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DEPIK Jurnal Ilmu - Ilmu Perairan, Pesisir dan Perikanan

p-ISSN (Print): 2089-7790, **e-ISSN (Online):** 2502-6194

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PUBLISHER ADDRESS:

Faculty of Marine and Fisheries
Universitas Syiah Kuala
Jalan Meureubo No. 1, Kopelma Darussalam
Banda Aceh, 23111, Indonesia

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DEPIK
Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
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Description scleractinian coral from Miang Island, East Kalimantan

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ARTICLE INFO

Keywords:
Hard coral
Acropora
Porites
Identification
Miang Island

DOI: 10.13170/depik.11.3.29277

ABSTRACT

The exact number of coral species in Indonesia is not unclear yet, in 2002 the coral taxonomist stated 590 species, and which was supported by an Indonesian coral taxonomist, eight years later. The current coral species data is 605 from the Coral Triangle Region area (CT). The eastern of Indonesia, which is located in the Coral Triangle Region, has received a lot of attention from coral researchers, due to coral species that have been described. On the other hand, the coral reef from the western part of Indonesia, including in the East Kalimantan, has not been explored much. Through the ecoregion view, E. Kalimantan region is clustered into ecoregion 43 (Sulu Sea) which has 540 coral species. Miang Island is one of the inhabited islands from E. Kalimantan, and has an unexplored coral reef ecosystem. The method had been used in this research is descriptive, which uses photos of live corals to describe colony characteristics corals. The results of the study had described 10 families of coral that make up coral reefs on Miang Island.

Introduction

Veron *et al.* (2009) mapped coral species based on geography into 141 ecoregions and then this division became known as Coral Geographic. A total of 798 coral species have been described from all these ecoregions or clusters. The Coral Triangle (CT) has attracted the attention of coral experts among all the existing ecoregion clusters. CT is a merger of marine areas of Indonesia, Filipina, Malaysia, Timor Leste, Papua New Guinea and Solomon Islands whose total area is 5.5×10^6 km^2. Five hundred seventy-four species of hard coral have been described from CT's area which 553 species can be found in the Raja Ampat Islands, Indonesia (Hoeksema, 2007; Veron, 2002; Veron *et al.*, 2009; Veron, 2011). So Raja Ampat is known as a coral biodiversity hot spot in the world. In addition, three other places in Indonesia are known as hot spots for coral, i.e. the northern tip of Sulawesi, Ambon Island, and Kei Islands (Asaad *et al.*, 2018). All those mentioned places have become home to>4000 other marine species (Asaad *et al.*, 2018; Miller *et al.*, 2016).

Coral biodiversity is usually measured using the diversity of species present in an area. Traditionally, coral identification uses a skeleton morphological approach that differs between taxa (Kitahara *et al.*, 2016; Veron, 2013; Veron, 2011). Since there are too many morphological features to describe, coral taxonomists use a system called key identification to simplify them. Another way to identify corals is by using a genetic approach. Recently, coral has been classified using both methods and resulting in changing species names and species moved to another family (Huang *et al.*, 2014; Kitahara *et al.*, 2016; Veron, 2013).

Both methods have advantages and drawbacks, by combining these methods will minimize the weaknesses of each methodology. For instance, coral

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p-ISSN 2089-7790; e-ISSN 2502-6194
Received 25 November 2022; Received in revised from 26 Desember 2022; Accepted 27 Desember 2022
Available online 28 December 2022

morphology has challenges for hybridization and plasticity issues. Hybridization is determined as the exchange of species genes and resulting heterogeneity of outcomes. Extensive and persistent introgressive mating episodes, along with morphological, behavioral, and/or ecological differences, can result in species fusion and the eventual extinction of pure parental species (Flot *et al.*, 2011; Hobbs *et al.*, 2022; Willis *et al.*, 2006). This process also led to emerging new species or new morphology of the coral (Willis *et al.*, 2006). For instance, *Acropora prolifera* has been suggested as the only coral hybrid from the Caribbean because there is no fossil record of this coral while the other similar coral e.g., *A. cervicornis* and *A. palmata* had a fossil record of approximately six millions years ago (Willis *et al.*, 2006). Plasticity is defined as a change in the morphology and physiology of coral due to organisms' development and ecological factors (Todd, 2008). Acroporids and Pocilloporids coral is the most coral found in plasticity adaptation in the field (Flot *et al.*, 2011; Todd, 2008).

Miang Island is located in ecoregion 43 (Sulu Sea) with the number of coral species in this cluster is 540 (Veron *et al.*, 2011; Veron *et al.*, 2009). Coral reefs on Miang Island are composed of various biotas such as corals, sponges, soft corals, various algae, and other invertebrates (Irawansyah et al., 2019). Based on Irawansyah *et al.* (2019) and Rosdianto (2022) the average live coral cover in the waters of Miang Island naturally is between 27-30%. The low live coral cover on this island may be caused by several things, such as high competing biotas such as macroalgae, sponges, and soft corals, low coral recruitment, unstable aquatic substrates, high sedimentation, and rising global CO_2 concentrations (Hoey *et al.*, 2011). The purpose of this study is to describe various coral species in Miang Island as a basis for information on the diversity and biodiversity of coral reefs in this region.

Materials and Methods

Location and time of research

The research was conducted from 28th April to 3rd May 2018 in Pulau Miang, East Kalimantan. The survey was carried out at four points to describe coral reefs of Miang Island, the northern part (St.1), the western part (St.2), the eastern part (St.3), and the southern part (St.4) of Miang Island. Station 1 (00° 58.816' N, 117° 58.538' E), station 2 (00°43,839' N, 117°59.551' E), station 3 (00°43.901' N, 118°01.385' E), station 4 (00°43.044' N, 118°01.172' E). The sampling point can be seen in Figure 1.

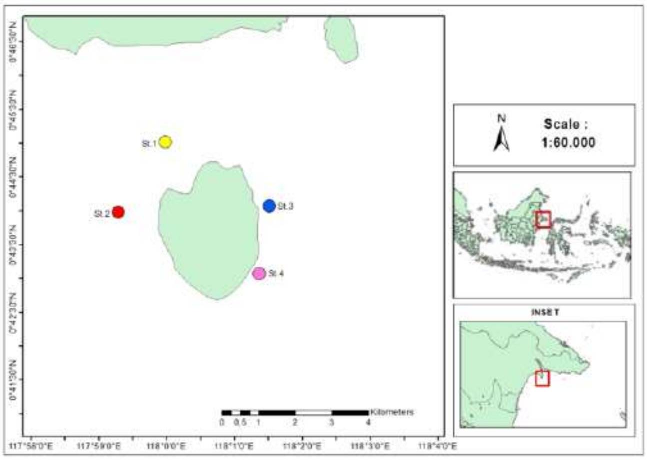

Figure 1. The research location.

Sampling and coral identification

Coral sampling followed purposive sampling (Luthfi *et al.*, 2018), in which 4 stations were decided according to certain considerations. In this research data has been taken from the depth of 5 and 10 m. A 100 m tape lined on the reef area synchronously or parallel to the island coastline then a *Quadrat Transect* 1x1m placed along the tape and coral photographed using Canon PowerShot G15 with an underwater housing (Luthfi *et al.*, 2018). The photos were then analyzed using Photoshop and ImageJ software, while coral identification used a visual method regarding Kelley (2009), Kurniawan *et al.* (2019), and Veron (2000).

Results

The result showed that coral genera had been found from Miang Island were 31 of 10 coral families, they were: Acroporidae, Agariciidae, Diploastreidae, Euphylliidae, Fungiidae, Lobophylliidae, Merulinidae, Pocilloporidae, Poritidae, and Psammocoridae.

Discussion

Family Acroporidae (complex) and Diploastreidae (robust)

Acropora echinata. *A. echinata* corals have characteristic branching similar to bottle brush, while the axial and radial corallites are difficult to distinguish because they have a similar shape, which is a short tube (Wallace, 1999). These corals are commonly found throughout the Indo-Pacific region including Miang Island (Figure 2a). *Acropora microphthalma*. This type of coral is very much found at a depth of 5 m on Miang Island with large colonies measuring more than 1 m. The main character of this coral is that it has small branches, with a straight shape surrounded by radial corallites of small and uniform size (Fukami *et al.*, 2021). The color is usually brown to cream

(Figure 2b). *Acropora cytherea*. A characteristic of *A. cytherea* is a thin sheet like a table, sometimes stacked. Branches are tiny even when living in waters with strong currents the branches will merge with each other. Axial corallites are long tubular with short corallite radials with open calyces (Fukami *et al*., 2021). The most common color found is brown (Figure 2c). *Acropora muricata*. Colonies of this coral are arborescent with large branches; the most easily recognizable feature is that these corals have radial corallites of the same size and neatly lined up (Fukami *et al*., 2021). The color commonly found in the waters of Miang Island is brown with bright branching ends (Figure 2d).

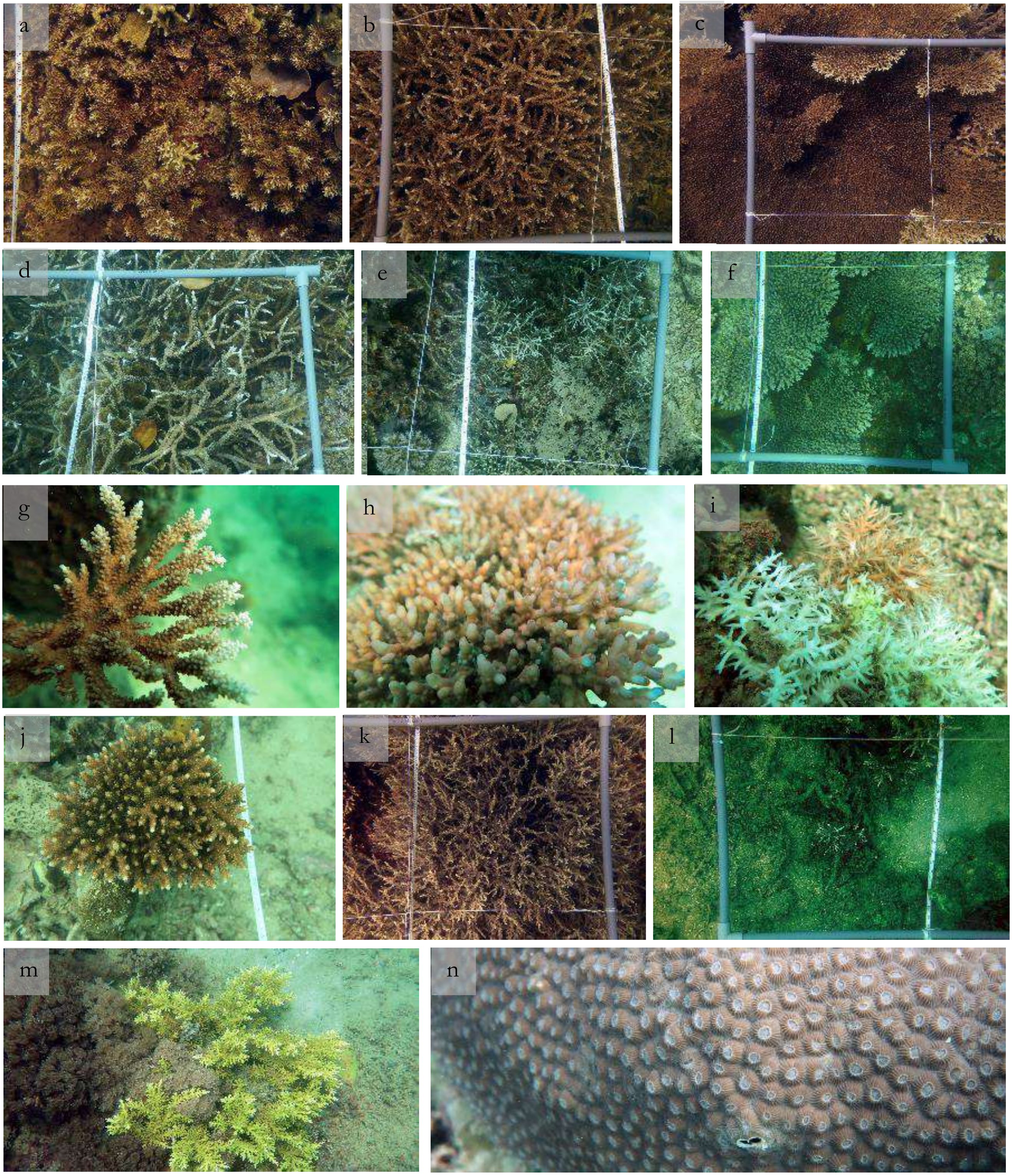

Figure 2. Acroporidae (a-m) and Diploastreidae (n).

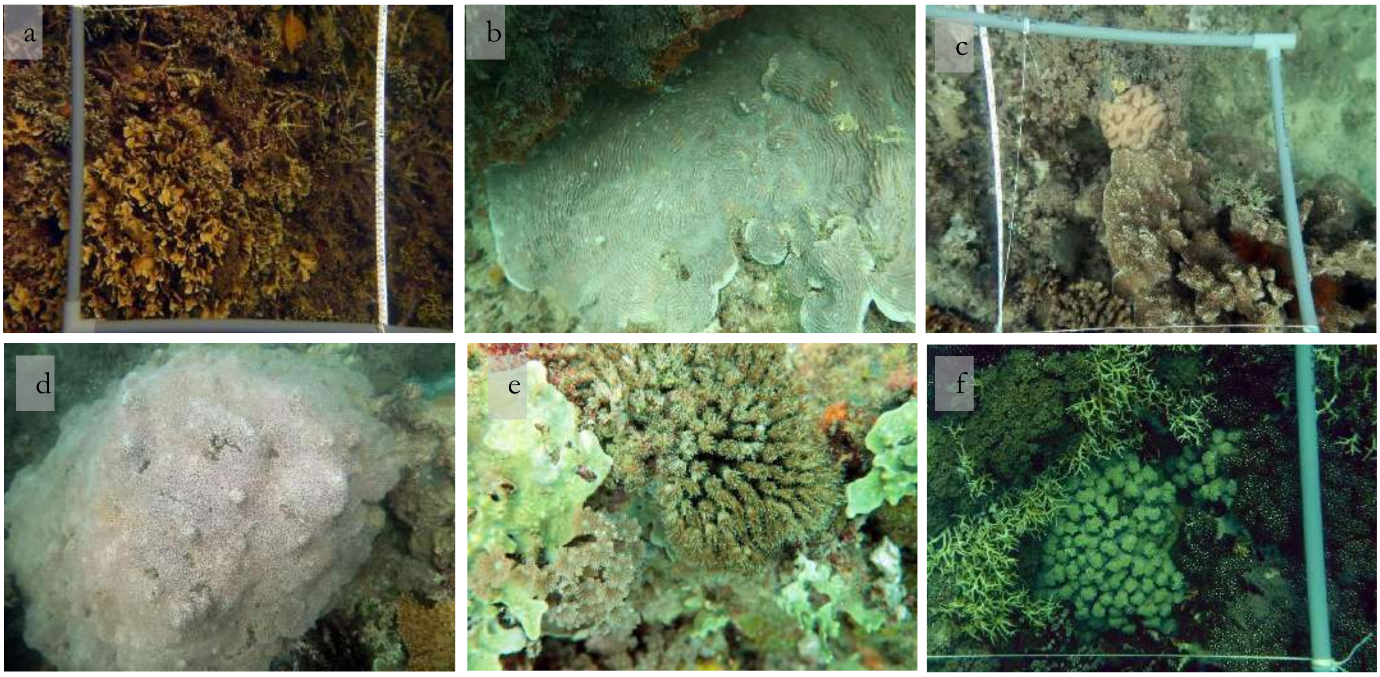

Figure 3. Family Agariciidae (a-c) and Euphyllidae (d-f)

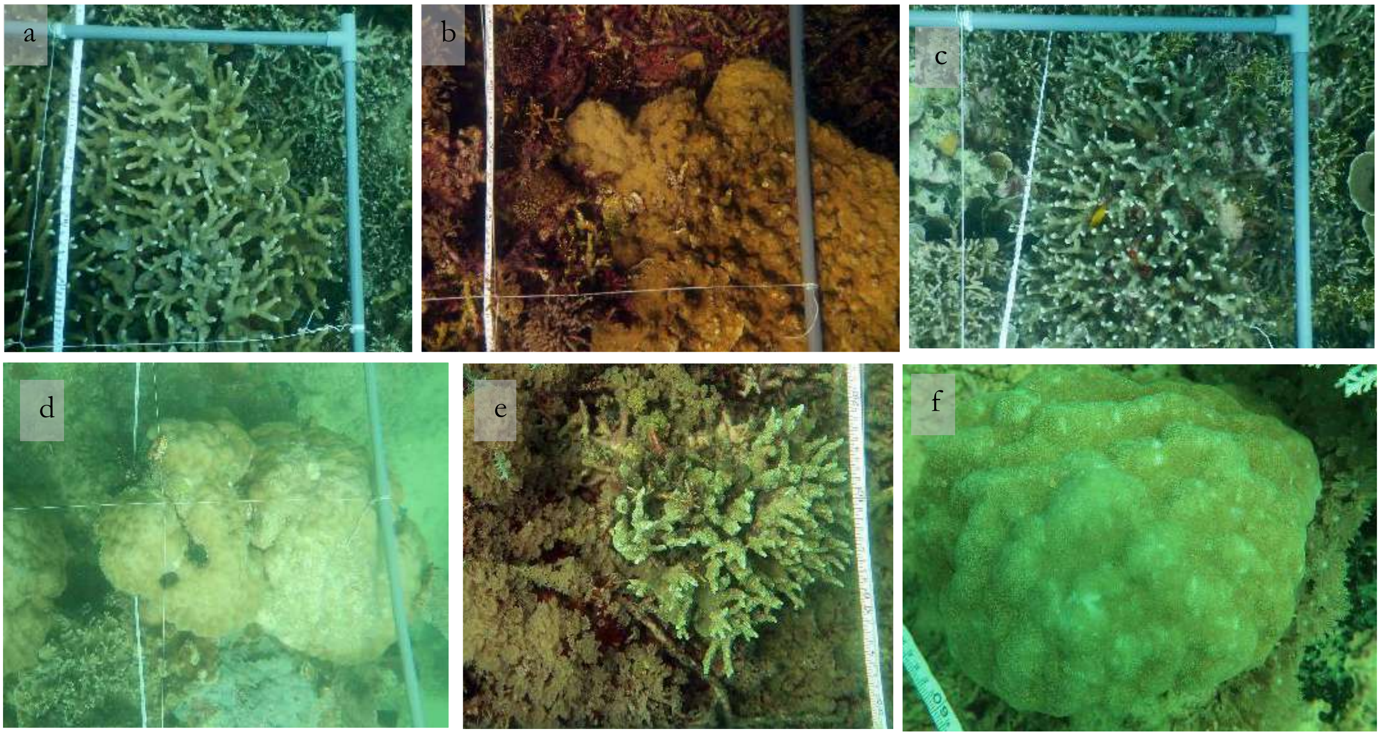

Figure 4. Family Poritidae.

Acropora derawanensis. Colonies are arborescent prostrate (Richards *et al*., 2008; Wallace, 1999). In addition, this coral branch is very small and at the end, there is an axial corallite in the form of a tube surrounded by small tube-shaped radial corallites as well (Figure 2e). *Acropora hyacinthus*. The character of *A. hyacinthus* colonies is to have tabulate growth (table-shaped) and sometimes pile up. It has tiny branches with corallite axial at the ends. When viewed from above, the radial clusters of corallites around the axial corallites are shaped like roses, and this is the characteristic of *A. hyacinthus* when in nature. On Miang Island many are found at depths of less than 5 m (Figure 2f).

Acropora clathrata. It is in the form of a table with an anatomoses branching model (shaped like a leaf skeleton) and small and thin branches so that it looks solid. Axial corallites are tubular with radial corallites mostly nariform (Rahmani and Rahimian, 2013). The colony color is usually cream to brown (Figure 2g). *Acropora granulosa*. Colonies are rounded, : if the colony is more than 1 m long, it will look like a table (Wallace, 1999). The main branch will be filled with small branches which are sometimes composed of more than one corallite axial. The corallite radials are small in size surrounding the corallite axial. The colors found are beige and brown (Figure 2h).

Acropora turaki. Colonies are arborescent (like trees) with branches in the form of bottle brushes. Axial corallite is shaped like a long tube and radial corallite has a shape similar to the axial (Wallace, 1999). In the natural context, it will look like a straight line (Figure 2i). *Acropora digitifera*. The form of digitate colonies, with small cylindrical branches with tapered ends (Suzuki *et al.*, 2008; Wallace, 1999). Radial corallite is at the end of the branching with a tube-like shape and is surrounded by corallite radials of various sizes in the form of a tube with a half opening (flaring) (Figure 2j). *Acropora* sp. This coral was found abundantly at a depth of 5-7 m in the northern part of Miang Island, the branches are small with corallite radials close to each other. In one branch there are sometimes 2 axial corallites (Figure 2k). *Acropora multiacuta*. The character of this coral is that it has a long corallite axial. Colonies are usually small (Figure 2l). *Acropora caroliniana*. Colonies had short branching, tubular axial corallites and beneath them were tubular radial corallites (Figure 2m). *Diploastrea heliopora*. This coral is very easy to recognize when in nature, massive form with a diameter of more than 2 m. Coralite plocoid shaped like a small dome and very tight can be found throughout the surface of coral colonies. The columella can be seen clearly in the middle of the corallite. Color when alive is greenish-beige (Figure 2n).

Family Agariciidae (complex)

Pavona cactus. Colonies are composed of a thin sheet, which looks like a wrinkle on the surface layer. This wrinkling is due to a line of costa- septa connecting the tiny polyps (Willis and Ayre, 1985). The habitat of these corals is generally in reef-flat areas and lagoons with less strong currents (Figure 3a). *Pachyseris speciosa*. Colonies of *P. speciosa* are usually laminar in shape, corallites do not have walls and a distinctive feature is that there is a bulge (valley) parallel to the tip of the colony, making this species very easy to identify (Babcock *et al.*, 2003). On Miang Island it can be found on the north side of the island with a depth of about 5 m. The color of this coral colony is usually brown with the color of the tip of the colony being slightly lighter and tends to be white (Figure 3b). *Pachyseris rugosa*. Colonies are small with creeping to laminar growth forms. Small corallites are hidden between carinae (patterns on the surface of Pachyseris corals). The septa and costae become one, hence the name septo-costae (Veron, 2000). The general color of this coral is cream to brown (Figure 3c).

Family Euphyllidae (complex)

Galaxea sp. Colonies are massive with polyps on top. The septa are sharply elongated with a curved sword-like shape and are surrounded by tentacles and are elongated during the day. The colony color is green and sometimes brown (Figure 3d). Galaxea astreata. Colonies are sub-massive with tubular corallites, : the number of septa is between 8-12 with a pointed and long shape (Wepfer *et al.*, 2020). Very rarely found on Miang Island (Figure 3e). *Plerogyra simplex*. Branched colonies with short branches and of the same size. Phacheloid branching form. This type of coral is very easy to recognize by the presence of white bubbles called vesicles, sometimes you can also see tentacles protruding between these vesicles. Colony color is mostly cream. Rarely found on Miang Island (Figure 3f).

Family Poritidae (complex)

Porites negrosensis. The trait of Porites is that they have irregular branches, with corallites in the basin (excavated corallite). Colonies of these corals can be more than 1 m in size and the bottom of the colony will be laminar (Figure 4a). *Porites* sp. Porites have various growth forms from encrusting, massive, and branching. Because the polyps are so small so sometimes difficult to identify them directly in the field. In general, some encrusting Porites are very similar to Montipora (Figure 4b). *Porites cylindrica*. Colonies are branches with a branch length of about 30 cm and a diameter of 4 cm. The branches of this coral are cylindrical with blunt branch ends. The most common color found is brown (Figure 4c). *Porites lutea*. Colonies are massive, sometimes if they are large they will form a helmet-like impression. Corallites are small 1-2 mm with tentacles occasionally active during the day. On the colony's surface, you will usually find a small mountain-like protrusion called a hillocky. Microscopically the number of pali present in the *P. lutea* corallite was 5 (Veron, 2000) (Figure 4d).

Porites lobata. Colonies life form usually massive or in some different area the life form is similar to a helmet since the bottom of colony does not reach the substrate. Coralites are cereoid in shape and very small (approximately 1 mm in diameter). Similar to *Porites lutea* which often found protrusions on the surface of this coral colony called hillocky. The most

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common color is cream or brown or in the shallow water areas of the colony has a purple color (Figure 4e). *Porites tuberculosa*. The colony has branching form with dense a branching which underneath of colony encrusting form. The conesteum of this colony has a bright color (Figure 4f).

Figure 5. Family Fungiidae (a-h).

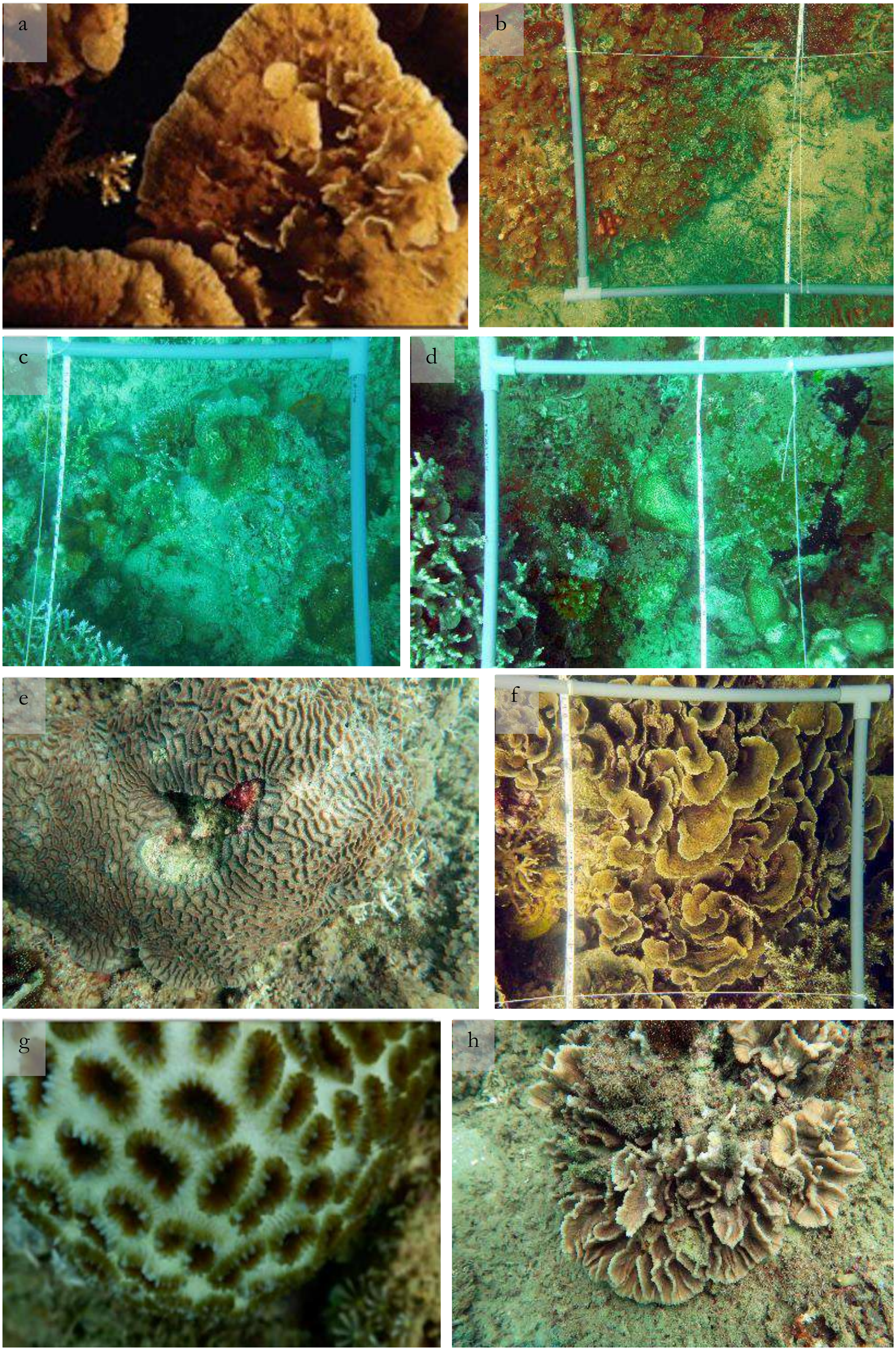

Figure 6. Merulinidae (a-h).

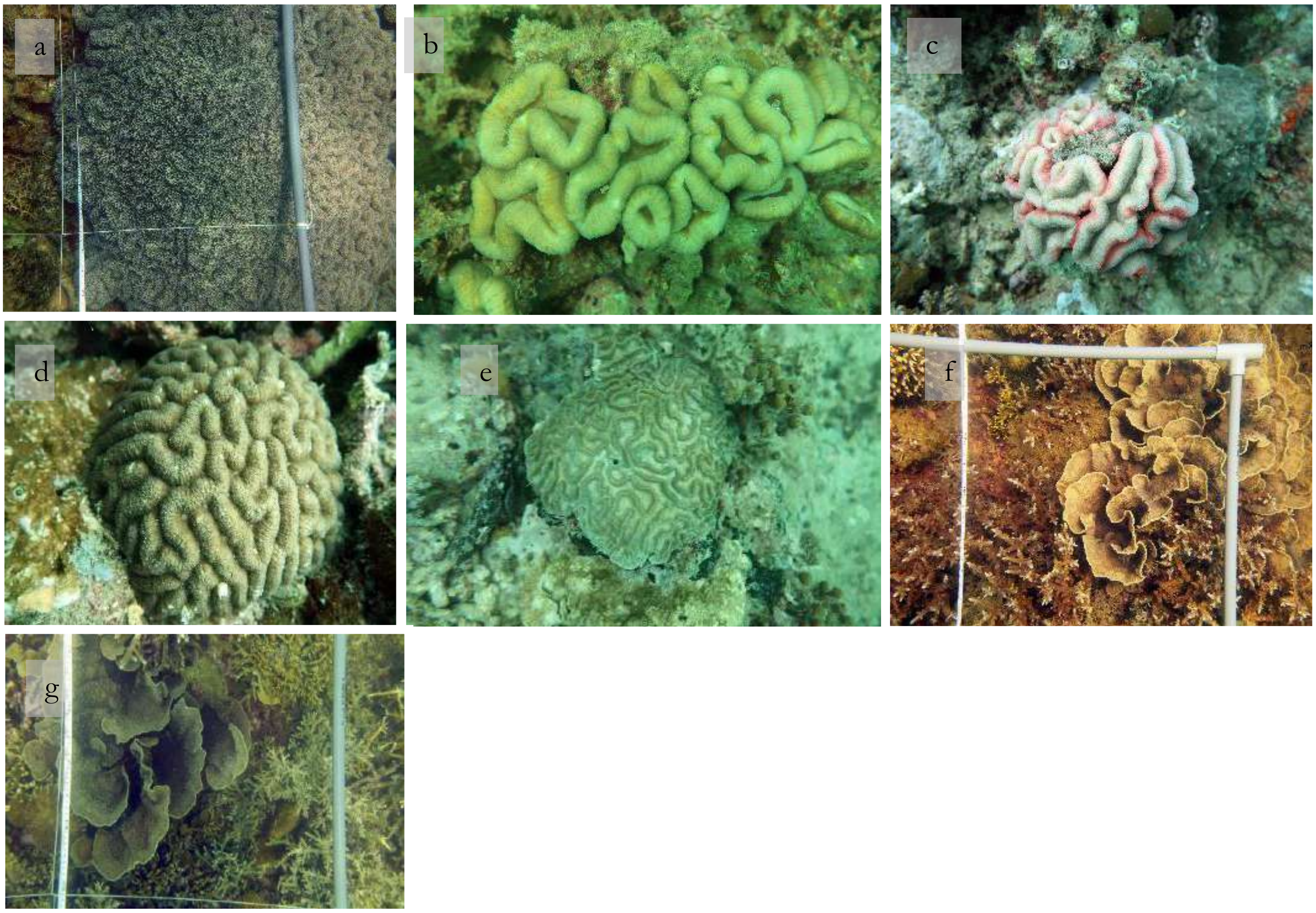

Figure 7. Lobophylliidae (a-g).

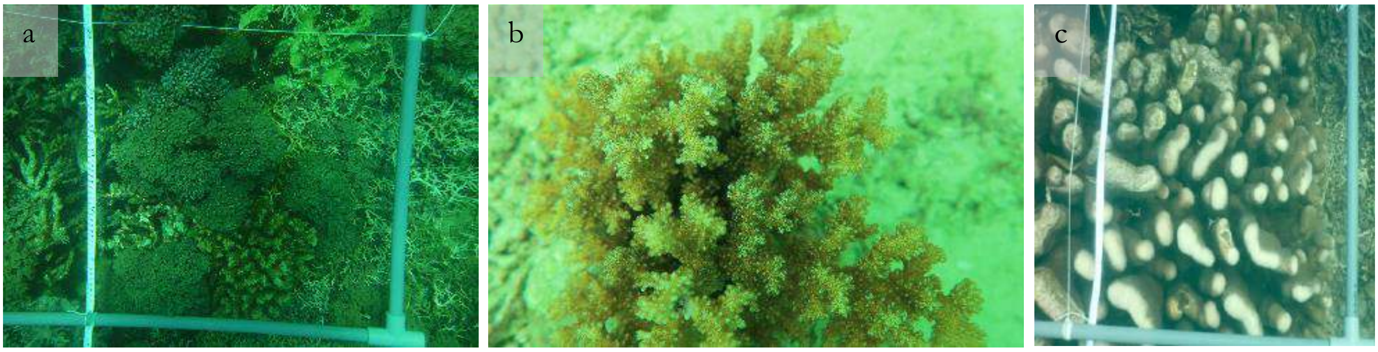

Figure 8. Family Pocilloporidae (a, b) and Psammocoridae (c).

Family Fungiidae (robust)

Fungia costulata. This coral is a free-living species, previously known as *Cycloseris costulata*. With a characteristic round shape with primary septa more prominent around the mouth of this coral. On Miang Island they were found in schooling at a depth of 5 m (Figure 5a). *Fungia* sp. This coral is a free-living species, with a characteristic round shape with more prominent primary septa around the mouth of this coral. On Miang Island they were found living individually at a depth of 9 m (Figure 5b). *Herpolitha limax*. Colonies are oval or elongated with rounded edges. The mouth is in the axial furrow and several mouths are on the outside. The septa have fine serrations (Figure 5c).

Halomitra pileus. The character of this coral is free-living with a colony shape like a dome. Coralites are scattered all over the coral surface. These coral septa are saw-like and tentacles appear only at night (Figure 5d). *Podabacia crustacea*. The Colonies of these corals are usually attached to the bottom substrate of the waters. The initial growth form of these corals is mobile and then will develop into laminar and sometimes form piles. Coralites are usually slightly protruding at the edges of the colony (Figure 5e). *Sandalolitha robusta*. It is one of the fungia coral that has oval or dome-shaped colonies. Unlike the others mushroom corals (Fungia) *S. robusta* does not have a mouth in the middle of the colony. The color of this colony is cream to brown.

The distribution is not very abundant on Miang Island (Figure 5f). *Ctenactis albitentaculata*. The polyp is oval with an axial furrow running along the length of the polyp, which contains several mouths of coral. The septa extend from the axial furrow to the edge of the polyp. The distinctive feature of this coral is the tentacles always retract even though in the day (Figure 5g). *Ctenactis echinata*. This species has one long polyp with septa and costae in the form of sharp teeth. On Miang Island it can be found at a depth of 5 m to the north of the island (Figure 5h).

Family Merulinidae (robust)

Merulina ampliata. This coral has a laminar life form has short valleys, and tentacles are not retracted during night. The septa are like ridges or granules (Figure 6a). *Hydnophora exesa*. Colonies are sub-massive, encrusting and sometimes laminar. It has conical mounds on the entire surface called a hydnophore or monticula. Polyps are laid on between monticula. Rarely found on Miang Island (Figure 6b). *Favites abdita*. Form massive and flattened form on early colonization. Corallite diameter is quite large, about 7-12 mm. Colonies are usually brown on the walls and green on the columella. This coral is very common among of Faviids (Figure 6c). *Leptoria phrygia*. Colonies are generally massive or sub-massive with meandroid-shaped corallites. The septa and costae form a zipper-like. The live colony colors are mostly cream and yellow (Figure 6d).

Platygyra daedalea. Colonies are massive with meandroid polyps form which have thick walls. The septa are straight with small bumps (Figure 6e). *Echinopora lamellosa*. Colonies are foliose and sometimes whorl form. Kalik of this coral is very small in size around 2-4 mm. It can be found in a sloping zone on Miang Island. This species is widespread worldwide waters (Figure 6f). *Dipastrea speciosa* (Caribbean: *Favia speciosa*). Colonies are massive, with corallites rounded and close to each other, most difficult to see. This coral has a contrasting coloration between the polyp and the costae (Figure 6g). *Pectinia lactuca*. Colonies of these corals have a foliose growth form with thick vertical sheets. The distribution of this coral is very wide from the Indo-Pacific to the Indian Ocean. The habitat of this coral is around the reef slope with high turbidity waters (Figure 6h).

Family Lobophylliidae (robust)

Lobophyllia sp. similar to *Lobophyllia flabelliformis*. The colony is dom shaped. The polyp is a flabello-meandroid type and has very thick soft tissue covering the polyp's skeleton (Figure 7a). *Lobophyllia robusta*. This coral only consists of a few corallites. Coral polyps are covered with a thick blanket of living coral tissue (Figure 7b). *Lobophyllia hemprichii*. Colonies are round to flattened with pacheloid corallites. The width of the valley varies from 15-40 mm. The septa will look rough like saw blades when the soft tissue gets into the skeleton. The general characteristic of this type of coral is that it has 2 colors when in the water, gray around the valley and mouth and pink or red on the outside (Figure 7c).

Symphyllia radians. Massive colonies are sometimes flattened in the early growth phase, valley width is 20-25 m with an irregular meandroid shape. The wall of this colony looks big because the thick soft tissue covers the colony wall. This coral is wdespread in the Indo-Pacific region (Figure 7d). *Symphyllia agaricia*. Colonies are rounded (hemispherical) to flat. The valley is meandering with an average width of 35 mm. Colony walls seem thin because the soft tissue that covers them is not too thick. The septa are large and have rather large serrations so that they will be clearly visible when in the field (Figure 7e). *Oxypora glabra*. Colonies are laminar with rough jagged edges. Rarely sre corallites are at some distance from each other, the septa and columella are joined together and appear as coils or protrusions (Figure 7f). *Echinophyllia* sp. Colonies up to 50 cm wide, laminar in shape, with wavy ends. All over the colony's surface will be scattered corallite in the form of fat protrusions. Yellow and sometimes green. Mostly found in the waters of Miang Island (Figure 7g).

Family Pocilloporidae (robust)

Pocillopora eydouxi. The characteristic is flat and solid vertical branches. Under normal conditions, the branches are far from each other (Schmidt-Roach *et al*., 2014). There are bumps on all surfaces of the branches called verrucae, while the polyps are very small scattered over the verrucae and between them (Figure 8a). *Seriatopora hystrix*. Colonies of *S. hystrix* have tiny branches with pointed ends (Bongaerts *et al*., 2011). Branches are short. Corallite is in the form of dots that are neatly lined up at the branches. This coral is commonly found especially in waters that have strong currents (Figure 8a yellow arrow).

Pocillopora verrucosa. This coral colony is characterized by many irregular branches (ramose) and verrucate (small protrusions) with a diameter in its branches were 3-7 mm. Some colonies have compact branches and others have long branches, This is closely related to the water currents where these corals grow (Britayev *et al*., 2017). The stronger the current, the more compact the branching form.

The colors of these corals when alive vary from cream, to brown, pink, and blue (Figure 8b).

Family Psammocoridae (robust)

Psammocora digitata. Colonies are encrusting to sub-massive for the juvenile phase, and will be columnar on adult. The close of the calyx forms a flower-like (Benzoni *et al*., 2010; Stefani *et al*., 2008). Color when alive is beige to brown (Figure 8c).

Conclusion

Miang Island has extraordinary coral reef resource potential, There are 10 families with more than 58 types of hard corals found. Even though no new species were reported from this research, this paper will extend data base of scleractinian coral at ecoregion 430 as well as in Indonesia in general.

Acknowledgments

We would like to thank Government of Kutai Timur for financing of this research and also the students of Acropora Universitas Brawijaya for assistance during the field work. Finally, we thank the anonymous reviewers for their insightful comments on the manuscript.

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How to cite this paper:

R. Rosdianto, S.A. El Rahimi, A. Kryk, S. Arsad, O. M. Luthfi, M.A.B. Luthfi. Description scleractinian coral from Miang Island, East Kalimantan. Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan, 11(3): 508-516.