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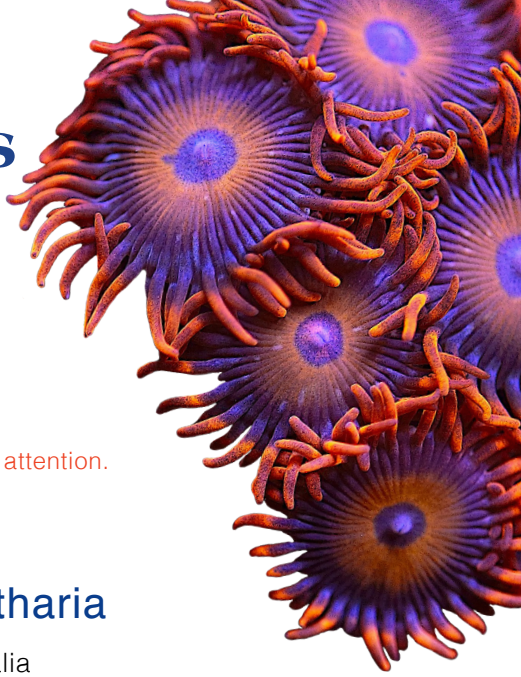


# The Power of Palytoxins

By Amy McKenna M.S., Kevin Erickson M.Sc. Published August 21, 2016

STOP, if you suspect you are suffering from palytoxin exposure, seek immediate medical attention.

WARNING: Some may find the following images graphic in nature.

## Discovery

A Hawaiian legend tells the tale of how villagers on Maui, in seeking revenge for fishermen who kept disappearing, caught a Shark God with a hunger for human flesh and ripped him to pieces. They burned the pieces and tossed the ashes into a tide pool. But the ashes from the demon caused ugly brown anemones to grow in the tide pool. Later, the villagers learned that a blade smeared with these “limu” would cause certain death of the victim. The little anemones came to be known as “Limu Make O Hana” or Seaweed of Death from Hana (Palytoxin: Prehistory).

Thanks to modern day science, those brown anemones, named *Palythoa toxica*, are now known to be members of zoanthid corals and the certain death contact with them caused is a result of poisoning by palytoxin. The isolation of palytoxin was achieved in December 1961 when researchers convinced local Hawaiians to reveal the location of the tidepool containing the Limu, the knowledge of which was “kapu” or taboo (Deeds et. al. 2011, Palytoxin: Prehistory). The samples tested revealed a unique toxin in efficacy, size, and mechanism of action. Since then, palytoxin (PTX) has been found in many more zoanthid species around the world, as well as red algae, a sea anemone, and several dinoflagellates.

There is some speculation that palytoxin is not produced by the zoanthids themselves, but by Ostreopsis dinoflagellates that the animals bioaccumulate (Violand 2008) Alternately, that the bacteria that live symbiotically in the coral are the producers of the toxin (Tartaglione et. al. 2016). More studies need to be conducted, however palytoxin poisoning does occur in dinoflagellate blooms in the Mediterranean area from aerosolization of the marine toxin.

## Order Zoantharia

| | |
|---|---|
| Kingdom: | Animalia |
| Phylem: | Cnidaria |
| Class: | Anthozoa |
| Subclass: | Hexacorallia |
| Order: | Zoantharia |
| Family: | Zoanthidae |

A colony of “dragon eye” coral, *Zoanthus sp.* Public Domain, WikiMedia [https://goo.gl/lyMdPp]

Zoanthids are known by several names in the aquarium trade industry including carpet coral, button polyps, “palys”, “zoas”, and “zoos”. They are an order of Cnidarians that is commonly found in reef tanks since they propagate easily and provide color. While related to corals, Zoanthids are neither corals nor soft corals. There is a distinction between *Zoanthus* and *Palythoa*, however the previous terminology is very strongly rooted in the hobby (Sprung 2015). According to Julian Sprung – and the taxonomic designation – the common name of “paly” refers to more than just genus Palythoa, it refers to genus Zoanthus. Referring to the above taxonomic chart, the genus is the next lower classification, as it becomes more specific.

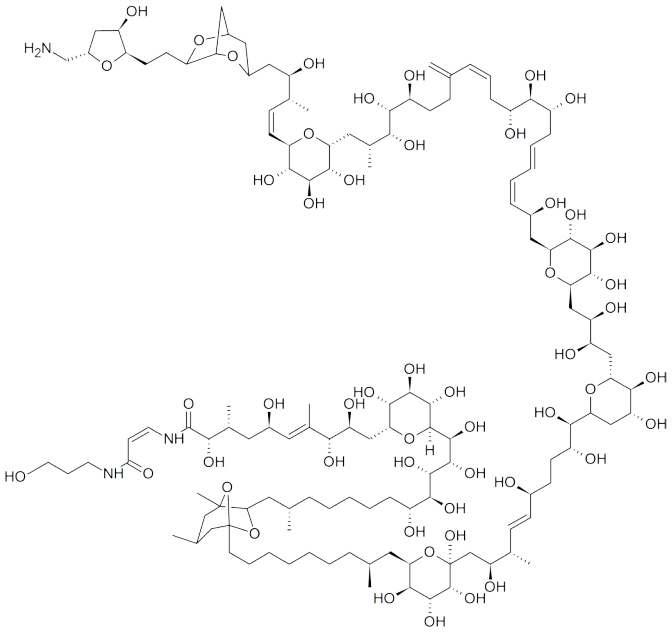
True *Palythoa* are brownish though some have bright shades of green. They are also very slimy and the tissue itself feels rough as they incorporate sand and other hard material into their tissue to strengthen themselves (Sprung 2003). The family Zoanthidae is the exception and they do not incorporate any particulates into their body. The organization of the tentacles into two distinct rows is the main shared characteristic of zoanthids. These animals typically feed by photosynthesis aided by zooxanthellae. Zoanthids can also capture particulate matter and plankton in the water column. They are typically a colonial organism but can also be found as individual polyps. Cnidarians have the oldest extant lineage of venomous animals in the world and their venom delivery

Palythoa grandis (*Sun zoanthids*) Public Domain, WikiMedia [https://goo.gl/xCBSRt]

system is as varied as the Cnidarians themselves. Even among jellyfish, the venom ranges in effectiveness from a mild itch to near immediate death for an adult human. However, the toxin of zoanthids is unique, even among the Cnidarians. This is palytoxin. It is produced by both *Palythoa* and *Zoanthus* sp. though the latter produces far less palytoxin than the former (Deeds 2011, Sprung 2015).

## Palytoxin

Palytoxin is the most highly toxic, non protein substance known to humans. Its molecular weight is high, at 3300 dalton. Compare it to similar toxins such as batrachotoxin (from the poison dart frog), saxitoxin (paralytic shellfish poison), and tetrodotoxin (found in pufferfish, triggerfish, blue ring octopus, and moon snails) which are all less than 500 daltons in molecular weight (Moore 1971).



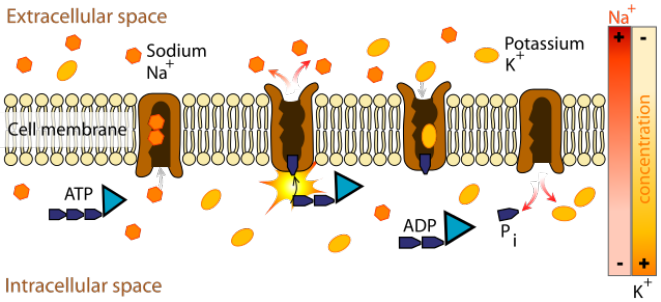
The molecular structure of Palytoxin. Public Domain, WikiMedia [https://goo.gl/h57hsQ]

Its $LD_{50}$, the dose that kills 50% of a population in a given time, is 0.15-0.3 µg/kg administered by IV in mice. By comparison, the most venomous snake has an $LD_{50}$ of 25 µg/kg and batrachotoxin has an $LD_{50}$ of 2-7µg/kg. This means that a tenth of the weight of a grain of rice of palytoxin, injected intravenously, would kill a 200 lb man. While palytoxin has no effect on worms, crustaceans and fish, who feed on the zoanthids, the toxin can bioaccumulate and cause poisoning in humans after fish and crustacean consumption (Deeds 2011, Gussow 2014, Schemmer 2008). Palytoxin can kill stony coral, though not soft coral, so it is not recommended to combine them in the same tank (Sprung 2015).

The extreme toxicity occurs in vertebrate cells, but with no cell specificity, so every cell that is exposed to the toxin is affected. Palytoxin acts extracellularly; it binds to surface cell receptors and creates a 'pore' in the cell membrane. Specifically, it binds to $Na^+$, $K^+$ -ATPase, or the sodium pump enzyme in charge of osmoregulation (Bignami 1992). This is the same binding site as ouabain, the plant derived toxin used as arrow poison in eastern Africa. For this reason it's speculated that ouabain could be used to reduce the symptoms of palytoxin poisoning, though efficacy is untested (Chhatwal 1983). Sodium pumps are found in every vertebrate cell and are necessary for cell viability.

Osmoregulation is key to cellular function and is controlled by the sodium pump in the cell membrane.

This pump is an enzyme that regulates the input and output of sodium ($Na^+$) and potassium ($K^+$) ions. $Na^+$ and $K^+$ gradients in mammalian cells are in constant flux as the cell, and by extension the organism, seeks homeostasis in order to maintain cell volume. Too many $Na^+$ and $K^+$ ions inside the cell and water will be pulled in until the cell bursts. Too many solutes outside, and water leaves the cell until they shrivel. The movement of water and solutes across the cell membrane is what determines blood pressure and by extension, the health of the organism. By creating a pore in the cell, palytoxin is able to disrupt the osmotic balance of the cell. $Na^+$ and $K^+$ flood into the affected cell and water follows until the cell lyses (bursts) and dies (Na/K-ATPase).




The mechanism of the sodium-potassium exchange pump. To maintain a balance of ions and water, ATP (cellular energy) is used to power the pump to transport Sodium out of the cell and Potassium into the cell. When Palytoxin binds to the pump, it is left open and ion exchange is no longer regulated. Public Domain, WikiMedia [https://goo.gl/b2GYyO]

## Symptoms of Exposure

### WARNING: Some may find the following images graphic in nature.

Given the nature of palytoxin to be nonspecific in its cellular targets, there are multiple symptoms that can be indicative of exposure depending on how a victim is exposed. The initial lethal dose studies found that mice exhibited decreased locomotion, paralysis in their hind limbs, diarrhea, severe convulsions and shortness of breath. Most people who have experienced palytoxin exposure report feeling like they're coming down with allergies, a cold, or the flu before recalling specific incidents with their reef tanks and live rock. Generally, palytoxin is lethal if ingested or injected. Contact through the skin or eyes, or by inhalation, is hazardous and still requires medical attention (Deeds 2010; Tartaglione 2016).

Pets are also at risk and symptoms include vomiting,

**Symptoms in Humans**

| | |
|---|---|
| Fever | Chills |
| Cough/Coughing up Blood | Shortness of Breath |
| Nausea | Muscle Pain |
| Bitter Metallic Taste | Burning in Eyes |
| Numbness | Cardiac Problems |
| Depression | High Blood Pressure |
| Coma | Death |

restlessness, and heavy breathing. If you observe these symptoms in a pet after working on a reef tank or live rock that contains zoanthids, contact your veterinarian immediately. Notably, symptoms can vary based on how exposure to palytoxin occurs. Contact on unbroken skin will likely lead to general cold and flu-like symptoms with possible numbness in the limb that came in contact with palytoxin. If the skin is broken due to a scrape or a cut, the symptoms will occur much faster and can include infection, numbness and muscle pain. If palytoxin is able to enter the bloodstream it can be fatal. Ingestion, similarly, of either water or the animal themselves, can also be fatal as well as cause heart problems and breathing difficulties.

The hands of Jim Craig in 2009 after cleaning *Palythoas* off of a shelf in a frag tank. More at [http://forums.tfhmagazine.com/viewtopic.php?f=8&t=26273]. Photo used with permission.

If water that has contained zoanthids or mucous from a zoanthid enters the eye through spray, or touch contact, blindness may result as well as itching, burning and redness. Inhalation of aersolized palytoxin from the spray of fragging or steam if zoanthids are mistakenly boiled when saving life rock can lead to extensive breathing difficulties and hospitalization. There is nothing in humans or their mammalian pets that isn't susceptible to palytoxin.

## Personal Stories and Medical Case Studies

In 2007, a man cut his hand on rock while cleaning his saltwater aquarium (Hoffmann 2008). Two hours later he noticed weakness, shivering, and numbness in his fingers. Sixteen hours later he collapsed at work and was admitted to the hospital where he was dizzy, had speech disturbance and glassy eyes. Similarly, a member of a Virginia area marine aquarist society wrote of his experience with palytoxin in 2013. He cut his hand moving rock around. Later, he picked up another rock and his injured finger immediately started burning. He had squished a small group of palythoas. The next morning throbbing pain woke him up and his hand and arm were swollen. He went to the ER and informed the doctors of the possible palytoxin poisoning. He was treated with antibiotics and released, and symptoms gradually improved (L8 2 RISE 2013).

"*Palythoa sp.*", courtesy of Andrew Butterworth (aka Butters) [http://goo.gl/S1Dkmm]

On a message board, a man recalled an attempt to save live rock for later use and boiled them on the stove as is common in saltwater fishkeeping (Superrmario 2013). What he didn't know was that palytoxin is heat resistant and can aerosolize. He, his wife and their dog were sick within hours with cold and flu like symptoms. A trip to the ER and chest x-rays revealed symptoms of bronchitis. Thankfully, they knew the likely source of their symptoms and were able to educate the doctor, who had no prior knowledge of palytoxin. They were sent home with an inhaler and antibiotics and gradually recovered. Their dog recovered as well.

In 2010, a reefer in Michigan rearranged items in his tank that he had sold. He neglected to wash his hands and rubbed his eye a short time later. That evening his eye felt irritated and he tried several over the counter methods to ease the irritation including flushing the eye with water and using rewetting drops. Those drops caused extreme pain and he went to the ER. At an opthamologist followup they recommended he see an eye specialist in Ann Arbor. The eye could barely be pried open. He was prescribed antibiotics and steroid drops. He could not see out of the eye except light; no shapes or colors were visible. His eyesight has slowly recovered though doctors are unable to predict if any permanent damage has occurred (acerhigh 2010). In 2015, a man required hospitalization in the ICU after a zoanthid squirted him in the eye (Ruiz 2015). Most recently, a *Palythoa* sp. expressed mucous directly into the eye of a coral farmer who also experienced pain, swelling and corneal injury (Chaudhry 2016).

A man cleaned some Zoantharia corals in his basement sink with hot water with no protective equipment. His wife and daughter were also present in the home. Symptoms including a cough, fever, chills and weakness appeared within 1-2 hours of cleaning. They all went to the ER though the man was the most severe. He required supplemental oxygen and when nebulizer treatments made no change was admitted to the ICU. He was finally discharged after a week. His wife and daughter had a shorter stay but still required hospitalization (Hall 2015).

An experienced aquarist nearly died from palytoxin poisoning. He had left rock with zoanthids overnight in a bucket. They had died so he scrubbed the rocks with hot water. He wore gloves and eye protection. However, he breathed in vaporized palytoxin, which remained despite the dead zoanthids. He thankfully printed out information on palytoxin to take with him to the ER, where he worsened, becoming paralyzed and coughing up blood. He did slowly recover (Kreeger 2012). A man in Virginia had a similar experience with boiling water and zoanthids. His case was not nearly as bad (Steveoutlaw 2007).

## Safe Handling Practices

In addition to wearing long gloves and eye protection, a face mask is advisable to avoid breathing in palytoxin in the event that it becomes aerosolized. Rather than boiling rock for reuse, soak

rock and coral in 10% bleach for thirty minutes to adequately kill any remaining zoanthids and neutralize any remaining palytoxin (CDC, Lowes 2015).

If possible, clean rock outside, but if that is not possible and live rock must be handled in an enclosed space, open windows and run a fan for adequate ventilation. Do not pressure wash them or use a bandsaw on zoanthid containing rock, as this can aerosolize palytoxin as well (Sprung 2015). When treating zoanthids that are overgrown with hair algae, keep the hydrogen peroxide ($H^2O^2$) dip short. Leaving the animals in the solution too long or at too high of a concentration will cause a release of palytoxin as a local fish store in Colorado can attest (Anecdote).

There are no best practices or official evidence-based handling guidelines according to the CDC as research still needs to be done (Hamade 2015). While laboratory levels of safety are not financially feasible for the average reefkeeper, following as many CDC guidelines for handling toxins of biological origin as possible should minimize hazardous incidents (http://www.cdc.gov/biosafety/publications/bmbl5/BMBL5_appendixI.pdf). Keep any water that has contained zoanthids away from pets and children, as ingestion of palytoxin can be fatal. Gloves are even more critical if you have any open wounds as injection of palytoxin directly into the bloodstream can be fatal if not treated. Once you are finished cleaning and/or defragging rock, wash your gloves in the sink before removing them and wash your eye protection once your gloves are safely removed (Groseclose 2015).

If you exhibit symptoms of palytoxin exposure after handling rock, coral and water from your tank, take yourself to an emergency room immediately. To better assist doctors, print out some of the following publicly available resources regarding palytoxins so they can make the best decisions possible in your health care.

- CDC Morbidity and Mortality report on Palytoxin Inhalation Exposure [goo.gl/YR72yq]
- NIH Toxicology Data Network Entry on Palytoxins [goo.gl/s24Frh]
- A recorded presentation from the Alaskan Section of Epidemiology [goo.gl/spT89H]
- Palytoxin exposure through skin injury [goo.gl/hvbMEs]

## In Conclusion

There are three genera of Zoanthids that are known to contain varying concentrations of palytoxins: *Zoanthus* sp., *Palythoa* sp., and *Protopalythoa*. There are no home tests to determine if a specimen contains palytoxins until symptoms appear after exposure. If you have these animals in your reef tank, be aware of the danger they pose and handle them with care and admire their color from the other side of the acrylic or glass.

## Summary

- Palytoxin exposure can occur through ingestion of animals that have eaten zoanthids, inhalation of vapor containing palytoxin, or through physical contact of skin with the corals.
- Seek medical attention immediately if you develop flu like symptoms within a few hours of handling coral, live rock, or cleaning your aquarium.
- Exercise caution and assume your live rock has palytoxin producing zoanthids, always use proper protective equipment such as goggles, long gloves and a face mask when rearranging and cleaning your tank.
- If possible, handle any possible zoanthids with tongs to avoid contact with potential palytoxin containing slime.
- Clean your gloves first before removing them, then goggles and mask

## References

References can be found on the web article: http://masna.org/masna-education/palytoxin/

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