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Biodiversity Magnets in Urban Wetlands

Floating Islands

Text and images by Benjamin Lee

1. Both dragonflies and damselflies, such as this Sultan (*Camacinia gigantea*), are drawn to perches on a man-made floating island.

In a post-wild world where natural habitats are shrinking, man-made floating islands provide the much-needed refuge for biodiversity, especially in an urban context.

"I myself saw several of these islands in a small lake of sulphurous water not far from the Tiber; they were mostly circular or oval, and rose to four or six inches above water. Their surface is flat and grassy, and at the edges of them a few larger plants grow, which act as sails, so that even the lightest breeze pushes the island from one part of the lake to another. The largest of them are a few yards in diameter, yet nonetheless can sustain a few men standing upon them."

—Francesco Lana de Terzi, in *Magisterium naturae, et artis*

Floating Islands—A Natural History

Floating islands have had a long history. One of the earliest reports of such an "aquatic landform" was about a lake in Italy named Lago Della Regina documented by Italian Jesuit Francesco Lana de Terzi, who was also a naturalist (Van Duzer 2001). Essentially, such islands are formed by the growth of various plant species on masses of organic matter and they vary in size (John et al. 2009). They are quite common in tropical wetlands, as shown by the Kuttanad-Vembanad Wetland Ecosystem (KVWE) in India (see John et al. 2009) and Tonle Sap, the largest inland lake in Southeast Asia found in Cambodia. In the northern hemisphere, examples of natural floating islands occur in Turkey (Bulut 2011) and Hungary (Somodi and Botta-Dukát 2004).

Lentic, or "still waters", are ideal for the formation of floating islands, due to the relative stability of the water body and water levels (Azza et al. 2006) and the high nutrient levels giving such bodies a eutrophic condition (Somodi and Botta-Dukat 2004). The formation of such floating mats or islands of plants takes place in three main ways according to Clark and Reddy (1998): (1) floating organic substrate with submerged aquatic vegetation rising to the water surface; (2) rhizomes of aquatic plants colonising the water surface from a nucleus formed by floating aquatic vegetation that is either unattached or expanding from the shoreline; and (3) units of rooted vegetation and substrate splitting simultaneously from the bed and floating away. The fourth way in which floating islands are formed is much rarer and it has been hypothesised by a staff member of the U.S. Geological Survey to involve an initial film of floating travertine, which is a precipitate of calcium carbonate. In Zacaton, Mexico, the floating islands of several species of zacate grass began as "travertine rafts" with accumulated dust. Birds probably aided in the dispersal of grass seeds to these rafts (Van Duzer 2001). Various grass species, shrubs, and cacti have flourished on these islands as a result of colonisation and ecological succession.

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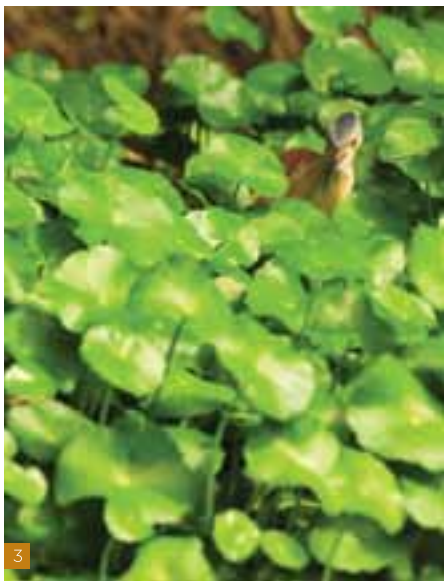

Man-made Floating Islands —A Type of Constructed Wetland

In the last few years, man-made floating islands have been installed in several water bodies of varying sizes throughout Singapore as part of Public Utilities Board's Active, Beautiful and Clean (ABC) Waters Programme to improve the quality of water in urban catchments (PUB 2011), as well as in efforts by National Parks Board (NParks) in greenery diversification and the infusion of biodiversity into the urban environment. These floating islands (also called floating wetlands) are a subset of constructed wetlands, and they are a recent innovation to improve water quality where the construction of traditional wetlands is unfeasible (Hwang and LePage 2011). The other two types of constructed wetlands in Singapore are surface flow wetlands (for example, Alexandra Canal) and sub-surface flow wetlands (for example, Lorong Halus Wetland).

Constructed wetlands serve to remove particles and contaminants through the appropriate use of plant species in a carefully configured wetland and the regular maintenance and replacement of plant species. In the case of man-made floating islands, emergent aquatic plants are grown in a multilayer-mesh matrix or mat, and the exposed plant roots occupy the water column just beneath the mat. These plants aid in the removal of contaminants from the water through the filtration and absorption of nutrients and contaminants into the plant tissues. To be more precise, the biofilm—consisting of a community of microorganisms present on the plant roots—assists in the removal of ammonium, nitrate, phosphate, and heavy metals (Stewart et al. 2009). Other man-made floating islands do not have roots penetrating the mesh in the initial set-up but over time the roots may penetrate the degraded mesh.

2. A heronry not far from the Sengkang Floating Wetlands.

3. A yellow bittern *Ixobrychus sinensis* forages in a thick growth of water pennywort *Hydrocotyle* sp.

4. An established floating island in Sengkang, a district in the north-east of Singapore.

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5. Floating islands at Pandan reservoir.


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Floating Islands Throughout Singapore

Man-made floating islands in Singapore are built by at least three different companies with their proprietary systems, and they vary in size. The most well-known example of a floating wetland complex is probably the Sengkang Floating Wetlands (PUB 2010), which is slightly less than half a hectare in size and which used some 18 species of wetland plants in its construction. These plant species are mostly aquatic emergents, such as the umbrella plant *Cyperus alternifolius*, narrow-leaved cattail *Typha angustifolia*, fragrant pandan *Pandan amaryllifolius*, dwarf papyrus *Cyperus haspan* var. *vivipurus*, aquatic canna *Canna glauca*, and blue rush *Lepironia articulata*. In addition to these plants with phyto-remediation properties, mangrove and coastal species are sometimes used as shoreline plants in a floating island planting palette. The seashore morning glory *Ipomoea pes-caprae* and piai raya *Acrostichum aureum* are two such plant species featured in Sengkang. A comprehensive account of aquatic and semi-aquatic plants to be used in such wetlands is given by Yong et al. (2010). The water bodies where the rest of the man-made floating islands have been established are diverse. We have introduced vegetated islands to: the quarry pools of Singapore Quarry, and Bukit Batok Nature and Town Parks; the reservoirs of Pandan, Lower Seletar (Enviro-Pro 2009), and just off Gardens by the Bay East; and lastly, a storm water pond beside a "green" hospital in Yishun. Small waterbodies in parks, private property, public institutions, and golf courses throughout the island are perfect for such floating islands in increasing the biodiversity on the property as well as improving the Singapore Index score on Cities Biodiversity.

Habitat and Wildlife Values

While the phyto-remediation functions of such floating wetlands are well studied and documented (Headley and Tanner 2006), there is hardly any detailed research on the biodiversity, habitat, and wildlife values of man-made floating wetlands. In natural floating islands, such as those in Zacaton, turtles and snakes have been reported to be inhabiting those islands (Van Duzer 2001). Aquatic invertebrates and fish are also known to seek shelter and feed under the cover of floating islands. In Lake Malawi in Africa, floating islands act as a fish-aggregating device (FAD) and a remarkable dispersal vehicle for a few species of cichlids and other fish species. These natural floating masses of vegetation help transport fishes across a few kilometres of deep water, and thus play an important role in the evolution and speciation of fishes in Lake Malawi (Oliver and McKaye 1982). On their own, the nearshore fishes would not attempt to swim across a deep-water column.

In a post-wild world where natural habitats are shrinking, man-made floating islands provide the much-needed refuge for biodiversity, especially in an urban context. Such floating islands add structural complexity and provide both food and shelter to wildlife (see Kircher 2004 and Ngiam 2011). In rapid surveys of demonstration floating islands in Singapore, aquatic invertebrates, such as baetid mayflies and damselfly larvae, as well as fish like the marbled gudgeon *Oxyeleotris marmorata* have been found to inhabit the root mats beneath the water surface (Lee and Lim 2012) (personal communications, Chong Jun Hien and Robin Ngiam). Butterflies, beetles, and dragonflies forage and perch on spontaneous wildflowers and reeds to take in the sun. Birds are perhaps the most conspicuous wildlife utilising man-made floating islands locally, including sunbirds, kingfishers, and herons, as well as their allies, crakes and rails, and both species of migrant reed warblers. In Bukit Batok Nature Park where a floating island has been established since 2010, a songbird of global conservation concern, the straw-headed bulbul *Pycnonotus zeylanicus*, is frequently seen in transit on the island in its flight across the quarry pool. Lizards, from the enormous water monitor *Varanus salvator* to the small flat-tailed gecko (*Cosymbotus platyurus*), have also found a home on floating islands.

6. An assembled island towed to the fallen tree in the water, where the floating islands will be anchored to.

7. One of the methods of establishing plants on a man-made floating island. Plants are placed onto a floating platform formed by buoyant PVC tubes and a mesh-netting.

8. A final check on a completed island before it is towed out into the middle of the quarry pool in Bukit Batok Nature Park.


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Improving Floating Islands for Biodiversity

Most engineered floating islands in Singapore are small and were built as test-beds for improving water quality. Hence, the role of such islands as wildlife habitats and magnets of biodiversity is limited. It is generally recognised that the size of the man-made floating island and the structural complexity of the emergent plants dictate the complexity of both aquatic and non-aquatic food webs. In the next few years, as we move from trials to implementing more substantial areas of floating islands in reservoirs and other water bodies for effective water treatment, we should put more thought into making such islands more conducive for biodiversity.

Depending on the location of these floating islands, some of these can be expanded and modified to take a heavier load by including some low fruit-bearing shrubs, such as the Singapore Rhododendron *Melastoma malabathricum* (see Yeo and Tan 2011), without compromising their cleansing function. This is to attract perching frugivorous birds, which may help in the dispersal of seeds from other plants onto the island. Where possible, floating islands should be permitted to have other weeds and plants that arrive by natural colonisation, as long as they do not impede the phyto-remediation function that they are supposed to perform. This would prevent a biotic homogenisation of plant species used on floating islands. As seen on trial wetlands in Singapore Quarry, flowering plants colonising these islands are welcoming for various pollinators, especially bees and butterflies. Native plants should be used where appropriate. A floating island that is free-form and has less sharp edges is best. It would be better if it uses a fallen tree (in the water) as a nucleus for an island. A good case in point would be the island built at Bukit Batok Nature Park. The branches serve as perches for many species, including birds, dragonflies, and basking skinks and monitors.

Because floating islands can be deployed in the middle of a water body and offer a sense of security, they will be a draw for many species of birds that live near water and possibly our resident smooth otter (*Lutrogale perspicillata*). A cleared area or stage on a thickly vegetated floating platform in a few strategic places in Serangoon Reservoir may just do the trick in infusing some biodiversity back into our Garden City! CG

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9. The floating island at Bukit Batok Nature Park has certainly flourished and is a fine example of how a floating island should be built for infusing biodiversity into the landscape.

10. Floating islands, when strategically placed, offer a refuge for many birds, especially those that are associated with vegetation near water bodies such as the resident straw-headed bulbul shown.

11. Providing perches at various heights can increase biodiversity on floating islands. A pair of white-throated kingfishers perches on a fallen tree trunk on the floating island at Bukit Batok Nature Park.