# PROSPECTS FOR THE BIOLOGICAL CONTROL OF THE ENVIRONMENTAL WEED, *ZANTEDESCHIA AETHIOPICA* (ARUM LILY)

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**Summary** The fruits of *Zantedeschia aethiopica* (arum lily), an environmental weed in Australia, were examined for seed predators in its region of origin, South Africa. Damage attributable to insects (up to 31% of seeds) was caused by polyphagous species, none of which would be suitable for use as a biological control agents in Australia. The prospects of finding suitable biological control agents and the difficulties of implementing biological control against this potentially important horticultural species are discussed.

## INTRODUCTION

*Zantedeschia aethiopica* (L.) Spreng. (arum lily) (Araceae) is a noxious weed in Western Australia because it is toxic to livestock and can dominate summer wet pastures in the lower south west of the State. Control of arum lilies in pasture is relatively easy with the use of herbicides such as ester 2,4-D, glyphosate or chlorsulfuron (Panetta 1988, Parsons and Cuthbertson 1992, Dodd *et al.* 1993). The plant is also naturalized in south-eastern Australia and Queensland (Hnatiuk 1990), but in these States it is generally not regarded as a significant agricultural weed.

Arum lily also invades native vegetation and has become an important environmental weed in Western Australia (Keighery 1990, Dixon and Keighery 1995). A major nature conservation area affected is Garden Island, a 1200 ha nature reserve near Perth which includes the HMAS Stirling Naval Base. Management of the Island is the responsibility of the Australian Navy and this has involved the use of herbicides to spray arum lily. The spraying operation is difficult because of access and given the need to minimize damage to native plants.

Arum lily is native to South Africa and was introduced into Australia, probably as a horticultural plant. The weed has no close relatives in southern Australia. The Australian Araceae includes 8 genera, mostly found in northern and subtropical areas, but also eastern New South Wales (Hnatiuk 1990). Panetta (1988) has documented aspects of the biology of the weed in Western Australia. There appears to be no seed bank. Seeds are the major means of spread and birds that feed on the ripe berries assist in dispersal.

The growing importance of the weed in Western Australia, its comparatively isolated taxonomic position, and its presence in native vegetation indicates that biological means should be considered as part of the control strategy. Here we present the results of a preliminary survey for possible biological control agents and raise some of the issues to be addressed if the plant is to be targeted for biological control.

## MATERIALS AND METHODS

Arum lily in South Africa was surveyed on 14 days, between 21 January and 8 February 1996. The timing of the survey was guided by the South African literature on the plant and was aimed at finding plants with infructescences still green with developed seeds before the fruits become yellow (ripe).

Roadside surveys were used to locate sites where arum lily was present, based on the plant's distribution given in Letty (1973). In addition, searches were made in suitable habitat such as wetlands. The presence of live arum lily determined the selection of study sites. The presence of staminodes (sterile male flowers) among the female flowers was used to identify the species (Letty 1973). At the study sites, plants were examined for signs of insect related damage.

The survey concentrated on locating organisms that damaged seeds. Given a relatively short-lived seed bank (Panetta 1988) and the possible importance of the plant in floriculture, it was decided to start with a search for organisms that directly destroy the seed. At each site the plants were inspected for herbivores, and arthropods feeding on the leaves were collected for later identification. Ten immature green infructescences were collected if present at a site. The infructescence is composed of a central axis from which radiates the fruits, each containing one to several seeds. The infructescence is partly covered by the green base of the spathe. The spathe surrounds the infructescence like a cloak so that on one side it is partly open exposing the fruits whereas those fruits at the opposite side are completely enclosed. Five fruits spaced evenly from proximal to distal ends of the infructescence were taken from both the edge nearest the overlap formed by the spathe (exposed fruits) and opposite the overlap (enclosed fruits) and the seeds within dissected with a scalpel and examined using a 10× hand lens. The remaining fruits were examined for external evidence of seed damage and the infructescence dissected longitudinally and examined for evidence of internal feeding or damage.

## RESULTS

Twenty nine study sites were examined, including 20 in areas with predominantly winter rainfall and nine in areas with even annual rainfall. However, at these sites and in contrast to south west Australia, there was no evidence of summer senescence of plants, confirming Letty's (1973) observation that arum lily is evergreen in South Africa. Despite a large number of apparently suitable habitats being present, arum lilies were difficult to find in South Africa, in contrast to south west Australia. Also, the density of arum lily within populations found in South Africa appeared less than those in Western Australia.

Fruits were obtained from 25 of the study sites. A total of 7757 fruits were examined on the 199 infructescences that were collected. From the fruits 8597 seeds were dissected and examined for damage. Up to 18 seeds were found in each fruit, although the mean number of seeds per fruit was 4.4 ± 0.06 (± SE, N=1959) (Figure 1). This is similar to the number found by Panetta (1988) for fruits from Western Australia (means of 4.4, 4.0 and 3.4 seeds per fruit from three sites).

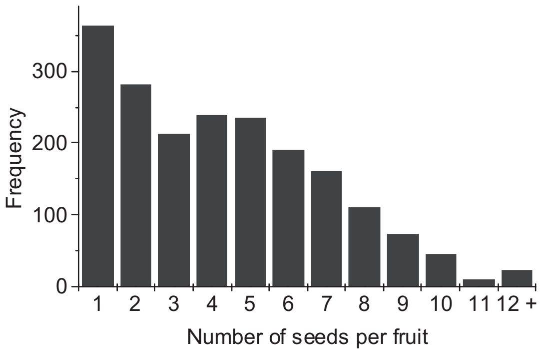


**Figure 1.** Frequency distribution of number of seeds per fruit of *Zantedeschia aethiopica* in South Africa.

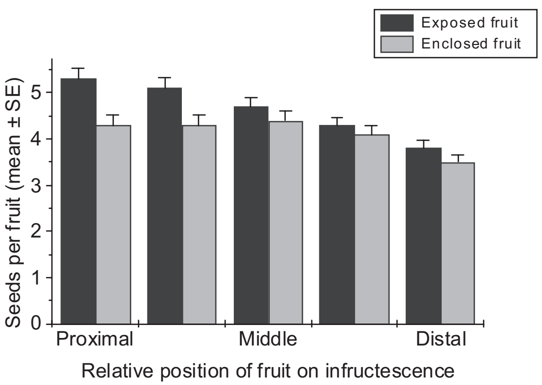


**Figure 2.** Number of seeds per fruit in relation to the position on the infructescence.

The number of seeds per fruit varied with the position on the infructescence. Fruits at the proximal end (nearest the stem) had more seeds than fruits at the distal end of the infructescence (Figure 2). The number of seeds per fruit also differed between exposed and enclosed fruits especially at the proximal end (Figure 2).

There were 38 ± 2 (mean ± SE, N=203) fruits per infructescence (Figure 3). This was lower than has been observed in Australia (Panetta 1988). He reported for three sites, 41, 54, and 51 fruits per infructescence (LSD=9.1). The percentage of developed fruits per infructescence in South Africa was 68 ± 4 (mean ± SE, N=56). This is lower than results reported for Australia by Panetta (1988) (89%, 74%, and 84% of female flowers developing into fruits, LSD=11.01).

**Seed damage** The evidence for seed damage was discoloured seed contents or empty seeds. The most common insect observed on fruits was the pentatomid bug, *Nezara viridula* (L.). Other Hemiptera (an unidentified Pentatomidae and *Cenaeus carnifex* (Fabricius) Pyrrhocoridae), were also observed feeding externally on fruits. *Nezara viridula* nymphs and adults caged with freshly collected infructescences resulted in fruits containing very high levels of discoloured or empty seeds. *N. viridula* observed in the field probed fruits or remained in a feeding position on the fruits. The insect is known to be a polyphagous feeder on fruits and seeds (Annecke and Moran 1982) and it was concluded that it was the main cause of seed damage observed during the survey. No arthropods were found inside the seeds or tunnelling in the fruit or infructescence.

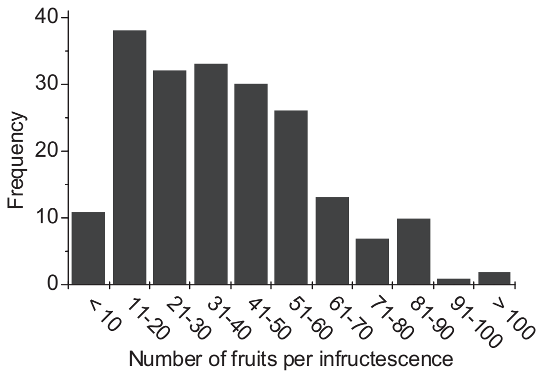


**Figure 3.** Frequency distribution of fruits per infructescence.

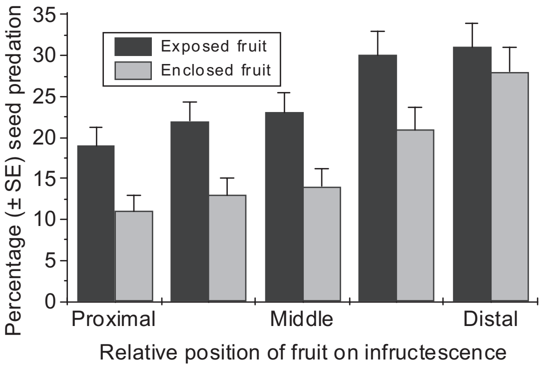


**Figure 4.** Percentage seed damage relative to a fruits position on the infructescence.

The level of seed damage varied from 0 to 100% of seed in an infructescence. The average seed damage depended on the position of the fruit in the infructescence and varied from an average of 11% of seeds (for proximal fruits fully enclosed by the spathe) to an average of 31% (for fully exposed distal fruits) (Figure 4).

Seeds are stacked in layers in the fruit as their number increases. Without exception, the damaged seeds were positioned in the outside layer of the fruit. This strongly indicates that the source of damage of seeds in fruits was external to the infructescence (most likely the seed sucking bugs) and not caused by a pathogen or other organism originating from the stem or core of the infructescence (even so, pathogens could cause a reduction in seed set by affecting spadix development or pathogens could be transmitted by the insects).

**Other phytophagous organisms** The most common phytophagous arthropod observed during the survey was the larvae of an unidentified sphingid moth, possibly from the genera *Hippotion* or *Theretra*. *Hippotion eson* (Cramer), and *H. celerio* (L.) are polyphagous species that also feed on *Zantedeschia* species in southern Africa (Pinhey 1975). Two other sphingid species, *Theretra cajus* (Cramer) and *T. monteironis* (Butler) have only been recorded from *Zantedeschia* species (Pinhey 1975). The host range of these species might be worth a closer examination. *Hippotion celerio*, *Theretra oldenlandiae* (Fab.) and *T. tryoni* (Misk.) are the only moth larvae reported from arum lily in Australia (Common 1990).

No other insects likely to be host specific are known from arum lily. The polyphagous mealybug, *Pseudococcus longispinus* (Targioni-Tozzetti) was commonly observed among the fruits of arum lily during the survey, seemingly not causing any damage. The South African National Insect Collection records *Pseudococcus capensis* Brain on arum lily. This insect has frequently been confused with pest *Pseudococcus* species (Annecke and Moran 1982). Among the mites, the polyphagous species *Calacarus citrifolia* Keifer, a polyphagous eriophyid, and the polyphagous tetranychids, *Bryobia praetiosa* Koch, *B. neopraetiosa* Meyer and *Tetranychus ludeni* Zacher have been recorded on arum lily (Meyer 1981, Neser unpublished).

A fungal disease, a blackish grey necrotic blotch on leaves (possibly *Phoma zantedeschiae* Dippenaar, a widespread disease of arum lily (Boerema and Hamers 1990)), was found at most sites.

## DISCUSSION

We timed our survey for January–February based on South African records and found immature green infructescences and live plants throughout the study area. In contrast, plants in Western Australia had already fruited and senesced by this time, leaving no above ground parts alive. Interestingly, Letty (1973) uses the character ‘evergreen’ as a key element to taxonomically separate *Z. aethiopica* from its congeners. Fortunately there are other differentiating characteristics such as the presence or absence of staminodes. The species in South Africa is variable (Letty 1973) and we noticed double spathes and maculate leaves (leaves with white spots) on rare individual plants during our survey. We believe that the Australian arum lily is the South African *Z. aethiopica* and that the differences are due to the plants’ reaction to the different climate and edaphic factors found in Australia. However, the usual experience of biological control researchers is that a range of methods, in particular molecular techniques of plant taxonomy, will be required to confirm the plant’s identity and origin.

The absence of specialized seed predators in a plant with large and abundant seeds is surprising. *Z.* is the only species in the genus in the western Cape Province, since the genus has a mostly tropical and subtropical distribution (Letty 1973). Taxonomically isolated plant species tend to have a less diverse phytophagous fauna (Strong *et al.* 1984). This is ascribed to a lack of a suitable pool of herbivorous species to provide the resource for the evolution of specialized host-associated species.

The survey mainly examined infructescences with fruit. The effect of insects or pathogens on the transition from inflorescence to infructescence is unknown. At this stage it is also not known if insects and pathogens affect the tubers and stems of the plant and this will need to be examined in more detail.

Pathogens from South Africa should also be considered for biological control purposes. However, it is important that the plant be studied first in Australia to determine which pathogens are already present. For example, the dasheen mosaic virus, which is a major pest of arum lily overseas, has been reported from Australia (Greber and Shaw 1986). Also, there may be local pathogens that might be suitable for development as mycoherbicides. To this end, a survey for pathogens has started in Western Australia.

Further assessment is needed of potential conflicts of interest before arum lily could be declared a target for biological control. For example, arum lily could be further developed as a flower crop, both in cultivation or by harvesting from the wild.

## ACKNOWLEDGMENTS

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