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Review:
Biology of the commercially used sea urchin *Tripneustes gratilla* (Linnaeus, 1758) (Echinoidea: Echinodermata)

ABDUL HAMID A. TOHA[1,♥], **SUTIMAN B. SUMITRO**[2], **LUCHMAN HAKIM**[2], **NASHI WIDODO**[2], **ROBI BINUR**[3], **SUHAEMI**[4], **AJI W. ANGGORO**[5]

[1]Department of Fisheries, Faculty of Fisheries and Marine Sciences, Universitas Papua. Jl. Gunung Salju, Amban, Manokwari 98314, West Papua, Indonesia. ♥email: hamid.toha@gmail.com
[2]Department of Biology, Faculty of Mathematics and Natural Science, Universitas Brawijaya. Malang 65145, East Java, Indonesia
[3]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Papua. Manokwari 98314, West Papua, Indonesia
[4]Department of Marine Science, Faculty of Fisheries and Marine Science, Universitas Papua. Manokwari 98314, West Papua, Indonesia
[5]Indonesian Biodiversity Research Center (IBRC). Denpasar 80223, Bali, Indonesia

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Abstract. *Toha AHA, Sumitro SB, Hakim L, Widodo N, Binur R, Suhaemi, Anggoro AW. 2017. Review: Biology of the commercially used sea urchin* Tripneustes gratilla *(Linnaeus, 1758) (Echinoidea: Echinodermata). Ocean Life 1: 1-10. Tripneustes gratilla* is a species of sea urchin in shallow tropical waters. The species is economically and commercially important, has ecological value, and prospects as a biological control agent. It is considered as the commercially traded sea urchin. Overexploitation has caused a sharp decline in *T. gratilla* populations. Understanding biological aspects of *T. gratilla* is critical to the sustainable use of this resource in the future.

Keywords: Economically important, sea urchin *Tripneustes gratilla*

INTRODUCTION

*Tripneustes gratilla*is sea urchin that is classified into kingdom Animalia, phylum Echinodermata, subphylum Echinozoa, class Echinoidea, subclass Euechinoidea, infraclass Carinacea, superordo Echinacea, ordo Camarodonta, infraordo Echinidae, superfamily Odontophora, family Toxopneustidae and genus *Tripneustes* (L. Agassiz 1841) (Kroh 2013). This species has distinct morphological characters (Toha et al. 2012) and various colours of spine and tube feet (Toha et al. 2015).*T. gratilla* has been categorized as primary herbivore (Lawrence and Agatsuma 2013, Unsworth et al. 2010)and its distribution is spread throughout the tropical waters of the Pacific and Indian Oceans (Kroh 2013).

Tripneustes gratilla (Linnaeus 1758) is economically important, due to its value in supporting small-scale fisheries and commercial trade, and is important ecologically (Williams 2002; Juinio-Meñes et al. 2001; Toha and Zain 2003; Toha 2006; Rahman et al. 2009; Toha et al. 2013). The sea urchin is also reported to own a prospect as a biological control agent (Stimson et al. 2007). It contains bioactive compounds useful for drug discoveries and pharmacological research (Takei et al. 1991; Nakagawa et al. 2003).

This paper covers comprehensive information on morphology, ecology, genetics, and conservation of this species. This we hope can provide important information to improve human welfare through the advancement of science development, technology, and environmental science.

MORPHOLOGY

Tripneustes gratilla is a round shaped sea urchin with different morphological characters. Its body surface has colourful short spine and tube feet (Toha et al. 2015)which can be moved for defense and locomotion. Its body (termed corona or test) is divided into an aboral and oral surface. Surfaces are separated by the ambitus (horizontal circle with large diameter). Each surface is ended with a circular opening covered by flat structures. There are two major openings in the corona, namely the peristome and periproct.*T. gratilla* is enclosed within a test like structure which consists of unified plates forming container where the species conduct its activities. Its testis a body part that determines its general morphology.

Tripneustes gratilla has different diameters and heights which are influenced by age and maturity. Some of them have 16.5-94.5 mm (Eklöf et al. 2009), 90 mm (Dafni and Tobol 1986), 97.9 mm (Fouda and Hellal 1990, and 120 mm (Coleman 1991) in diameter. And some of them have 155 mm (Baker 1968) heights. A maximum size of 160 mm test diameter is reported by Rahman et al. (2014). Test diameter observed in Indonesian waters ranges from 82.1 mm (Darsono and Sukarno 1993) and 100 mm (Radjab 1997). While Toha et al. (2012) recorded different sizes in area around Papua; Manokwari 56.97-77.92 mm; Saubeba 76-90.37 mm; Wasior 62.1-93.46 mm; Biak 50-87.5 mm and Serui 58-77 mm.

HABITAT

Tripneustes gratilla is known to inhabit different habitats (Lyimo et al. 2011) including: seagrass (Traer 1980, Calvin et al. 1985; Sammarco 1987; Sumitro et al. 1992; Aziz 1994; Susetiono 2004; Lyimo et al. 2011), algae, microalgae and macro algae (Ogden et al. 1989, Lyimo et al. 2011), sand with coral rubble, coral reef with reef flat (Lyimo et al. 2011; Lawrence and Agatsuma 2013).

However, in particular parts of the world *T. gratilla* is found to thrive in typically similar habitats. In Japan, *T. gratilla* is observed in coral reef intertidal and subtidal zones (Shigei 1970). In Okinawa, Japan this species is found in sandy reef, seaweed and algae areas on a reef flat (Shimabukuro 1991). In Papua New Guinea *T. gratilla* is observed in *Thalassia hemprichii* fields (Nojima and Mukai 1985, Mukai et al. 1987) while in the Philippines *T. gratilla* lives in sea grass areas dominated by *Thalassia* and *Enhalus* species and *Sargassum* sp. (Regalado et al. 2010). In Indonesia, this species lives in sandy and muddy bottom reef areas as well as sea grass and algae flourishing habitats (Toha et al. 2012). *T. gratilla* also is also occasionally found in sandy and muddy sand covered by sea grass at 0.5-20 meters depth (Radjab 2004).

Tripneustes gratilla can be observed up to a depth of 75 m (Lawrence and Agatsuma 2013), but according to Lawrence (2007) is most common in very shallow water on a variety of hard substrates between depths of 2 and 30 meters. Ogden et al. (1989) spotted this species along Hawaii living in coral reef areas with sandy lagoon covered with seagrass and algae. In general *T. gratilla* is found in the intertidal and littoral zone of coral reef ecosystems with sea temperature ranging from 23.6-26.8°C (Shigei 1970) in Japan. In Ambon, Indonesia, *T. gratilla* lives within 23.3-26.2°C (Silahooy et al. 2013) and in Madagascar lives in 26-32°C ranges. However Toha et al. (2012) reported that this species is found within 30-31°C, 30-32$^{o}/_{oo}$ salinity and pH 7.3-8 respectively, and Dafni (1992) reported survival below 15°C. A report from Aqaba, Jordan, showed that this species could not move when transposed from 27 to 22°C (Lawrence 1973). This evidence indicates that there is an inactivity period during summer due to temperatures from 21-27°C (Dafni 1992). The highest latitude this species can be found is in South East Easter Island (Fell 1974) where sea temperature ranges from 17.5-24°C (DiSalvo et al. 1988).

DISTRIBUTION

Tripneustes gratilla is spread out throughout Western Pacific; Eastern Africa (Red Sea throughout Natal), Southern Islands (from Norfolk and Kermadec Island through Marquesas and Hawaii), Australia (from Port Jackson in eastern coast through Shark Gulf in western coast) and Southern Japan (including Bonin Islands) (Mortensen 1943). Lessios et al. (2003) and Lawrence and Agatsuma (2013) also reported that *T. gratilla* also spread extensively from Central Pacific through African Coast in the Indian Ocean. According to Shokita et al. (1991), *T. gratilla* is a sea urchin species found extensively along the Indian Ocean, Pacific and Indo Pacific, Indo Malaya including Australia, Japan, Eastern Coast of Africa and Eastern part of Hawaii (Kroh 2013).

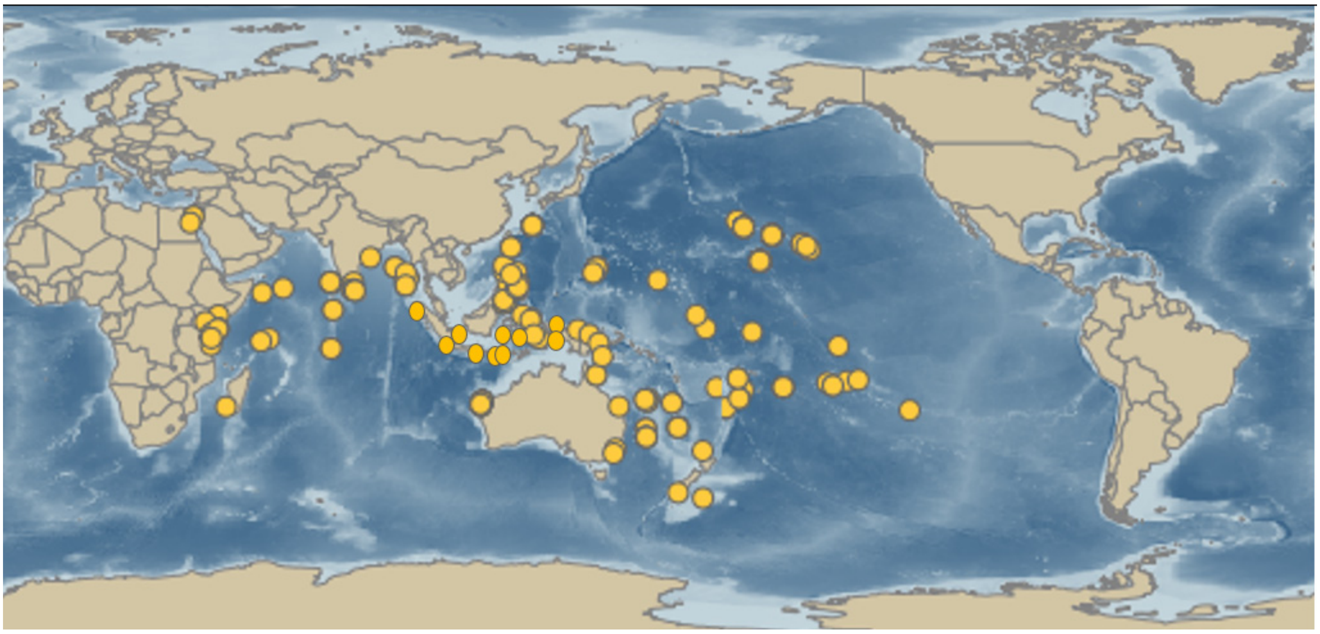

Figure 1. Distribution of sea urchin *Tripneustes gratilla*. Yellow dots indicate locations of *T. gratilla* (Modified from http://iobis.org/mapper/?taxon=*Tripneustes*%20gratilla)

In Indonesia, *T. gratilla* is spread out throughout all oceans including the eastern part of Indonesia (Aziz 1993) except the Arafura Sea (Clark 1946). *T. gratilla* is also found in Kema (Supono and Arbi 2010),Merah Cape (Lembeh Strait) (Susetiono 2004), Kapoposan Islands (Tuwo 1995), Spermonde Islands in Southern Sulawesi (Tuwo and Tresnati 1995), Morotai Beach in Northern Halmahera (Yusron 2006), Osi Islands in Western Seram Northern Maluku (Syam et al. 2002), Banda Neira (Andamari et al.1994), Tamedan in South East Maluku (Radjab 1997), Ambon (Silahooy et al. 2013), Buton in South East Sulawesi (Kasim 2009), Southern Lombok Beach (Aziz 1994), Nusa Dua Bali (Darsono and Sukarno 1993) and Balekambang-southern Malang (Sumitro et al. 1992). In addition, *T. gratilla* was also found in Padaido-Papua (Radjab 2004) and other Papua region such as Saubeba, Rendani Beach, Tanjung Pepaya, Nabire, Wasior, Biak (Toha and Fadli 2008; Toha et al. 2012). *T. gratilla* is spread out throughout all Papua-Indonesia with different local names (Toha and Zain 2003; Toha et al. 2014). *T. gratilla* was also found in Sanur-Bali, Tomia (Southeast Celebes), Jayapura (Papua), Palu, Donggala, Togian (middle Celebes).

DENSITIES

Density of *T. gratilla* varies over time and location. The lowest density was found during February 2006 and was increasing after two years (Edgar et al. 2009, Valentine and Edgar 2010). While in habitat covered sea grass and non sea grass density vary from 0.18±0.16 ind./m^2 to 0.54±0.21 ind./m^2 (Lyimo et al. 2011).

Mukai et al. (1987) observed the highest density of *T. gratilla* in less than one-meter depth in PNG where seagrass was found covering 80% of the observed areas. Alcoverro and Mariani (2002) observed average density of 1.5 ind./m^2 in Mombasa Kenya. Uy et al. (2000) also found the same quantity in the Philippines. In southern Guimaras, Philippines, density ranges from 0.06-0.58 ind./m^2. A very high density is observed at Lucero, Bolinao, Pangasinan (Philippines) reaching 4.6 ind./m^2 (Juinio-Meñes et al. 2008a). However, density of more 4 ind./m^2 is also reported in few places in Lord Howe Island Marine Park (Valentine and Edgar 2010). In Hawaii and Red Sea *T. gratilla* density ranges from 2.9-4.4/m^2 (Ogden et al.1989) and 50 ind./m^2 (Dafni and Tobol 1986) respectively.

In Indonesia average density of this species varies in different locations. In the area around Osi Island the density is approximately0.754±0.152 ind/m^2 (Syam et al. 2002), while around Nusa Dua, Bali, Darsono and Sukarno (1993) reported the density was around 0.278 ind/m^2, in Banda Neira around 2.83 ind/m^2 (Andamari et al.1994), and in Kema 0.84 ind/m^2 (Supono and Arbi 2010).

Dotan (1990) stated that *T. gratilla* distribution around Aqaba Gulf follows no specific patterns time wise, which was not directly correlated with coverage and with high variation from time to time. High density of *T. gratilla* potentially affects abundance and distribution of macroalgae (Stimson 2007).

BEHAVIOR

Tripneustes gratilla typically lives in a group with patchy distribution patterns (Aziz 1993; Syam et al. 2002; Toha and Fadli 2008) to increase fertilization success (Levitan 2004). However, observations in Indonesia showed species distributions overlapping in one place with *Toxopneustes pileolus*, *Mespilia globules*, *Temnotrema toreumaticus*, and *Pseudoboletia maculata* (Aziz 1993) though with a tendency to live separately from other species.

This distribution, however, remains inconsistent; some individuals may be found to live separately from other individuals. Nojima and Mukai (1985) observed that some of *T. gratilla* have a tendency to live in couples, while populations that showed no individual-to-individual body contact were observed, even with high density (Shimabukuro 1991). Despite some observation in Madagascar finding that this species lives without a specific distribution pattern (Maharavo et al. 1994), Lawrence and Agatsuma (2013) reported that *T. gratilla* is often found in groups of three or four, often touching and even overlapping.

Maharavo et al. (1994) also reported that this species has a strong tendency to consume seagrass in one certain area before moving to another area with high density of sea grass. Nojima and Mukai (1985) found that these species move 1.3 meters/day haphazardly in seagrass beds. Another observation showed that *T. gratilla* aggregated in groups of 10-20 individuals in Madagascar and some were dominated by *Thalassodendronciliatum* (Alcoverro and Mariani 2002). *T. gratilla* has variable feeding habits, grazing nocturnally in Reunion Island (Lison deLoma et al. 1999) and diurnally in the Aqaba Gulf (Schumacher 1974).

Tripneustes gratilla exhibits cryptic covering behaviors, which serve as protection from predators, light exposure, and strong currents (Park and Cruz 1994). Ziegenhorn (2016) found that *T. gratilla* partially underneath rocks covered more, and with more algae than urchins totally underneath rocks. Ziegenhorn (2016) also found that *T. gratilla* had a distinct preference for cover that best protects them from UV radiation. Spine loss did not significantly affect urchin ability to cover, and urchins with removed spines still preferred opaque cover.

DIET

According to Rahim and Nurhasan (2016) seagrass and seaweed are the main diets for most sea urchin, and *T. gratilla* is the most well-known seagrass grazer (Lyimo et al. 2011). Information on feeding preference is important to study the effect of sea urchin to sea grass beds, which could also contribute important information to sustain management of sea grass ecosystems (Eklöf et al. 2008).

Sea grass is mostly herbivore though some species also found to consume animal related materials (Lawrence 1975). According to de Loma et al. (2002), sea urchins feed on detritus material from seagrass as well as epiphytic and epibenthic micro and macroalgae, depending on variable factors including food availability and food preference (Lyimo et al. 2011).

The diet of T. gratilla varies depending on habitat (Lawrence and Agatsuma 2013) and development stage. The larval stage requires an external source of food to allow juvenile benthic development. Pre-feeding embryos cannot directly eat phytoplankton and will grow epithelial cells on their surface that can detect food particles and decompose them into organic materials (Miner 2007). *Early stage T. gratilla* eat sessile diatoms while bigger individuals consume macroalgae (*Sargassum* spp., sea weed, and microflora) (Shimabukuro 1991).

Tripneustes gratilla is an omnivore that generally lives around the substrate and eats various types of algae, periphyton, and sea grass (Eklöf et al. 2008; Stimson et al. 2007; Tomascik 1997) as well as some crustaceans and mollusks (Radjab 1997). *T. gratilla* mostly consume sea grass of different types including *Thalassodendron ciliatum*, *T. hemprichii*, *E. acoroides*, *Syringodim isoetifolium*, *Cymodocea rotundata*, and other types of algae (Alcoverro and Mariani 2002; Kasim 2009; Lyimo et al. 2011). Laboratory scale experiment showed that *T. gratilla* preferred fresh brown algae *Eckloniaradiata* and dislike dry *Ecklonia radiata, Sargassum linearifolium* and *Ulva lactuca* (Dworjanyn et al. 2007; Cyrus et al. 2015).

Tripneustes gratilla in Hawaii was observed to consume macroalgae and sand containing macroflora (Ogden et al. 1989). While a further investigation in the Philippines showed the remnants of *T. hemprichii*, *Halimeda*, *S. isoetifolium* and *rubles* in their intestine, which shows that this may be their main source of food (Klumpp et al. 1993). However, the most dominant seaweed found in Madagascar in their intestine was *S. isoetifolium* (Vaïtilingon et al. 2003). In Papua New Guinea, *T. gratilla* consumes *Cymodocea* spp., *E. acoroides, Halophila ovalis, S. isoetifolium*, *Thalassia hemprichii* (Hattori et al. 1985). While in Kenya and Tanzanian it consumes *T. ciliatum* (Alcoverro and Mariani 2002) and mixes of *S. isoetifolium*, *C. rotundata, Halodule uninervis*, and *T. hemprichii* (Lyimo et al. 2011) respectively.

In Indonesia, *T. gratilla* eats variety of diets. In Bali it eats cuts of *Ulva* sp. and seagrass leaves (Darsono and Sukarno 1993). In Southeast Maluku it dominantly consumes *E. acoroides*, *T. hemprichii* and *Caulerpa* sp., *Padina* sp., *Sargassum* sp. *T. gratilla* was also reported to consume crustaceans (Copepoda, Amphipoda), mollusks (Gastropoda, Bivalvia) (Radjab 1997).

REPRODUCTIVE CYCLE

Tripneustes gratilla was observed to exhibit an annual reproductive cycle with variable intensities. *T. gratilla* has annual reproduction cycle which is influenced by various parameters including water temperature, day length and feeding activities (Vaïtilingon et al. 2005). Both male and female have a reproductive system that is divided into five different gonads. Despite being sexually dimorphic, it is difficult to distinguish males and females externally except if the gonad is in a mature stage. The mature female's gonad is bright orange while male's cement is bright yellow when mature. Gonad or called ROE is not only where egg or sperm production takes place but also the main food storage chamber (Bruce 1988).

Maximum gonad size can reach 10-15% of its net body weight (Fouda and Hellal 1990). Individual weight is 25-89g, while gonad weight varies between 0.203-1.925g, equal to 0.003-0.042% of the total body weight (Radjab et al. 2010). Gonad production increases when its size reaches 70 mm and has shown no observed decreasing pattern even when its size reaches 100 mm. Muthiga (2005) reported that no significant correlation between gonad index and shell diameter while significant correlation is found between gonad weight and shell diameter.

Gonad production is influenced by diet. Male and female gonad production is a slight difference in output quantity (Lawrence 1987). However, this has never been thoroughly observed in the species. *T. gratilla* in sandy areas produce less sperm and egg than those living in sea grass (Jafari and Mahasneh 1984). Seasonally, most gonad peak production happens in spring (Tuason and Gomes 1979).

Gonad development occurs when its diameter reaches 50 mm at age less than one year (Dafni and Tobol 1986; Juinio-Menez et al. 1998). Mortensen (1943) reports that the gonophores open at an earlier state in some regions (gonads will already be present in those specimens). Gonad index increases at 70 mm size and remains at this index even when its diameter reaches 100 mm. Gonad maturity levels can be explained through a few steps (Radjab 1997) and these are 0 (neutral), 1 (initiation), 2 (developed), 3 (early maturity), 4 (mature), 5 (spawning) and may vary depending on time of observation (Radjab 1997).

On a laboratory scale, early maturity occurred when the diameter reached 40 mm (Radjab et al. 2010) and first maturity occurred at 1.5 years old when shell diameter reached 60 mm (Trinidad-Roa 1989). Observation in Tamendan and Japan shown that gonad mature and spawn whole year around (Radjab 1997) and in the summer and fall respectively. In Bali gonad matures at diameter of 40 mm (Darsono and Sukarno 1993).

Spawning season varies in *T. gratilla*. In Taiwan, it happens in fall (Chen and Chang 1981), in the northern Red Sea (Pearse 1974) and Gulf of Aqaba (Kidron et al. 1972) in spring, summer through fall in Kenya (Muthiga 2005), and in fall at the Philippines (Chen and Chang 1981). While in Tamendan, South East Maluku, Indonesia spawning seasons was predicted between August and September and continues through to mid October (Radjab 1997). Other observations in the Philippines also show that *T. gratilla* may spawn throughout the year Tuason and Gomez (1979)

Eggs and sperms mature throughout the year in Solitary Island with peak production occurring in fall and winter.

However, *T. gratilla* can only induce fertilization in fall (O'Connor et al. 1978). Gonad development phase is correlated with granule accumulation that started from March through June and declines in summer in Okinawa. This mature gonad is packed with eggs and spermson September (Shimabukuro 1991). Gametogenic activities occur throughout the year.

Pearse (1974) concluded that reproductive effort in *T. gratilla* doesn't correlate with temperature. Contrary to this, Chen and Chang (1981) stated that geographical variations in spawning correlate with temperature. Another observation reported that *T. gratilla* had mature and spawning phases each month, but an increased percentage of spawning phases observed in August and September (Radjab 1997).

LIFE CYCLE AND GROWTH

Sea urchins can live up to 100 years. Maximum age estimates acquired through growth zone in tiny skeleton bones in *Lytechinus variegatus* show that this species can live to maximum 4 years (Beddingfield and McClintock 2000), while the same method of measurement used for *Strongylocentrotus intermedius* resulted in a maximum age estimate of 10 years (Agatsuma 2001). Another method using C^{14} showed that *S. franciscanus* could live more than 100 years (Ebert and Southon 2003). *T. gratilla, however,* have been found to live relatively in a short time period. According to Lawrence (2001) and Shimabukuro (1991) *T. gratilla* can not live more than two years. Ebert (1982) also reported that *T. gratilla* could only live to maximum 1 year.

Tripneustes gratilla experiences few growth cycles in its life, with egg fertilization through to adult consisting of two cycles which include pre-adult (embryonic phase, larvae and juvenile) and the adult phase (Shokita et al. 1991). *T. gratilla* takes about two to five years to become a reproducing adult.

Generally sea urchins are of single sex with prevalence in spawning areas, and are able to disengage their sperms and eggs in the water column for fertilization (Levitan 2005, 2006; Rogers-Bennett 2007; Byrne et al. 2010). *T. gratilla* spawn once a year. Fertilized eggs will then turn into blastula and gastrula and subsequently grow into a planktonic prismatic stage. Inline with skeleton growth, the prismatic stage develops into larvae (echinopluteus or pluteus), which has a number of cilia, which may vary between 4 or 8 depending on the development stage (Byrne et al. 2008a, 2008b).

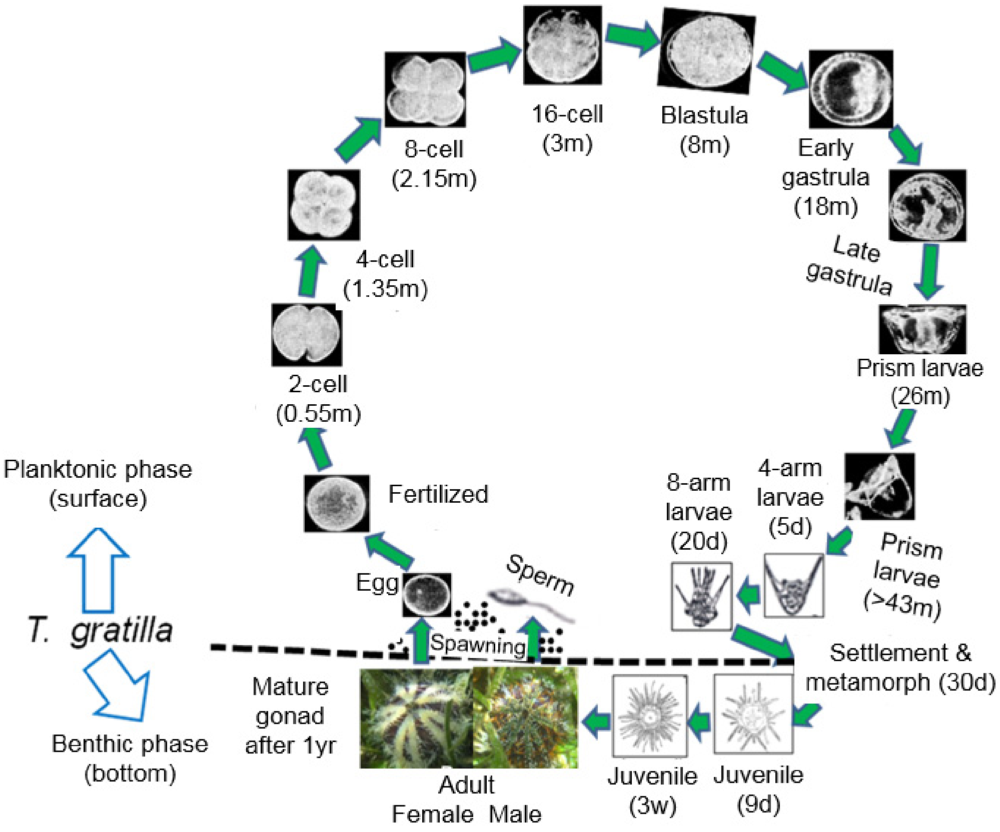

Figure 2. Life cycle of *Tripneustes gratilla*

Laboratory scale observations in Japan show that larvae *T. gratilla* can develop completely within 20-30 days depending on temperature and food supplies (Shokita et al. 1991). However, an experiment in the Philippines showed that average larval duration was 42-52 days (Junio-Menez et al. 1998). Shokita et al. (1991) also reported that larval cycle (prismatic larvae, 4 and 8 arms larvae) in wild environments can persist for up to 25 days.

Laboratory observation shows that this species can attain complete metamorphosis within 18 days, while similar observation in Taiwan show this duration can take up to 30 days (Chen and Run 1988). Shimabukuro (1991) reported that diameter growth in *T. gratilla* could reach 60-70 mm. Similar observations in the Philippines (Bacolod and Dy 1986) and the Aqaba Gulf (Dafni 1992) reported that *T. gratilla* grew to 60 mm within five months of observation. Shell diameter growth in Tamedan, South East Maluku was on average 0.05 mm/day while growth in weight can reach 0.10 g/day (Radjab 1997).

Tripneustes gratilla found living in Southern Guimaras, the Philippines can reach 60 mm within 8 months (Regalado et al. 2010), though similar studies in the same place a year before showed that the same diameter was reached within 10 months (Beldia et al. 2003). The difference in growth parameters shows that habitat condition and diet may affect growth level and maximum size in *T. gratilla* (Regalado et al. 2010, Juinio-Meñes et al. 2008). Shimabukuro (1991) also reported that growth could also slow down when this species experiences stress. Furthermore, it was reported that the growth could escalate when this species changes its diet from sessile diatoms to macroalgae. Individual diameter can also reach 10 mm in June and 60-70 mm in November.

RECRUITMENT

According to Ebert (1982) recruitment in this species can be patchy due to random movement of this species throughout the area it inhabits. This finding is supported by Dafni and Tobol (1986) who found random areas of recruitment in the Red Sea. The random areas recruitment success is related to its ability to live in different habitats including sand and sea grass beds, lagoon, coral reefs and the intertidal zone. According to Juinio-Meñes et al. (2008b) recruitment success in farming scale is influenced by biophysical and local management intervention.

Recruitment reaches a peak in November in the Philippines with a smaller peak in March (Bacolod and Dy 1986). Another observation in the same place also shows that this species mainly recruits in April and May. Observations from Papua New Guinea suggest that recruitment only happens once in a year (Mukai et al. 1987). However the same observations during 1980-1981 by (Dafni 1992; Dafni and Tobol 1986) shown that *T. gratilla* with less than 10 mm in size are found in large quantities in January through February, May through June and in August (Dafni 1992; Dafni and Tobol 1986).

MORTALITIES

Pacific and Atlantic population of *Tripneustes* have shown a high mortality and fecundity rate with also fast individual and population growth (Lawrence and Agatsuma 2013). Mortality in *T. gratilla* is influenced by several factors including seasonal rains and bad weather (Vaïtilingon et al. 2005), decreased recovery (Ebert 1982), succession (Dafni 1992; Dafni and Tobol 1986), entrapment in shallow water (Shimabukuro 1991), habitat alteration and predation (Regalado et al. (2010), natural death (Juinio-Menez 2008) and many other unknown factors (Eklöf et al. 2009).

Regalado et al. (2010) reported that mortality in *T. gratilla* can reach 99.3%. Juinio-Menez (2008) also reported that natural mortality in different sites in Luzon Northwestern and Central Philippines varies from 91-96% and 99% respectively. High mortality in Hawaii, Kenya, Seychelles, and Israel can be caused by low recovery capacity after a one-year period (Ebert 1982). Dafni (1992) and Dafni and Tobol (1986) also reported that mass mortality in Eilat typically happens twice during winter succession. However, low mortality is observed during rainy seasons on shallow reef flats in Okinawa (Shimabukuro 1991).

PREDATORS

Tripneustes gratilla is hunted by humans for its delicious gonads, and other predators include parrotfish, triggerfish and pufferfish (Mahon and Parker 1999), which also consume its gonads and shell contents. Specifically, in sea grass areas, *T. gratilla* is hunted by *Cassis*sp (Tertsching 1989). However, the main predators of T. gratilla in protected areas and hard, rough substrates are sea stars (*Protoreaster linki*) (Shears and Babcock 2002, Bonaviri et al. 2009; Eklöf et al. 2009). Eklöf et al. (2009) also found that *T. gratilla* has many other predators including Asteroidea, Gastropoda, Balistidae and Labridae.

COMMUNITIES

According to Valentine and Edgar (2010), *T. gratilla* has a specific role as an ecosystem engineer. High density can cause a significant decrease in algal coverage including red and brown algae. Encrusting coralline algae coverage increases with higher densities of *T. gratilla* (Bacolod and Dy 1986). *T. gratilla* is also a pest in sea grass farming though recovery process is not entirely affected it. Hyper-abundant populations of *T. gratilla* have been observed to overgraze complete seagrass beds of primarily *Thalassodendron ciliatum* on the Kenyan coast (Alcoverro and Mariani 2002; Zanre and Kithi 2004; Uku and Björk 2005).

GENETIC

More than 274 nucleotide sequences for *T. gratilla* are available in the NCBI database (http: //www.ncbi.nlm.nih.gov/nuccore). Including the full *T. gratilla* mitochondrial genome ranging from 15720-15725 bp. Available sequences include many samples from COI partial group (more than 220 partial sequences).There are various uses for nucleotide sequences, such as for morphological and molecular phylogeny (Littlewood and Smith 1995), genetic patterns (Liggins et al. 2014), marker organization (Carlon and Lippe 2007), primary design for barcoding (Hoareau and Boissin 2010), phylogeny and expression (Gibbons et al. 1994), mtDNA phylogeny (Zigler and Lessios 2003), retrovirus-like element (Springer et al. 1991), evolutionary history of larval skeleton morphology (Kinjo et al. 2008), and others.

Studies on molecular genetics of the *T. gratilla* show that high gene flow up to more than hundreds of kilometers is a standard characteristic of all sea urchin species possessing a planktonic larval stage (Lessios et al. 2001, Liggins et al. 2014), and similar patterns are found from *T. gratilla*in Indonesian waters (Toha et al. 2014).

CONSERVATION

Tripneustes gratilla has not yet been assessed for the IUCN Red List. However, *like* other sea urchins, it has biological characteristics that make it susceptible to overexploitation. In general, sea urchins mostly prefer particular habitats, and their slow movement restricts their distribution and may cause them to be vulnerable to local extinction. In general, sea urchin fisheries do not have any management system or local restrictions. Sea urchins are also a target for biotechnology and a variety of biologically active compounds has been isolated from the sea urchin species. Target species for these purposes is not specific and there is some financial benefit to local communities. It is necessary to regulate this industry to ensure maintain viable populations (Micael et al. 2009).

Conservation is important in order to protect *T. gratilla* stocks. Several steps conducted for echinoid conservation in France (Mediterranean and Atlantic), Ireland, Iceland, South Korea and Philippines and China are: entry limitation (moratorium) followed with active programs to reduce latent businesses, resources survey at various complexity levels, to use an annual total fishing permit based on resources analysis, zonal and regional management towards rotational harvest points, and to use a minimum legal size (Williams 2002).

In the Philippines, Marine Science Institute has opened a *T. granilla* hatchery at the reef flats of Bolinao, Pangasinan. In South Korea, on a coastal scale, this is done through village collaborations that decide how many people have access and when to do. Vessel permit restrictions are also a sea urchin fisheries management strategy in South Korea. Sea urchin fisheries in Russia are set by regulating total allowable catch based on fisheries free-survey and fisheries information analysis. Minimum size permits and fishing season are also implemented to protect their spawning.

In New Zealand, sea urchin fishery is a non-quota fishery and managed through various permits and season and fishing ground closures. On the other hand, Tasmanian sea urchin fishery has been regulated through moratorium strategy for new entrants in 1990s and the permit cannot be moved. In 2002, Tasmania conducted a competition of total allowable catch, in which it was divided into zones and the total allowable catch was used to encourage management and regulation. In New South Wales, the sea urchin fishery used entry limitations through removable permits. Area closures are applied to restrict access.

The present conservation mechanism should be integrated and consistently set up on a global scale. Furthermore, sea urchin fisheries need an ecosystem approach through increase in information exchanges between government institutions, NGOs, and academician, and inter-stakeholder dialogues, including industries and sea urchin resources communities. Development and integration of several suggestions for size and spatial scale difference considerations (local, regional and global) will allow sustainability in using sea urchin species as resources. There is also clear necessity to raise our biological knowledge on the target species to promote that group diversity is maintained (Micael et al. 2009).

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