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Islands and Birds

by Harold Heatwole, and Peter Saenger

The islands of the Great Barrier Reef range from tiny sand patches so small you can barely stand on them to mountainous islands more than 150 square miles long with rocky peaks rising 3,650 feet above sea level. Some are remote and visited only by an occasional, lone scientist or beachcomber; others are built-up tourist resorts with helicopters constantly flying people in and out. The islands are also a haven for birds.

Islands and birds go together. Birds deposit guano on islands, which not only forms phosphate rock (or cay rock), but also fertilizes the soil and thus stimulates plant colonization. Birds also bring seeds to islands. In turn, the islands provide birds with a place to breed and/or nest without the disturbance of humans or mainland predators, such as rats, foxes, snakes, monitor lizards, and raptorial birds.

Although there are many species of birds on the islands, there are only two kinds of islands on the Great Barrier Reef: continental islands and cays.* Continental islands are located on continental shelves that were once part of the mainland geological formation, but became isolated as either the land sank, the sea level rose, or a combination of the two occurred. Cays are formed *in situ* as the sea and wind act on local sediments. While cays may lie on continental shelves or on remote reefs, they were never part of the mainland.

Along the Great Barrier Reef, the prevalence of these two types of island changes. The northern and southern parts of the reef contain numerous cays, whereas the central region has few. Throughout there are more than 240 cays. By contrast, the continental islands are located primarily in the central section of the reef. All in all, more than 2,100 individual reefs make up the main barrier, with 540 continental islands closer inshore supporting fringing reefs.

Cays

On the Great Barrier Reef, sand cays are composed primarily of the remains of marine organisms, such as coral, mollusk shell, calcareous algae, and foraminiferans. These organisms may be ground into small particles to form sand; water currents then deposit them on the top of the reef. A cay evolves as enough sand accumulates to be exposed at low tide and winds add more sand on top. Since cays are formed at the surface, they can date only from the time the coral reached present sea level; those on the Great Barrier Reef are only about 4,000 years old.

A view of the Swain Reefs showing two small sand cays, Bacchi Cay in foreground, Thomas Cay in background. (Photo courtesy of Menna Jones)

In addition to currents and winds, storms also are a potent force in cay development. Hurricanes can tear pieces of coral from the reef front and hurl them onto the reef. These large pieces of shingle may accumulate and form a shingle cay. On some islands, successive storms have left their mark in concentric ridges of shingle, the most recent storm composing the outer ridge and earlier ones forming the inner ridges.

Once formed, cays often change their shape. One way this occurs is through the formation of beach rock. Beach rock develops below the sand surface at the periphery of a cay. How it forms is still not completely understood, but it seems to involve the precipitation of calcium salts among the sand grains, consolidating them into rock. This can occur very rapidly. When the beach subsequently erodes, the exposed beach rock is left as an outcrop.

Cays are not only unstable, but because of the various ways they are formed, they are quite diverse: they can be all sand, all shingle, combinations of both, or have large outcrops of beach rock or cay rock.

Occurring only on the northern Great Barrier Reef, low-wooded islands form from a combination of a sand cay on the leeward side of a reef platform and a shingle cay on the windward side. The

* Keys is the American spelling. Cays is used elsewhere in the English speaking world.

A colony of Crested Terns nesting on Bell Cay, Swain Reef. (Photo courtesy of H. Heatwole)

depression between the two is then colonized by mangrove trees which, in turn, result in deposition of organic materials and the build-up of sediment. Thus, low-wooded islands often are composed of sand, shingle, and organic sediment.

Colonization of Islands

Amazing though it is, even tiny, remote islands support plants and animals. Continental islands have a head start in this regard since some of their species may have been stranded when the island formed, and have simply persisted there ever since. For coral cays, the situation is quite different. When cays emerge from the sea, they contain no terrestrial life: all their plants and animals must reach them across a seawater barrier.

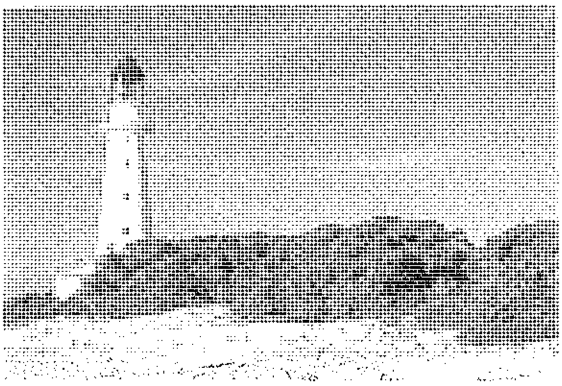
The ways that life arrives are varied. Many insular plants have seeds or fruits that can float for weeks or even months and remain viable in seawater for long periods of time. Such plants are dispersed long distances by sea currents. Others have hooks or sticky secretions on their fruits, or seeds that adhere to feathers; these plants are widely dispersed by birds as they fly from island to island. Still other plants reach the islands inside birds' digestive systems.

On One Tree Island, 48 percent of the plant species were sea dispersed and 22 percent bird dispersed. The rest were distributed either by the wind, humans, or unknown means. Curiously, few species of plants seem to reach the islands by wind. In general, the pioneer plants on small and/or new islands are sea dispersed while plants in the center are bird dispersed.

Along with plants come insects, many of which reach the islands through offshore winds. When the winds are right, many insects reach tiny, remote Willis Island, 280 miles from Australia; some are even blown from as far away as New Guinea, a distance of more than 370 miles. Although nearly 97 species of insects were carried to this island in a single season, most did not become established. Even small, weakly flying insects can be passively wafted by winds. Such strong flyers as butterflies and dragonflies, however, can cover long distances under their own power.

Another way that small, terrestrial invertebrates—insects, spiders, centipedes, and mites—reach islands is by flotsam. Logs or other debris cast adrift from beaches or flooded rivers carry on or within them a surprising variety of such animals, and help colonize distant islands.

Even after these invertebrates and plants reach the islands, they still must survive the hot, salty, waterless, and nutrient-poor conditions of newly formed sand cays. Thus, only the hardiest species persist on newer islands. As cays grow large enough to retain freshwater, and the interiors are further removed from the effects of salt spray, conditions become more benign, and more immigrant species become established. Plants help both stabilize the substrate and enrich the soil with organic matter as they die and decay. These improved conditions allow additional species of plants to colonize. The variety of plants increases from four or five species to as many as 40 species on older cays. These insects and plants change the



Beach near lighthouse bordered by shrubs (Octopus Bush, Argusia argentea*) on North Reef Cay, Capricornia Reefs. (Photo courtesy of H. Heatwole)*

The forested interior of a cay in the Capricorn Islands, Masthead Island. (Photo courtesy of H. Heatwole)

environment. For example, plants cast shade and lower the ground temperature, form leaf litter which serves as cover for invertebrates, and add organic matter to the soil.

On very small or newly formed cays, the food basis for the terrestrial community is not the plants that colonize, but the marine community. The first truly terrestrial organisms that become established on new islands are scavengers feeding on dead fish, other marine organisms that wash up onshore, and on guano and the carcasses of dead seabirds. These include earwigs, beetles, and flies. Next to settle on the cays are predators such as spiders, centipedes, and other invertebrates that feed on scavengers. Proof of this is the number of sand cays, completely devoid of vegetation, that have been found to have scavenger-based communities, complete with predators, of up to 11 species of terrestrial invertebrates. The final colonization phase involves the establishment of green plants, and the subsequent herbivores and additional species of predators. As the islands grow and contain increasing numbers of plant species, the local plants become the principal food base for the community, which thus depends progressively less on the marine community.

Insular Instability

Continental islands are more stable than cays because of their rocky substrate, high topography, and relatively large size; cays, in contrast, are usually small, flat, and sandy. While some cays remain in the same place for a long time, others have only a stable center and the edges, particularly the ends, shift back and forth with temporal changes in currents. Varying currents and storms can build and erode cays. Some cays tend to move in a continuous direction, eroding from wave action on the windward side, and redepositing sand on the leeward side. Cays can creep progressively across the reef seemingly destined to disappear over the reef edge into deep water.

Instability is related partly to cay size. The smaller, lower cays are generally less stable than the larger ones. Successive aerial photographs can map the changes of an island such as Bylund Cay in the Swain Reefs section of the Great Barrier Reef. In 20 years, this cay moved across its reef so much that only about a fourth of it overlapped in photographs taken in 1964 and again in 1984.

Insular Vegetation

As an island changes, so does its vegetation. Cay vegetation relates to an island's size, age, and stability. Generally, the larger the island, the greater the number of species of plants. Large cays are less susceptible to washover by the sea, except on the edges, and the intensity of salt spray diminishes toward the interior. Many islands have a ring of shrubs, especially *Argusia argentea* and *Scaevola sericea*, around the edge. A comparison of the levels of salt spray on the seaward and interior sides of the shrubs demonstrates that they form an effective barrier against air borne salt and thus ameliorate conditions inside the shrub ring. This permits plants that could not otherwise survive to grow, increasing the number of species that can eventually culminate in a forest.

In these ways, the cay and its vegetation develop together in five stages. In the first Pioneer Stage, only low, hardy plants cover the entire island sparsely. Next the Herb Flat Stage contains two vegetation zones: 1) the pioneer vegetation around the edge where conditions are harsh and unstable; and 2) a denser, lusher cover with more species in the milder interior conditions. The third stage is the Shrub-Ring Stage which differs from the second one by the presence of shrubs separating the beach and interior zones. In the fourth Parkland Stage, shrubs and trees occur in the interior herb flat forming an open woodland. Finally, the Forested Stage features a series of concentric vegetation zones: the pioneer vegetation on the edge followed by a ring of shrubs with a forest replacing herb flat and parkland in the center.

Although many islands on the Great Barrier Reef conform to these stages, many do not, but instead are affected by local conditions. Shrub rings

Mangroves (Rhizoho form part of the vege courtesy of Peter Sae

may be incomplet parkland in some areas with brackis of succulents, and conditions.

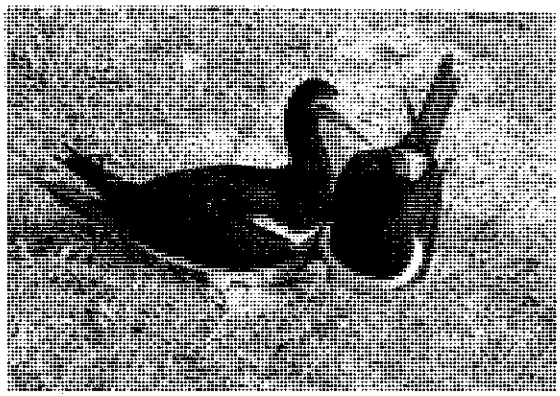
Composite special case. The sections often rese shingle cays, respe islands with mang many species of m sites, the mangrov communities. In o species of trees oc sediments. The se woodland on the forest, primarily of *stylosa*, but occasi This mangrove for sediment zone wh exposed windwar shrubs in small, ou

Mangrove islands is often rev of deterioration. S one side, a lopsid while the sea eats directly on the late the Pioneer zone i the mature vegeta words, when erosi opposite sides, the as a remnant near part of the island i

Seabirds and Vege

Island vegetation a associated. Not or islands and fertiliz plants by tramplin gannets can break soil. Where bird d some cays to appe are in the soil.

*Mangroves (*Rhizohora stylosa*) with their graceful stilt roots form part of the vegetation of low wooded isles. (Photo courtesy of Peter Saenger)*



A pair of Brown Boobies and their chick on Bylund Cay, Swain Reefs. (Photo courtesy of H. Heatwole)

may be incomplete or the interior may have parkland in some places and forest in others. Low areas with brackish water seepages may have a mat of succulents, and mangroves may produce different conditions.

Composite islands with mangroves are a special case. The vegetation of sand and shingle sections often resembles that of sand cays and shingle cays, respectively. However, the parts of islands with mangroves are unique and consist of many species of mangrove trees. In the leeward sites, the mangroves are divided into two communities. In one, mature woodlands of up to six species of trees occur on the higher, more protected sediments. The second community, peripheral to woodland on the leeward reef margin, is a mangrove forest, primarily of the stilt-rooted *Rhizophora stylosa*, but occasionally containing other species. This mangrove forest extends out to the edge of the sediment zone where live corals begin. The more exposed windward sites support dwarfed mangrove shrubs in small, outlying patches.

Mangrove or otherwise, the development of islands is often reversed by a degradational process of deterioration. Since cays usually erode only on one side, a lopsided vegetational pattern occurs: while the sea eats away the beaches and encroaches directly on the later-stage vegetation on one side, the Pioneer zone is still intact between the sea and the mature vegetation on the other side. In other words, when erosion and sand deposition occur on opposite sides, the central type of vegetation is left as a remnant near the eroding edge, and the newer part of the island is covered with pioneer vegetation.

Seabirds and Vegetation

Island vegetation and seabirds are intimately associated. Not only do birds carry seeds to the islands and fertilize the soil, but they also affect plants by trampling on them. Heavy birds such as gannets can break off parts of plants and compact soil. Where bird densities are high, this effect causes some cays to appear bare when, in fact, live roots are in the soil.

For example, Gannet Cay was once heavily vegetated with Tah-vine (*Boerhavia diffusa*). Now the large fleshy roots send up shoots, but they seldom get more than a half inch tall with a few small leaves before birds destroy them. Eventually, if this situation continues, the roots use up their stored energy reserves and die. In this extreme case, birds virtually strip a cay. Wire-mesh cages that exclude seabirds have been built around several small plots on Gannet Cay, and the vegetation growing inside shows the effect of the absence of birds.

Another way seabirds adversely affect plants is by producing excessive guano. Although guano is beneficial as fertilizer, too much can burn plants. Although some species of plants on coral cays can tolerate levels of guano that would kill other plants, even these plants can succumb to both the trampling and excess guano prevalent immediately around nests.

Sometimes, however, another cycle occurs: birds nesting on bare sand improve the soil and permit plants to grow. This provides suitable nesting sites for additional species of birds that, in turn, kill the plants, opening up bare patches. When these birds leave and the vegetation recovers, this cycle continues as birds return to nest on the sand.

Birds on the Islands

Continental islands have a wide variety of land birds living in habitats similar to those they occupy on the mainland. Cays, in contrast, have fewer such habitats and thus more seabirds than land birds.

Seabirds are mainly associated with coral cays where they breed. The Great Barrier Reef, with its abundance of cays and coral reefs is one of the richest areas in the world for tropical and subtropical seabirds. Twenty-nine species of seabirds from seven different families, including gulls, terns, gannets, shearwaters, herons, and frigatebirds are distributed throughout this region. Of these, 19 species breed there with colonies occurring on at least 78 different islands.

Sea Turtles

The Great Barrier Reef is one of the few places in the world where several species of sea turtles still abound. Although vast numbers of immature and adult green turtles, Chelonia mydas, *live year round within the Great Barrier Reef, most that breed there actually live in the waters of neighboring countries. Green turtles, for example, inhabiting the Coral Sea/Arafura Sea region, usually migrate to breed on a few coral cays such as Raine Island and Pandora Cay in the north and the Capricornia Islands in the south.*

The Hawksbill turtles, Eretmochelys imbricata, *live sparsely on every coral and rocky reef, and also migrate to specific nesting beaches–small sand cays on the inner shelf in the far northern section and in Torres Strait. Some, however, migrate internationally to breed as far afield as the Solomon Islands. Most loggerhead turtles,* Caretta caretta, *living in the Coral Sea/Arafura Sea region breed on the small sand cays of the Capricornia Section and the surf beaches of the adjacent mainland in the south. Loggerheads live principally in the sandy lagoons of the reefs and in the inshore bays.*

While green and loggerhead turtles migrate across deep oceanic waters, the flatback, Natator depressa, *never leaves the shallow waters of the continental shelf. Within the Great Barrier Reef, flatbacks migrate to the southern end to nest on continental islands such as Peak and Wild Duck Islands. Small numbers of olive ridley turtles,* Lepidochelys olivacea, *also live in the inshore turbid waters along the reef, but it is not known where they breed, only that they have not been found breeding within the Great Barrier Reef.*

Each turtle has a home feeding ground, probably encompassing 100,000 square meters, where it can be found for many years. At breeding time, the adults migrate to their own specific breeding areas. The peak breeding season lasts from October to February, but may occur less frequently at other times of the year. Courtship occurs in the sea; each female mates with a series of different males for a few days. In this way, she acquires enough sperm to fertilize the hundreds of eggs she lays in the following weeks. The males return home after a month of courtship while the females move to their inter-nesting habitat, usually quiet, shallow areas near the nesting beaches.

During one nesting season, each female will lay three to five clutches of approximately 120 eggs (with flatbacks averaging 50 eggs to the clutch) in two weekly intervals. According to estimates of growth rates, the turtles appear to be about 50 years old when they mature for first breeding. After a breeding season, female turtles return immediately to their home feeding ground where they remain for many years before migrating again, usually to breed at the same beach.

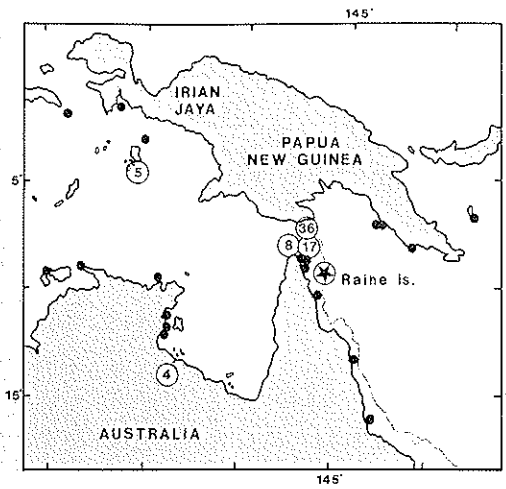
Many green turtles, *Chelonia mydas*, nest on Raine Island, one of the few remaining green turtle rookeries in the world and the only one in the southern Pacific Ocean. (Photo courtesy of Colin Limpus)

When sea turtles nest, they dig a large pit in the sand in which they lay their eggs. In so doing, they break vegetation and tear up whole plants by the roots. On small islands, the nesting area may cover the entire island, and be heavily pitted throughout. Only the pioneer plants, especially the vines and those that send out runners, survive; thus, sea turtles tend to keep the parts of the islands where they nest in the pioneer stage.

Sea turtles require specific nest temperatures. Temperature at nest depth determines the location of major turtle rookeries. Turtle eggs will not hatch if the nest sand is cooler than 24 degrees Celsius or warmer than 34 degrees Celsius. The beaches of the Great Barrier Reef are a suitable temperature for successful year round breeding in the north, but are suitable only for summer breeding in the south.

The nest temperature during the middle 50 percent of incubation determines the sex of the hatchlings. Each species has a temperature that determines sex and uses nesting beaches that provide the range of temperatures necessary to ensure hatchlings of both sexes. However, the number of turtles that survive from hatchlings to breeding adults is extremely low, perhaps as low as a few hatchlings per 10,000.

Sea turtles and their eggs long have been the traditional food of coastal and island peoples. Unfortunately, turtle and egg harvests have



Feeding ground recaptures of female turtles, *Chelonia mydas*, tagged while nesting at Raine Island and adjacent Pandora Cay. Circles designate a single recapture; circled numbers denote multiple recaptures.

escalated in the 20th century with the use of more efficient catching techniques and improved transport facilities. This, along with the degradation of many turtle habitats, now threatens sea turtles. Positive conservation management by both Australia and her neighbors is required to ensure the survival of turtles, which by their intrinsic biology, cannot adapt to long-term intensive harvests or rapid alteration of their environment.

—Colin Limpus, Australian National Parks and Wildlife Service

Some of the colonies are large: 20,000 Sooty Terns (*Sterna fuscata*) nest on Michaelmas Cay and 10,000 on Raine Island (along with 12 other species); 70,000 Black Noddies (*Anous minutus*) nest on Heron Island and 160,000 on North West Island. In addition, 8,000 Common Noddies (*Anous stolidus*) nest on Michaelmas Cay and 6,000 on North Reef Cay on Frederick Reef; 750,000 Wedge-tailed Shearwaters (*Puffinus pacificus*) nest on North West Island. The amounts and types of seabirds that breed on any particular island usually depend on the accessibility to their hunting grounds and the presence of suitable habitats for nesting.

Some islands are more important breeding sites than others. The 10 most important ones in descending order are: Raine, Bramble, Michaelmas, Swain Reefs (a number of small cays), Masthead, North West, One Tree, Wilson, Pipon, and Fairfax. Many more are collectively important nesting areas such as the Capricorn group of islands. Including both breeding and non-breeding birds that use the cays for roosting, there are an estimated 1.5 million Wedge-tailed Shearwaters, half a million Black Noddies, more than 3,000 each of Crested Terns and Bridled Terns, and 2,000 each of Black-naped Terns and Roseate Terns in the Capricorn area.

Along with the seabirds, many shorebirds and waders, such as sandpipers, plovers, curlews, whimbrels, and tattlers inhabit the beaches of cays. These birds are closely linked with the sea, but are not usually considered true seabirds. Some remain only seasonally or during pauses in their migratory flights. The reefs and beaches of some of the Great Barrier Reef islands have become important habitats for their feeding and roosting since estuaries and continental shores have either been destroyed or populated by humans.

Land birds are a less conspicuous part of the avifauna of cays, although a few species such as the Silvereye (*Zosterops lateralis*), Buff-breasted Rail (*Rallus philippensis*) and Bar-shouldered Dove (*Geopelia humeralis*) breed on the more heavily vegetated cays. Many land birds that are lost, blown offshore by storms, or merely stop during migration are non-breeding transients on cays. For example, 18 transient species of land birds have been sighted on One Tree Island.

As long as there are islands, birds probably will inhabit them. Continental islands and cays attract different species of birds because of their varying resources. As cays and their vegetation change, so does the bird fauna. Some of the islands and cays are already national parks, a situation that will protect the birds and encourage them to continue nesting there.

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