



Grouper DNA barcoding studies in Indonesia: A short review

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ABSTRACT

Indonesia is recognized as one of the areas that have the highest reef fish biodiversity in the world. One of the commercially valuable fish in this area is the groupers (locally name "kerapu"). At least 76 grouper species have been reported in Indonesian waters, with three species were categorized into "vulnerable", five species "Data Deficient", and 68 species under the "Least Concern" category based on IUCN classification. The increasing exploitations rate had been reported caused the grouper stocks in Indonesia to decrease and threatened extinction. However, only limited scientific data is available regarding the grouper in Indonesia, including their identification. In most fish landing sites across Indonesia, the groupers are morphologically identified and recorded as "kerapu" to replace their scientific species names. Accurate species identification is essential in designing appropriate and sustainable management of fisheries resources. One of the tools that have been used in fish identification is DNA barcoding. In the last two decades, this molecular method has been applied to identify many fish groups globally, including grouper fish. This study reviewed the DNA barcoding approach in grouper identification in Indonesia based on the available literature.

Introduction

Indonesia is one region with the highest reef fish biodiversity globally (Allen and Erdmann, 2012). One commercially valuable fish in this area is the groupers (Maulida *et al.*, 2020; Syafei and Sudinno, 2018; Yulianto *et al.*, 2015). At least 76 grouper species have been reported living in Indonesian waters, with three species were categorized into "vulnerable", five species "Data Deficient", and 68 species under the "Least Concern" category based on IUCN classification (IUCN, 2021). The increasing number of exploitations reported caused grouper stocks in Indonesia to decrease and threatened extinction (Fadli *et al.*, 2021; Yulianto *et al.*, 2015). In addition, the use of destructive fishing techniques also affected the fish populations in the wild

(Batubara *et al.*, 2017; Muchlisin, 2008; Muchlisin *et al.*, 2015).

Albeit their high economic value in Indonesia, limited scientific information on grouper is available, especially their taxonomy information. In most fish landing sites across Indonesia, the groupers are morphologically identified and recorded as "kerapu" to replace their scientific species names hindering accurate fish recording (Fadli *et al.*, 2021). In addition, morphological identification also required extra accuracy and can lead to misidentification if done without adequate knowledge (Sulistiyowatia *et al.*, 2018; Syafei and Sudinno, 2018). Accurate species identification is vital in designing appropriate and sustainable management of fisheries resources (Ardura *et al.*, 2013).

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One of the tools that have been used in fish identification is DNA barcoding. In the last two decades, this molecular method has been employed to identify many fish species globally (Abdullah and Rehbein, 2017; Ali et al., 2020; Bakar et al., 2018; Bamaniya et al., 2016; Bingpeng et al., 2018; Delrieu-Trottin et al., 2019; Duarte et al., 2017; Fadli et al., 2020; Nugroho et al., 2017; Nurilmala et al., 2016; Steinke et al., 2017; Wang et al., 2018; Wibowo et al., 2018) including grouper fish (Alcantara and Yambot, 2016; Basheer et al., 2017; Fadli et al., 2020; Fadli et al., 2021). This method is relatively new in Indonesia, so its use is still limited. It is necessary to conduct a literature review to find out to what extent this approach has been used in Indonesia. Identify which species have been researched, which locations have not been reached, etc., so that the knowledge gaps can be incorporated in future studies. Hence, this study reviewed the DNA barcoding approach in grouper identification in Indonesia based on the available literature.

DNA barcoding

The DNA barcoding technique was introduced in 2003 and has become standardized in molecular taxonomy (Hebert et al., 2003). This approach utilizes a DNA sequence as a taxon 'barcode' of the mitochondrial cytochrome oxidase subunit I gene (COI). There are some advantages of DNA barcoding; (1) DNA barcoding has shown precise discrimination of species groups that have similar morphological shapes (Pavan-Kumar et al., 2018), (2) It can distinguish fish at various developmental phases (Hubert et al., 2010), (3) It can distinguish defective and deficient specimens (Sembiring et al., 2015) and also detect fish in seafood goods (Chin Chin et al., 2016; Marko et al., 2004).

An electronic databank called the Barcode of Life Data System (BOLD; <http://www.boldsystems.org/>) supports DNA barcoding immense data stored worldwide been created. This web-based catalog permits the acquisition, storage, analysis, and publication of DNA barcode data (Ratnasingham and Hebert, 2007). Over 231,000 animal and 69,000 plant species are documented in BOLD (<http://www.boldsystems.org/>; retrieved on May 7, 2021). Fishes are among the highest barcoded aquatic groups globally, and a project contributed to fishes called The Fish Barcode of Life (FISH-BOL) (<http://www.fishbol.org>) has been launched (Ward, 2009). A guideline collaborators' set of rules is also accessible to homogenize the data compilation and compliance in the FISH-BOL databank (Steinke and

Hanner, 2011). Finally, this approach has developed a progressively vital taxonomic instrument for species recognition and is generally accepted.

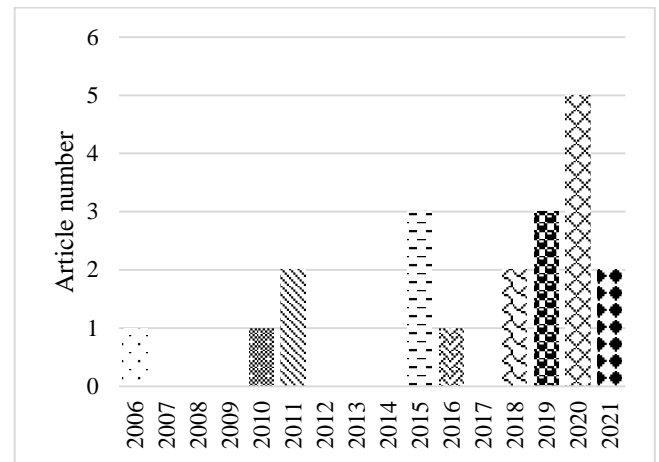


Figure 1. The number of grouper DNA barcoding research in Indonesia (2006-2021) based on the published studies.

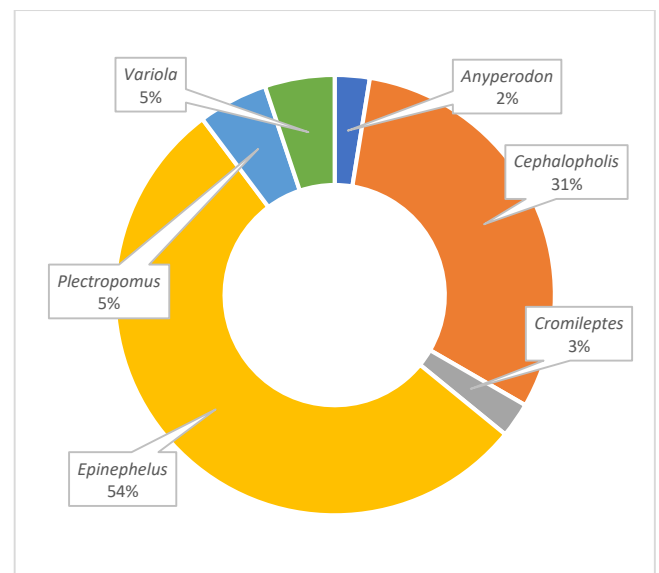


Figure 2. Composition of the studied grouper genera using DNA Barcoding.

Grouper DNA barcoding studies in Indonesia

In total, 20 studies related to grouper DNA barcoding in Indonesia were found in this study from 2006 – 2021 (Figure 1). These 20 studies comprised 39 species in six genera, especially the groupers, with high economic value. The studied genera were *Anyperodon* (Ariyanti and Farajallah, 2019a), *Cephalopholis* (Andriyono et al., 2020; Andriyono and Suciyono, 2020; Ariyanti and Farajallah, 2019a; Ariyanti et al., 2015; Fadli et al., 2021; Fadli et al., 2020; Gaither et al., 2011; Kamal et al., 2019; Sari et al., 2015), *Cromileptes* (Nuryanto et al., 2018; Susanto et al., 2011; Susanto et al., 2010), *Epinephelus* (Abdullah and Rehbein, 2017; Andriyono et al., 2020; Andriyono

and Suciyo, 2020; Antoro et al., 2006; Ariyanti and Farajallah, 2019a, 2019b; Aznardi and Madduppa, 2020; Fadli et al., 2021; Fadli et al., 2020; Jefri et al., 2015; Kamal et al., 2019; Kusuma, 2018; Nuryanto et al., 2018; Santosa et al., 2021; Sari et al., 2015; Yulidaria, 2020), *Plectropomus* (Fadli et al., 2021; Nuryanto et al., 2018), *Variola* (Abdullah and Rehbein, 2017; Andriyono et al., 2020; Fadli et al., 2021; Fadli, Nor, et al., 2020; Kamal et al., 2019; Sari et al., 2015) (Tabel 2). Genus *Epinephelus* being the highest percentage of the studied grouper (54%), and the lowest is from the genus *Anyperodon* (2%) (Figure 2, Table 1).

The sampling sites for the grouper DNA barcoding studies in Indonesia expanded from Aceh in the western Indonesia region until Papua in the Eastern part of Indonesia. Surprisingly, no sites from Kalimantan Island and limited sampling sites from Northern Sulawesi, Maluku, Southern Papua, etc., were sampled. *Epinephelus areolatus* was the dominant species found in 13 study sites (Figure 3, Table 1). Kalimantan, Sulawesi, Maluku, and Papua are in the mid-Indonesia region. This area is the center of the coral triangle and is recognized as the hot spot of tropical marine biodiversity (Veron et al., 2009). Ma et al. (2016), in their research of the historical biogeography of groupers that covered 87% grouper species globally, revealed that the Central Indo-Pacific region (including the mid-Indonesia region) had the highest new grouper species and hypothesized that this region is central to the survival for epinephelids during the Pleistocene epoch. The absence of a sampling site in this area will provide an incomplete picture regarding the genetic pattern of grouper in Indonesia.

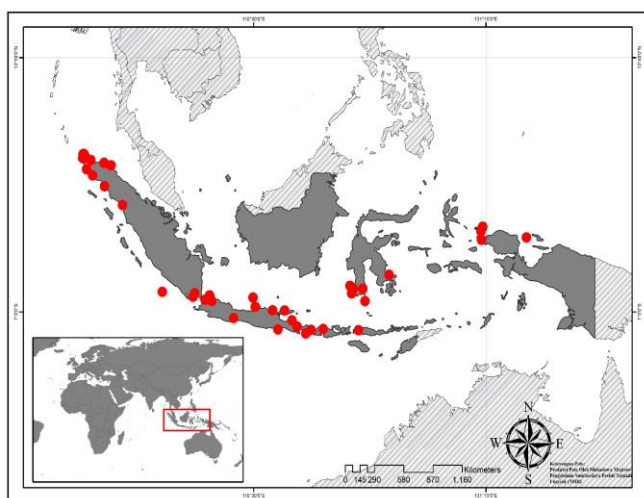


Figure 3. Map of location for grouper DNA barcoding research.

Various sets of primers were used in these researches, namely Fish F1, Fish R1, Fish F2, Fish R2, AF282, AF283, FH70, RH70, Fish BCL, Fish BCH, 16SAR, 16SBR, Em-01, Em-03, Em-08, Em-07, and Em-10 (Table 2). Research on the *Anyperodon* genus Ariyanti and Farajallah (2019a) found that mitochondrial COI primers AF282, AF283 have successfully been used to identify the *Anyperodon leucogrammicus* species. Research on DNA barcoding in the genus *Cephalopholis* was carried out using different mitochondrial COI primers, including Fish F1, Fish R1 (Ariyanti et al., 2015; Fadli et al., 2021; Fadli et al., 2020); FH70, RH70 (Kamal et al., 2019) Fish BCL, Fish BCH (Andriyono et al., 2020; Andriyono and Suciyo, 2020); 16SAR, 16SBR (Sari et al., 2015); AF282, AF283 (Ariyanti and Farajallah, 2019a) and has been reported to have identified several species in the genus *Cephalopholis*, namely: *C. boenak*, *C. cyanostigma*, *C. formosa*, *C. leopardus*, *C. miniata*, *C. nigripinnis*, *C. sexmaculata*, *C. sonnerati*, *C. spiloparaea* and *C. urodeta*. Further research on the genus *Cromileptes* using primers Fish F1, Fish R1 (Nuryanto et al., 2018); Fish F2, Fish R2 (Susanto et al., 2011; Susanto et al., 2010) have identified the species *C. altivelis* (Table 2).

The studies on DNA barcoding in the genus *Epinephelus* using primers Fish F1, Fish R1 (Fadli et al., 2021; Fadli et al., 2020; Jefri et al., 2015; Kusuma, 2018); Fish F2, Fish R2 (Nuryanto et al., 2018); Fish BCL, Fish BCH (Andriyono et al., 2020; Andriyono and Suciyo, 2020); AF282, AF283 (Ariyanti and Farajallah, 2019a, 2019b); 16SAR, 16SBR (Sari et al., 2015); FH70, RH70 (Kamal et al., 2019); Em-01, Em-03, Em-08, Em-07, Em-10 (Antoro et al., 2006) has been used successfully for species identification of *E. areolatus*, *E. bleekeri*, *E. coeruleopunctatus*, *E. coioides*, *E. erythrinus*, *E. fasciatus*, *E. fuscoguttatus*, *E. beniochus*, *E. longispinis*, *E. melanostigma*, *E. merra*, *E. oncus*, *E. poecilnotus*, *E. polyphkadion*, *E. quoyanus*, *E. sexfasciatus*, *E. spilotoceps*, *E. tauvina*, *E. tukula*, and *E. undulosus*. In the genus *Plectropomus* using primer Fish F1, Fish R1 (Fadli et al., 2021); Fish F2, Fish R2 (Nuryanto et al., 2018) has successfully identified the species *P. leopardus* and *P. maculatus*. Species identification in the genus *Variola* was carried out using several mitochondrial COI primers, such as Fish F1, Fish R1 (Abdullah and Rehbein, 2017); Fish F2, Fish R2 (Abdullah and Rehbein, 2017); FH70, RH70 (Kamal et al., 2019); Fish BCL, Fish BCH (Andriyono et al., 2020); 16SAR, 16SBR (Sari et al., 2015) and based on the data has succeeded in identifying the species *V. albimarginata* and *V. louti*.

The implication to grouper management in Indonesia

Conservation genetics is defined as using genetic techniques to solve conservation biology problems (Allendorf et al., 2010). This method is currently extensively utilized to assist biodiversity management and conservation and aquatic ecosystems worldwide. Numerous genetic procedures have previously been employed in marine management and conservation, as well as DNA barcoding. Establishing DNA barcoding data for grouper is essential for forensic

identification in tackling seafood fraud worldwide (Chin Chin et al., 2016; Marko et al., 2004). In addition, genetic analyses of the mtDNA have widely been used to detect fish population structure globally and in particular areas. Many marine organisms in the Indonesia waters show solid genetic structuring, while others reveal genetic homogeneity, thus demanding different conservation management approaches (Carpenter et al., 2011; Mat Jaafar et al., 2012), and the need for genetic studies in support of management.

Table 1. Distribution of species at the location of grouper DNA barcoding research in Indonesia (+: found).

| Species | Location | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--------------------------------------|----------|------------|------------|------|-------------|------------|--------|----------|------------|---------|----------|---------|----------------|--------------|-------------|-------------|--------|-------------|--------|--------|--------|-----------|------------|------|--------|----------|-------------|---------|--------|------------|-------------|---|
| | Sabang | Aceh Besar | Banda Aceh | Sigi | Lhokseumawe | Idi Rayeuk | Galang | Meulaboh | Tapak Tuan | Sibolga | Bengkulu | Lampung | Bandar Lampung | Pulau Seribu | Muara Angke | Pangandaran | Jepara | Karimunjawa | Madura | Gresik | Malang | Situbondo | Banyuwangi | Bali | Lombok | Makassar | Tana Toraja | Kendari | Flores | Raja Ampat | Biak Numfor | |
| <i>Anyperodon leucogrammicus</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | + |
| <i>Cephalopholis argus</i> | + | | | | | | | | | | | | | | | | | | | | | | | | + | | | | | | | |
| <i>Cephalopholis boenak</i> | | + | | | | + | | | + | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Cephalopholis aurantia</i> | + | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Cephalopholis cyanostigma</i> | | | | | | | | | | | | | | | | | | | | | | | | + | | | | | | | | |
| <i>Cephalopholis formosa</i> | + | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Cephalopholis leopardus</i> | + | | | | | | + | | | | | | | | | | | | | | | | | + | | | | | | | | |
| <i>Cephalopholis miniata</i> | + | + | | | | | | | | | | | | | | | | | | | | | | + | + | | | | | | | + |
| <i>Cephalopholis nigripinnis</i> | + | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Cephalopholis sexmaculata</i> | | + | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Cephalopholis sonnerati</i> | + | + | + | + | | | | | + | | | | | | | | | | | | | + | | + | | | | | | | | |
| <i>Cephalopholis spiloparaea</i> | | + | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Cephalopholis urodeta</i> | | + | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Cromileptes altivelis</i> | | | | | | | | | | | | | | | + | | | + | | | | | + | | | | | + | | | | |
| <i>Epinephelus areolatus</i> | + | + | + | | + | + | | | + | | | + | | | + | | | + | + | | | | | | | + | | | + | | | + |
| <i>Epinephelus bleekeri</i> | | | | | | + | + | | + | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Epinephelus coeruleopunctatus</i> | + | | + | | | | | | | | + | | | | | | | | | | | | | + | | | | | | | + | + |
| <i>Epinephelus coioides</i> | | | | | | | | + | + | + | | + | | | + | | | + | + | | + | | + | | | | | | + | + | | |
| <i>Epinephelus erythrurus</i> | | | | | | | | | | | | | | | | | | | | | | + | | | | | | | | | | |
| <i>Epinephelus fasciatus</i> | + | + | | | | | | | | | | + | | | | | | | | | | | | + | + | | | | | | | + |
| <i>Epinephelus flavocaeruleus</i> | | | | | | | | + | + | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Epinephelus fuscoguttatus</i> | | | | | | | | | | | | | | | | | | | | | | | | + | | | | | | | | |
| <i>Epinephelus heniochus</i> | | | | | | | | | | + | | | | | | | | | | | | | | | | | | | | | | |
| <i>Epinephelus longispinis</i> | + | | | | | | | | | | | + | | | | | | | | | | | | | | | | | | | | |
| <i>Epinephelus melanostigma</i> | + | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | + |
| <i>Epinephelus merra</i> | + | + | | | | | | | | | + | | | | | | | + | | | | | | | + | + | | + | + | | | + |

| Species | Location | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------------------------------|----------|------------|------------|------|-------------|------------|--------|----------|------------|---------|----------|---------|----------------|--------------|-------------|-------------|--------|--------|-------------|--------|--------|--------|----------|------------|------|--------|----------|----------|---------|--------|------------|------------|--|---|
| | Sabang | Aceh Besar | Banda Aceh | Sigi | Lhokseumawe | Idi Rayeuk | Calang | Meulaboh | Tapak Tuan | Sibolga | Bengkulu | Lampung | Bandar Lampung | Pulau Seribu | Muara Angke | Pangandaran | Banten | Jepara | Karimunjawa | Madura | Gresik | Malang | Stubondo | Banyuwangi | Bali | Lombok | Makassar | Tanakeke | Kendari | Flores | Raja Ampat | Biak Nunor | | |
| <i>Epinephelus ongus</i> | | | | | | | | | | | | | | | | | | | + | | | | | | + | + | + | + | | | + | | | |
| <i>Epinephelus poecilonotus</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Epinephelus polybekadion</i> | | | | | | | | | | | | | | | | | | | | | | | | | | + | | | | | | | | |
| <i>Epinephelus quoyanus</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | + |
| <i>Epinephelus sexfasciatus</i> | | | | | + | | + | | + | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Epinephelus spilotoceps</i> | + | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Epinephelus tauvina</i> | + | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Epinephelus tukala</i> | | | | | | | | | + | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Epinephelus undulosus</i> | + | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>Plectropomus leopardus</i> | | | | | | | | | | + | | | | | | | | | | | | | | | | | | | | | | | | + |
| <i>Plectropomus maculatus</i> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | + |
| <i>Variola albimarginata</i> | + | + | + | + | | | | + | + | | | | | | | | | | | | | | | | | + | | | | | | | | |
| <i>Variola louti</i> | + | + | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Tabel 2. List of grouper DNA barcode studies in Indonesia.

| No | Genus | Species | COI Primers | Red List IUCN | Population Trend | References |
|----|----------------------|--------------------------------------|--|----------------|------------------|---|
| 1 | <i>Anyperodon</i> | <i>Anyperodon leucogrammicus</i> | AF282, AF283 | Least Concern | Unknown | (Ariyanti and Farajallah, 2019a) |
| 2 | <i>Cephalopholis</i> | <i>Cephalopholis argus</i> | Fish F1, Fish R1, Cyt b, GnRH, S7 | Least Concern | Stable | (Fadli et al., 2021; Fadli et al., 2020; Gaither et al., 2011) |
| 3 | <i>Cephalopholis</i> | <i>Cephalopholis aurantia</i> | Fish F1, Fish R1 | Least Concern | Unknown | (Fadli et al., 2021; Fadli et al., 2020) |
| 4 | <i>Cephalopholis</i> | <i>Cephalopholis boenak</i> | Fish F1, Fish R1, FH70, RH70 | Least Concern | Stable | (Fadli et al., 2021; Kamal et al., 2019) |
| 5 | <i>Cephalopholis</i> | <i>Cephalopholis cyanostigma</i> | Fish BCL, Fish BCH, 16SAR, 16SBR | Least Concern | Stable | (Andriyono et al., 2020; Sari et al., 2015) |
| 6 | <i>Cephalopholis</i> | <i>Cephalopholis formosa</i> | Fish F1, Fish R1 | Least Concern | Stable | (Fadli et al., 2021; Fadli et al., 2020) |
| 7 | <i>Cephalopholis</i> | <i>Cephalopholis leopardus</i> | Fish F1, Fish R1, 16SAR, 16SBR | Least Concern | Unknown | (Fadli et al., 2021; Fadli et al., 2020; Sari et al., 2015) |
| 8 | <i>Cephalopholis</i> | <i>Cephalopholis miniata</i> | Fish F1, Fish R1, Fish BCL, Fish BCH, AF282, AF283, FH70, RH70, 16SAR, 16SBR | Least Concern | Stable | (Andriyono et al., 2020; Andriyono and Suciyo, 2020; Ariyanti and Farajallah, 2019a; Fadli et al., 2021; Fadli et al., 2020; Kamal et al., 2019; Sari et al., 2015) |
| 9 | <i>Cephalopholis</i> | <i>Cephalopholis nigripinnis</i> | Fish F1, Fish R1 | Least Concern | Unknown | (Fadli et al., 2021; Fadli et al., 2020) |
| 10 | <i>Cephalopholis</i> | <i>Cephalopholis sexmaculata</i> | FH70, RH70 | Least Concern | Unknown | (Kamal et al., 2019) |
| 11 | <i>Cephalopholis</i> | <i>Cephalopholis sonnerati</i> | Fish F1, Fish R1, Fish BCL, Fish BCH, FH70, RH70, 16SAR, 16SBR | Least Concern | Stable | (Andriyono et al., 2020; Fadli et al., 2021; Fadli et al., 2020; Kamal et al., 2019; Sari et al., 2015) |
| 12 | <i>Cephalopholis</i> | <i>Cephalopholis spiloparaea</i> | FH70, RH70 | Least Concern | Unknown | (Kamal et al., 2019) |
| 13 | <i>Cephalopholis</i> | <i>Cephalopholis urodeta</i> | FH70, RH70 | Least Concern | Stable | (Ariyanti et al., 2015; Kamal et al., 2019) |
| 14 | <i>Cromileptes</i> | <i>Cromileptes altivelis</i> | Fish F1, Fish R1, Fish F2, Fish R2 | Data Deficient | Decreasing | (Nuryanto et al., 2018; Susanto et al., 2011; Susanto et al., 2010) |
| 15 | <i>Epinephelus</i> | <i>Epinephelus areolatus</i> | Fish F1, Fish R1, Fish F2, Fish R2, Fish BCL, Fish BCH | Least Concern | Unknown | (Abdullah and Rehbein, 2017; Andriyono et al., 2020; Aznardi and Madduppa, 2020; Fadli et al., 2021; Fadli et al., 2020; Jefri et al., 2015; Santosa et al., 2021; Yulidaria, 2020) |
| 16 | <i>Epinephelus</i> | <i>Epinephelus bleekeri</i> | Fish F1, Fish R1 | Data Deficient | Decreasing | (Fadli et al., 2021) |
| 17 | <i>Epinephelus</i> | <i>Epinephelus coeruleopunctatus</i> | Fish F1, Fish R1, AF282, AF283, 16SAR, 16SBR | Least Concern | Stable | (Ariyanti and Farajallah, 2019a; Fadli et al., 2021; Fadli et al., 2020; Jefri et al., 2015; Kusuma, 2018; Santosa et al., 2021) |

| No | Genus | Species | COI Primers | Red List IUCN | Population Trend | References |
|----|---------------------|-----------------------------------|---|----------------|------------------|---|
| 18 | <i>Epinephelus</i> | <i>Epinephelus coioides</i> | Fish F1, Fish R1, Fish F2, Fish R2, AF282, AF283, Em-01, Em-03, Em-08, Em-07, Em-10 | Least Concern | Decreasing | (Abdullah and Rehbein, 2017; Andriyono et al., 2020; Andriyono and Suciyo, 2020; Antoro et al., 2006; Ariyanti and Farajallah, 2019a; Fadli et al., 2021; Jefri et al., 2015; Santosa et al., 2021) |
| 19 | <i>Epinephelus</i> | <i>Epinephelus erythrurus</i> | AF282, AF283 | Least Concern | Unknown | (Ariyanti and Farajallah, 2019b) |
| 20 | <i>Epinephelus</i> | <i>Epinephelus fasciatus</i> | Fish F1, Fish R1, AF282, AF283, FH70, RH70, 16SAR, 16SBR | Least Concern | Unknown | (Ariyanti and Farajallah, 2019a; Fadli et al., 2021; Fadli et al., 2020; Jefri et al., 2015; Kamal et al., 2019; Santosa et al., 2021; Sari et al., 2015) |
| 21 | <i>Epinephelus</i> | <i>Epinephelus flavocaeruleus</i> | Fish F1, Fish R1 | Least Concern | Unknown | (Fadli et al., 2021) |
| 22 | <i>Epinephelus</i> | <i>Epinephelus fuscoguttatus</i> | 16SAR, 16SBR | Vulnerable | Decreasing | (Sari et al., 2015) |
| 23 | <i>Epinephelus</i> | <i>Epinephelus beniochus</i> | Fish F1, Fish R1 | Least Concern | Unknown | (Fadli et al., 2021) |
| 24 | <i>Epinephelus</i> | <i>Epinephelus longispinis</i> | Fish F1, Fish R1 | Least Concern | Unknown | (Fadli et al., 2021; Fadli et al., 2020; Jefri et al., 2015; Santosa et al., 2021) |
| 25 | <i>Epinephelus</i> | <i>Epinephelus melanostigma</i> | Fish F1, Fish R1, AF282, AF283 | Least Concern | Unknown | (Ariyanti and Farajallah, 2019a; Fadli et al., 2021; Fadli et al., 2020) |
| 26 | <i>Epinephelus</i> | <i>Epinephelus merri</i> | Fish F1, Fish R1, Fish BCL, Fish BCH, FH70, RH70, 16SAR, 16SBR | Least Concern | Stable | (Andriyono et al., 2020; Jefri et al., 2015; Kamal et al., 2019; Kusuma, 2018; Santosa et al., 2021; Sari et al., 2015) |
| 27 | <i>Epinephelus</i> | <i>Epinephelus ongus</i> | Fish F1, Fish R1, Fish F2, Fish R2, Fish BCL, Fish BCH, AF282, AF283 | Least Concern | Unknown | (Andriyono et al., 2020; Ariyanti and Farajallah, 2019a; Jefri et al., 2015; Nuryanto et al., 2018; Santosa et al., 2021) |
| 28 | <i>Epinephelus</i> | <i>Epinephelus poecilonotus</i> | Fish F1, Fish R1, Fish BCL, Fish BCH | Least Concern | Unknown | (Andriyono et al., 2020) |
| 29 | <i>Epinephelus</i> | <i>Epinephelus polyphekadion</i> | Fish F1, Fish R1 | Vulnerable | Decreasing | (Sari et al., 2015) |
| 30 | <i>Epinephelus</i> | <i>Epinephelus quoyanus</i> | Fish F1, Fish R1, AF282, AF283 | Least Concern | Unknown | (Ariyanti and Farajallah, 2019a) |
| 31 | <i>Epinephelus</i> | <i>Epinephelus sexfasciatus</i> | Fish F1, Fish R1 | Least Concern | Unknown | (Fadli et al., 2021) |
| 32 | <i>Epinephelus</i> | <i>Epinephelus spilotoceps</i> | Fish F1, Fish R1 | Least Concern | Stable | (Fadli et al., 2021; Fadli et al., 2020) |
| 33 | <i>Epinephelus</i> | <i>Epinephelus tawina</i> | Fish F1, Fish R1 | Data Deficient | Unknown | (Fadli et al., 2021; Fadli et al., 2020) |
| 34 | <i>Epinephelus</i> | <i>Epinephelus tukula</i> | Fish F1, Fish R1 | Least Concern | Unknown | (Fadli et al., 2021) |
| 35 | <i>Epinephelus</i> | <i>Epinephelus undulosus</i> | Fish F1, Fish R1 | Least Concern | Unknown | (Fadli et al., 2021; Fadli et al., 2020) |
| 36 | <i>Plectropomus</i> | <i>Plectropomus leopardus</i> | Fish F1, Fish R1, Fish F2, Fish R2 | Least Concern | Decreasing | (Fadli et al., 2021; Nuryanto et al., 2018) |
| 37 | <i>Plectropomus</i> | <i>Plectropomus maculatus</i> | Fish F2, Fish R2 | Least Concern | Unknown | (Nuryanto et al., 2018) |
| 38 | <i>Variola</i> | <i>Variola albimarginata</i> | Fish F1, Fish R1, Fish F2, Fish R2, Fish BCL, Fish BCH, FH70, RH70, 16SAR, 16SBR | Least Concern | Decreasing | (Abdullah and Rehbein, 2017; Andriyono et al., 2020; Fadli et al., 2021; Fadli et al., 2020; Kamal et al., 2019; Sari et al., 2015) |
| 39 | <i>Variola</i> | <i>Variola louti</i> | Fish F1, Fish R1 | Least Concern | Stable | (Fadli et al., 2021; Fadli, Nor, et al., 2020) |

Conclusion

Based on this short literature study, it is indicated that the grouper DNA barcoding research in Indonesia is still limited. Six grouper genera have been barcoded and dominated by the genus *Epinephelus* (54%). *Epinephelus areolatus* was the dominant species found in 13 study sites. The sampling sites for the grouper DNA barcoding studies in Indonesia expanded from Aceh in the western Indonesia region until Papua in the Eastern part of Indonesia. However, no sites from Kalimantan Island and limited sampling sites from Northern Sulawesi, Maluku, Southern Papua, etc., were sampled. The research on DNA barcoding needs to be increased to help develop conservation management and sustainable fisheries resource management.

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