disciplines, from weed scientists and engineers to economists. Finally the Meeting formulated four important recommendations.

1. It resolved to express strong support for the activities of the Food and Agriculture Organization (FAO) Plant Protection Committee for the Southeast Asian and Pacific region and to bring to its attention the urgent need for effective measures to prevent the international movement of noxious plants especially molesting salvinia (*Salvinia molesta* D.S. Mitchell) which is apparently limited to a relatively few countries in the region namely: Indonesia, Malaysia, and Singapore, as well as neighbouring countries such as Australia, New Zealand, India, and Sri Langka.

2. The Workshop resolved that the questionnaire campaign to monitor aquatic weed problems should be continued and expanded. It is also recommended that this monitoring work should be included by the United Nations Environment Programme (UNEP) in its Global Environmental Monitoring System.

3. It was further resolved that, in order to deal with aquatic weeds in the SEAMEO region, international organizations such as FAO, United Nations Educational, Scientific and Cultural Organizations (UNESCO), Man and the Biosphere (MAB), International Hydrological Decade (IHD), and UNEP are requested to include aquatic weed problem in their respective programs and to consider and provide the necessary financial support to BIOTROP and other concerned institutions for promoting research and control of aquatic weeds.

4. It was further resolved that an international meeting on this subject be convened in cooperation and with the assistance of UNESCO (MAB and IHD) and FAO for comparison and exchange of ideas for workers in this field.

FUTURE PROGRAM ON AQUATIC WEEDS

A manual of Southeast Asian Aquatic Weeds is envisioned as a result of the inventory and detailed mapping of aquatic weed species in the region.

In the autecological and synecological research there is a need, when appropriate, to develop techniques of system analysis to facilitate understanding of complex ecosystems and to make possible the identification of critical or sensitive relationships. The work will include: reproduction and dispersal, plant growth rates and nutritional studies, competition and succession, etc. Furthermore the autecological as well as synecological studies will serve as an appropriate base for preventive measure programs.

For a proper resource management, standard techniques to assess economic losses caused by aquatic weeds will be developed. This should include studies on the qualitative as well as quantitative data on the optimum amounts and composition of aquatic vegetation in relation to fish production, relation to other pests as rats (*Rattus* spp.), snails (*Limnaea* spp.), etc.

Biological control methods will be encouraged in the near future and it is aimed at having suitable facilities to serve the need of the region for the full scale testing and introduction of insects for release on several of the major aquatic weed species.

Waterhyacinth Problems In The Fitzroy Region Of Central Queensland[1]

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ABSTRACT

Waterhyacinth [*Eichhornia crassipes* (Mart.) Solms] is a serious problem in the Fitzroy Basin of Central Queensland. Because it is proving extremely difficult to control, various methods of control in the river and lagoons are discussed, together with the possibility of it being harvested, and used as a cattle feed during periods of drought.

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INTRODUCTION

Waterhyacinth has become a troublesome weed in stationary, or slow-flowing fresh waters in tropical and subtropical areas throughout the world, including Australia. In common with other places, the plant affects the ecological balance of infested waters (6), increases water loss through evaporation (20), aggravates the mosquito problem (16), and interferes with river traffic (25). The problem is magnified by rapid proliferation of the plant (10), and yet the weed has favorable attributes (17, 19).

Waterhyacinth spread to the State of Queensland from

New South Wales around 1900 (4). It was confined to lagoons adjacent to the Fitzroy River until after the completion of a barrage at Rockhampton in 1970. By late 1973 large areas were covered from bank to bank with waterhyacinth. This build-up occurred despite releases of impounded water, and limited spraying by the City Council with 6,7-dihydrodipyrido(1,2-*a*:2′,1′-*c*)pyrazinediium ion (diquat) and 1,1′-dimethyl-4,4′-bipyridinium ion (paraquat) upstream of the barrage. Aerial spraying below the barrage with (2,4-dichlorophenoxy)acetic acid (2,4-D) cleared the river temporarily until the December 1973 flood flushed the river clear. Reinfestation after a series of dry seasons is however likely, because waterhyacinth persists in lagoons, and seeds remain viable for many years (10).

Chemical spraying in mid-stream presents no problems, but treatment of river banks, tributaries, and lagoons is difficult. To be effective, chemicals would have to be sprayed regularly for an indefinite period. The cost would be high, and there are environmental risks (5), particularly as the water is used for human consumption. Spraying also has the disadvantage of returning nutrients from decaying vegetation which would be available for regrowth.

Harvesting, on the other hand, removes nutrients along with the plants. The harvested waterhyacinth could be used as manure (1), or as a mulch (19). Its potential as an animal feed has received considerable attention (3, 12, 14), because of its high lysine content (7, 18). An analysis of locally collected plant material was therefore undertaken, with the latter in mind. One of several lagoons near Rockhampton has not been colonized by waterhyacinth. As lagoons could differ in water quality, analyses were performed with a view to providing the basis for chemical control particularly applicable to lagoons.

METHODS AND MATERIALS

Water samples were collected weekly during September and October 1973 from an infested area (Yeppen lagoon), from the weed-free Gracemere lagoon, and from an agricultural bore drawing underground water from the Gracemere lagoon. Samples were analyzed on the day of collection by titrimetry, flame photometry (2), or atomic absorption spectroscopy.[3]

Healthy plants for growth trials were collected 2 km upstream of the barrage. They were grown under natural light, at ambient temperature in 45 liters of water covering an area of 1,700 cm^2. Water was supplied, with weekly changes, from each of the above sources.

In November and December 1973 plants in three representative 1-m^2 plots, close to the river bank, and 200 m upstream of the barrage, were harvested, and the plant material analyzed for nutritional components in triplicate (21, 23).

RESULTS AND DISCUSSION

Water from both the weed-free Gracemere lagoon and the weed-infested waters from Yeppen lagoon, was similar in composition (Table 1). Both supported waterhyacinth growth to the same visually determined extent.

Table 1. Analysis of water samples used for growth trials.

Component[a]	Yeppen Lagoon	Gracemere Lagoon	Gracemere Bore	Gracemere Bore after plant removal[b]
Calcium	10	15	140	111
Magnesium	13	11	143	138
Sodium	10	22	508	560
Potassium	10	10	5	16
Lithium	0.3	0.3	0.4	0.6
Total hardness	78	83	851	846
Silicate	—	—	14	15
Phosphate	—	—	42	48
Chloride	—	—	770	1148
Dissolved solids	253	600	3621	—
Conductivity	157	282	5130	—
pH	7.9	7.4	7.8	8.3

[a] Concentrations in mg/liter, except that total hardness is expressed as calcium carbonate and conductivity as mhos/cm.
[b] Waterhyacinth left for 7 days before water analysis

Since the Gracemere lagoon catchment includes areas surrounding the Mt. Morgan copper mine, attention was focussed on this metal, but it could not be detected. Presence of algal growth, which is sensitive to copper, also makes it unlikely for copper to be the growth inhibiting agent.

Water samples were examined before, and 1 week after the introduction of plants into the laboratory. The plants died in bore water within a week, and although overall stoichiometry was not good, there was an absorption of divalent metal ions (1.9 meq/liter), and a displacement of sodium and potassium (2.5 meq/liter), presumably as a result of a plant-induced ion transfer.

These findings raise the question as to the feasibility of controlling the weed in the lagoon network by adding chemicals to alter the ionic environment.

The bore water examined had been classed as safe for agricultural uses, but proved toxic to the plant. Laboratory studies on various metal ions will allow further study of plant responses, and perhaps establish the toxic factor prior to field trials. Alterations in concentrations of particular elements will change the quality of the water and may prove detrimental to some organisms. However, providing it remains suitable for agriculture, the prevention of the ultimate movement of waterhyacinth from the lagoons to the river would contribute much to an overall control scheme for the region. Furthermore such an adjustment, would need to be made annually after flushing of the lagoons during the wet season. This would be more favorable economically than regular spraying with commercial herbicides.

Dry matter digestibility of the plant material was 85 or 81%, depending on which of two equations (22) was used for the calculation (Table 2). Both values differ from the 55% in vivo value obtained from organic matter digestibility of waterhyacinth silage (14). While comparison with silage may be inappropriate, in vitro digestibilities do not always agree with in vivo values (15). It is also recognized that there are seasonal composition changes

[3]Parker, C.R. 1972. Water Analysis by Atomic Asorption Spectroscopy. Publ. Varian Techtron, Springvale, Aust.

TABLE 2. WATERHYACINTH COMPONENTS OF NUTRITIONAL INTEREST.

Component		Content (%)[a]	Yield (kg/ha)
Total Plant material		100.0	104,000
Water		95.2 ± 0.2	98,980
Dry matter		4.8 ± 0.2	5,020
Dry matter		100.0	5,020
Cell walls		67.5 ± 1.0	3,390
	cellulose	31.2 ± 0.1	1,570
	hemicellulose	28.4 ± 0.6	1,420
	lignin	4.2 ± 0.1	210
	residual ash	3.7 ± 0.3	190
Cell contents		32.5 ± 1.0	1,630
Protein		5.7 ± 0.1	290
Total ash		20.4 ± 0.6	1,020
Phosphorus		0.2 ± 0.0	10

[a] ± Standard error of the mean

(8), and that nutrient levels affect plant contents (11), all which could account for divergent results.

Waterhyacinth is not high in total nitrogen, but it could be valuable when other feeds are scarce. Supplies of waterhyacinth after a good wet season may be unreliable, but the plant could be abundant following a series of dry seasons. Local graziers have found the weed in lagoons to be useful in times of drought. Waterhyacinth may have a place as a supplement, particularly if mixed with urea, or if ensiled with more nutritious components (14), although it is claimed that this would only be economical when other feed was relatively expensive.

It is likely that harvesting lagoons would be impractical and uneconomical. A harvester that dumped the wet weed on the river bank would restrict its use to properties with a river frontage. On the other hand, with a water expressor (3, 13) the economics appear to be more favorable. Although some soluble protein would be lost during crushing, the residues are still almost as high in protein as the dried material (3). If such a press could operate on a rivercraft (9, 24), then the expressed product could be moved to sites away from the riverside.

At its peak the waterhyacinth was estimated to have covered 2,000 ha of the river, which would amount to some 10 million kg dry matter (Table 2). If harvested and dried,[4] this could maintain 5,000 head of cattle at 10 kg dry matter per animal per day through an average Central Queensland dry season of 200 days. Assuming conservatively that plant numbers double every 4 weeks, then a monthly harvest of half the crop would produce drought feed for 30,000 cattle a year. It would need to be established if there are sufficient nutrients in the river to permit such harvesting indefinitely.

The main argument against harvesting is that plant growth would need to be promoted, thus adding to proliferation and its attendant problems. The strategy that would need to be adopted for repeated harvesting may not be compatible with the desire for eradication. However, if the economics, coupled with drought-feeding were to prove more favorable than other means of control, then perhaps some compromise could be arrived at.

[4]Fomin, V.I. and H.D. Bruhn 1972. Dewatering and dewatering processes. A bibliography. Research Division, College of Agricultural and Life Sciences. University of Wisconsin. R 2386.

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