

ZOANTHIDS (CNIDARIA: VERRILL, 1865) DWELLING THE FOUR ROCKY HABITATS ALONG THE PAKISTAN COAST

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ABSTRACT

Field observations as well as laboratory rearing experiment were carried out. During the study four (4) different species of zoanthids dwelling rocky intertidal platforms of Sindh coast belonging to three (3) genera were collected and identified from four (4) different localities. Other than that laboratory, rearing experiment was also performed on trial basis for all four species. Identified species were *Zoanthus sansibaricus* (Carlgren, 1900), *Z. vietnamensis* (Pax and Müller, 1957), *Epizoanthus scotinus* (Wood, 1957) and *Palythoa tuberculosa* (Esper, 1791). Except *Zoanthus sansibaricus* aforementioned three species have never been reported previously from Pakistan. Collection sites are Buleji, Manora, Paradise point and Sunera beach. Field surveys made during September and October 2016. During laboratory trials *Zoanthus sansibaricus*, *Z. vietnamensis* and *Epizoanthus scotinus* were reproduced successfully. However, *Palythoa tuberculosa* did not reproduce sexually in aquarium although it was also maintained successfully.

Key-words: Zoanthids, diversity, Rocky shores, Karachi, Pakistan, Arabian Sea.

INTRODUCTION

Commonly known button polyps or zoanthids are soft bodied most vibrant invertebrates belong to phylum Cnidaria. They may be found single or in colonial form attached to the intertidal rocks, some on the sponges or other corals from shallow water or deep seas (Trivedi and Vachhrajani, 2014; Reimer and Miyake, 2009; Irei *et al.*, 2011; Gul, 2013).

To date about 354 known species holding different morphological characters belonging to zoanthids have been reported worldwide (Trivedi and Vachhrajani, 2014; Appeltans *et al.*, 2012). Genus *Acrozoanthus* and *Isaurus* encrust sediments into their tissues except *Zoanthus* (Khushali *et al.*, 2014; Reimer, 2007). Zoanthids contain symbiotic relationship with Zooxanthellae “*Symbiodinium*” (Algae or dinoflagellate) for photosynthesis but some species also feed on Planktons, brine shrimps, small fishes or invertebrate food solutions. They require calcium and some amount of Iodine for an excellent growth. They reproduce by budding and fragmentation (Trivedi and Vachhrajani, 2014; Reimer *et al.*, 2006; Sinniger *et al.*, 2010; Sinniger, 2011). Zoanthids act as epizoic organisms i.e. they live in association with other flora and fauna without harming them. For instance crabs like *Brachyuran*, *Atergatis* and *Eriphia*, *Ulva* sp are found in association with *Zoanthus sansibaricus* and Xanthid crabs in association with *Palythoa* sp. (Reimer *et al.*, 2010; Khushali, 2015). Recently from American Samoa yellow zoanthids found colonizing the base of a dead golden octocoral have been recorded (NOAA, 2017). Moreover, some zoanthids have toxicological effects as well. Farooq *et al.* (2017) found corneal toxicity associated with aquarium coral palytoxin species.

In Pakistan, only cursory information is available over Zoanthids. Some taxonomic work has been done along the Karachi coast which only documented the presence of *Zoanthus sansibaricus* at Manora of Karachi coast (Gul, 2013) while earlier another study discovered a new alkaloid zoanthaminone isolated from a *Zoanthus* sp. (Atta-ur-Rahman, 1989).

They are difficult to identify morphologically hence, their taxonomy is neglected to be explained (Reimer *et al.*, 2006; Sinniger *et al.*, 2010; Reimer and Miyake, 2009; Irei *et al.*, 2011; Gul, 2013; Trivedi and Vachhrajani, 2014) and there is an immense need of molecular investigations to appropriately identify them, in spite the taxonomic classification (Van der Land and Hartog, 2001). Therefore, from Pakistan in-depth studies are also very much essential to explore zoanthid fauna on appropriate level as well as to safeguard local species from various climatic and anthropogenic threats.

Aim of the study was to investigate the species diversity of Zoanthids along the Karachi coast, Pakistan as there is any pertinent record of Zoanthids is not available in published literature from Pakistan, therefore preliminary studies were taken that will be helpful in future wild stock management and conservation perspective.

MATERIALS AND METHODS

A total of five (5) field surveys made during September 2016 and October 2016 on selected rocky ledges which are Buleji (24° 50' 356" N 066° 49' 368" E), Paradise (39.7596° N, 121.6219° W) and Manora (24° 47' 869" N 066° 58' 030" E) and Sunera beach of (24° 50' 559" N 066° 46' 528" E) along the Karachi coast (Fig. 1). During field surveys photographs of zoanthid colonies were made and GPS device used to record geographic position of the subjected location. Other than that hand held refract meter, PH meter, digital and mercury thermometers were also used to record in situ and in aquarium (ex situ) physical parameters like Salinity, PH, air and water Temperature respectively. Polyp collection also made from the wild stock by hand for laboratory rearing purpose. Some features of study areas are given below:

Study Area (Fig. 1)

Manora Rocky Ledge (24° 47' 869" N 066° 58' 030" E, Elevation: 10 feet): Located southwest to Arabian Sea.

Buleji (24° 50' 356" N 066° 49' 368" E, Elevation: 12 feet): Located southwest to the Arabian Sea comprised of about 8 km long rocky platform. Buleji is sandy from eastern side while mainly rocky from its western side. It contains some muddy patches in eastern flank while tidal pools in western side (Saifullah, 2009). Its rocky platform is triangular in appearance and highly diversified in Flora and Fauna (Afsar *et al.*, 2012).

Paradise Point (39.7596° N, 121.6219° W): It comprises of rocky sandstones and it is an eroding beach which is under the influence of strong wave action and high tides that is why its natural arch or zero point has vanished now that was once exist.

Sunera Beach (24° 50' 559" N 066° 46' 528" E): Sunera beach is next to Sonari and situated at the boundary between Sindh and Balochistan provinces near Hub River. Benthic profile is rocky with predominately occupied with large and small boulders, caves, shelters and a parallel prominently uplifted rocky platform containing fossil records of oyster beds present along the beach.

Collection identification and maintenance

During surveys, patch sizes recorded at three intertidal zones of each site. Collected samples of Zoanthids transported alive to the laboratory for preliminary cultural trials where placed in aquarium safely by maintaining required Salinity and PH. Total number of polyps counted before placing in aquarium. Periodically Lugol's iodine solution used to boost the Zoanthid's growth in aquarium. Moreover, some collected material also preserved in 4% formaldehyde solution as earlier described by Gul (2013).

Laboratory rearing trials carried out during September 2016 to January 2017 and for this 60-80 liter glass aquaria filled with sea water used with adequate aeration and light system. After maintaining physical parameters, collected polyps of all four species placed in aquarium. Light and aeration provided by using a robust system in aquarium. Data recorded on weekly basis i.e., PH, salinity, temperature, No. of polyp for each species to record growth pattern and possible mortalities.

All of the collected material was identified by the help of certain published literature and collection available in the online libraries i.e., Borneman, 2001; Cairns *et al.*, 2003; Reimer *et al.*, 2004 and 2006; Gotshall, 2005; Reimer, 2007; Reimer and Hickman, 2009; Sinniger, 2011; Appeltans *et al.*, 2012; Gul, 2013; Trivedi and Vachhrajani, 2014; Khushali *et al.*, 2013; Khushali, 2014; Morandini *et al.*, 2015; IUCN, 2016.

RESULTS

Identified Species

A total of four (4) species belonging to three genera have been collected and identified from rocky intertidal ledges of Sindh coast which are Manora, Buleji, Paradise and Sunera beach (Figure 1 and 2). Identified species are *Palythoa tuberculosa* (Esper, 1791) *Zoanthus sansibaricus* (Carlgren 1900) *Zoanthus vietnamensis* (Pax and Müller, 1957) and *Epizoanthus scotinus* (Wood 1957). Species were identified on the basis of external taxonomic characteristic features. Systematic classification of identified species is as given below:

Kingdom Animalia

Phylum Cnidaria (Verrill, 1865)

Class Anthozoa (Ehrenberg, 2834)

Subclass Hexacorallia (Haeckel, 1896)

Order Zoantharia or Zoanthiniaria (Gray, 1832)

Suborder Brachycnemina (Haddon & Shackleton, 1891)

Family Sphenopidae (Hertwig, 1882)

Genus *Palythoa* (Lamouroux, 1816)

1. Species *Palythoa tuberculosa* (Esper, 1791)

Family Zoanthidae (Rafinesque, 1815)

Genus *Zoanthus* (Lamarck, 1801)

2. Species *Zoanthus sansibaricus* (Carlgren, 1900)

3. Species *Zoanthus vietnamensis* (Pax and Müller, 1957)

Suborder Macrocnemina (Haddon & Shackleton, 1891)

Family Epizoanthidae (Delage & Hérouard, 1901)

Genus *Epizoanthus* (Gray, 1867)

4. Species *Epizoanthus scotinus* (Wood, 1957)

Identifications of above mentioned four (4) species were made in the light of description provided by earlier workers. Generally, *Palythoa tuberculosa* polyps aggregate to form colony together and a single polyp has been described as a thick and short body column, containing a wide oral disk on top with surrounding tentacles comprised in two rows. When these polyps are out of water, the tentacles and oral disks are folded back into the body column. Colours scheme includes brown, cream and yellow radiate (Ryland and Babcock, 1991; Mather and Bennet, 1993; Delbeek and Sprung, 1997; Borneman, 2001; Reimer, 2007; Deeds *et al.*, 2011).

Zoanthus sansibaricus also occur in colonies in intertidal and shallow waters mostly in strong water currents locations or areas exposed to strong wave action. In general outside of the polyp is consistent, exhibit light to dark gray-blue shades with no noteworthy markings on exterior. Tentacles up to 40–58 besides extensive variation in oral disk colors, patterns, and in colors of tentacles (Reimer *et al.*, 2004, 2006; Reimer and Hickman, 2009; Gul, 2013).

Zoanthus vietnamensis colonies may extend up to 10-15cm. Outside of a polyp's body column grayish blue in color. Bright pink loop around the top of the body column. Pink loop is most apparent when the tentacles are folded back into the body (Reimer, 2007; Khushali *et al.*, 2014).

Table 1. *In-situ* observations and polyp collection details from survey sites.

Site	Date of Collection	Species	Tidal level	Patch size	No. of polyp collected
Buleji	9/16/2016	<i>Palythoa tuberculosa</i>	Mid-Tide	12 x 9	38
		"	Mid-Tide	5 x 6	18
		"	Mid-Tide	3.1 x 1.3	
		<i>Zoanthus sansibaricus</i>	Low Tide	13 x 5	6
		"	Low Tide	8 x 5	53
Paradise	9/16/2016	<i>Zoanthus sansibaricus</i>	Low Tide	5.5 x 3.5	60
		<i>Palythoa tuberculosa</i>	Low Tide	2 x 1.5	
Manora	9/30/2016	<i>Epizoanthus scotinus</i>	Low Tide	13 x 8	40
		"	Low Tide	5 x 3	21
		"	Low Tide	15 x 8	57
		<i>Zoanthus sansibaricus</i>	Low Tide	7.5 x 2	73
		"	Mid-Tide	1.5 x 1.5	50
		"	Low Tide	6 x 2	60
		<i>Zoanthus vietnamensis</i>	Mid-Tide	3 x 1.5	28
Buleji	9/30/2016	"	Low Tide	18 x 15	200
		<i>Zoanthus sansibaricus</i>	Low Tide	10 x 7	130
		"	Mid-Tide	9 x 4	100
		<i>Palythoa tuberculosa</i>	Low Tide	6 x 3.5	180
		<i>Zoanthus vietnamensis</i>	Low Tide	8 x 4	>500
Sunera	10/18/2016	<i>Palythoa tuberculosa</i>	Low Tide	-	
		"	Mid-Tide	-	
		<i>Zoanthus sansibaricus</i>	Low Tide	-	

Epizoanthus scotinus with bright orange colour zoanthids found on rocks, from lower intertidal to 54 meters. Reproduce sexually and asexually producing dense aggregations of clones (Cairns *et al.*, 2003; Gotshall, 2005; Sinniger, 2011).

Status and Growth Patterns of Zoanthids along the collection Sites:

Field surveys revealed that there are plenty of Zoanthids present along the rocky beaches of Pakistan related to different genera specifically *Zoanthus*, *Epizoanthus* and *Palythoa*. An excellent growth is seen along the low tidal regions of the coasts but sparse growth is also seen at the mid tidal regions while at high tidal regions there is very little or negligible growth of Zoanthids. *Zoanthus* and *Epizoanthus* sp are found extremely abundant at low tides while sparse at mid tides while that of *Palythoa* their growth patterns are slightly different to *Zoanthus* species and found in all three intertidal zones (Table 1). In situ observations taken on zoanthid populations inhabiting all four aforementioned sites plus notes taken to keep records of occurrence at these sites as mentioned below and shown in Table 1.

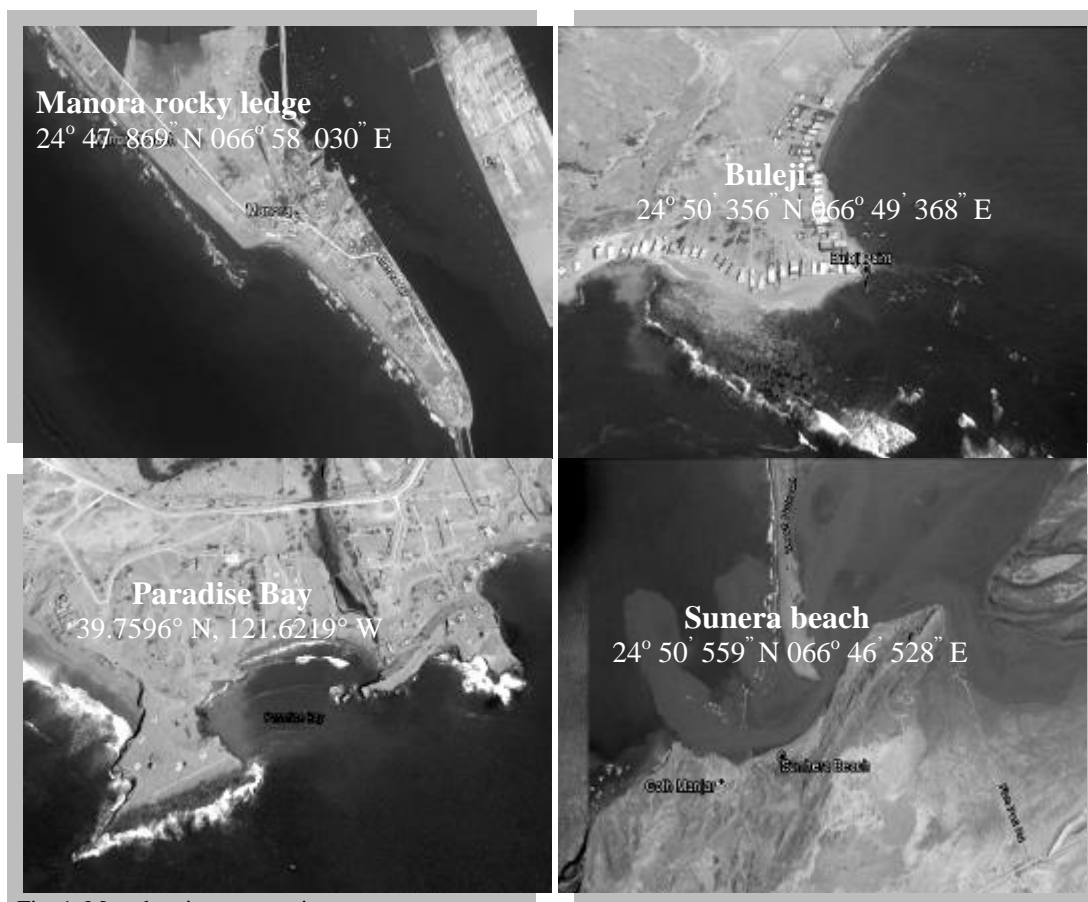


Fig. 1. Map showing survey sites.

Buleji:- Three species of *Zoanthus* and *Palythoa* have been recorded at Buleji which are namely *Zoanthus vietnamensis*, *Zoanthus sansibaricus* and *Palythoa tuberculosa*. **Paradise:-** Patches of *Zoanthus sansibaricus* and *Palythoa tuberculosa* were found at the Paradadise during September 2016.

Manora:- We have only seen *Zoanthus sansibaricus* at Manora but unique patches of *Epizoanthus scotinus* with bright orange colors and low densities have also been observed in lower tidal zone which are not found to any other survey sites except Manora.

Sunera:- *Zoanthus vietnamensis*, *Zoanthus sansibaricus* and *Palythoa tuberculosa* species were found at Sunera at low and mid tidal levels.



Fig. 2. Identified Zoanthid species maintained in aquarium for laboratory culture trials: *Zoanthus sansibaricus* (A), *Zoanthus vietnamensis* (B), *Epizoanthus scotinus* (C), *Palythoa tuberculosa* (D).

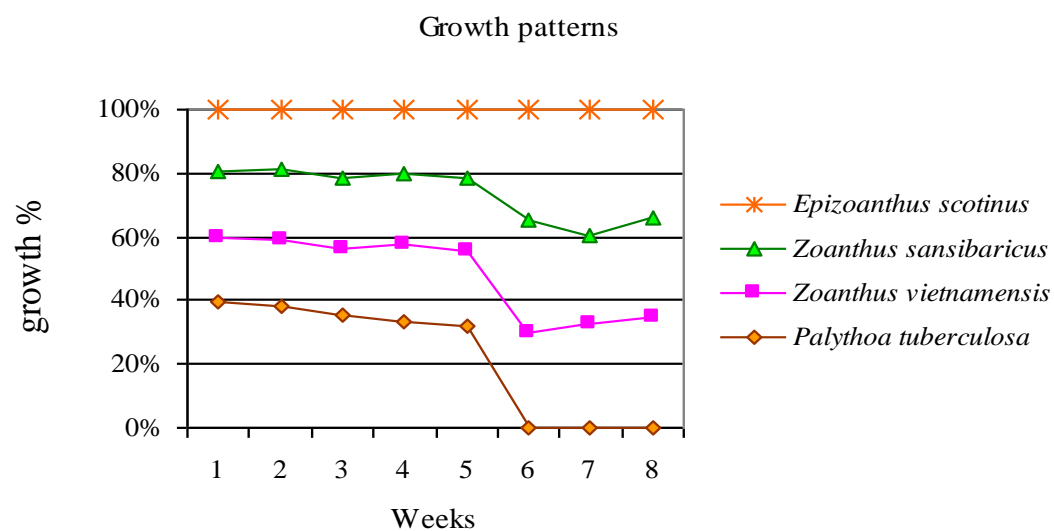


Fig. 3. Trend lines showing growth patterns of Zoanthids over eight weeks; maintained in aquarium for laboratory culture trials in optimum conditions.

Ex situ growth of collected Zoanthids in aquarium:

The growth of collected Zoanthids judged during September 2016 to January 2017 (Figure 3). Zoanthids have successfully maintained under special observations. Zoanthids related to genus *Zoanthus* and *Epizoanthus* have shown stability under artificial environmental conditions as well as reproduced sexually. In contrast only few which are related to *Palythoa* genus survived for about a month and then died. No sign of polyp multiplication shown by *P. tuberculosa*. Whereas an increase in reared polyps of *Zoanthus vietnamensis*, *Zoanthus sansibaricus* and *Epizoanthus scotinus* was recorded after two weeks that continued over eight weeks. Best growth seen in *Epizoanthus scotinus* that undergo multiplication and persistent growth over eight weeks as shown in Figure 3. While other two zoanthus species shown slight declining trend over a month and *P. tuberculosa* completely declined after four weeks under optimal conditions (Fig. 3).

The growth of Zoanthids boosted with Lugol's Iodine Solution that administered weekly in a small quantity. Recorded salinity range was 34 (minimum) to 38 (maximum) parts per thousand during experiment. Whereas temperature fluctuated between 19 (minimum) to 29 (maximum) and PH remained around eight (8) on average during the study period.

DISCUSSION

Information's on zoanthids from Pakistan are scarce only few published reports are available i. e., *Zoanthus sansibaricus* is reported from Manora rocky ledges, Karachi, Pakistan but it was not confirmed on appropriate level thus molecular identifications is required (Gul, 2013). There is no further work done about Zoanthids regarding their status and identification along the Pakistan Coasts and especially on their culture trials. The present study is not only the first step with respect to exploration of zoanthids at four sites and their status, besides it was the first ever laboratory rearing effort for culture trials of native Zoanthids species collected from the respective sites.

Zoanthids are abundant along the rocky ledges of Pakistan coast. *Zoanthus sansibaricus*, *Z. vietnamensis*, *Epizoanthus scotinus* and *Palythoa tuberculosa* that have been collected from the respective beaches i.e. Buleji, Paradise and Manora rocky ledges and Sunera belong to three (3) Genera: *Palythoa*, *Zoanthus* and *Epizoanthus*. From India Khushali and Pradeep (2013) found *Z. vietnamensis* at Veraval and Sutrapada coast. Other than that they have also reported *Z. sansibaricus*, *P. mutuki*, *P. tuberculosa* from India.

Some of the species of Zoanthids also contain stinging cells known as Nematocysts that containing poisonous chemical or toxin called the Palytoxin produced by *Palythoa* sp. while some species for instance, *Zoanthus* sp, contain biologically active compounds like norzoanthamine which is known to have leukemia and osteoporosis controlling properties (Mehra *et al.*, 2015; Genji *et al.*, 2010). Other than Ophthalmological constraints have been recorded caused by palytoxins (Farooq *et al.*, 2017; Vassallo 2017). Another study proved the presence of an acid α -Amino- β -phosphonopropionic in *Zoanthus sociatus* (Kittredge and Hughes, 1964). *Zoanthus* sp are recently recorded to have some fluorescent proteins like Zs Green (zFP506) and Zs Yellow (zFP538) (Krishna and Gophane, 2013; Khushali *et al.*, 2014).

The samples collected for growth purpose in aquarium resulted in efficient growth except *P. tuberculosa* that was not reproduced. While other three *Zoanthus* and *Epizoanthus* species have grown successfully under artificial environmental conditions whenever their Physico-Chemical parameters maintained up to their optimal requirements. Although *Epizoanthus scotinus* has been placed in IUCN red list of threatened species (IUCN, 2016) but during ex situ experiment species growth was remain 100% and *E. scotinus* found to be most persistent among all species. Zoanthid aquarium trade is very common in many countries thus; zoanthids are common in home aquariums. Apart from that in Pakistan still aquarium trade is not well known. Commonly these beautiful organisms are considered comparatively trouble-free to keep in home aquarium furthermore are often recommended to new aquarium keepers (Sud 2013). Thus, several aquarium shop staff and at home certainly several people had experienced palytoxin poisoning resulting in severe inception of clinically attuned symptom (Hamade *et al.*, 2015).

As aforementioned that aim of the study was to investigate the occurrence and species diversity of Zoanthids in and around the Karachi coast, Pakistan due to lack of pertinent record of Zoanthids in published literature from Pakistan, therefore preliminary studies were taken. It is concluded that above mentioned species were superficially identified and preliminary efforts been made to rear them in artificial environment to assess their stability and growth potential. However, it is suggested that critical taxonomic revision and identifications on molecular level may be carried out for confirmation. Thus, DNA bar-coding studies are required for authentic results.

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REFERENCES

- Afsar, N., G. Siddiqui and Z. Ayub (2012). Updates of records of selected Prosobranch Gastropod species found along the coasts of Sindh and Balochistan, Pakistan. *Pakistan Journal of Zoology*, 44: 267-275.
- Appeltans W., P. Bouchet, G.A. Boxshall, C. De Broyer, N. J. de Voogd, D.P. Gordon, B.W. Hoeksema, T. Horton, M. Kennedy, J. Mees, G.C.B. Poore, G. Read, S. Stoeher, T.C Walter and M.J. Costello (Eds.). (2012): *World Register of Marine Species*.
- Atta-ur-Rahman (1989). Isolation and structural studies on new natural products of potential biological importance. *Pure and Applied Chemistry*, 61: 453-456.
- Borneman, E. H. (2001). *Aquarium Corals: Selection, Husbandry and Natural History*. T.F. H Publications. 464 pp.
- Cairns, S.D., D. R. Calder, A. Brinckmann-Voss, C.B. Castro, D.G. Fautin, P.R. Pugh, C.E. Mills, W.C. Jaap, M.N. Arai, S.H.D. Haddock and D.M. Opresko (2003). Common and Scientific Names of Aquatic Invertebrates from the United States and Canada: Cnidaria and Ctenophore, Second Edition. *American Fisheries Society Special Publication*, No. 28. XI-115.
- Carlgen, O. (1900). Ostafrikanische Actinien. Gesammelt von Herrn Dr. F. Stuhlmann 1888 und 1889. *Mittheilungen aus dem Naturhistorischen Museum*, 17: 1-124.
- Deeds, J. R., S. M. Handy., K. D. White and J. D. Reimer (2011). Palytoxin Found in *Palythoa* sp. Zoanthids (Anthozoa, Hexacorallia) Sold in the Home Aquarium Trade. *PLoS ONE* 6: e18235. <https://doi.org/10.1371/journal.pone.0018235>
- Esper, E. J. C. (1791). *Der Pflanzenthier in Uebildungen nach der Natur*. Nurnberg, pp. 312.
- Delbeek, J.C. and J. Sprung (1997). *The Reef Aquarium*. Vol. 2, Ricordea Publishing, 546 pp.
- Farooq, A. V., A. G. Gibbons., M. D. Council., G. J. Harocopos., S. Holland., J. Judelson., B. L. Shoss., E. J. Schmidt., U. K. Md Noh., A. D'Angelo., R. V. Chundury., R. Judelson., V. L. Perez., A. J. W. Huang (2017). Corneal toxicity associated with aquarium coral palytoxin. *American Journal of Ophthalmology*, 174: 119-125.
- Genji, T., S. Fukuzawa and K. M. Tachibana (2010). Distribution and Possible Function of the Marine Alkaloid, Norzoanthamine, in the Zoanthid *Zoanthus* sp. Using MALDI Imaging Mass Spectrometry. *Marine Biotechnology*, 12: 81-87.
- Gotshall, D.W. (2005). Guide to marine invertebrates: Alaska to Baja California, 2nd ed. (revised). *Sea Challengers* 117 pp.
- Gul, S. (2013). Occurrence of zoanthid colonies (Cnidaria: Hexacorallia: Zoantharia) at Karachi coast, Pakistan: A Preliminary report.. *International Journal of Biology and Biotechnology*, 10: 153-154
- Hamade, A. K., S. E. Deglin., J. B. McLaughlin., J. R. Deeds., S. M. Handy and A. M. Knolhoff (2015). Palytoxin Inhalation Exposures Associated with Zoanthid Corals in Aquarium Shops and Homes, Alaska, 2012-2014. *Morbidity and Mortality Weekly Report MMWR*, 64: 852-855.
- Irei, Y., Y. Nozawa and J. D. Reimer (2011). Distribution patterns of five zoanthid species at Okinawa Island, Japan. *Zoological Studies*, 50: 426-433
- IUCN (2016). IUCN Red List of Threatened Species version 2016.3. <http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T30386A9533467.en>
- Khushali, P.M. (2014). Occurrence of Zoanthid genus *Isaurus* from Saurashtra coast, Gujarat, India. *European Journal of Zoological Research*, 3: 5.
- Khushali, P.M. (2015). Ecological Assessment and Distribution Pattern of Some Anthozoans along Saurashtra Coast Of Gujarat, India. *Maharaja Sayajirao University of Baroda*, 11: 1-157
- Khushali, P.M and C. M. Pradeep (2013). Brachycnemic Zooxanthellate Zoanthids (Cnidaria: Zoantharia) of Saurashtra Coast: A Preliminary Survey. *Research Journal of Marine Sciences*, 1: 10-13.
- Kittredge, J. S. and R. R. Hughes (1964). The Occurrence of α -Amino- β -phosphonopropionic Acid in the Zoanthid, *Zoanthus sociatus*, and the Ciliate, *Tetrahymena pyriformis*. *Biochemistry*, 3: 991-996
- Krishna, J.M and A. Gophane (2013). Cnidarian from the Coast of Goa Identified to the Species Level. *Journal of Pharmacognosy and Phytochemistry*, 2: 209-218
- Mather, P. and I. Bennet (eds.) (1993). *A Coral Reef Handbook 3rd Ed*. Surrey Beatty and Sons PT Ltd., Chipping Norton, NSW Australia.
- Mehra, R., D. S. Yadav., P. Kundu., W. Rehman and F. Bast (2015). First report of *Zoanthus pulchellus* from India. *Journal of Marine Biosciences*, 1: 1-4
- Morandini, A.C., S. Gul, V. Häussermann and U. Pörschmann (2015). Checklist of cnidarians from Pakistani waters. *The Journal of Biodiversity data*, 11: 1-8

- NOAA. (2017). Yellow zoanthids colonizing the base of a dead golden octocoral skeleton. Several living colonies of golden octocorals in the background. Image courtesy of the NOAA Office of Ocean Exploration and Research., American Samoa. '' <http://oceanexplorer.noaa.gov/oceanos/explorations/ex1702/dailyupdates/media/feb22.html>
- Pax, F., I. Müller (1957). Zoantharien aus Viet-Nam. *Mémoires du Muséum national d'histoire naturelle* (Paris), 16: 1–40
- Reimer, J. and C. Hickman (2009). Preliminary survey of zooxanthellate zoanthids (Cnidaria: Hexacorallia) of the Galápagos and associated symbiotic dinoflagellates (*Symbiodinium* spp.). *Galápagos Research*, 66: 14–19.
- Reimer, J., S. Ono, K. Takishita, Y. Fujiwara and J. Tsukahara (2004). Reconsidering *Zoanthus* spp. diversity: molecular evidence of conspecificity within four previously presumed species. *Zoological Science*, 21: 517–525. doi: 10.2108/zsj.21.517
- Reimer, J., S. Ono, Takishita, K., J. Tsukahara and T. Maruyama (2006). Molecular evidence suggesting species in the zoanthid genera *Palythoa* and *Protopalythoa* (Anthozoa: Hexacorallia) are congeneric. *Zoological Science*, 23: 87–94. doi: 10.2108/zsj.23.87
- Reimer, J. D. and H. Miyake (2009). Recent research on ignored taxa: diversity of zoanthids (Zoantharia: Hexacorallia). *Kaiyo Month. Zoological Sciences of Japan*, 41: 302–312.
- Reimer, J. D., M. Hirose and P. Wirtz (2010). Zoanthids of the Cape Verde Islands and their symbionts: previously unexamined diversity in the Northeastern Atlantic. *Contributions to Zoology*, 79: 147–163
- Reimer, J. D. (2007). Preliminary survey of zooxanthellate zoanthid diversity (Hexacorallia: Zoantharia) from southern Shikoku, Japan. *Kuroshio Biosphere*, 3: 1–16.
- Ryland, J. S. and R. C. Babcock (1991). Annual cycle of gametogenesis and spawning in a tropical zoanthid, *Protopalythoa* sp. *Hydrobiologia*, 216/217: 117–123.
- Saifullah, S. M. (2009). A Preliminary Survey of the Standing Crop of Seaweeds from Karachi Coast. *Botanica Marina*, 16: 139–144
- Sinniger, F. (2011). *Epizoanthus scotinus* Wood, 1957. In: Fautin, Daphne G. (2013). Hexacorallians of the World. Accessed through: *World Register of Marine Species* <http://www.marinespecies.org/aphia.php?p=taxdetails&id=283864>
- Sinniger, F., J. D. Reimer and J. Pawlowski (2010) The Parazoanthidae (Hexacorallia: Zoantharia) DNA taxonomy: description of two new genera. *Marine Biodiversity*, 40: 57–70. doi: 10.1007/s12526-009-0034-3
- Sud, P., M. K. Su, H. A. Greller, N. Majlesi and A. Gupta (2013). Case series: inhaled coral vapor—toxicity in a tank. *Journal of Medicinal Toxicology*, 9: 282–286.
- Trivedi, J. N. and K. D. Vachhrajani (2014). Study of the Macro Faunal Associates of the Littoral Zoanthid *Palythoa mutuki* (Cnidaria, Anthozoa) from Saurashtra Coast, Gujarat, India. *International Journal of Marine Science*, 4: 1–9
- Vanderl and, J. and J.C. den Hartog (2001). A check-list of the marine species in Europe and a bibliography of guides to their identification. Collection Patrimoines Naturels. *European Register of Marine Species* 50: 106–109.
- Vassallo, J. (2017). A Case of Keratoconjunctivitis Secondary to Aquarium Zoanthid Coral Exposure. *Ophthalmology and Vision Science* 1.1: 33–35.
- Wood, R. L. (1957). *Identification and microanatomical study of a new species of Epizoanthus* (Zoanthidae). Ph.D. thesis, University of Washington, Seattle. 82 pp.

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