SAPPHIRES OF THE DEEP - STAR-GAZING AT SODWANA

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and Hendrik Jerling[2]
Photography by David Barnes
and Hendrik Jerling

Gerhard's logbook entry

Twinkle, twinkle little star, How I wonder what you are ……

I floated into a galaxy of stars at 08:12 on the morning of 30 April 2005. At fifteen metres below the surface, doing an additional precautionary safety stop at Deep Sponge Reef, I had transcended into a serene submarine realm of exquisite, celestial beauty and was now surrounded by countless tiny specks, glowing with fierce intent in the crystal clear, azure waters of Sodwana Bay. Glittering stars. Brilliant, blazing, blue.

Francois de Clercq[3] and I had scraped algae from the memorial tombstone of Riaan Bouwer[4] at 32 metres a few moments earlier and I reflected on how fitting a tribute this was to Riaan as I reached out to a star, but it instantaneously flicked out of existence. I was awestruck and cautiously extended my hand to another, but the result was the same. It simply disappeared - as always …….. the impossible dream.

Fishermen call them Cuda or Couta stars/lights. They are often observed close to the surface from fishing boats and divers on the East coast of Africa are familiar with them, but most divers rather simplistically ascribe this remarkable phenomenon to phosphorescence. The fact that they are always observed in broad daylight seemed to indicate that this was not the case, but I was out of my depth here. David Barnes of Coral Divers at Sodwana Bay was of the opinion that these might be minuscule crustaceans, reflecting sunlight - a sudden flick would enable them to vanish without a trace. Johan Boshoff[5], on the other hand, told me that he had seen vast numbers of these stars at Sodwana, emitting blue light at depths of 100 metres plus and I began to suspect that this was either a form of bioluminescence or iridescence.

An extensive surfing session on the internet did not render much, but I did come across two articles written by Susan Scott[6] which indicated that she might have observed the same little stars whilst diving at Hanauma Bay in May 2002. This was particularly interesting because I also discovered that the coral reefs and marine life at Hanauma Bay appeared to be virtually the same as that of Sodwana. I emailed messages to a number of people (including Susan Scott), but only professor Perissinotto of the University of KwaZulu-Natal and Dr. Hendrik Jerling of the University of Zululand responded. They had no clear-cut answers and further enquiries elsewhere were fruitless. It was evident that I would have no option but to catch a few stars.

[1] Gerhard is an advocate from Pretoria and both a Divemaster and Master Diver.
[2] Hendrik L. Jerling (PhD), Department of Zoology, University of Zululand, KwaZulu-Natal, South Africa.
[3] Owner of Ocean Divers, Pretoria
[4] Riaan Bouwer perished whilst diving for Coelacanths in June 1998
[5] Editor of Divestyle
[6] Columnist responsible for Ocean Watch in the Honolulu Star-bulletin

I discussed my quest with David Barnes and he immediately responded enthusiastically, demonstrating why Coral Divers is still the premier dive resort in South Africa.

We launched our expedition at Sodwana Bay on Monday, 26 September 2005, but conditions were appalling. A north-easterly gale had been howling for a few days and it was clear from the outset that some serious diving would be called for. The team was comprised of David Barnes, Evlyn Hunter-Smith, Brett Ayres[7] and I. We set our bearings to an uncharted destination in the vicinity of Hot Spot where David had previously noticed a constellation of brightly sparkling stars and Brett skilfully launched the boat through horrendous breakers.

We descended into an awful, amber-green, muddy sea at 09:27 and dived to the bottom at 31 metres, where we found ourselves on a pristine coral reef probably never dived before. Visibility was a dismal 3 to 4 metres, but we nevertheless became aware of vast shoals of fish. This would obviously be a truly amazing dive site on a clear day.

We encountered the first glints of neon blue on our ascent at between 15 and 10 metres and cautiously proceeded to coax a few sparks into transparent zip-lock plastic bags. Some actually maintained a steady glow inside the bags for a few moments, but then became invisible.

Disaster struck, however, when the bags were dropped in the boat due to the rough seas on our way to shore. Only one bag remained, but it contained a solitary leave-shaped golden flake, barely one millimetre long. David was convinced that this was actually a star, a golden star. But I was sceptical and disappointed. I wanted to see something capable of radiating blue, true blue. Not a microscopic chip that resembled an off-colour fish scale!

Two hours later I met an excited David and Evlyn on the cool veranda of my Coral Divers home from home. They had managed to place the tiny critter in a plastic container and it was alive and well. We moved the container into direct sunlight on the pool deck and gaped at our catch through a magnifying lens. It was swimming around, flapping its tail like a lobster. The miracle happened a little later - when the object of our attention gradually started to turn from gold to blue whilst basking motionless in the rays of the sun.

We had actually managed to capture a star!

That night I had the honour of naming the new reef. The decision was easy. I named it after the man who had discovered it and proclaimed that it would henceforth be known as David's Reef!

The weather forecast for Tuesday was not good, but our minds were set. Nothing short of a hurricane would stop us from returning to the sea the next morning.

[7] Dive Instructors of Coral Divers, Sodwana.

We launched with Simon Bunn[1] as our skipper and headed out in the direction of Seven Mile Reef after successfully negotiating the thundering waves and had to hang on for dear life. We were doing battle with a north-easterly wind and were up against an angry sea, but eventually managed to reach the exact spot we were looking for - just South of Seven Mile Reef. Simon would be joining us on the dive and he entrusted the boat to Geoffrey who had agreed to be our topman.

We dived at 08:53 and once again descended into the murky depths of the ocean. Conditions were much worse than the day before, but we did spot blue glitter on our way down. We reached the bottom at 30 metres and saw a moray eel and a giant turtle, but not much else and slowly started to make our way back to the surface, huddling closely together.

It was then that we heard them. The whales. Unmistakably. We could not see them in the ambient virtual darkness, but they were all around us and we listened in awe to the haunting, eerie sound of these primordial leviathans in close proximity, singing their ancient sad, sad song of unspeakable sorrow. Melancholically wailing, lamenting our intrusion into their sovereign domain. Or was it the loss of their lodestars, the loss of a few precious splinters of original light ……..?

We found the tiny torch-bearers keeping vigil at about fifteen metres and were transfixed, watching them dance in the surreal incandescence of flambeaux.

I had to remind myself that we were merely collecting a few samples of infinitesimal zooplankton organisms for research purposes and we eventually returned to our boat with about six specimens. But we were in jubilant spirits and galloped home with the wind, riding the crests of gigantic waves. Jesser Point was deserted when we beached shortly after 10:00, all further dives for the day having been aborted.

We had hoped that we would be able to keep our stars alive until we could get them to a research institute, but by Wednesday morning it became clear that they were fading and David consequently filmed them in a shallow container with about 5mm of seawater. He did a superb job and his macro photos of our stars may well be the first ever of living specimens.[2] He also managed to capture a few stars on video – showing them frantically darting about, frequently flipping sideways and flashing that magnificent, iridescent blue.[3]

We managed to contact Hendrik Jerling and he travelled all the way to Hluhluwe that same afternoon with a view to collecting our specimens (preserved in ethyl alcohol) as well as a CD with David's amazing (world first?) photos and video footage of the living creatures. He spared no pains and reported back a few days later. Our stars were tiny crustaceans. David Barnes had been right all along, but I leave the rest of the story to Hendrik ……..

[1] Also a Coral Divers Instructor
[2] David used a Canon EOS 20D with a macro lens
[3] Using a Panasonic Video camera

Hendrik's journal entry

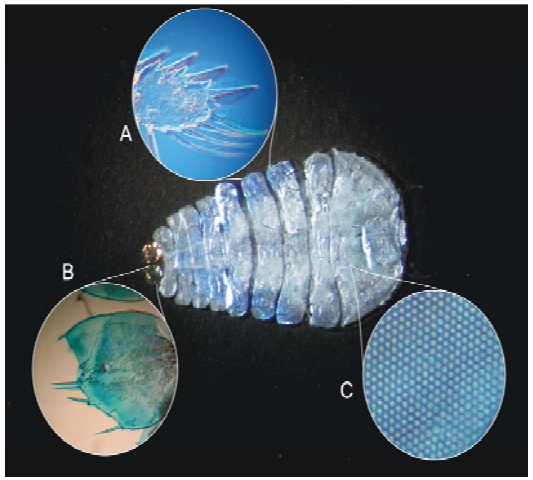
It was possible to identify the critters, under low magnification, as a type of crustacean called a copepod. Further identification required careful examination and comparison of their appendages using a compound microscope. The organisms are male sapphirinid copepods. Two species were present in the sample: *Sapphirina opalina* and *Sapphirina ovatolanceolata*. These species have been known to marine zooplankton researchers for more than a century and were first described by J.D. Dana in 1849- 1852. The Sapphirinidae is a taxonomic family under the crustacean class Copepoda (Greek – kope = oar, podos = foot, i.e. oar foot). The name Sapphirinidae comes from the word for the sapphire gemstone, because of the striking blue iridescence displayed by some species within this family.

Sapphirinidae are widely distributed in the world's oceans and about eight species may occur in the ocean waters near Sodwana. They are flat, leaf-like, planktonic organisms ranging between about 1 to 7mm in length, depending on the species. Although many copepods are filter feeders, feeding on microscopic algae and organic particles in the water column, sapphirinids are carnivorous. They are free living during the day but apparently attach to larger organisms such as salps (gelatinous zooplankton) at night, feeding on their tissues. They occur in the epipelagic layers (upper open ocean waters) down to about 100m, but some species have been sampled in deeper waters of 250m. In contrast to most other zooplankton many sapphirinids are positive phototaxic (attracted to light) and migrate upwards in the water column during the day.

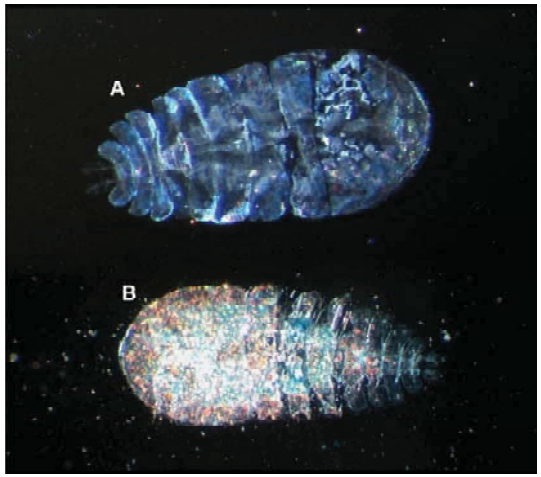
The sapphirinids are well known for their spectacular iridescent capabilities and are often referred to as the jewels of the sea. Old Japanese fishermen referred to iridescent water caused by sapphirinids as "tama-mizu", meaning jewelly-water. Only the males are iridescent with different species reflecting different colour patterns. Blue is a dominant colour. The use of swimming and migration behaviour in combination with iridescence is apparently important in mate recognition.

Many invertebrate and vertebrate marine organisms produce bioluminescence. This is different from iridescence; bioluminescence is a biochemical reaction that produces biological light (e.g. fireflies) and is only really visible in the dark or very dim light conditions. Fluorescence and phosphorescence are terms that are often erroneously used as synonyms for bioluminescence, but they refer to different luminescent phenomena. During fluorescence, named after the mineral fluorite, ultraviolet light is absorbed by the fluorescent material and visible light radiated, only while the UV light is still shining on it. Phosphorescence occurs when certain materials absorb radiant energy and produce luminescence after the radiation that caused it has stopped; think of "glow in the dark" toys.

Iridescence involves the diffraction, reflection and interference of sunlight by specialized structures in or on the organism. It is quite common in the animal kingdom; well known examples include many butterflies and sunbirds. Iridescence in male sapphirinids is due to multi-layered platelets of guanine crystals in the dorsal part of the outer body layer. Sunlight is diffracted and reflected as it travels through the platelet layers. The reflected light rays are of different wavelengths, which cause interference. Active movement of the copepod, relative to the light source and observer, will result in rapid changes of the observed reflected colour mosaic, causing the striking iridescent appearance.



Light microscope image of the dorsal side of a *Sapphirina opalina* male, mounted on a microscope slide. Length - 4.2 mm. A and B (250 x magnification) are examples of appendages used to identify and distinguish different species. A is part of one of the swimming legs on the ventral side and B the end section of the tail. C (1500 x magnification) shows the microscopic platelets that cause iridescence, these structures are only present on the dorsal sides of males and are absent in females.



Light microscope images of two *Sapphirina ovatolanceolata* males. Length - 3.5 mm. The images show that under incident illumination iridescence still occurs, to some extent, even in preserved specimens. A is mounted on a microscope slide and B suspended in the preservative. The different reflected colours depend on the relative position of the reflecting platelets to the incident light rays and the position of the observer.

Boltovskoy, D. (ed) 1999. South Atlantic Zooplankton. Backhuys Publishers, Leiden.

Chae, J. and Nishida, S. 1994. Integumental ultrastructure and color patterns in the iridescent copepods of the family Sapphirinidae (Copepoda: Poecilostomatoida). Mar. Biol., vol. 119, pp. 205-210.

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The Authors

Hendrik Jerling

Gerhard Jansen van Vuuren

Hendrik's Presentation at the International Conference in Maputu

Scuba divers reported mysterious bright flashes of light while d iving in the epipelagic zone, during daylight hours, off the coast at Sodwana Bay (27 º31'S 32º41'E).

Mr. G. Jansen van Vuuren and diving instructors from Coral Divers at Sodwana Bay collected a few specimens at a depth of 15 m.

I identified the specimens collected as males of two sapphirinid copepod species: *Sapphirina ovatolanceolata* and *S. opalina.* They were first described 157 years ago by Dana (1849).

This is probably the first record of these species along the eas tern coast of South Africa.

The bright flashes of light are not bioluminescence but rather d ue to iridescence caused by multi-layered platelets of guanine crystals in the dorsal part of the integument (Chae and Nishida 1994).

Only the males are iridescent, with different species reflecting different colour patterns.

These organisms are apparently well known in ocean waters around Japan and old Japanese fishermen referred to iridescent water caused by sapphirinids as "tama-mizu", meaning "jewelly water" (Chae and Nishida 1994).

The purpose of this presentation is firstly to show "non - planktonologists" what these animals look like and also to illustrate some of the characteris tics used in the identification of the species .

Dana, J.D. 1849. Conspectus Crustaceorum. Conspectus of the Crustacea of the Exploring Expedition.-- American Journal of Science and Arts, Series 2, 8: 424 -428.

Chae, J. and Nishida, S. 1994. Integumental ultrastructure and color patterns in the iridescent copepods of the family Sapphirinidae (Copepoda: Poecilostomatoida). Marine Biology 119, 205 -210.

Sapphirina ovatolanceolata male (Figs1 - 5)

Fig. 1 Male – length 3.5mm. Photomicrograph of preserved specimen using incident illumination. Cephalosome wider than long, slightly pointed on frontal margin. Ocular lenses not visible dorsally.

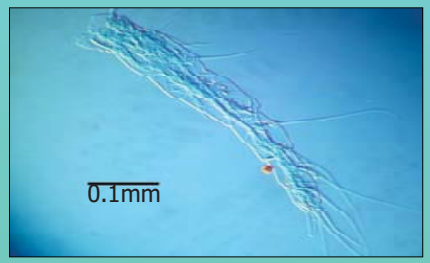

Fig. 2 Antenna 1.

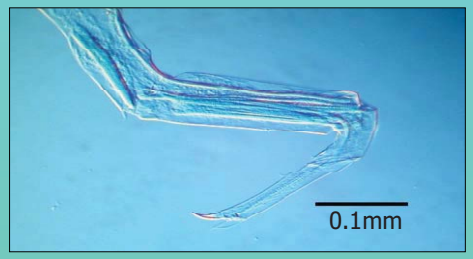

Fig. 3 Antenna 2.

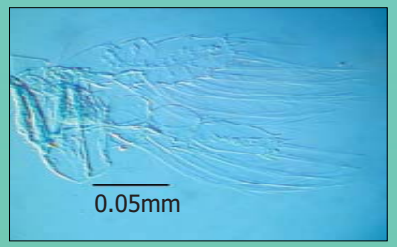

Fig 4 Leg 4. Endopod longer than exopod.

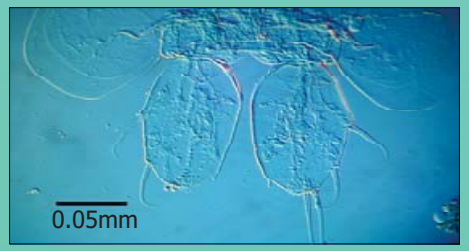

Fig. 5 Caudal rami twice as long as wide. Small projection on inner distal margin.

Sapphirina opalina male (Figs 6 – 10)

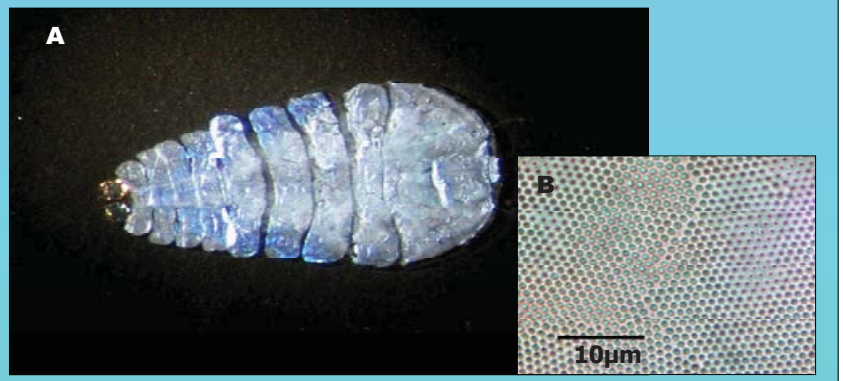

Fig. 6. A - Male, length 4.2mm. Photomicrograph of preserved specimen using incident illumination. Cephalosome wider than long, not pointed on frontal margin. Ocular lenses visible dorsally.
B – High magnification of dorsal iridescent cuticle showing honeycomb structure of multilayered platelets.

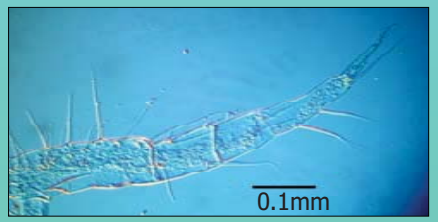

Fig. 7 Antenna 1. Tip of terminal segment with two setae fused at the base.

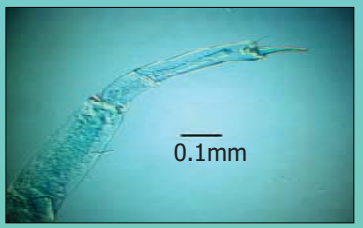

Fig 8 Antenna 2.

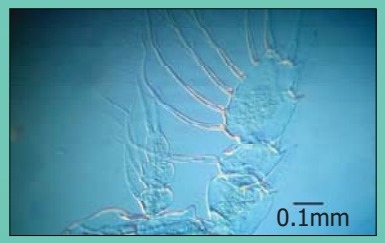

Fig. 9 Leg 4. Endopod less than half the length of exopod.

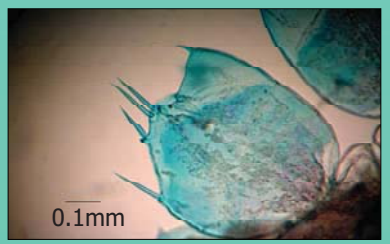

Fig. 10 Caudal ramus about as long as wide. Large projection on inner distal margin.