

Surrounding the 17 000 islands that make up Indonesia are some of the most biodiverse marine environments in the world. In fact, so many marine organisms abound that the country has been designated the centre of marine biodiversity. A large part of this biodiversity occurs within coral reefs and in particular, among the *Acropora* or staghorn corals.

Director of the Museum of Tropical Queensland at Townsville, Dr Carden Wallace, has dedicated her life to 'discovering' and describing the diversity of staghorn corals, which number 350 'nominal' and 104 'valid' species*. Her knowledge of their systematics and biogeography is helping an international team of scientists to unlock the secrets of Indonesia's biodiversity.

'We're trying to understand why Indonesia is so biodiverse,' Wallace says. My approach is to document all the *Acropora* species present and see where they fit in terms of the evolution of the group. So I look at their place in the phylogenetic (evolutionary) tree.'

By examining coral skeletons, Wallace can trace their ancestry. More ancient staghorn corals tend to be chunky and only slightly branched, while modern corals are often delicate and highly branched. Other microscopic details such as the shape and size of the 'corallites', the cups in which coral polyps sit, add to the evolutionary picture. Wallace's research, backed up by the fossil record, has convinced her that the staghorn corals did not originate in Indonesia.

'A feature of reef coral distribution is that the numbers of coral genera decline in a concentric pattern, from a high in the Indo-West Pacific, and from smaller centres in the Western Indian Ocean and Caribbean,' she says. 'This distribution pattern has fuelled



Branches of evolution

the idea that areas of high coral diversity are the origin of that diversity, and that this diversity gradually declines from a "centre of origin".

'However fossil evidence, documented by Brian Rosen at the Natural History Museum in London, has shown that the genus *Acropora* originated in either northern Africa, Spain, Italy or Yugoslavia, but not Indonesia.'

A recent discovery by Wallace and her museum colleagues, of several recently evolved species of *Acropora* in Indonesia, strengthened Wallace's view that the Indo-Pacific corals evolved as a composite fauna with origins in a number of events in space and time.

But just what these events were is the subject of at least five hypotheses put forward by Wallace and her five international collaborators. Until recently, Wallace's favoured theory was that the waters around Indonesia were a relic of the

Tethys Sea, which separated the Asian and Australian continents more than 200 million years ago. When Australia broke off from Gondwanaland, it moved north towards Asia, as did many smaller pieces of land that make up Indonesia today. This continental movement disrupted the Tethys Sea, leaving relics of the marine flora and fauna in small pockets around Indonesia.

'When you look at the sea you're looking at the opposite of the land,' Wallace says. 'Rather than looking at what's come together, you're looking at what's been chopped up in the marine environment.'

This theory could account for the occurrence of many ancient and modern *Acropora* in Indonesian waters.

'I found one *Acropora* species that may be a 'missing link' and therefore is reasonably ancient,' says Wallace. 'However, I subsequently found recently evolved species that indicated a link with the Western Pacific.'

Wallace has recently warmed to a second hypothesis, proposed by her colleague, Dr Gustav Paulay of the University of Guam. He suggests that during the Ice Age, many organisms became extinct because they lived in reef lagoons that dried up. To repopulate those areas, common shallow water species may have migrated from other parts of the world, but rarer lagoonal species may have remained trapped in deepwater lagoons.

'There is evidence of a group of organisms that became extinct in the central part of the Pacific Ocean, and were restricted to the deep, calm lagoons you get in



Indonesia and parts of Papua New Guinea and the western Pacific,' Wallace says.

'I have collected many unusual corals from Indonesia, which I thought were ancestral, but my studies are beginning to show they're more recent. So rather than being tied up with events that happened 200 million years ago (Tethys Sea), they might have only evolved two million years ago (Ice Age). But that's not to say there isn't the odd Tethyan relic in there as well.'

Wallace and her colleagues are collating their specimens and data into a form that addresses their various hypotheses.

'We're trying to find out which theories fit with our collective data, and whether there are any we haven't thought of,' Wallace says.

An important outcome of this work will be a better understanding of the links between the marine diversity of different countries, and the implications for conservation. Central to this understanding is the concept of 'connectivity'.

'No reef exists in isolation, because coral spawn travels to other reefs and oceans. And the corals and fish in one reef come from other places,' Wallace says. 'If one reef is damaged, it depends on reefs elsewhere to be restored to its natural state. You need to maintain this connectivity or you'll damage more than the original reef. So an understanding of what you have is essential in planning its care.'

** Nominal means in name only. Many Acropora have been classified as different species, but are actually variations of the same species. The valid species name is the name of the 'true species' after variations within 'nominal' groups have been accounted for. The oldest name is selected as the valid name for the species.*

Right: Dr Carden Wallace: her knowledge of staghorn corals is helping to unlock the secrets of Indonesia's extraordinary marine biodiversity.

Top and lower left: The Museum of Tropical Queensland houses two major research collections of corals. The Australian Institute of Marine Science Monograph Coral Collection consists of 18 000 specimens and documents variability within all corals of the Great Barrier Reef. The Worldwide *Acropora* Collection consists of 15 000 staghorn coral specimens collected worldwide. These are documented in Wallace's book *Staghorn Corals of the World*, and an interactive CD-ROM key to the identification of staghorn corals (both available through CSIRO Publishing). The museum also houses major collections of marine mammals and deep-sea animals.

Wendy Pyper talks to Dr Carden Wallace about the role of staghorn corals in tracing the history of Indonesia's spectacular marine biodiversity.

