Notes and records

The impact of *Azolla filiculoides* Lam. on animal biodiversity in streams in Zimbabwe

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Introduction

Floating aquatic plants have created difficulties in the management of aquatic resources in southern Africa. The Kariba weed, *Salvinia molesta* Mitchell, and the Water Hyacinth, *Eichhornia crassipes* (Mart.) Solms, have been widely documented (Mitchell, 1973; Bond & Roberts, 1978; Ashton *et al.*, 1979; Mitchell & Rose, 1979; Marshall, 1989) but less is known about *Azolla filiculoides* Lam. It arrived in Zimbabwe in about 1980 and now infests water bodies throughout the country, although it is not yet officially considered to be a problem (Chikwenhere, 1994).

Floating plants can affect the water beneath them by forming thick mats which eliminate submerged plants and algae, prevent photosynthesis and block oxygen diffusion from the air, causing it to become anaerobic (Gopal, 1987), as well as reducing or eliminating populations of fish and other animals from the water beneath them. The wide distribution of *Azolla* in Zimbabwe suggests that it may be affecting animal biodiversity in many dams and streams. This paper gives the results of a brief survey of two streams near Harare, Zimbabwe and is the first to assess the effect of *Azolla* on animal populations in the country's streams.

Methods

Samples were taken in September and October 1998 at three stations; A and B on the Gwebi River, about 23 km and 35 km, respectively, to the north-west of Harare, while C was in the Norah River about 30 km east of the city. Each offered three distinct habitats in close proximity: (a) pools with well-formed mats of *Azolla*, (b) pools with submerged indigenous macrophytes (*Potamogeton* sp. at A and B, *Aponogeton* sp. at C), and (c) pools without vegetation.

The dissolved oxygen concentration in the water was determined by the Winkler method (Golterman & Clymo, 1969). Fish and tadpoles were caught with a hand net (60 cm diameter, 70 cm deep, 5 mm mesh), which was swept vigorously close to the river bed, ten times for 1 min at a time. Invertebrates were sampled with a hand net (30 cm diameter, 50 cm deep, 0.5 mm gauge mesh) with five sweeps, each lasting 30 s being made in each habitat. All the specimens were combined into one sample, identified to family level, and their relative abundance was expressed semiquantitatively in categories of 1–10, 10–100 and 100–1000, according to the SASS4 (South African Scoring System version 4) system for the biomonitoring of water quality (Thirion, Mocke & Woest, 1995).

Results and discussion

The concentration of dissolved oxygen was always highest in the pools with submerged macrophytes and lowest beneath the *Azolla* mat (Table 1). Fish were significantly more numerous (χ^2 test, $P < 0.05$) among the macrophytes at stations A and B, but there was no difference between the pools with *Azolla* and those without macrophytes. Station C differed in that more fish were captured in the pool without vegetation, but the numbers in the pool with *Azolla* were significantly lower. Tadpole numbers were always significantly higher in the pools with macrophytes and lowest in the pools with *Azolla*, except at station B were there was no significant difference between the pool with *Azolla* and the pool without macrophytes.

An average of 8.3 invertebrate families were collected under the *Azolla*, significantly fewer (χ^2 test, $P < 0.05$) than the number in pools with or without plants (19.0 and 17.3, respectively) (Table 2). The abundance of annelids and gastropods, and Odonata, Hemiptera, Coleoptera

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Table 1 The concentrations of dissolved oxygen (mg L^{-1}) and the numbers of fish and amphibian tadpoles caught in each habitat at each station. *Az* = *Azolla*, Mac = macrophytes present, OW = open water without macrophytes

	A			B			C		
	Az	Mac	OW	*Az*	Mac	OW	*Az*	Mac	OW
Dissolved oxygen	0.7	5.1	3.5	3.5	6.5	6.9	4.2	5.1	4.5
Fish									
Barbus lineomaculatus Boulenger							1	9	43
Barbus paludinosus Peters	27	220	18	1		2	3	15	7
Barbus trimaculatus Peters		5							
Clarias gariepinus (Burchell)			1						
Pseudocrenilabrus philander (Weber)		2			7				
Total fish	27	227	19	1	7	2	4	24	50
Amphibia									
Bufo gutteralis Power					3			2	
Hyperolius sp.				28	26		6		
Rana angolensis Bocage		542	17		74	19		150	73
Xenopus laevis Daudin								6	
Total amphibia		542	17	28	103	19	6	158	77

Table 2 The relative abundance of the major invertebrate groups in each of the three habitats at each station. The symbols denote that at least one family in a group was present, with the numbers in each sample indicated by: ○ = 1–10, ● = 11–100, ■ = 101–1000

		Azolla			Macrophytes			Open water		
	No. of families	A	B	C	A	B	C	A	B	C
Annelida	1	○			■	○		●	●	○
Crustacea	1			○			○	○	○	
Hydracarina	1	○		○					○	
Ephemeroptera	2	○					●	○		○
Odonata	8	○	○	○	●	●	○	○	○	●
Hemiptera	9		○	○	■	●	○	●	●	○
Trichoptera	1						○			
Coleoptera	5	○	○	○	●	●	○	●	●	○
Diptera	3	○	○		■	●	●	■	○	●
Gastropoda	4	○	●		○	○		○		
Pelecypoda	1			○						
No. of families	26	11	9	5	19	21	17	20	16	16

Table 3 The mean frequency distribution (%) of abundance classes of invertebrate families in pools covered by *Azolla*, and those with other macrophytes or open water

Relative abundance	Azolla	Macrophytes	Open water
1–10	96.0	63.2	76.9
11–100	4.0	29.8	21.2
101–1000		7.0	1.9
No. of families (mean)	8.3	19.0	17.3

and Diptera was reduced beneath the *Azolla* mat, with most families yielding fewer than 10 specimens and none more than 100 (Table 3).

The impact of *Azolla* was similar to that of *Salvinia molesta* in Lake Kariba, where the biomass of benthic invertebrates fell from 106 mg m^{-2} to 1 mg m^{-2} after the establishment of a *Salvinia* mat (McLachlan, 1969). This was probably a consequence of the reduced concentrations of dissolved oxygen, especially at station A, where a thick layer of decomposing plant material was deposited below the *Azolla* mats. The implications are serious for the stream biota because small perennial streams in Zimbabwe are important refuges for small cyprinid fishes and riverine frogs, whose populations have been reduced elsewhere in the country by numerous reservoirs.

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