BIOLOGICAL CONTROL OF *SALVINIA MOLESTA* IN KAKADU NATIONAL PARK, NORTHERN TERRITORY

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Summary: The extent of mats of the aquatic weed *Salvinia molesta* and population size of the biological control weevil *Cyrtobagous salviniae* were measured on six waterbodies in Kakadu National Park between 1986 and 1989. The extent of mats varied throughout each year but generally increased during the study period. *Cyrtobagous* population size varied seasonally and did not reach densities recorded during successful control of *Salvinia* elsewhere. The reason for the failure of the weevil to control the weed may be related to high surface water temperatures. A linear regression of the natural logarithm of the *Cyrtobagous* population index on water temperature 90 days before population sampling showed a significant negative relationship, P=0.01, R=0.84.

INTRODUCTION

The weed *Salvinia molesta* currently threatens the wetlands of Kakadu National Park. The plant is a free floating aquatic fern indigenous to south-east Brazil. It is sterile, propagating vegetatively from fragments, and populations can double in size in as little as 2.2 days (3). It has spread widely throughout the tropics in the last 50 years and is ranked with water hyacinth as one of the two worst aquatic weeds in the world (8).

The plant was found in Magela Creek, now within Kakadu National Park, in 1983. Government agencies in the region initially proposed chemical control with the aim of eradication, but subsequent discoveries of large infestations left biological control as the only option. The weevil *Cyrtobagous salviniae* was introduced to the infestation in early 1984. In contrast to successful control of *Salvinia* in other areas (5) *Cyrtobagous* has not successfully controlled *Salvinia* in Kakadu to date. This paper reports a study of the extent of *Salvinia* mats, size of *Cyrtobagous* populations and associated environmental conditions in Kakadu National Park since May 1986.

METHODS

The aerial extent of *Salvinia* mats, the size of *Cyrtobagous* populations and the water temperature was measured in 6 major billabongs within the Magela floodplain during the period May 1986 - December 1989. Samples were taken monthly during 1986 and otherwise generally at 3 month intervals except for 1988 when sampling was not carried out.

The extent of *Salvinia* mats was mapped in the field on 1:5,000 base maps prepared from aerial photography. An index of *Cyrtobagous* populations was obtained by extracting the weevils from 1kg (fresh weight) of *Salvinia* taken from 5 locations in each billabong. Billabongs were divided into 5 regions and one sample was taken from each, the location being chosen randomly using a spinning direction indicator. Water temperature at 2 cm below the surface was recorded at each sampling point.

Weevils were extracted from *Salvinia* samples using two methods. One sample chosen at random from each billabong was dried in a Berlese funnel until the plant material was dry and brittle to touch, as described by Boland and Room (2). The remaining four samples were submerged in water for a period of 8 hours and weevils were counted as they rested on the margin of the container at the water surface.

Nitrogen content of eleven *Salvinia* samples from the Magela Creek infestation, collected in June and September 1986, was analysed using Kjeldahl total nitrogen method.

The relationship between size of *Cyrtobagous* populations and water temperature was examined using linear regression (7). Significance of the regression model was tested with Students t test.

RESULTS AND DISCUSSION

Despite introduction of *Cyrtobagous* approximately four years ago, *Salvinia* could not be considered under satisfactory control. *Cyrtobagous* population density and water temperature appear to vary in a regular pattern throughout each year, with extent of *Salvinia* mats increasing over time (Fig. 1).

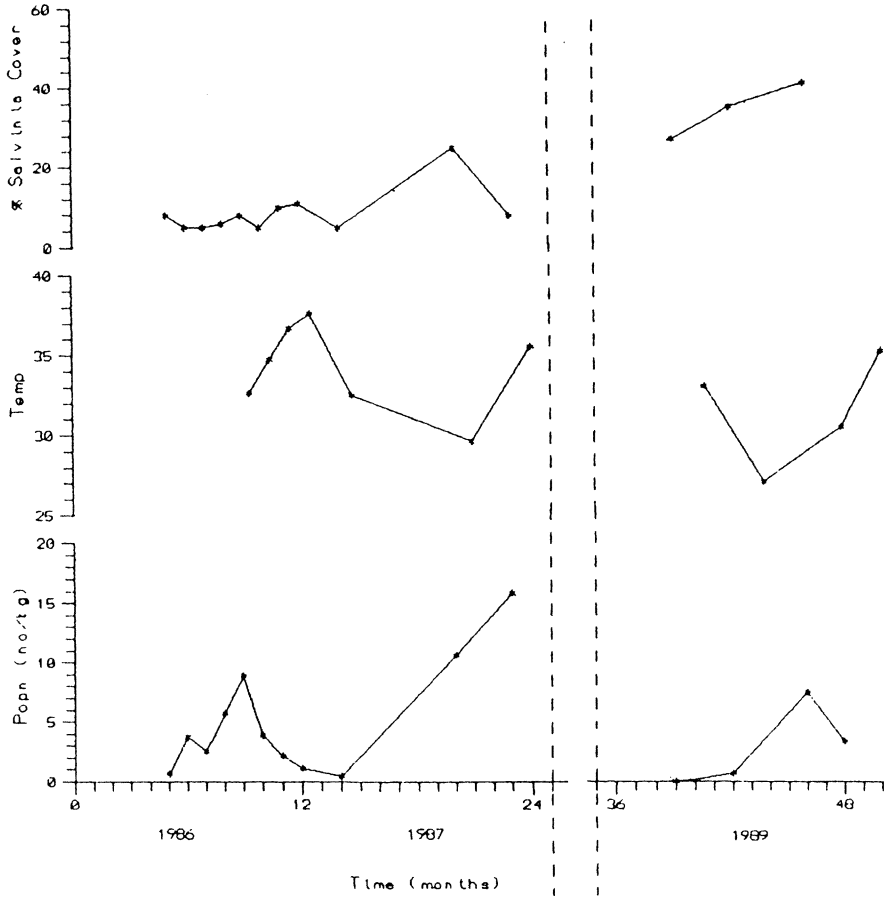

Figure 1. Changes in percent cover of *Salvinia*, water temperature and *Cyrtobagous* population size over time.

Reasons for the failure of *Cyrtobagous* to control *Salvinia* are not clear. The weevils generally persisted in each billabong but did not reach high densities. The maximum density recorded in this study was 69 adults/kg (bucket extraction) and 35 adults/kg (Berlese extraction). The highest mean density for all billabongs on any sampling date was 15.90 adults/kg (±16.56 s.e.) in November 1987. These figures are well below the maximum density of 317 adults/kg reported during successful control of *Salvinia* in Papua New Guinea (4) and below the minimum of 420 - 720 adults/kg suggested for control at relatively low nitrogen (3). Maximum growth rates are correspondingly lower. Room and Thomas (6) recorded in Papua New Guinea an exponential growth rate (r) for adults of .0263/day over 260 days. The highest

growth rate recorded in any billabong in this study for a similar period was .0101/day (264 days) with the highest rate between any two sampling periods being .0198/day (73 days).

Low levels of nitrogen have been found elsewhere to impede the establishment of *Cyrtobagous* (6). The nitrogen content of the eleven samples analysed ranged from 1.8% to 2.7% nitrogen dry weight, well above concentrations at which *Cyrtobagous* growth has been shown to be inhibited. Room *et al* (4) found that at seven sites in Australia where *Cyrtobagous* had become established, nitrogen content of *Salvinia* ranged from 1.2 to 1.8%. It therefore appears unlikely that nitrogen is limiting the growth of *Cyrtobagous* in the Magela Creek system although further information on nitrogen levels throughout the year is required to establish this conclusively.

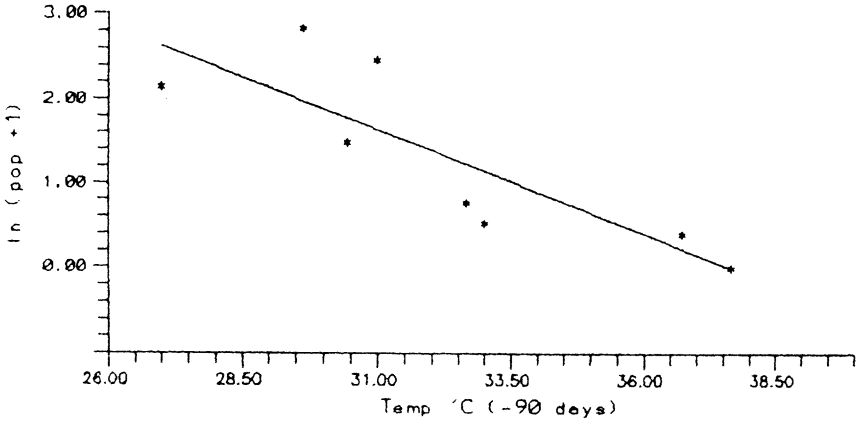

Figure 2. Temperature (90 day) prior verses *Cyrtobagous* population index (transformed by ln (Index + 1))

The size of *Cyrtobagous* populations varies seasonally as does surface water temperature (Fig. 1). Peak population levels appear to be reached approximately three months after water temperatures are at their lowest (early to mid dry season) and populations fall as temperatures rise during the late dry season. A regression of the index of *Cyrtobagous* population transformed by ln (Index+1), (y) on surface water temperature three months before population sampling, (x) gives the regression equation y = -0.248x + 9.325 and is significant (P=0.01), R=0.84 (Fig. 2). The mean population index and surface water temperature for all six billabongs are used in the analysis.

Despite suggestions that temperature will not limit the ability of the weevil to control *Salvinia* (4), the apparent relationship between high water temperature and low *Salvinia* populations found on the Magela system requires further investigation.

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