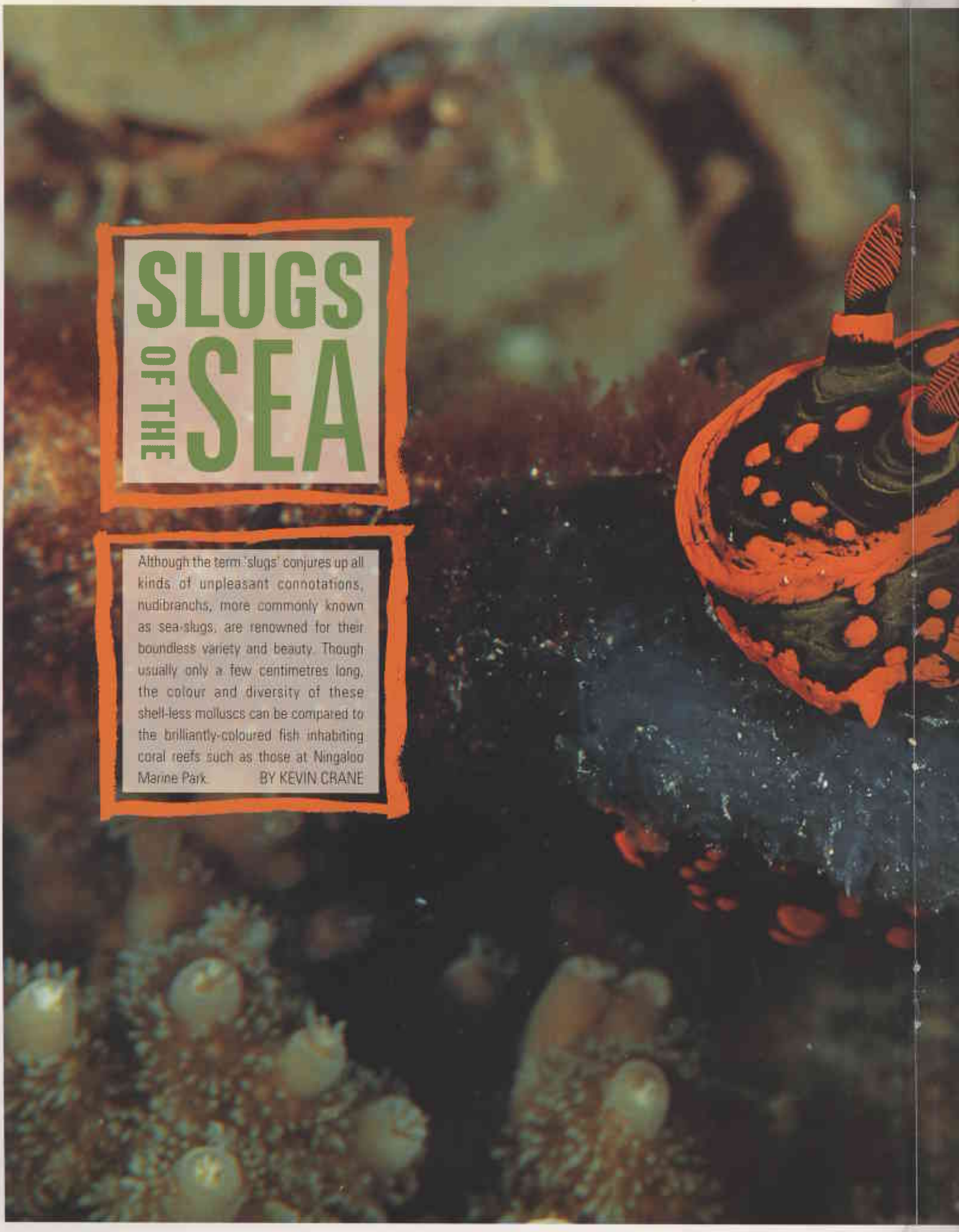

SLUGS OF THE SEA

Although the term 'slugs' conjures up all kinds of unpleasant connotations, nudibranchs, more commonly known as sea-slugs, are renowned for their boundless variety and beauty. Though usually only a few centimetres long, the colour and diversity of these shell-less molluscs can be compared to the brilliantly-coloured fish inhabiting coral reefs such as those at Ningaloo Marine Park.

BY KEVIN CRANE

Nudibranchs (pronounced 'noo-dee-branks') are widespread throughout Western Australia's marine environment. On reef walls or reef tops of Marmion Marine Park, near Perth, or other parts of south-western Australia, diminutive blue and orange nudibranchs may nestle among an array of other invertebrates, such as sponges, on which some predate. At places like Ningaloo Marine Park, in the State's north west, nudibranchs with extremely elaborate gills can sometimes be seen. The striking patterns of neon orange and green on their velvety black bodies almost defy description. These are just a few examples of the hundreds of species of nudibranchs that have so far been recorded in Western Australian waters.

Nudibranchs are molluscs belonging to the gastropods, the largest class of molluscs. Among the gastropods, the marine snails (such as cowries, abalones and so on) and the land snails (such as the common garden snail) are far more numerous. The sea-slugs comprise not only the nudibranchs, but also the bubble shells, sea hares, sacoglossans (a diverse group with shelled and shell-less forms), side-gilled sea-slugs and pteropods, which lead a planktonic existence. While they are the most physically diverse group of gastropods, they comprise only a few thousand species and comparatively little is known about them.

Sea-slugs include species in all stages of the evolution from snails to slugs. Primitive sea-slugs like bubble shells still have a shell into which the animal is able to withdraw. In many other species, however, the shell has become reduced to the point where the animal is unable to withdraw into it. Sea hares, for example, have only a thin internal shell. Nudibranchs are at the pinnacle of this evolutionary tree. Having lost all traces of a shell, they are by far the largest group of sea-slugs and are found in a vast variety of body shapes and range from a few millimetres to 30 centimetres long.

The word nudibranch is Latin and literally means 'naked gill'. The name refers to the circle of exposed gills on the back of many species. Nudibranchs are only distantly related to land slugs. They are exclusively carnivorous, and depending on the family and species, often feed on a specific species of prey. Some species, for instance, feed exclusively on mollusc eggs, others on a particular species of sponge.

Of the four main groups of nudibranchs, the dorids and aeolids are by far the most diverse. The dorids are the largest group, ranging from less than a centimetre to 30 centimetres long. Members of this group typically have a mantle around the body, which forms a skirt enclosing the animal. The anus of dorid nudibranchs is usually in the centre of the back, surrounded by a circle of delicate gills. These gills can be quickly retracted if the animal is disturbed. Aeolid nudibranchs can be capable of moving quickly and may reach 15 centimetres long. They typically have long, narrow bodies with numerous outgrowths known as cerata on their backs. These blood-filled tubular organs act as gills, and each ceras has a branch of the digestive gland inside it. However, they cannot be retracted if disturbed. The other two groups, arminids and dendronotids, have fewer members.

SURVIVAL IN THE SEA

Most molluscs have a hard outer shell into which the animal can withdraw. Like medieval knights in armour, molluscs with shells can protect their soft, vulnerable bodies from potential predators. Nudibranchs have gone against the normal evolutionary trends for this group. Along with some other sea-slugs and cephalopods, such as octopuses, squid and cuttlefish, they have done away with the external shell. Although it provides the animal with protection, the presence

Previous page
This nudibranch's bright colours signify danger and warn predators to stay away.
Photo – Pip O'Dell

A diver encounters a type of nudibranch known as a Spanish dancer (*Hexabrauchus sanguineus*).
Photo – G. Saueracker/Lochman Transparencies

Right: This dorid nudibranch (*Jorunna funebris*) grows up to five centimetres in length, is common in tropical waters and is found as far south as Perth. Its stunning colour patterns make it a rewarding find for divers.
Photo – Pip O'Dell

of a shell comes at a very high cost. Building any thick, solid skeleton requires considerable energy and materials. Shells are also very cumbersome. They inhibit movement, decreasing the area that can be covered in the search for food while, at the same time, increasing the amount of food required.

With no shells for protection, nudibranchs have had to develop a vast armoury of alternative defences. Many dorid nudibranchs, for example, can produce a distasteful noxious secretion to deter potential predators, such as fish. Observant divers may occasionally see a fish grab and swallow a nudibranch, only to spit it back out seconds later. The secretion itself comes from skin glands on the animal's back. It is still unclear whether most species synthesise these chemicals themselves, or whether they are sourced from the food they are eating.

However, it appears that a group of brightly coloured dorid nudibranchs, known as the chromodorids, are able to gather the distasteful chemicals from the food they are eating. Chromodorids feed on a group of sponges that produce foul-tasting substances for their own defence. Chromodorids seem to be able to engulf these chemicals without harm and move them to special glands on their back.

Perhaps the most remarkable and innovative defence mechanism is found in aeolid nudibranchs. Aeolids feed on cnidarians, which include sea anemones, hydroids, jellyfish, soft corals and hard corals. Cnidarians have evolved special stinging cells called nematocysts. Most people would be familiar with nematocysts in the form of the tiny stinging cells they encounter when stung by blue bottles or the feared box-jellyfish (see box). As they feed, aeolid nudibranchs are able to remove undamaged nematocysts and store them in their bodies for future use. When attacked, they can discharge the stinging cells to deter their predators. Although the discharge mechanism is not fully understood, predators that attempt to eat the animal can expect their mouths to

NEMATOCYSTS

Corals, sea anemones and jellyfish are all members of a large group of marine animals, known as cnidarians, which use stinging cells called nematocysts to capture their prey. These tiny stinging cells line the tentacles. They also protect the animal from being eaten by other creatures. A single tentacle of a Portuguese man-o'-war contains hundreds of thousands of nematocysts. In some species they simply act by wrapping around the prey and entangling it, while in others they have a sticky coating that enable the prey to be held until it can be eaten. Cnidarians include one of the deadliest animals in the world - the feared box jellyfish found in northern waters of our State. The nematocyst of the box jellyfish consists of a coiled thread, with a hollow barbed tip that works like a harpoon. Upon discharge, bought on by even the slightest brushing, the thread bores its way into the tissues, everts (turns inside out) and injects a toxin with a paralysing action. Vinegar neutralises this discharge mechanism and should be poured over a box-jellyfish wound to neutralise any undischarged and potentially fatal nematocysts.

The deadly box jellyfish

Dorid nudibranchs, such as those left and above, typically have an anus, surrounded by a circle of retractable gills in the centre of the back, and a skirt-like mantle around the body.
Photos – Pip 'O Dell (*left*) and Clay Bryce (*above*)

Below: Aeolid nudibranchs, such as this *Moridilla brocki*, have long narrow bodies with numerous non-retractable outgrowths known as cerata, on their backs.
Photo – Clay Bryce/Lochman Transparencies

be 'lit up' by a battery of stinging cells. This must surely be one of the grandest examples of theft in the animal kingdom.

A free swimming nudibranch (*Glaucus* sp.) uses this defence mechanism and can even sting humans. It has an air pocket in its stomach that causes it to float belly up. *Glaucus* collects the nematocysts from the planktonic cnidarians on which it feeds. The severity of the sting will vary with the type of prey eaten. They have been shown to contain nematocysts from the Portuguese man-o-war jellyfish, but beware, their sting may be even worse. Not only do they have the incredible ability to collect nematocysts from their prey, they can also sort them, storing only the most virulent and potent.

Other defence mechanisms in nudibranchs are more general. As many nudibranchs feed on only one species of prey, camouflage is a simple way to avoid detection, as they will normally only have to blend into one particular background. By either being coloured the same as their prey or by being translucent, nudibranchs are able to hide in the open. Some species have body extensions that mimic the texture of their prey with amazing accuracy. For example, the body of one sea-slug, *Verconia verconis*, has a similar appearance to the pink sponge on which it feeds. Some species without elaborate defence mechanisms mimic the colours of species that do. They rely on potential predators failing to distinguish between themselves and other species with more advanced defence mechanisms.

Few people look at nudibranchs without gazing in awe at the intricate and vivid colour patterns that characterise many of these animals. Paradoxically, these soft-bodied animals use the unusual survival strategy, in the fish-eat-slug world beneath the sea, of attracting attention to themselves. The strategy is simple. Predators quickly learn to avoid noxious or stinging nudibranchs by avoiding associated colour patterns. Although a few nudibranchs may die as each new generation of predator learns to avoid the same patterns, the species is clearly protected at a population level. The use of colour as a defence mechanism has been intensively studied in the insect world, where butterflies store noxious chemicals from plants in those parts of the body most vulnerable to bird attack.

LIFE HISTORY

For all their beauty and ingenuity, nudibranchs are only short-lived, with life spans usually lasting less than a year and often as little as a month. All nudibranchs are hermaphroditic, that is,

the animal acts as both a female and a male. However, self-fertilisation does not take place. Copulating pairs transfer sperm into each other by a penis. Eggs are usually deposited by each individual in a coiled mass on the substrate. A few species emerge from the egg as a crawling juvenile. However, most emerge as free swimming veliger larvae with a tiny remnant shell. These swim about in the water column until they are ready to settle on the bottom.

Settling larvae grow rapidly, spawning as soon as they reach maturity. Their life cycle is often tied directly to the food they consume. Being exclusively carnivorous and often tending to feed on one or perhaps only a few species of prey, food sources can become quickly consumed. In an unforgiving environment, this simply means they perish if food stocks are exhausted. This can lead to highly variable numbers and explains why at a given location, nudibranchs may be found in great numbers on one occasion, and then be almost non-existent on another.

It has recently been discovered that one species of aeolid nudibranch may not even have to feed at all after its first few meals of hydroids, and other species only need to feed irregularly. Scientists have known for some time that microscopic algae known as zooxanthellae are abundant in the tissues of reef-building corals and hydroids. Like other plants, zooxanthellae are able to produce sugars by converting energy from the sun by means of photosynthesis. The tissues of their animal hosts provide them with a safe

Top right: Nudibranchs are carnivores which often feed on a single species, in this case on ascidians.
Photo – Pip O'Dell

Centre right: Unlike nudibranchs, sea hares have a small, thin horny shell that is partly or completely covered by the mantle.
Photo – Jiri Lochman

Right: Most Western Australian specimens of *Nembrotha purpureolineata* have been collected from the Abrolhos Islands.
Photo – Peter & Margy Nicholas/Lochman Transparencies

Above left: The nudibranch *Phyllidia occellata* extracts toxic chemicals from the sponges on which it feeds, and will exude an unpalatable noxious substance if disturbed. Its distinctive colour pattern ensures it is not mistaken as harmless.
Photo – Ann Storrie

Above right: A mating pair of *Nembrothia rutilans*. Nudibranchs are hermaphrodites, which means that they can mate with any other individual. Each animal injects sperm into the other.
Photo – Clay Bryce/Lochman Transparencies

Left: The well-camouflaged *Verconia verconis* is hard to distinguish from the sponge on which it feeds.
Photo – Peter & Margy Nicholas/Lochman Transparencies

environment as well as nutrients necessary for growth and reproduction. In return, excess sugars and oils produced by the zooxanthellae are used by the animal hosts for their own nutrition. This mutual benefit to both organisms is known as symbiosis and may account for up to 50 per cent of the nutritional requirements of the coral. It is true to say Western Australia's coral reefs, including those in the Ningaloo and Rowley Shoals Marine Parks, would not appear in the grandeur they do today if it were not for these tiny microscopic photosynthesising organisms.

Some aeolids are able to kidnap the living microscopic algae unharmed from their cnidarian prey and transport them to areas of the body with high exposure to the sun. Not fussed by the change of host, the zooxanthellae continue to photosynthesise as long as they have sufficient sunlight, oxygen and nutrients to grow and reproduce. This symbiotic relationship can be so productive that some species never or seldom have to feed again for the rest of their lives.

Nudibranchs are truly a marvel of nature. It is remarkable that a single group of animals can have evolved such diverse and biologically complex adaptations to survive in an ecosystem that even today is very little understood by humans. The ocean remains one of the last frontiers for scientists, and Western Australia is fortunate in having relatively pristine waters, compared with other parts of the world. It is vital that we conserve the health of this amazing marine environment and all the plants and animals that live within it, from the grandeur of our coral reefs to the less noticeable, but equally delightful, slugs of the sea.

Kevin Crane is a technical officer with CALM's Swan Region Marine Operations Unit, where he assists with the day-to-day management of Perth's marine parks, offshore islands and wildlife. He can be contacted on (09) 432 5113.

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LANDSCOPE

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Rainbow lorikeets. Are they pests? Will they displace our native birds? Do we need to control their numbers, and if so, how? Find out more on page 17.

*A subspecies of granny bonnets (*Isotropis cuneifolia *subsp.* glabra*) found in a threatened community on the Swan Coastal Plain. See story on page 35.*

'The Magic of Magenta' co-author Mal Graham clearing an Aboriginal soak in Lake Magenta Nature Reserve. See our story on page 41.

A rat by any other name...? In 'Dinkum Aussie Rats' Andrew Burbidge discusses the use of common and Aboriginal names for native rodents.

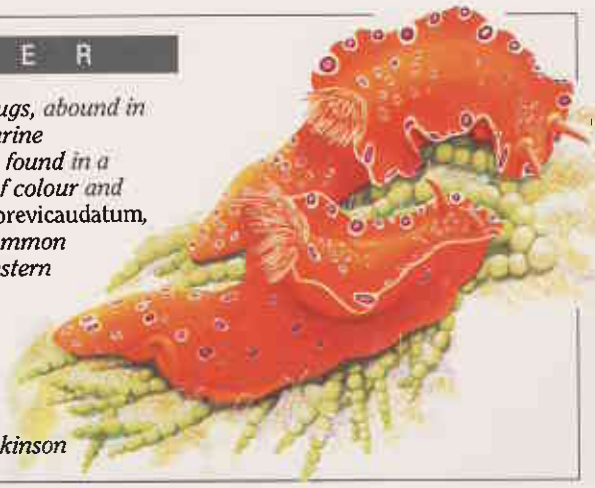
In 'Saving the Giants', read how a new Tree Top Walk in WA's south-west is set to become one of Australia's nature-based tourism icons.

FEATURES

REGULARS

COVER

Nudibranchs, or sea-slugs, abound in Western Australia's marine environment. They are found in a tremendous diversity of colour and form, the Ceratosoma brevicaudatum, *illustrated here, is a common inhabitant of south-western waters. See page 28 to learn more about the 'Slugs of the Sea'.*



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