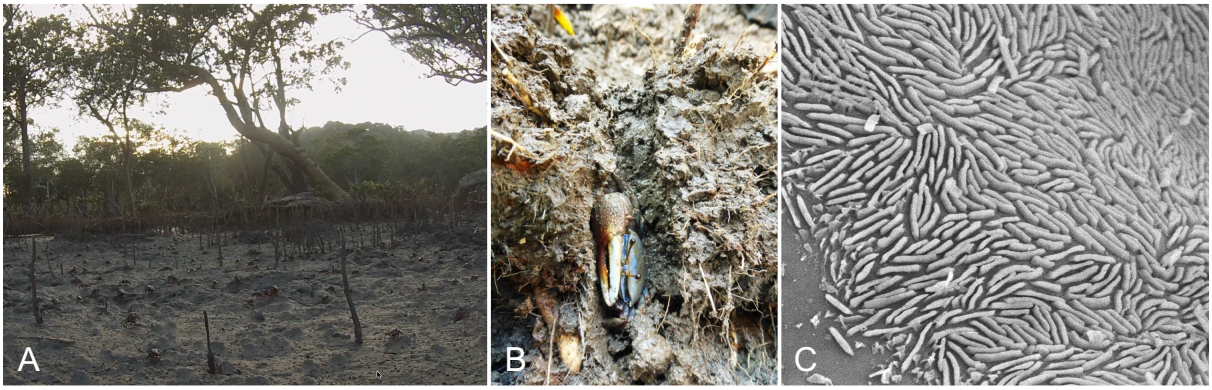
# MicroDefender: Iluma (*Ilumatobacter*)

(Ramona Marasco and Marco Fusi)




*Fiddler crabs in South African mangroves (A) foraging at low tide (photo by Marco Fusi); (B) burrowing to continue breathing air during high tide (photo by Ramona Marasco). (C) Microscopic view of crab gills showing the attached microbial community (image courtesy of Elisa Garuglieri).*

**Claim to fame: removal of toxic ammonia from the gill surface of aquatic animals**

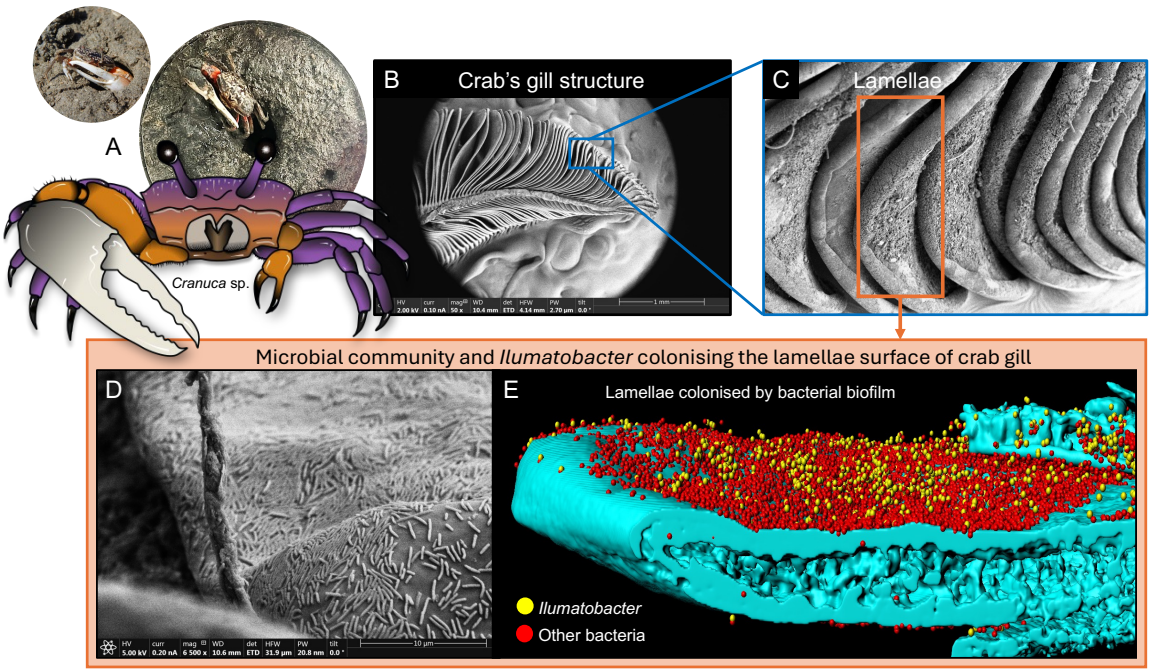
Aquatic animals breathe by using gills, which are specialised organs that extract oxygen from the water. As water flows over the thin surfaces of the gills, oxygen molecules dissolved in the water move into the animal's blood. But gills do not just handle oxygen—they are also the main "gateway" for animal waste products. For example, when marine animals eat, their bodies break down the food to obtain the energy they need to move and grow. This same process also produces waste, and one of the main waste molecules from food proteins is ammonia ($NH_3$), which the animal must eliminate to stay healthy. Unlike land animals, marine animals lack kidneys to convert ammonia into less toxic forms, so they release ammonia directly through their gills into the surrounding water. This process is usually effective because ammonia dissolves quickly in water and is carried away. However, in places like muddy mangrove creeks or shallow tidal pools, fish, crabs, shrimp, and many other animals live in still water or even air for part of the day. Under these conditions, the ammonia released from their bodies cannot be flushed away quickly and begins to build up in their body tissues, irritating or damaging the animal's organs, including the gills.

Luckily, this is where microorganisms, like *Ilumatobacter* ("Iluma"), become heroes! In fact, Iluma steps in as a hidden ally, converting such a dangerous compound into safer substances, acting like tiny cleaners and protectors. This is one of the reasons why helpful microbes like Iluma are so important: they use animal waste as food and energy sources, thereby preventing accumulation and toxic effects. Without helpers like Iluma, many marine animals would have to work harder to breathe and survive!

***Meet Iluma: Who is it? Where did scientists find it?*** *Ilumatobacter* is a genus of bacteria first described by scientists in 2009, when the species *Ilumatobacter fluminis* was discovered living in a river sediment. Its name comes from two old words: the Greek *iluma*, meaning "sediment", i.e., the sample in which it was found, and the Latin *bacter*, meaning "rod", i.e., the shape of this bacterium under the microscope. Iluma cells measure 2-3 micrometres in length and have thick protective walls that help them survive. This bacterium belongs to a larger group of bacteria called actinobacteria, known for their ability to survive in harsh or changing environments. Scientists found members of this genus in many aquatic places—riverbeds, marine sediments, and even wastewater treatment plants—where they quietly recycle organic matter and help keep ecosystems

balanced. Surprisingly, researchers also discovered that Iluma often lives in close association with marine animals, including crabs, fish, shrimp, and other coastal species along tropical shorelines. Microscopy revealed that Iluma can indeed attach to and colonise the gill surface of these animals, representing one of the most abundant groups in the microbial community.

***Why does Iluma live in association with animals?*** Coastal environments are home to many small animals such as fiddler crabs, mud-dwelling shrimps, and coastal fish that dig sediments, crawl, swim, and filter water. Because Iluma is already present in water and sediments, the likelihood of these animals encountering it is very high. In fact, when these animals breathe, water flows across their gills, which are covered in tiny folds and films (i.e., lamellae) that hold moisture and nutrients, the kind of comfortable, food-rich place where Iluma can thrive. Scientists studying gill microbiomes have indeed found clear evidence that Iluma settles and grows on the gill surface, forming a thin carpet with its neighbours, the so-called biofilm.




*Where Iluma lives. (A) A fiddler crab that uses gills to breathe. (B) The gills are made of many thin layers, like the pages of a book. (C) Each layer is called a lamella, and this is where tiny microbes live. (D) Under the microscope, we can see the bacteria sitting on the gill surface. (E) Special fluorescent tags reveal Iluma (yellow) living alongside other friendly bacteria (red), forming a thin biofilm that helps crabs eliminate toxic compounds they release through their lamellae.*
*Image credits: Ramona Marasco, Marco Fusi, and Elisa Garuglieri.*

But why would a bacterium choose to live on the gills? And why would an animal allow bacteria to cover the very surface it uses to breathe? The answer has to do with food and cleaning services, or in scientific terms, a "mutualistic relationship" or "symbiosis" in which both partners benefit. When crabs, shrimp, or fish digest their food, they release ammonia and other organic compounds that, if not removed from the body tissues, can become toxic and harm the animal. For Iluma, these same molecules are food—almost like snacks passing by with every breath. So, by living on the gills, Iluma gets a constant supply of food without having to search for it, allowing it to conserve energy, grow steadily, and perform its specialised cleaning role, removing ammonia and keeping the host chemically balanced.

***Iluma: such an important partner for marine animals.*** In addition to removing ammonia, Iluma produces specialised molecules that prevent harmful bacteria from settling on

the gills, protecting the host from microbes that could cause irritation or disease. At the same time, other toxic gases, such as hydrogen sulphide ($H_2S$), can be released from sediment and accumulate in water in mangroves and other marine ecosystems, giving off a bad rotten-egg smell. Iluma, also in this case, can detoxify this molecule to a non-toxic form while using it as an energy source, especially under microaerophilic or aerobic conditions, as in gills.

All these functions make Iluma an essential ally for marine animals. For example, in studies of mangrove crabs that dig and live in muddy estuaries, individuals with higher Iluma populations on their gills showed better respiratory efficiency and lower physiological stress even under air exposure. Moreover, in small coastal fish, Iluma has been linked to improved tolerance to low-oxygen water, as reducing ammonia and other toxic compounds increases gill efficiency in oxygen uptake. This shows that Iluma's activity is not just chemical—it has real and measurable effects on animal health!

***Iluma's natural friends and teamwork.*** Even though Iluma plays an important role on the gills, it is not a lone worker. Iluma thrives as part of a team of microorganisms, each contributing different skills that help maintain a healthy, balanced gill environment. Iluma, for instance, interacts and works with bacteria, such as *Alteromonas*, *Rhodobacter*, and *Pseudoalteromonas,* each of which has a different job. *Rhodobacter* species are known for producing protective surface molecules that form a smooth, stable coating over the gills—almost like a soft, invisible shield that helps maintain a stable environment. *Alteromonas* helps break down bits of organic matter carried in the water, preventing sticky layers from forming on the gill filaments. *Pseudoalteromonas* is known for producing natural antimicrobial compounds that, together with those released by Iluma, discourage harmful or aggressive bacteria from settling on the gills. Together, these neighbours help create the right conditions—a balanced pH, shared nutrients, and a well-organised biofilm structure—that allow Iluma to focus on its cleaning role, transforming ammonia and other waste products into harmless forms. In this way, the gill microbiome works like a small, well-coordinated neighbourhood, where each microorganism has a job, and everyone benefits from working together!

**Why Iluma is important for marine ecosystems and for us**

While scientists are still uncovering new species and learning more about this unusual bacterium, Iluma is now recognised as a common helper for many marine animals, including crabs, shrimp, fish, and shellfish, which promotes breathing and staying healthy. As a consequence, it indirectly helps maintain cleaner water, balanced nutrients, healthier food webs, and more stable coastlines (SDGs 2, 8, 13, 14). In fact, the hosts of Iluma have critical ecological roles in marine and coastal ecosystems, with crabs aerating sediments, fish grazing algae, shrimp recycling nutrients, and shellfish filtering water. If the health of these animals declines, ecosystem functions weaken. By supporting these animals, Iluma contributes to the good health and stability of our marine ecosystem! In simple words: *When we protect the ocean, we protect Iluma… and when Iluma thrives, marine life thrives with it.*

***Iluma is a superhero that protects coastal animals vital to ecosystem health from self poisoning!***