invasive throughout southern Africa, mainly as a result of human activities (Jacot Guillarmod 1979). Attempts to control the weed have led to different control options being developed, including herbicidal control, mechanical control and biological control. In South Africa, the biological control program has been in place since 1974, with an interruption of 8 years between 1977 and 1985 (Hill and Cilliers 1999). In the course of the program, five arthropod natural enemies were released against the weed: *Neochetina eichhorniae*, *Neochetina bruchi*, *Orthogalumna terebrantis*, *Eccritotarsus catarinensis* and *Niphograpta albiguttalis*. Even with these species released there is a perception that, in South Africa, the correct 'suite' of insects to biologically control the weed has not been introduced. As a result, additional natural enemies are being sought for control of water hyacinth. In this paper we discuss the suitability of *Cornops aquaticum*, a grasshopper species, for release in southern Africa.

Information from the Literature

Cornops aquaticum was identified by Perkins (1974) as being one of the most damaging insects associated with water hyacinth in the plant's region of origin. However, it appears that fears regarding this insect's host specifi-

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city have prevented it from being given serious consideration as a biological control agent for the weed. Silveira Guido and Perkins (1975) investigated the biology and host specificity of *C. aquaticum* and found that, under laboratory starvation trials, it was able to feed and develop on three species within the Commelinaceae and also on the following species in the Pontederiaceae (*Eichhornia azurea, Eichhornia crassipes* and *Pontederia cordata*). Limited feeding, but no development, was recorded on rice and sugarcane.

Laboratory Determination of Biology

The grasshopper was collected from Brazil (1995), Trinidad and Venezuela (1996) and Mexico (1997) and imported into quarantine in South Africa. The adult female inserts its eggs into the base of the petiole. According to Silveira Guido and Perkins (1975) the endophytic position of the egg packets provides moisture for development and the arenchyma tissue of the water hyacinth petiole prevents excess water uptake. This might well be significant in the host specificity of the insect, as it appears as if the adult female has very specific ovipositioning requirements. These requirements are unlikely to be present in plant species outside of the Pontederiaceae. The egg cases are produced inside a case of foamy substance, that functions as a 'plug' to encapsulate the eggs. The oviposition site is identifiable by this plug, which the female uses to cover the oviposition hole. Eggs that were not oviposited within the plant tissue did not develop.

An incubation period of 25–30 days was recorded. Newly emerged nymphs begin to feed immediately on the water hyacinth leaves. There are 6–7 instars (usually 6) which range in length from 6–8 mm in the 1st instar to 25–30 mm in the 6th instar. The adults are long lived (55–110 days) and the females produce a high number of offspring: between 60 and 560. The insects are highly mobile and very damaging to water hyacinth, both as adults and throughout the immature stages.

Laboratory Host Specificity

Nymphal no-choice trials

Host range was determined through nymphal no-choice trials on 64 plants in 32 families, selected on relatedness to water hyacinth, similarity in habitat and economic importance (Table 1). Details of the development of *C. aquaticum* adults from no-choice nymphal starvation trials are presented in Table 2. Five newly hatched, first-instar nymphs were placed on each of the test plant species. Feeding damage, nymphal development and mortality were recorded daily.

On the majority of species tested, no feeding was recorded and the nymphs died within the first week. Nymphal feeding was recorded on several species outside the Pontederiaceae family. Some nibbling was recorded on rice and cabbage, but no development was recorded. A few nymphs developed to 2nd instar stage on radish, 3rd instar stage was reached on *Nerine* sp. (Amaryllidaceae) and 4th instar stage on *Commelina africana* and *Murdannia simplex* (both Commelinaceae). Complete nymphal development occurred on *Canna indica*, but the surviving number was low compared with survival on water hyacinth. Feeding and development were also recorded on pickerel weed, but nymphal survival was low compared with nymphal survival on water hyacinth. Of 50 nymphs placed on banana, one developed to adulthood.

Of the native Pontederiaceae, feeding was recorded on *Eichhornia natans* but, compared with water hyacinth, the plant produces very little emergent leaf material on which the nymphs can develop completely. This species also has a slender petiole that is submerged below the water and will not support ovipositioning. Limited feeding and development were recorded on *Monochoria africana*. The insects preferred to feed on the epidermis of the petiole, and although this was damaging to the plant, it seemed to provide the nymphs with insufficient nutrition to develop. Full nymphal development was recorded on *Heteranthera callifolia* and although it was lower than on water hyacinth it is still reason for concern.

Adult no-choice trials

Among the 16 species tested, oviposition was recorded on water hyacinth, *M. africana* and pickerel weed (Table 3). Only a few eggs were recorded on pickerelweed, and only one eggpacket was recorded on *M. africana.* Oviposition probes are holes made by females looking to lay eggs at the base of the petiole. Probes were recorded on water hyacinth, *M. africana* and pickerelweed. It appears as if the internal structure of the *M africana* petioles is not suitable for oviposition. In several replicates of non-target species, egg cases were laid on the sides of the cages and pots, indicating that the females were under oviposition stress and plants presented to them did not offer suitable oviposition sites.

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Table 1. Results of the first instar nymph[a] host-specificity tests of *Cornops aquaticum* on selected plant species

Plant species	No.	Common name	Feeding	Development
Aponogetonaceae				
Aponogeton distachyos L.	10	Cape pondweed	0	0
Alismataceae				
Alisma plantago-aquatica L.	6	Water alisma	0	0
Poaceae				
Zea mays L.	10	Maize	0	0
Arundo donax L.	10	Spanish reed	0	0
Phragmites australis (Cav.) Steud.	10	Reed	0	0
Oryza sativa L.	8	Rice	+	0
Saccharum officianum L.	5	Sugarcane	0	0
Araceae				
Zanthedeschia aethiopica (L.) Spreng.	20	Arum Lily	0	0
Colocasia esculenta L. Schott	15	Taro	0	0
Zamioculcas zamiifolia (Lodd.) Engl.	7		0	0
Stylochiton sp.	7		0	0
Restionaceae				
Elegia racemosa (Poir) Pers.	5	Restio	0	0
Eriocaulaceae				
Eriocaulon dregei Hochst var *sonderanium* (Körn) Oberm.	5		0	0
Commelinaceae				
Commelina africana L.	14		+	0
Murdannia simplex (Vahl) Brenan	3		+	+
Pontederiaceae				
Eichhornia crassipes (Mart.) Solms-Laub.	45	Water hyacinth	+	+
Eichhornia natans (P. Beauv.)	6		+	0
Monochoria africana (Solms- Laub.) N.E.Br	5		+	+
Heteranthera callifolia Kunth	5		+	+
Pontederia cordata L.	10	Pickerelweed	+	+
Juncaceae				
Juncus kraussi Hochst. subsp. *krausii*	5	Rush	0	0
Colchicaceae				
Gloriosa superba L.	7	Flame lily	0	0
Asphodelaceae				
Chlorophytum comosum (Thunb.) Jacq.	6	Hen and chickens	0	0
Alliaceae				
Agapanthus africana (L.) Hoffing	10	Agapanthus	0	0
Allium ampeloprasum (L.)	5	Leek	0	0
Allium cepa L.	5	Onion	0	0

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Table 1. (Cont'd) Results of the first instar nymph[a] host-specificity tests of *Cornops aquaticum* on selected plant species

Plant species	No.	Common name	Feeding	Development
Liliaceae				
Kniphofia linearifolia Bak.	6	Red-hot poker	0	0
Tulbachia sp.	10		0	0
Euricomis sp.	10		0	0
Lillium sp.	10		0	0
Bulbine sp.	6		0	0
Aloe sp.	5		0	0
Behnia reticulata Didrichs	5		0	0
Asparagus officinalis L	5		0	0
Amaryllidaceae				
Crinum bulbispermum (Burm. f.)	10	Orange River lily	0	0
Clivia minata (Lindl.)	10	Bush lily	0	0
Nerine sp.	5		+	+
Hypoxidaceae				
Hypoxis sp.	5		0	0
Iridaceae				
Watsonia sp.	5		0	0
Musaceae				
Musa paradisica L.	10	Banana	+	+
Cannaceae				
Canna indica L.H. Bailey	10	Canna	+	+
Chenopodiaceae				
Beta vulgaris L. var. *cicla*	10	Spinach	0	0
Euphorbiaceae				
Manihot esculenta Crantz	5	Cassava	0	0
Brassicaceae				
Raphanus sativus L.	10	Radish	+	+
Brassica oleracea L.	7	Cabbage	+	0
Brassica rapa L.	5	Turnip	0	0
Leguminaceae				
Pisum sativum L.	10	Pea	0	0
Phaseolus vulgaris L.	10	Bean	0	0
Onagraceae				
Ludwigia stolonifera (Guill. & Perr.) Raven	5		0	0
Trapaceae				
Trapa natans L. var *bispinosa* (Roxb) Makino	5	Water chestnut	0	0
Halorgidaceae				
Laurembergia sp.	5		0	0

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Table 1. (Cont'd) Results of the first instar nymph[a] host-specificity tests of *Cornops aquaticum* on selected plant species

Plant species	No.	Common name	Feeding	Development
Apiaceae				
Daucus carota L. var. *sativus*	10	Carrot	0	0
Hydrocotyle sp.	5		0	0
Solanaceae				
Lycopersicon lycopersicum (L.)	10	Tomato	0	0
Solanum melogena L. var. *sativus*	10	Eggplant	0	0
Capsicum annuum L.	10	Pepper	0	0
Rubiaceae				
Coffea sp.	5	Coffee	0	0
Cucurbitaceae				
Cucurbita pepo L.	5	Marrow	0	0
Cucumis sativus L.	5	Cucumber	0	0
Citrillus lanatus (Thunb.)	5	Watermelon	0	0
Asteraceae				
Lactuca sativa L. var. *capitata*	10	Lettuce	0	0

a. Five first instar nymphs per replicate

Table 2. Mean number of *Cornops aquaticum* adults reared from plant species during no-choice nymphal starvation trials

Plant species	No.	Mean number of adults/replicate[a,b]
Eichhornia crassipes	45	3.47 (0.93)
Heteranthera callifolia	6	2.8 (1.21)
Pontederia cordata	10	1.60 (1.08)
Canna indica	10	1.10 (1.45)
Musa paradisica	10	0.02 (0.14)

a. Five first-instar nymphs were used per replicate.
b. Figures in parentheses represent the standard deviation.

Field observations in the region of origin

Observations of host range were made at several localities in northern Argentina and in Peru.

In Argentina, 28 sites were surveyed. Of all the insect species surveyed, at all the sites *Cornops aquaticum* was considered to be the most damaging to water hyacinth. *Cornops aquaticum* was also found to be widespread and abundant on water hyacinth. Egg cases were recorded on water hyacinth, *Eichhornia azurea* and pickerel weed. The insect was found to be less abundant on pickerel weed, suggesting it is an inferior host. *Cornops aquaticum* was not recorded on *Canna glauca* or the two *Commelina* species even when growing close to water hyacinth supporting high populations of the grasshopper.

In Peru, 30 sites were surveyed. *Cornops aquaticum* was recorded on water hyacinth and *Pontederia rotundifolia.* The grasshopper was abundant on *P. rotundifolia* and caused severe damage to plants. The predaceous weevil, *Ludovix fasciatus,* was also found, and even with its presence *Cornops aquaticum* was still abundant.

Discussion

Cornops aquaticum is a very damaging natural enemy of water hyacinth and is likely to make a valuable contribution to the control of this weed in South Africa. This is evident from the fact that, despite being heavily parasitised by the weevil *Ludovix fasciatus* in its region of origin, it is still abundant and damaging to water hyacinth. This weevil is not present in South Africa, so it is predicted that the impact of the grasshopper on water hyacinth would be greater.

Table 3. Mean number of *Cornops aquaticum* adults surviving and egg cases laid on test plant species during adult, no-choice trails. Two pairs of adults were used per replicate and each replicate lasted seven days.

Plant species	Common name	n	Mean number of egg cases/ replicate[a]	Mean number of probes/ replicate[a]
Eichhornia crassipes	Water hyacinth	8	5.21 (3.56)	3.67 (3.27)
Monochoria africana		6	0.04 (0.19	2.83 (1.72)
Heteranthera callifolia		6	0.00 (–)	0.00 (–)
Eichhornia natans		3	0.00 (–)	0.00 (–)
Pontederia cordata	Pickerel weed	4	2.02 (0.80)	3.45 (1.67)
Canna indica	Canna	8	0.00 (–)	0.00 (–)
Musa paradisica	Banana	6	0.00 (–)	0.00 (–)
Commelina africana		8	0.00 (–)	0.00 (–)
Murdannia simplex		4	0.00 (–)	0.00 (–)
Zea mays	Maize	3	0.00 (–)	0.00 (–)
Raphanus sativus	Radish	3	0.00 (–)	0.00 (–)
Brassica oleracea	Cabbage	5	0.00 (–)	0.00 (–)
Nerine sp.		4	0.00 (–)	0.00 (–)
Oryza sativa	Rice	6	0.00 (–)	0.00 (–)
Zanthedeschia aethiopica	Arum lily	3	0.00 (–)	0.00 (–)
Colocasia esculenta	Taro	3	0.00 (–)	0.00 (–)

a. Figures in parentheses represent the standard error.

The indigenous *Eichhornia* species in Africa, *Eichhornia natans*, supports development of the grasshopper nymphs, but the lack of emergent leaf material and the submerged petioles suggest that the plant will not sustain a population of *C. aquaticum* in the field. Of the other plants in the Pontederiaceae in Africa, *M. africana* does not support full development of the nymphs, and *H. callifolia,* although heavily attacked, did not support oviposition and is considered to be inferior to water hyacinth as a host.

Cornops aquaticum is considered to be oligophagous on Pontederiaceae and should be released only in countries that do not have native Pontederiaceae or where the spillover feeding on native Pontederiaceae would be tolerable. Silveira Guido and Perkins (1975) found that, under high population levels in the laboratory, nymphs fed on members of the Commelinaceae, rice and sugarcane in the Gramineae, and *E. azurea* and *P. cordata* in the Pontederiaceae. However, development was recorded only on *Commelina* spp. outside of the Pontederiaceae. Under performance, or choice tests, they found that damage occurred to the same *Commelina* species and to rice and sugarcane. While we recorded some nibbling on rice, we have not recorded any feeding on sugarcane. Furthermore, Bennett (1970) found that only water hyacinth was attacked during choice tests with other species.

The host-specificity testing of this insect is incomplete. However, despite relying on the most conservative host-specificity tests (nymphal starvation trials) the insect has shown a high degree of specificity to water hyacinth.

Future Research

The emphasis in future research will be on the testing of the insect under more natural conditions. These tests might give less ambiguous results that would clarify the host specificity of *C. aquaticum.* Open field trials in the region of origin are an option, while we believe that choice trials with adults and nymphs will clarify these results (Marohasy 1998). Tests will be conducted using native Pontederiaceae from the southern African region, water hyacinth, canna and banana. All these plants showed development of the nymphs. Special attention will be given to development and ovipositioning of *Cornops aquaticum* under open field conditions.

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