

## ARTICLE

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Halobates male and live eggs on a *Spirulla* shell. Eggis in orange are almost ready to hatch.

# Life on the high seas – the bug Darwin never saw

## Introduction and historical background

Among millions of insect species known in the world only five species of *Halobates* (Heteroptera: Gerridae) are able to live in the high seas. The general public is probably not aware that there are insects living on the open ocean and even most marine scientists have never seen a live or preserved specimen with their own eyes. The genus *Halobates* was first collected during a Russian oceanographic expedition around the world between 1815 and 1818. It was described by an Estonian naturalist who served as the physician during the voyage. The paper was published in German in a rather obscure journal (Eschscholtz 1822). It has brief descriptions of 85 insects including three species of *Halobates*: *H. micans*, *H. sericeus* and *H. flaviventris*. There was no information on their biology or distribution. We presume that the 22

years old Charles Darwin was unaware of this publication when he set sail on the HMS Beagle with captain Robert Fitz-Roy on 27 December 1831. As far as we could determine Darwin never saw any *Halobates* during the voyage that lasted almost 5 years (completed on 02 October 1836). He suffered seasickness almost all the time and even observations on seabirds and sea mammals were very scarce in his diaries. Although he was among the first to use a plankton net, no effort was made by the Beagle to sample specifically the sea surface community, the pleuston (Cheng, 1975), to which *Halobates* belongs.

## General information on *Halobates*

*Halobates* remained largely unknown after its first description except for the addition of several new species, many have later been synonymised (see Herring 1962). The first

monograph on the genus, comprising 11 species, appeared some 60 years later when additional collections and observations were made on the H.M.S. Challenger during 1872-1876 (White 1883). Sir John Murray, the assistant scientist on the Expedition and founder of modern day oceanography, made the very first observation on their biology and distribution (Murray 1879). It is possible that Darwin might have been aware of their existence just before he died on 09 April 1882.

Forty five species of *Halobates* are now known worldwide (Andersen and Cheng 2004). Most are found in coastal habitats around tropical islands associated with mangroves or other land plants. Only five species are oceanic in habitat: *H. micans*, *H. sericeus*, *H. sobrinus*, *H. splendens* and *H. germanus*. They occur in tropical and subtropical regions of all three major

and 40°S, where the sea surface temperature in winter is above 20°C. All five species can be found in the Pacific Ocean, two, *H. micans* and *H. germanus* occur in the Indian Ocean, but only *H. micans* occurs in the Atlantic Ocean (Cheng 1989).

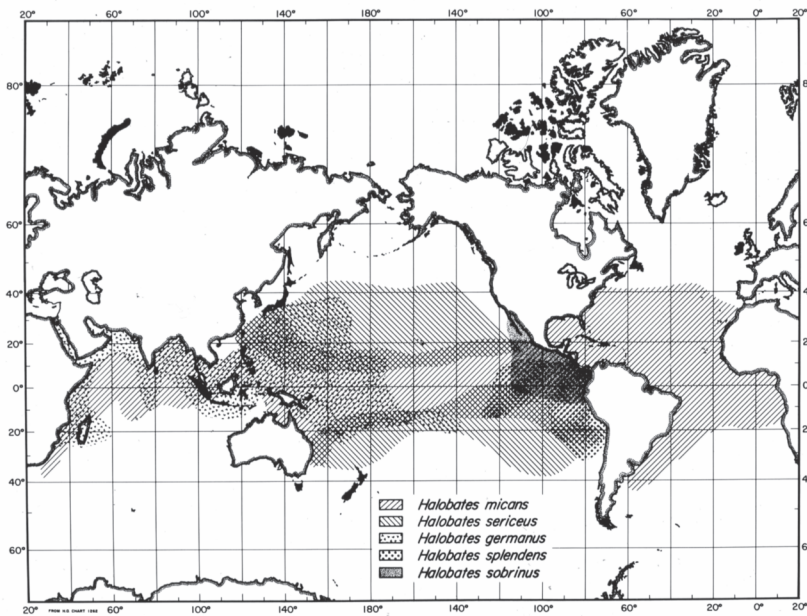
Although morphologically rather similar, coastal and oceanic *Halobates* are quite different in their life styles. Coastal species depend on terrestrial insects which fall to the sea surface for food, lay their eggs on rocks or tree roots and almost never venture out to the open water (Birch *et al.* 1979). Oceanic species, on the other hand, spend all their lives in the open sea thousands of kilometers away from land and never come to shore except when they are blown by onshore storms (Cheng 1985). They live in a two-dimensional world at the sea-air interface with no apparent physical barriers. Wings have never been found on any *Halobates* species. Unlike freshwater Gerridae where wings are present in dispersal morphs, ocean skaters have no need for wings. In theory they could skate over the ocean surface from shore to shore with nothing to prevent their movements.

There are five juvenile stages from egg to adult. The exact duration of each stadium is unknown as we have not been successful to culture them in the laboratory so far. Each larval stage probably lasts from 7-10 days, depending on water temperature. Adults measure only 5-6 mm in body length. Eggs are about 1 mm long and resemble miniature rice grain. They are laid on any floating material the females could find. Oviposition substrates may be hard to come by or limiting. Some 30,000 eggs have been found on a plastic milk jug in the eastern tropical Pacific (Cheng & Pitman 2002). They would feed on any organism trapped at the sea surface but little is known of their food preferences. We have not found their abundances to be related to densities of zooplankton organisms upon which they feed. In fact, in the Banda Sea (Indonesia), higher numbers were captured in oligotrophic waters during the NW monsoon than in the upwelling waters of the SE monsoon (Cheng *et al.* 1990). Although they have been found in the stomachs of sea turtles and several fish species, seabirds are their main predators (Cheng *et al.* 2010). Although much is known about their biology and distribution there are



*Halobates germanus* - female (above), male (below)





Distribution map of oceanic *Halobates* spp. (From Cheng 1985)

still many aspects of their life history that we know nothing about, e.g. what do the first instar nymphs feed on, how long the adults live, how the sexes find each other at sea in order to mate, etc. (Cheng 2008). Few photographs of pelagic *Halobates* exist in print and they have never been filmed in their natural environment, the open ocean.

#### The Dutch Beagle Voyage

An opportunity to study oceanic sea skaters in the wild came by an ambitious project of the Dutch broadcasting company VPRO. They planned a 35-part TV documentary "Beagle, On the Future of Species" to mark Charles Darwin's 200th birthday and the 150th anniversary of the publication of 'On the Origin of

Species'. VPRO chartered the Clipper Stad Amsterdam for a voyage following the route of the HMS Beagle. The construction of the 70 meters long, three-masted clipper was completed in 2000. It followed the classic design of the Cutty Sark but with modern modifications such as a diesel motor, bow thruster, water desalination plant, luxurious air-conditioned cabins, etc.. For the Beagle Project, the clipper was further modified to house two complete TV studios, satellite dishes and web cams. These were installed to ensure 24x7 contact with the public. Since she set sail from Plymouth on 1 September 2009 the Stad Amsterdam has carried an international cast of scientists, philosophers, historians, artists and biographers. Two of us (LC and MB) were invited to participate as scientists on the leg between Tahiti and Sydney to try and capture *Halobates* and to carry out some experiments on board. AS was invited as the resident artist/photographer for the entire voyage. We also challenged the film crew of VPRO to be the first to film *Halobates* in the wild.

Stad Amsterdam in the Galapagos.



Before we (LC and MB) joined the Stad Amsterdam we spent five days working at the Gump Station in Moorea. The station is operated by the University of California, Berkeley. It is situated on the western shore of Cook's Bay and has excellent facilities for conducting fieldwork. Our aim was to collect specimens of the coastal *Halobates hawaiiensis* to take on board so that we could carry out comparative studies between coastal and oceanic species. *H. hawaiiensis* is known to occur in some abundance in Cook's Bay and had been collected in previous visits by luring them to the dock by light at night (Tsoukatou *et al.* 2001). For some unknown reason we only collected two adult specimens during four nights of hunting! Survey of near shore habitats from land and by boat from the sea revealed no populations. We did encounter quite a large patch of flotsam consisting of coconuts, uprooted macro-algae, terrestrial plants, etc.. We are puzzled by the near absence of *H. hawaiiensis* around Moorea during our visit in mid January 2010. We are not sure whether this is a seasonal effect or due to environmental changes of their habitat.



Collecting at the entrance of Cook's Bay (above)

#### Work on board

In order to capture *Halobates* at sea we need to use a net that is specifically designed to sample animals at the sea-air interface. On the Stad Amsterdam we deployed a David-Hempel neuston net. It looks like a mini-catamaran with the two hulls made of hollow aluminum shells packed with foam. One or two nets could be strung between the two wings. Each net, measuring 5 m long with a 300 um mesh size, tapers towards the end which is attached to a plastic cod end. The net opening is stretched over a rectangular aluminium frame measuring 30 cm x 10cm. It is towed off the side of the vessel away from the bow waves at a speed of between three and four knots. During operation the lower bar is kept underwater such that it skims over the sea surface at all times during the tow. It is only operable with a sea state of four or less when the wave heights are below two meters. The maximum speed of the ship must not exceed four knots otherwise the catamaran tends to flip over or be damaged.

We were able to launch the net the night after we sailed from Papeete when the wind dropped and the

Stad Amsterdam leaving Plymouth (below).





David Hempel net in operation

clipper was on motor. We towed the net for 30 min at three knots and caught 11 specimens of *H. germanus* (one male, two females and seven nymphs). Only the three adults and one final instar female were caught alive. The remaining nymphs did not survive the tumbling in the net while it was being towed.

The four live specimens were allowed to dry themselves on filter paper before being released onto a small aquarium with fresh seawater. When placed on water they proceeded almost immediately to preen themselves with their front legs, presumably to spread water-repellent chemicals over the appendages. They start by cleaning the antenna first, holding each between the front tarsi and stroking it from the base to the tip. This was done several times for each antenna. The middle legs were preened in the same way next, followed by the hind legs. While cleaning the middle legs the female tipped over. It was able to right itself by somersaulting. Preening took about five minutes to complete. Afterwards the insects were observed to skate normally. However, they soon began to hit themselves against the aquarium wall. Since they never encounter physical barriers in their natural habitat they continued to hit the wall until they tired.

After settling down somewhat the male was observed to mount one of

the females. We were not sure whether mating was successful. The pair separated after about five minutes. In the Galapagos Islands mating pairs of the coastal species, *H. robustus*, have been observed to remain in copula for over nine hours (Foster and Treherne 1980). We added several floating plastic pieces to the aquarium to provide oviposition substrates but no eggs were found after four days. On a previous expedition to the Eastern Tropical Pacific females of *H. sobrinus* collected by dip net have been observed to lay eggs almost immediately upon capture when placed on wet blotting paper (Cheng, unpublished). Perhaps the females we captured were not sexually mature. We managed to keep the specimens alive on board for only seven days.

#### Winds and waves

After our successful net tow on the night of 25 January we were unable to launch the net again for more than 10 days. We were followed by 20-25 knot winds, rough seas, and several tropical cyclones. Even if all the sails were down the clipper would still be sailing at five to six knots, much too fast a speed for us to tow the net. We were making such good speed towards Sydney that would advance our arrival by three days. This was not acceptable since various arrangements made to

welcome our arrival could not be changed. To our great delight our request to make a stopover at Lord Howe Island was granted by the Australian authorities. We all looked forward with great anticipation to a visit of this paradise. Sadly our joy was short lived. There is a quota of 400 visitors at any one time and passengers from cruise ships were not allowed to land on the island. As the clipper was registered as a cruise ship we were unable to go to shore. We resigned ourselves to viewing the island from about 500 m away and to enjoy a few days of respite from the rolling sea.

#### Lord Howe Island Interlude

Lord Howe island was created by a volcanic eruption some seven million years ago. It is about 600 km away from mainland Australia. The island is only about 1 km long and up to 2 km wide at its widest part. There are two towering peaks at one end of the lagoon which harbours the southernmost coral reef in the Pacific. Much of the island is still covered by original vegetation. With some 300 inhabitants the chief income is from tourism. We were visited by Clive Wilson, a descendant of one of the earliest settlers on the island. He was apparently instrumental in the campaign to eradicate all the wild pigs in the island thus protecting the native



Lord Howe Island

thousands of seabirds nesting on various parts of the island. We spotted masked booby, shear waters, petrels, tropicbirds, etc. Masked boobies appeared to be the tamest and would glide close by the clipper, seemingly to observe us. While we were anchored in the lagoon at Lord Howe we spent several hours dip-netting at night. However, we did not spot, nor caught any *Halobates*.

#### Final push towards Sydney

After a two-day rest we left Lord Howe Island and continued our journey towards Sydney. The wind dropped so we were able to launch the net again that night. We caught many specimens of *H. sericeus*, the

species with an amphi-tropical distribution (Cheng 1997). The calm weather continued the following day. A two-hour day tow produced more than 100 individuals of *H. sericeus*. It was likely that there may be aggregates of the sea skaters on the ocean near us. It would have been a wonderful opportunity for us to launch the Zodiac and try to film them. However, the weather did not cooperate. The challenge of filming these unique creatures in the wild remains elusive.

We conclude that these tiny ocean skaters are apparently rather common organisms at the sea surface. Had we been able to carry out net tows more often during our voyage after leaving Papeete we probably would have

caught them in every tow. They could be easily observed on a calm day if one were specifically looking for them and be captured if one has the appropriate net. Darwin never saw them but we felt sure he would have looked for them had he known about their existence.

#### Footnote - Beetles on board

On 05 February, around 0400 hr, the crew discovered a dozen or so beetles on board. Six were captured alive and photographed. They appeared similar to the Burnt Pine longhorn beetle *Arhopalus ferus* (Mulsand) (Cerambycidae) reported as a forest pest from New Zealand. The clipper was at approximately 33° 19' S and 168° 37' E, some 200 miles north of the North Island of New Zealand. There was a easterly wind blowing at 20-25 knots all night. We suspect the beetles to have been blown from N.Z.

#### Acknowledgements

We are most grateful to the VPRO team for inviting us to participate in the Dutch Beagle voyage. We are especially indebted to the captain and crew of the Stad Amsterdam who have been most helpful and accommodating in helping us with our research needs. LC and MB wish to thank the staff of the Gump Biological Station in Moorea for providing excellent facilities for their short stay on the island.



Beelte on board (scale in inches).

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## Author biographies



Anthony Smith taking pictures of *Halobates* on board the Clipper Stad Amsterdam.



Lanna Cheng studied terrestrial insect population ecology at Oxford University. Her interest in marine insects began fortuitously when she married a phycologist and found herself attached to an oceanographic institute. "Marine Insects" which she edited and published in 1976 remained the only reference book on the subject. It is now out of print but is available on the University of California E-scholarship repository web site: <http://repositories.cdlib.org/sio/techreport/48/>. She has devoted her studies to *Halobates*, especially the five open ocean species and has published widely on the subject. At least five marine insects have been named in her honour. The bulk of her collection of *Halobates* have been deposited at the Zoological Museum, University of Copenhagen, which has the largest collection of this genus in the world. She has been a fellow of the Royal Entomological Society since 1966 and was one of four women who attended the first Verrall Supper opened to female entomologists in 1967.

Martien Baars is a zooplankton scientist at the Royal Netherlands Institute for Sea Research on the island of Texel but he did his PhD ('Running for life') on locomotory activity and population dynamics of carabid beetles on the moorland of Drenthe. During the preparation of the Indonesian-Dutch Snellius-II Expedition 1984/1985 he was requested by Lanna Cheng to collect *Halobates* in the Banda Sea. After cruises in both the SE and the NW monsoon, the eastern Indonesian waters were no longer a blank area on the *Halobates* distribution maps. Since then, *Halobates* has also been collected during Dutch cruises in the northwestern Indian Ocean between 1992-2000. During the planning stage of the Dutch Beagle Voyage Martien succeeded in getting the broadcasting company VPRO interested in trying to film *Halobates* in its natural environment.

Anthony Smith is an artist, naturalist and photographer from Cambridge, UK. He studied Zoology at Cambridge University, and has a particular fascination for animal behaviour and evolution. Anthony is also a long time Darwin enthusiast. After graduating from Cambridge he began a career as an artist – first specialising in wildlife subjects, and now also doing human figurative work. On the bicentenary of Darwin's birth in 2009, HRH Prince Philip unveiled a life-sized bronze statue that Anthony sculpted of The Young Darwin, for Christ's College Cambridge. He is a Fellow of the Linnean Society of London, and an Associate of the Royal British Society of Sculptors.

Illustrations - almost all taken by Anthony Smith