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Host Specificity of the Grasshopper, *Cornops aquaticum*, a Natural Enemy of Water Hyacinth

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The grasshopper, *Cornops aquaticum* (Bruner) (Orthoptera: Acrididae) was considered as a potentially damaging natural enemy for water hyacinth in South Africa. In the laboratory, the females inserted egg cases into the base of young petioles. The number of eggs per case ranged from 30 to 70. The incubation period ranged from 25 to 30 days. There are 6 or 7 nymphal instars, which feed on the leaves of the plants, causing extensive damage. The nymphal period is about 50 days. The adult longevity ranged from 55 to 110 days during which the females laid between one and seven egg cases after a 25 to 30 day pre-oviposition period. The laboratory host range of *C. aquaticum* was determined through nymphal, no-choice trials on 61 plant species in 31 families selected on relatedness to water hyacinth, similarity in habitat and economic importance. Complete nymphal development was recorded on *Pontederia cordata* L. (Pontederiaceae) (pickerel weed) which is an introduced and potentially invasive species in South Africa and *Canna indica* L. (Cannaceae) which is also invasive in wetlands in South Africa. Feeding and limited nymphal development (up to 3rd and 4th instar) was recorded on *Commelina africana* L., *Murdannia simplex* (Vahl.) Brenan (both Commeliniaceae), *Nerine* sp. (Amaryllidaceae), *Monochoria africana* (Solms-Laub.) N. E. Br. and *Eichhornia natans* (P. Beauv.) (both Pontederiaceae). Despite immature development on these species, female oviposition has only been recorded on water hyacinth and pickerel weed in the laboratory. Host plants of *C. aquaticum* in South America included water hyacinth, *Eichhornia azurea* (Sw.) Kunth. and pickerel weed. These results indicate that *C. aquaticum* is a highly damaging insect that might be suitable for release in South Africa.

Keywords: water hyacinth, *Cornops aquaticum*, biological control, Pontederiaceae

Introduction

Eichhornia crassipes (Mart.) Solms-Laub. (water hyacinth) originated in the New World tropics but is now widely distributed throughout the tropical and subtropical regions of the world (Center 1994; Wright and Purcell 1995) and is presently the most important aquatic weed in South Africa where it is the subject of a biological control programme (Hill and Cilliers 1999). It was first recorded in South Africa around 1900 and it was rapidly spread by gardeners, aquarium owners and boating enthusiasts (Jacot Guillarmod 1979). The lack of natural enemies and the presence of enriched waters have contributed to its establishment on water bodies throughout the country (Cilliers 1991) where it degrades aquatic ecosystems and limits their utilisation.

The grasshopper, *Cornops aquaticum* (Bruner) was identified by Perkins (1974) as being one of the most damaging insects associated with water hyacinth in its region of origin. However, it appears as though fears regarding this insect's host specificity has pre-

vented it from having 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 species in the Pontederiaceae (*Eichhornia azurea* (S.W.) Kunth*., Eichhornia crassipes* and *Pontederia cordata* L.) and limited feeding, but no development was recorded on three species within the Commelinaceae, rice and sugar cane. Silveira Guido and Perkins (1975) concluded that *C. aquaticum* is an oligophagous species in the Pontederiaceae and that some feeding could be expected on pickerel weed if the grasshopper was to be introduced to the USA for the control of water hyacinth.

Cornops aquaticum is being considered as an additional biological control agent for water hyacinth in South Africa. The grasshoppers were originally collected from water hyacinth in Manaus, Brazil in October 1995. Subsequent collections were made in Trinidad and Venezuela in April 1996 and from Mexico in October 1996. Following positive identification, the cultures were mixed.

Here we report on the life history and host specificity of *C. aquaticum* under quarantine laboratory conditions in South Africa.

Materials and Methods

Life history

All studies were conducted on whole water hyacinth plants growing in aquaria in a quarantine glasshouse where the temperature varied between 22 and 30°C. The plants were exposed to natural light and the photoperiod was approximately 12h in winter and 16h in summer.

The plants were inspected for oviposition and exuviae twice daily and the time of either an oviposition or moulting event was taken as halfway between the latest and the previous observation.

Host specificity

Laboratory host specificity was determined through nymphal no-choice trials on 61 plant species in 31 families selected on relatedness to water hyacinth, similarity in habitat and economic importance (Table 1). Five newly-hatched first instar nymphs were placed on each of the test plant species. Feeding damage, nymphal development and mortality was noted daily. In addition, observations of host range were made at several localities in northern Argentina and Peru.

Results

Life history

The adult females lay eggs in fairly large egg cases (mean of 36.10 ± 10.49 eggs per case, n = 15; mean of 27.28 ± 1.63 mm in length and 2.98 ± 0.68 mm in diameter, n = 15 egg cases). The egg cases are produced in two rows inside a case. The female inserts the egg case into the youngest petiole of the water hyacinth plant, usually just above the crown of the plant. The oviposition site is identifiable by a plug, which the female uses to cover the oviposition hole. Eggs that were not oviposited within the plant tissue did not develop. It appears as though the endophytic position of the egg case provides moisture for development and the arenchyma tissue of the water hyacinth petiole prevents excess water uptake and drowning of the eggs (Silveira Guido and Perkins 1975). This might well be significant in the host specificity of the insect as it appears as though the adult

female has very specific oviposition requirements that are unlikely to be present in plant species outside of the family Pontederiaceae.

Incubation is 25-30 days. Newly emerged nymphs begin to feed immediately on the water hyacinth leaves. There are 6 to 7 instars (usually 6) which range in length from 6-8mm in the 1st instar to 25-30mm in the 6th instar. The nymphal period lasts about 50 days. All stages are highly mobile and very damaging to the plant.

The adults can begin to copulate almost immediately after the last nymphal moult, but there is a 25-30 day pre-oviposition period after which the female lays between one and seven egg cases. Adult longevity can last from 55 to 110 days. The adults are very mobile, strong fliers and extremely damaging to the plant.

Host specificity

On the majority of species tested, no feeding was recorded and the nymphs died within the first week (Table 1). Feeding by nymphs was recorded on several species outside of the family Pontederiaceae including rice and cabbage but this was restricted to nibbling of the test plants and no nymphal development. A few nymphs developed to 2nd instar stage on radish, 3rd instar stage on *Nerinie* sp. (Amaryllidaceae) and 4th instar stage on *Commelina africana* L., *Murdannia simplex* (Vahl) Brenan (both Commeliniaceae) and *Monochoria africana* (Pontederiaceae) (Table 1). Complete nymphal development occurred on *Canna indica* L. but the number surviving was low in comparison to that on water hyacinth (Table 2). Heavy feeding damage and complete nymphal development was recorded on pickerel weed, although nymphal survival was inferior to that on water hyacinth (Table 2). While feeding damage was recorded on *Eichhornia natans* (P. Beauv.), the plant produces such little leaf material above the water surface that the nymphs were not able to complete development. In addition, this species has slender petioles, which are completely submerged which would not support oviposition by females.

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

Plant Species	n	Common Name	F[b]	D[c]
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	spannish reed	0	0
Phragmites australis (Cav.) Steud.	10	reed	0	0
Oryza sativa L.	10	rice	+	0
Saccharum officianum L.	10	sugarcane	0	0

Plant Species	n	Common Name	F[b]	D[c]
Araceae				
Zanthedeschia aethiopica (L.)Spreng.	20	arum lily	0	0
Colocasia esculenta L. Schott	15	taro	0	0
Zamioculcas zamiifolia	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 L. var. *africana*	14		+	+
Murdannia simplex (Vahl) Brenan	5		+	+
Pontederiaceae				
Eichhornia crassipes (Mart.) Solms-Laub.	45	water hyacinth	+	+
Eichhornia natans (P. Beauv.)	10		+	+
Pontederia cordata L.	10	pickerel weed	+	+
Monochoria africana (Solms-Laub.) N. E. Br.	5		+	+
Juncaceae				
Juncus kraussi Hochst. subsp. *krausii*	5	rush	0	0
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	5	onion	0	0
Liliaceae				
Kniphofia linearifolia Bak.	6	red-hot poker	0	0
Tulbaghia sp.	10		0	0
Euricomis sp.	10		0	0
Lillium sp.	10		0	0
Bulbine sp.	5		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 R. lily	0	0
Clivia minata (Lindl.)	10	bush lily	0	0
Nerine sp.	10		+	+

Plant Species	n	Common Name	F[b]	D[c]
Hypoxidaceae				
Hypoxis sp.	5		0	0
Iridaceae				
Watsonia sp.	5		0	0
Musaceae				
Musa paradisica	5	banana	0	0
Cannaceae				
Canna indica L.	10	canna	+	+
Chenopodiaceae				
Beta vulgaris L. var. *cicla*	10	spinach	0	0
Amaranthaceae				
Amaranthus hybridus L.	5	marog	0	0
Euphorbiaccae				
Manihot esculcutum	5	cassanua	0	0
Nymphaeaceae				
Nymphaea capensis Burm. f. var. *caerulea* (Sav.) Verdc.	10	blue water lily	0	0
Nymphaea caerulea Sav.	5	Egyptian lotus	0	0
Brassicaceae				
Raphanus sativus L.	6	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. and Perr.) Raven	5		0	0
Trapaceae				
Trapa natans L. var *bispinosa* (Roxb) Makino	5	water chestnut	0	0
Halorgidaceae				
Laurembergia sp.	5		0	0
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

Plant Species	n	Common Name	F[b]	D[c]
Rubiaceae				
Coffea sp.	5	coffee	0	0
Cucurbitaceae				
Cucurbita pepo L.	5	marrow	0	0
Cucumis sativus	5	cucumber	0	0
Citrillus lanatus (Thunb.)	5	watermelon	0	0
Asteraceae				
Lactuca sativa L. var. *capitata*	10	lettuce	0	0

[a] 5 first instar nymphs per replicate

[b] Feeding

[c] Development of nymphs past first instar.

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

Plant species	n	Mean number of adults/replicate[a,b]
Eichhornia crassipes	34	3.47 (0.93)
Pontederia cordata	10	1.60 (1.08)
Canna indica	10	1.10 (1.45)

[a] Five first instar nymphs were used per replicate.

[b] Figures in parentheses represent the standard error.

In Argentina, *C. aquaticum* egg cases, nymphs and adults were recorded on water hyacinth, *Eichhornia azurea* and *P. cordata*. However, less damage was recorded on pickerel weed, suggesting that it is an inferior host. At many of the sites surveyed, *Canna glauca* L. was a common component of the riparian vegetation. The grasshoppers were not observed on this species despite being abundant on water hyacinth growing in close proximity (Cordo *et al.* in prep.) suggesting that the development recorded in the quarantine laboratory could be artificial. In addition, two *Commelina* species were also found growing sympatrically with water hyacinth harboring high populations of *C. aquaticum*, no spill over feeding was recorded on these species. In Peru, *C. aquaticum* was recorded on water hyacinth and *Pontederia rotundifolia* L.f.. The grasshoppers were abundant on *P. rotundifolia* and caused sever damage to the plant despite the presence of a high popula-

tion of the predaceous weevil, *Ludovix fasciatus* (Gyllenhal). However, initial observations are that the grasshoppers on *P. rotundifolia* appeared, superficially different to those on water hyacinth in the field and in quarantine in South Africa. The identification of the specimens found on *P. rotundifolia* is being investigated.

Discussion

The grasshopper, *C. aquaticum*, has great potential for the biological control of water hyacinth in that it is extremely damaging to the plant. In addition, in the absence of the predaceous weevil, *L. fasciatus* which is abundant on the grasshopper in South America, *C. aquaticum* should become abundant in any region of introduction.

The results of the nymphal starvation trials conducted in this study were similar to those obtained by Silveira Guido and Perkins (1975) in that, under cage conditions, feeding was recorded on several species, including rice and limited development was recorded on species within the Commelinaceae. However, none of these species could be regarded as hosts for the grasshopper, and feeding on these species was most likely a product of an artificially extended host range due to restricted laboratory conditions. Furthermore, Silveira Guido and Perkins (1975) showed that in an open field cage situation, no damage was recorded on rice.

Canna indica could be considered as a host as extensive feeding occurred on this species and it did support nymphal development. Although canna is in a fairly unrelated family to the Pontederiaceae, this results is not surprising as *Canna glauca* is the recorded host for a closely related grasshopper species *C. frenatum cannae* (Roberts and Carbonell 1979). This suggests that while *Canna indica* falls into the physiological host range of *C. aquaticum*, the evidence from the country of origin suggests that the plant does not fall into the behavioural host range of the insect and is thus not under threat from the grasshopper. In the unlikely event of some damage occurring on canna in South Africa, this could be seen as beneficial as canna is an introduced species and is invasive in wetlands throughout the country (Wells *et al.* 1986).

Cornops aquaticum should be regarded as an oligophagous insect, utilising species in the family Pontederiaceae. However, both in the laboratory and in the field, it has a strong preference for water hyacinth. The Pontederiaceae flora in Africa is depauperate, comprising three native species, *Eichhornia natans*, *Monochornia africana* (Solms-Laub.) N. E. Br. and *Heteranthera callifolia* Kunth. Although nymphal feeding and development occurred on *E. natans*, its lack of emergent leaf material and oviposition sites indicates that it would not support a field population of the grasshopper and is therefore not under threat. *H. callifolia* has not yet been tested in this study. This species is an annual, very seasonal and sporadic in habit. It is rare in South Africa and has only been recorded on a few occasions, although it appears to be more common further north in Africa (Verdcourt 1961; Obermeyer 1985). As a result, we have not been able to collect and test it. However, it is likely that the grasshopper will feed and develop on this species, and, as it has similar petiole structure to water hyacinth, it will both probably support oviposition.

In the application for release of the mirid, *Eccritotarsus catarinensis* (Carvalho), it was argued that although the mirid was able to oviposit, feed and develop on *M. africana* and *H. callifolia*, the inferior performance of the mirid on these two species and the sporadic nature of the plants would preclude the insect from establishing a permanent population on them (Hill *et al.* 1999). Furthermore, if the plants were growing sympatrically with water hyacinth, the threat posed by the mirid was likely to be slight in comparison to

the possible competition for space caused by water hyacinth. These arguments could be used to petition for the release of *C. aquaticum* in South Africa.

Cornops aquaticum remains a very damaging insect on water hyacinth. However, it is an oligophagous on species within the Pontederiaceae. Therefore, it should only be considered for release in those countries which do not have native Pontederiaceae or where 'spill-over' feeding onto native Pontederiaceae can be tolerated.

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