FLOATING GRASS MATS OF THE NORTHERN TERRITORY FLOODPLAINS – AN ENDANGERED HABITAT?

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In 1920, a Northern Territory traveller and explorer, Carl Warburton, shot an egret near Cannon Hill, just west of the Alligator River (Fig 1). The bird fell some distance away across the plain, and with the intention of securing the plumes for a lady friend in Melbourne, he and a companion walked out to retrieve it. While doing so, they walked onto a patch of grass which started rocking under their feet (Warburton cited in Letts *et al.*1979). Returning later they found they had been walking on a mat of grass floating over a waterhole which, they noted with dismay, was "infested with large crocodiles" (loc. cit.). This appears to be the first record of floating mats in the Northern Territory.

VEGETATION OF FLOATING MATS

Similar types of floating communities have been reported from a number of areas around the world: the Amazon, (Junk, 1970, 1973); Florida, (Reid, 1952); Chamba, India,(Sahni, 1927); Jaipur, India, (Trivedy *et al.* 1978); Srinagar, India, (Kaul and Zutshi, 1966); Izhevsk, U.S.S.R., (Varfolomeyeva, 1977); Java, (Little, 1969); Australia, (Williams, 1979) and New Guinea, (Paijmans, 1976), and are probably even more widespread.

Floating mat communities can be said to consist of two elements. The primary, colonising plants (floating plants such as *Pistia stratiotes* (water lettuce) and *Eichhornia crassipes* (water hyacinth)) are the basis of the mat and form a substrate on which other, secondary colonisers can grow. Both primary and secondary species vary between localities. For example, in a number of areas where there were no floating mats the introduced water hyacinth (*Eichhornia crassipes*) has become a primary mat species colonised by more terrestrial, secondary species, such as *Leersia hexandra* and *Coix aquatica* (Junk, 1977). This secondary colonisation tends to consolidate the mats, allowing larger plants such as *Phragmites* sp. and *Typha* sp. to settle. Such basically "introduced" mats have been reported in man-made and natural lakes in Java (Little,1969) and Thailand (Junk, 1977) and because of associated increases in transpiration and changes in water quality (Trivedy *et al.* 1978) are considered a serious problem.

Natural floating mats in which the dominant species are grasses ("grass mats"), are recorded from the Amazon (Junk, 1970), India (Sahni, 1927), New Guinea (Paijmans, 1976) and Australia (Williams, 1979; Gilligan, 1979). The "floating island" mentioned by Sahni (1927) was in an advanced stage of secondary colonisation with one tall grass species, *Phragmites communis*, being dominant. *Leersia hexandra* is recorded forming natural floating grass mats in the Amazon (Junk, 1970) and New Guinea (Paijmans, 1976). In Australia, *Hymenachne amplexicaulis* (probably *H. acutigluma*) has been reported as forming a grass mat (Williams, 1979), as has *Paspalum paspaloides* (Gilligan, 1979). These probably form in the same way as the "introduced" floating mats do, with a primary floating species being colonised by secondary grasses.

Despite the widespread occurrence of floating plant communities, literature dealing with the subject is very scarce. The only major study appears to be the work of Junk (1970, 1973) working in the Amazon basin around Manaus. Here *Paspalum repens* and *Echinochloa polystachya* form "floating meadows" which cover large areas in the wet season, when the vast floodplain or "varzea" is inundated (Junk, 1970). These two species of grass formed eighty to ninety percent of all floating meadows examined.

Paspalum repens can be considered a true floating grass with terrestrial and aquatic forms. The aquatic form has floatation organs and grows to lengths greater than thirteen metres with floating clumps of roots at each node. In areas where the water level is fairly constant it may grow as a perennial (Junk, 1970). *Echinochloa polystachya* also has floatation organs and a terrestrial form though it remains rooted in the soil when the water rises. Both species can and do grow in seasonally inundated ares. Junk (1970) also reports floating mats which exist for much longer periods than the "floating meadows". In lakes around Manaus, where there is little water level fluctuation, floating mats of *Leersia hexandra* develop out from the bank. Unlike *P. repens* and *E. polystachya*, which rot relatively quickly and do not provide a suitable substrate for colonisation, *L. hexandra* rots slowly, perhaps because of its lower water content, and so provides such a substrate. Dense floating mats of layers of dead *L. hexandra* roots and stems can exceed fifty centimetres in depth, the age of the mat being indicated by its thickness and the extent of secondary colonisation

Figure 1. The 'Top End' showing the major rivers and places mentioned.

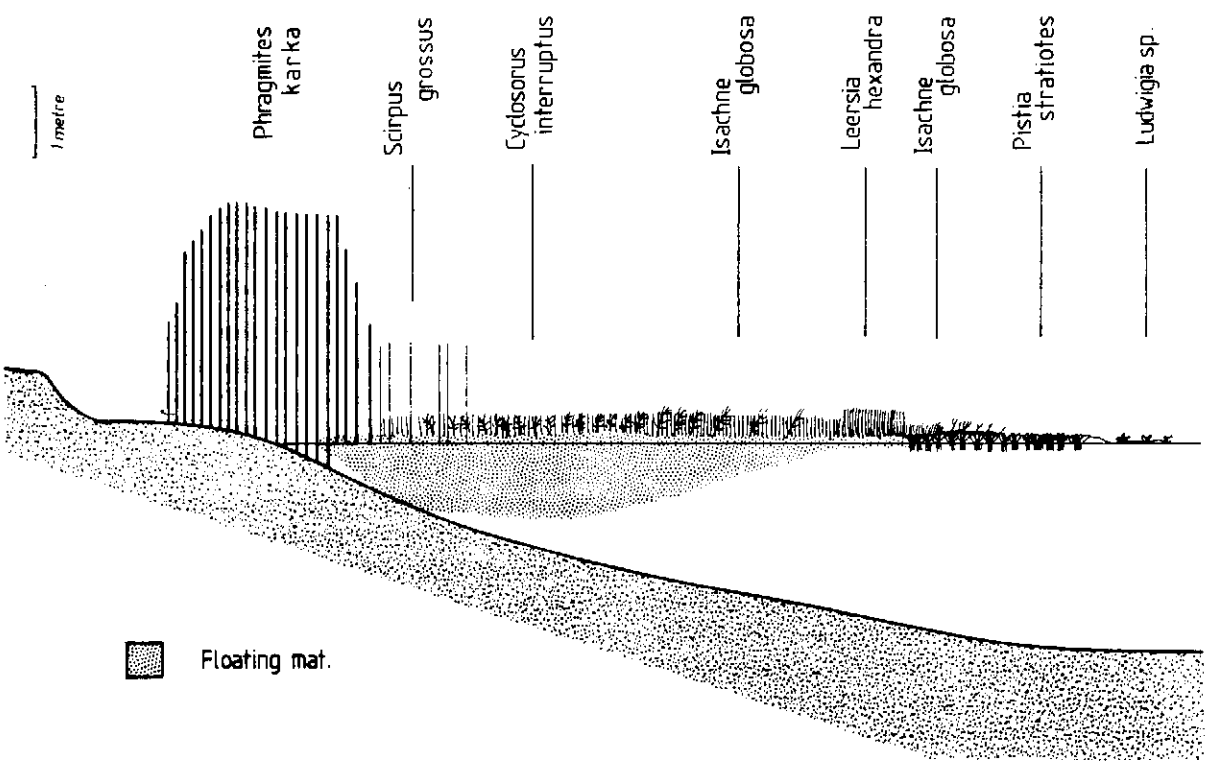

Figure 2. A diagrammatic profile of the bank and floating mat community at Bullcoin (Finnis River).

(Junk, 1970).

The "varzea" is subject to distinct "wet" and "dry" seasons with associated, major, seasonal fluctuations in water-level. These fluctuations are important determinants of the vegetation growing throughout the varzea, as tolerance to inundation is a major factor controlling the distribution of different species. Purely terrestrial plants are generally excluded from these areas, except annuals that colonise each year from adjacent permanently dry areas, or have seeds that can survive inundation. Perennial terrestrial plants are excluded from areas of seasonal inundation, if not by the physical effects of immersion, then by the problems of light attenuation in the turbid floodwaters. Similar constraints tend to exclude obligate submerged vegetation from seasonally inundated areas, either by exposing them to desiccation as water levels drop, or submerging them in water with inadequate light levels. This latter factor also tends to exclude obligate submerged vegetation from areas of permanent water. Although perhaps unsuitable for exclusively submerged aquatics or for terrestrial species, areas with marked water level fluctuations are often suited to the development of floating vegetation as the plants are always in ideal light and moisture conditions. Seasonally inundated areas may be colonised by plants with terrestrial and floating aquatic forms (such as *P. repens* and *E. polystachya* "floating meadows"), and permanent water bodies by floating mat vegetation such as that formed by *L. hexandra*.

According to Junk (1970, 1973) these floating communities are very important components of the "varzea" ecosystem. Large scale oxygen depletion has been reported from the bottom of varzea lakes in the Amazon (Schmidt cited in Junk 1973) which means that benthic fauna are excluded, at least temporarily, from large areas of benthic habitat (Junk 1973). The differing oxygen regimes and the mass of roots and rhizomes in the mat provide a variety of habitats and oxygen regimes for both sessile and pelagic fauna, which means a high diversity of ecological niches; faunal diversity is correspondingly high (Junk, loc. cit). Since the autochthonous phytoplankton production is small, Junk (1973) considered floating vegetation to be one of the richest biotopes in the water bodies of the varzea in terms of both faunal abundance and species diversity.

NORTHERN TERRITORY MATS

In Australia little attention has been directed to the floating mat communities. They exist in the Northern Territory floodplains, which are subjected to the same distinct "wet" and "dry" seasons as in the "varzea". In the Northern Territory over ninety percent of the rainfall occurs between October and March, and it is quite possible that many of the factors influencing vegetation in the Amazon apply there. However, in Australia there is strong concern that the mats are rapidly disappearing (Letts *et al.* 1979), and so, through the auspices of the Conservation Commission of the Northern Territory, preliminary studies in the Finnis/Reynolds rivers region (Fig. 1) were undertaken. These studies are still in progress, but certain trends are already apparent.

The whole of the middle and lower Finnis river was examined using recent aerial photographs at a scale of 1:16000 and by helicopter survey. In the dry season the middle reaches of the Finnis are broken into a series of permanent billabongs and it is within these billabongs that floating mats develop. The occurrence of floating mats in this area was mapped and an accessible billabong on the Finnis, considered representative, was chosen for closer study. Areas on the Reynolds River floodplain containing mats were visited on the ground and by air and photographed for comparison with the Finnis River study area.

The billabong studied in detail, Bullcoin (Boolkine) as it is known locally, is approximately four and a half kilometres long and one hundred and fifty metres at its widest point. The occurrence of floating vegetation was mapped on this billabong and different zones identified. A transect, perpendicular to the bank, was taken through a well developed mat, the vegetation mapped in detail and a three dimensional picture constructed which included vegetation height, mat thickness and water depth. The transect extended fifty-six metres out from the bank to the start of open water.

Zonation is very distinct (see Fig. 2): on the mat edge, where it meets open water, is a loose community of *Pistia stratiotes* and *Ludwigia* sp., both floating vascular plants. Moving towards the bank is a zone of *Leersia hexandra* up to fifteen metres wide; it is similar in structure to that described in the Amazon (Junk, 1970 q.v.). Closer to the bank is the "Cyclosorus" zone characterised by the presence of the fern *Cyclosorus interruptus* growing amongst grasses (mainly *Isachne globosa* and some *L. hexandra*). Also growing there are a number of vines (*Vigna* sp., *Merremia gemella, Aniseia martinicensis, Luffa cylindrica. Polygonum* sp.), the sedges *Cyperus platystylis* (approx. 1 metre) and *Scirpus grossus* (1-2 metres tall), and *Coleus scutellariodes*, a small, erect herb rooted in the mat. Here the mat is thickest, up to one hundred and twenty centimetres deep, and it will easily support the weight of a person. The "Cyclosorus" zone which occupied seventeen metres of the transect, is generally the most extensive. Further towards the bank *Scirpus grossus* is found. Here also is the same complement of vines, young *Phragmites karka*, a reedy grass growing to four metres high and some *Cyclosorus interruptus*. In some areas, thick belts of bullrush, *Typha* sp., extend out into the "Cyclosorus" zone from the "Scirpus" zone. The "Scirpus" zone is generally only two to three metres wide.

To the edge of the "Scirpus" zone grows the "Phragmites" zone, characterised by the presence of *Phragmites karka* up to four metres tall, with a mass of vines of the species mentioned growing throughout it. This zone may extend up to four metres away from the bank at Bullcoin, and in the Glasswater swamps just north of the Daly River, extended in clumps from one bank to the other (Fig. 3). *P. karka* also grows on the bank, though in the site studied, it had been largely

eradicated by heavy grazing. Where it once grew in thick clones up to twenty metres away from the water's edge (Petherick, pers. comm.), it is now in small clumps surrounded by bare soil or is in continuous stands immediately adjacent to the water's edge.

FAUNA

A series of experiments were carried out along the transect, and at points along the bank, to investigate the influence of the floating grass mats on the fauna of the water's edge. The first experiment used faunal utilization of the grass mat as a measure of importance: in particular the degree to which terrestrial vertebrates used the mat as an extension of the riparian habitat was examined.

The results examined so far are the small mammal live-trapping data. Fifty "Elliot" traps were placed on land and on the mat parallel to and 20 metres from the water's edge. Three species of vertebrates were caught: a rodent, *Melomys burtoni* : a skink, *Sphenomorphus douglasii* and a frog, *Limnodynastes convexiusculus*. Consistently more rodents were caught on the grass mat than on land. The most commonly caught animal was *S. douglasii* and many more were caught on the mat than on the bank. *L. convexiusculus* was caught only four times.

Preliminary observations and data analysis seem to support the hypothesis that the grass mats act as a food and habitat refuge in the dry season when the flush of growth initiated by the wet season dies off. The area studied had virtually no riparian vegetation at the end of the dry season (when the study was made) except immediately at the water's edge. The grass mats remain a very productive habitat throughout the year whereas the riparial habitat does not. This is evident from the large numbers of insects and other terrestrial arthropods disturbed when walking on the mat. Insects were sampled on and off the floating grass mat using sticky traps and water bath traps, and although these data have not been completely analysed, it is obvious that at the end of the dry season the floating mats are supporting many more insects than the adjacent bank.

DESTRUCTION OF MATS

The historical distribution of the floating grass mats in the billabong Bullcoin was mapped from 1963/64 and 1978 aerial photographs, which in both years were taken in June/July. Stereoscopic examination of the photographs allowed the floating grass mats and stands of *P. karka* to be easily distinguished. The loss of floating mats is dramatic: approximately thirty percent of Bullcoin was covered by floating grass mats in 1963/64, whereas in 1978 only five percent of the water's surface had floating mats. Studies of other billabongs covered by the photography show that the dramatic changes in vegetation in and around Bullcoin in the last twenty years are representative of the whole floodplain.

The loss of floating grass mats from this billabong appears to be largely attributable to the activities of the introduced feral water buffalo (*Bubalus bubalis*) and, to a lesser extent, cattle. Both species graze on the young *Phragmites* shoots, though actual trampling might be more destructive (Fogerty, 1981, pers. comm.). The levee or bank is heavily utilised by buffalo in the wet season as it is generally not inundated for long, and is often used as a "camp" from which grazing forays into inundated areas are made. The direct effect of this pressure is obvious in the dry season. The levees often have very little ground cover and the soil is heavily pugged. At Bullcoin, *P. karka* has essentially disappeared from most of the bank.

Water buffalo also graze the vegetation growing on the floating mats. This trampling and grazing can eventually break the connection between the floating mat and the bank, allowing the mats to be washed out of the billabong in the wet season, and onto the plain where they die. This destruction of floating mats is currently occurring in the Bullcoin study area.

The loss of grass mats by natural flooding was probably not important in most years. In exceptionally high water the current flow through billabongs is greatly increased and the strain on the attached section of the mat might be enough to break the anchorage to the bank. The outer margins of the mats where they are thinnest may be regularly broken off. The height of the *Phragmites karka* originally growing on the levee banks surrounding the billabongs would have prevented loose mats from washing out of the billabong altogether in an average wet season, as the flood height has exceeded this height only once in the last twenty years (Petherick, pers. comm.). A loose piece might re-attach to the bank if prevailing wind kept it on the bank long enough for grasses to grow over.

In the historical perspective, the spread of water buffalo appears to be closely associated with a reduction in the areas with floating mats. Water buffalo were introduced into the Northern Territory over one hundred and fifty years ago on the Cobourg Peninsula, but they did not occur west of the Stuart Highway until after the second World War, and did not appear in large numbers in the Finnis River until 1961 (Petherick, pers. comm.). It is apparent from the aerial photographs of 1963 and 1964 and discussions with local residents that from this time on rapid changes in vegetation began to occur which are still underway.

The records of early travellers such as Leichardt (1845) and Warburton (in 1920), suggest that the floodplains east of Darwin have undergone major changes in the last hundred years and water buffalo have been implicated in these changes. Floating grass mats have now a very limited distribution east of Darwin yet it appears that they were once much more widespread. They have disappeared from the Adelaide and Mary Rivers (Petherick, pers. comm.)., and are not now recorded from Cannon Hill where Warburton encountered them. *P. karka* was originally more extensive east of Darwin. It is estimated

that stages 1 and 2 of Kakadu National Park together originally contained three to four thousand square kilometres of *P. karka*; now there is less than one hectare growing within this boundary (Fox, 1981, pers. comm.). *P. karka* now has a very limited distribution east of Darwin.

As well as being important in anchoring the floating mats to the bank, *P. karka* is thought to play an important role in stabilizing the levee banks between the main channel and the floodplains. In some areas, the freshwater wetlands are below the level of the high tides and only the levees exclude the saline, tidal waters from intruding into the freshwater swamps. The destabilized levees are more susceptible to breaching by factors such as accelerated soil erosion, grazing, trampling and wallowing. Large areas of paperbark forests and other freshwater swamps have been killed by salt-water intrusion through breached levee banks (Stocker, 1971 and Fogerty pers. comm.).

Floating mat vegetation may originally have been a very important nesting habitat for the estuarine crocodile, *Crocodylus porosus*. In the Finnis and Reynolds River floodplains, *C. porosus* is common in freshwater billabongs and nests on the floating mats. It has been suggested that nesting on these floating mats may reduce flood-induced mortality of eggs, as in areas where *C. porosus* nest on solid substrates mortality due to flooding may be as high as ninety percent (Webb, *et al.* 1977). Crocodiles generally nest amongst tall vegetation (1-1.5m) on the grass mats (Webb, *et al.* 1982), which also tend to be the oldest and most stable parts of the mat. To re-establish mats of this nature might take decades and thus their loss may have a long term effect on the crocodiles.

The influence of floating vegetation on the freshwater aquatic communities was not looked at in this study, although it is known to have far reaching effects on the physicochemical environment and productivity (Rai and Datta Munshi, 1979). Barramundi (*Lates calcarifer*) apparently shelter under the mats and a local naturalist, Mr. J. Bell, told of how he used to set nets along the edge of grass mats, then disturb the water under the mat by jumping on it, thereby driving 'hundreds' of fish into the nets. He told of the decline in barramundi and other native fish in the years since the coming of the buffalo and the associated changes in the billabongs that accompanied the loss of mats.

As well as being a rich community in terms of faunal diversity and abundance, floating grass mats may also be an important reservoir of nutrients. A study in Jaipur of water hyacinth mats (*Eichhornia crassipes*) colonised by *Phragmites* sp. and *Typha* sp. showed much higher concentrations of calcium, phosphorus, nitrogen and magnesium in the mats than in the bottom sediment of surrounding water (Trivedy *et al.*, 1978). The grass mats are probably important in trapping nutrients washed through the billabongs in the wet season floods which would not otherwise be trapped and would not be available to be utilised.

It would thus appear that floating grass mats with well advanced secondary colonisation are not only an important extension of the bank habitat for terrestrial communities, but are also an important element in the productivity of the freshwater communities. Their loss can be expected to have serious implications for both the terrestrial and freshwater communities associated with the floodplain billabongs. At a time when the future of feral buffalo in the "Top-end" is being considered, due consideration must be given to these communities and to the pressure exerted on all freshwater and associated communities by feral grazing animals.

ACKNOWLEDGEMENTS

This study was initiated as a result of Mr. Petherick's long term interest in the floating grass mats and his steady recording of data over the last thirty years documenting the changes accompanying the colonisation by water buffalo of the Finnis and Reynolds Rivers (Petherick in preparation). We would like to thank him and Peter Fogerty for their help. We would also like to thank Johnny Bell, Rik Bukworth, Charlie Manolis and George Sack for their help. Finally, we would thank the Conservation commission of the Northern Territory who provided the financial and logistical support.

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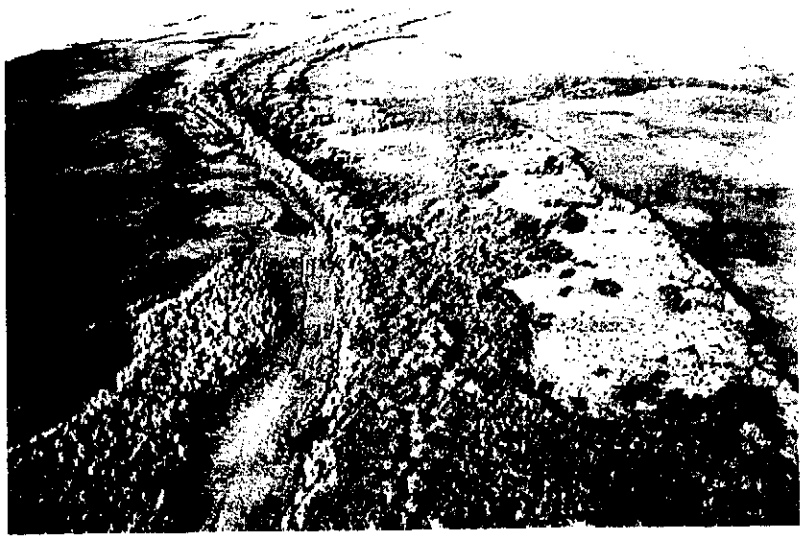

Figure 3.

A billabong in the Glasswater swamp region (see text). Here grass mats completely cover a billabong. The lighter area (centre right) is the free floating *Pistia stratiotes* (see text), which is in various stages of colonisation by grass species.

Figure 4.

An aerial view of a billabong almost completely covered by floating grass. No secondary colonisation of the grass mat has occurred. (Finnis River).