Parasitic Seaweed

photos and words
by John Huisman

Rarely seen, a group of miniscule seaweeds have adopted a seemingly alien lifestyle and become parasites, often of their close relatives. Here we look at how this unusual behaviour might have evolved, what it takes to be a parasite, and a closer look some of the distinctive species found in Western Australian seas.

Opposite page
Main The red seaweed parasite *Trichidium*, visible as white tufts on *Lophocladia kuetzingii*.
Inset Close-up view of the branching *Trichidium pedicellatum*.

Above The mistletoe *Amyema xiphophylla*, a hemiparasite on *Acacia*.
Photo – William Muir

Seaweeds are often described in derogatory terms such as 'foul smelling' and 'rotten'. Even 'weed' has negative connotations, despite very few seaweeds being actual weeds. 'Parasite' is a term that we rarely use when we refer to seaweeds. After all, seaweeds are photosynthetic, and, for all intents and purposes, are usually classed as plants, able to generate their own energy.

Parasitic plants do occur, and are common in Western Australia's terrestrial environment. The Christmas tree (*Nuytsia floribunda*, 'Moodjar' in Noongar), with its bright orange flowers, is hemiparasitic and gains part of its energy by stealing sap from the roots of neighbouring plants. The tree is a mistletoe, closely related to spectacular aerial species such as *Amyema xiphophylla* that are hemiparasites on *Acacia*. Despite these examples, the more common perception of parasites is of animals.

There is, however, a relatively small group of red seaweeds (approximately 120 species) that qualify for the term 'parasites', as they grow on and parasitise other red seaweeds. These parasites can usually be recognised by their appearance – white and unpigmented; their classification as 'red' algae is based more on their structure rather than their colour. They are typically small, often pustular, although several are branched and might easily pass for regular seaweeds if it wasn't for their lack of colour.

BIOLOGICAL BACKGROUND

That the red algae have been capable of adopting a parasitic lifestyle is most likely due to an unusual feature of this group: the ability to form secondary connections between cells, which often then leads to fusion of the cells and the sharing of cell contents. These connections and subsequent fusions are common in several groups of red algae, and is likely the same process when cells of the parasite connect and fuse with host cells. The fusion of cells allows the passage of cell contents between host and parasite, including organelles such as chloroplasts.

To qualify as a parasite, these seaweeds have to conform to a set of characteristics. Firstly, they should penetrate beyond the superficial layer of the host; secondly, they should be relatively small (generally less than one centimetre tall); thirdly they have minimal or no colour; and lastly all phases of the life cycle should be present on the same host.

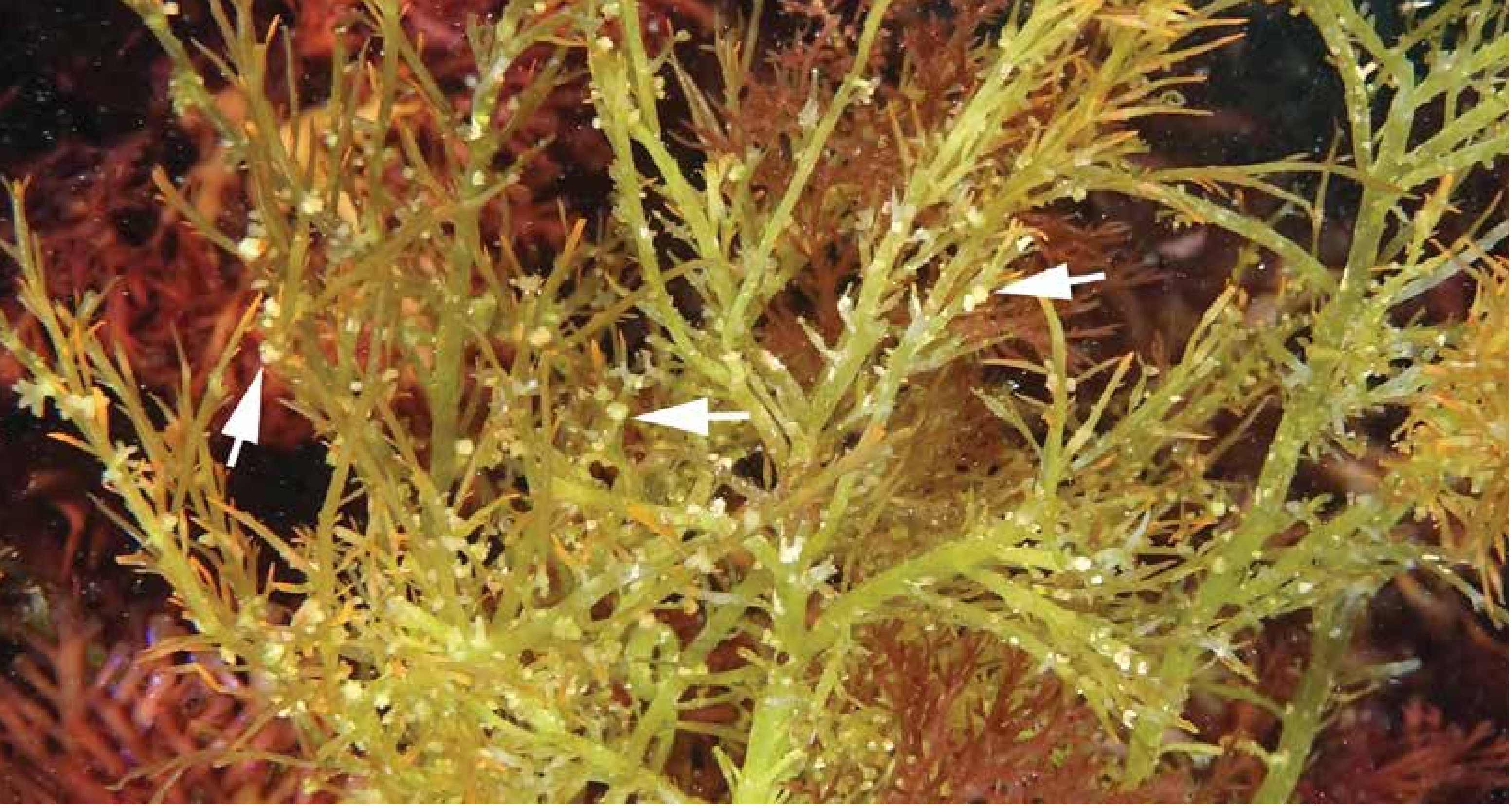
All parasites sexually reproduce, so it is clear that they are not just galls or deformities of the host seaweed. Red algal parasites are generally recognised as independent genera that include only parasitic species. They are often closely related to the host species (in the same taxonomic family) and in many cases DNA sequencing has placed them in the same genus, suggesting they may have evolved directly from the host. Some parasites have evolved from species closely related to the host, but no longer live on their direct ancestor. DNA analyses of the phylogenetic origin of red algal parasites, has suggested multiple independent origins, but equally that the parasite can be nested within the host genus. This could result in taxonomic changes where parasites lose their generic status.

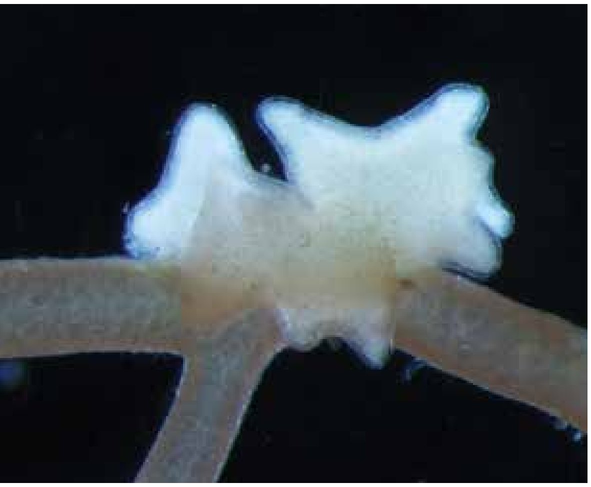
COST OF THE RELATIONSHIP

Superficially there does not seem to be any significant detrimental impact on the host plant, although this is difficult to assess in field material as the host seaweeds do not show obvious damage. However, a study that looked at growth rates of *Hypnea musciformis* infected by the parasite *Hypneocolax stellaris* in Hawaii found that, relative to uninfected plants, growth was reduced by up to 40 per cent in field material and 70 per cent in laboratory grown plants. *Hypneocolax stellaris* is a pustular species common in southern Australia, where it parasitises *Hypnea ramentacea*.

The biology of these parasites has been investigated in detail in only a small number of species, but of those species the parasite establishes a cellular connection with host cells by fusion, and then transfers organelles (nuclei, plastids and mitochondria) into the host cells. The parasite can then exert control over the host cells for its own benefit.

Parasites that infect closely related species (within their own family) have historically been known as 'adelphoparasites', and account for about 80 per cent of red algal parasites. While those that infect more distantly related species are termed 'alloparasites'. These categories are being replaced with terms that more closely reflect the biology of the parasites, with 'archaeplastic' referring to those parasites that retain a native chloroplast (formerly most alloparasites), and 'neoplastic' for those that 'hijack' host chloroplasts that are incorporated into





Top *Hypnea ramentacea,* with numerous pustular *Hypneocolax stellaris* (arrows).

Above Close-up view of the pustular *Hypneocolax stellaris.*

developing spores, rather than retain their own.

While native chloroplasts are retained in archaeplastic species, they have lost the genes for photosynthesis. However, they retain genes for other functions such as the synthesis of important compounds like amino acids. All parasites maintain a fully functioning mitochondrion (the organelle responsible for energy production) in their cells.

TAKING A CLOSER LOOK

Being small and inconspicuous, red algal parasites are often overlooked, and even diligent observers can miss them. In the early 1970s, the phycologist (a person who studies seaweeds) Gerry Kraft collected an unusual seaweed parasite growing on the red alga *Lophocladia kuetzingii* (at the time known as *Lophocladia harveyi*), from Port Denison in Western Australia. Realising the novelty of his find, Gerry returned to the locality twice in 1979 and 1980, but despite *Lophocladia* being present in abundance, there were no further traces of the parasite. A few years later, student Joanne Noble and Gerry formally described the parasite as the new genus and species *Trichidium pedicellatum*, along with two other red algal parasite species in the genera *Holmsella* and *Meridiocolax*. Currently there are 12 species of parasitic red algae known in Australia, in 12 separate genera. Many of these are poorly known, and *Trichidium pedicellatum* has remained unobserved in the almost 50 years since its first discovery.

The only known host of *Trichidium*, *Lophocladia kuetzingii*, is seasonally common at Cape Peron, south of Perth. While snorkelling there recently I noticed unusual white tufts growing on some of the plants, the tufts at most maybe half a centimetre tall. Initially suspecting them to be a reproductive structure, I collected some material and examined it in the laboratory under a microscope and discovered that these white tufts were in fact the long-lost *Trichidium*. Despite their small size, all the plants were reproductively mature and all life cycle stages were present. In the red algae this encompasses three phases, including a spore-bearing stage, which releases spores that grow into separate male and female plants, and a second spore-bearing stage that develops on the female plant after fertilisation.

The discovery of fresh material will enable us to assess whether *Trichidium* is indeed a parasite, and to undertake genetic analyses to better understand its relationship with the host *Lophocladia*. Despite their small size, red algal parasites are a fascinating group and there is still plenty to learn about their diversity and the evolution of their unusual lifestyle.

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