Ichthyological Research and Biodiversity of Marine Fishes in Indonesia

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Abstract. A brief review of ichthyological research and compiled results about the records of fishes from Indonesian waters are presented. A total of 4,954 species in 324 families of fishes are currently known from the area. Over half of the total number specimen collected were represented by the families of Pomacentridae, Labridae, Gobiidae, Apogonidae, Chaetodontidae, Serranidae, Acanthuridae, Lutjanidae, Carangidae, and Scaridae. These families comprise about 48.9% of the total species reported. The Ichthyofauna is dominated by reef-associated fishes and pelagic or benthic fishes inhabiting offshore habitats. The highest number of fish species was found to present around Sulawesi Island.

1. Introduction

Indonesia, situated in the tropical Indo-Pacific, comprises 17,504 islands with an overall coastline of more than 108,000 km. The area, rich in natural marine resources occupying a range of ecosystems, has long been considered extremely high marine biodiversity [1]. With marine ecosystems such as coral reefs, coastal areas, and continental shelves, marine fishes are among the primary marine food resources in this area.

The fish fauna is vibrant and no other region ranks with the Indonesian archipelago in the number of fishes, diversification, and habitats [2]. In particular, coral reef biota in the East Indies, defined as the East Indies Triangle (islands between Sumatra in the west, New Guinea in the east, and Luzon, the Philippines in the north), have the highest marine biodiversity, including fishes, in the world [3]. The central part of this region with the most coral reef habitats has recently been referred to as the Coral Triangle [4].

In the early days, most studies of Indonesian waters were made for navigational purposes, resulting now in a growing emphasis on research, including ichthyological research. The scientific research on fishes in Indonesian waters began in earnest visits of European explorers and naturalists’ visits in the early 19th century [1], [5]. Among fish scientists, the predominant Indonesian fishes researcher was Pieter Bleeker (1819–1878). During his life, he studied intensively and extensively the fish fauna of the Indo-Australian archipelago [6], [7]. After Bleeker’s death, the studies of Indonesian fishes were continued by Max Weber, who made collections in the Indonesian archipelago from 1888 to 1900. He also headed the Siboga Expedition in 1909 and 1910-and explored the marine fauna in deep basins of the Indonesian archipelago. He also collected fishes in the Indonesian archipelago, particularly the eastern region, with his co-worker Lieven Ferdinand de Beaufort. Weber published a monumental work, entitled Fishes of the Indo-Australian Archipelago, in 11 volumes between 1911 and 1962 [8].
After Weber died in 1937, his work was continued by L F de Beaufort, Wilbert McLeod Chapman, Frederik Petrus Koumans, and John Carmon Briggs [9], [10], [11].

The availability of complete and diverse data is an essential requirement to conduct research and planning policy briefs. Typically, these secondary data have not been appropriately collected and are usually scattered and cannot be obtained from one reliable source. The purposes of the present review are to provide brief information related to ichthyological research, fish biodiversity, habitats, and specimen collections for the last 15 years.

2. Materials and Method
The data of species here were compiled from various fish species checklists [1], [12], [13]. Online data of species were obtained essentially from the institution or museums that provides online data (http://data.gbif.org; http://fishbase.org; http://calacademy.org), that included: museums as Academy of Natural Sciences Philadelphia (http://clade.ansp.org), National Museum of Natural History/Smithsonian, Washington, US (http://collections.nmnh.si.edu); Florida Museum of Natural History, Florida, US (http://ffmnh.ufl.edu/fishes); http://lsa.umich.edu/ummz; National Museum of Victoria, Melbourne, Australia (http://ozcam.ala.org.au); Museum of Comparative Zoology, Boston, US (http://www.mcz.harvard.edu); Museum National d’Histoire Natural Paris, Paris, France (http://www.mnhn.fr); Los Angeles County Museum of Natural History, LA, US (https://nhm.org/site/research-collections/ichthyology); National Science Museum of Tokyo, Tokyo, Japan (https://www.kahaku.go.jp) and others museum. Other sources for this study are obtained from the published report Coremap, Indonesia (http://coremap.go.id), the fish collection data of the Research Station of Research Centre of Oceanography, Indonesian Institute of Sciences, Bitung, North Sulawesi, Indonesia, and several unpublished data.

Information on habitat and zoogeographic distribution of each species was based on data compiled in literature [14], [15]. Four principal habitat categories adopted herein included offshore, coral reef, seagrass bed, and mangrove. The offshore category, in particular, was the most inclusive term as it encompassed a range of benthic- and pelagic-related habitats as pelagic (i.e., aquatic, pelagic-neritic, pelagic oceanic) or demersal (demersal, benthopelagic, and deep demersal) species [15]. Zoogeographic distribution of categories for species was globally used following the terminology as follow as Indo-Pacific (IP), Indo-west Pacific (IWP), Western Pacific (WP), West-central Pacific (WCP), Circumtropical (CIR), Pacific Ocean (PO), Indian Ocean (IO), Atlantic Ocean (AO) [15].

3. Results and Discussion
3.1. Brief review of ichthyological research
A brief history of ichthyological research in Indonesia has estimated around 1750, and from 1750 to 1990, there were several well-known western Ichthyologists (e.g., Cuvier, Valenciennes, Bleeker, Günther, Fowler, etc.) who reported, listed, and published their species described (Figure 1 and Figure 2). The fish fauna of the Indonesian waters was poorly recorded and documented until relatively recent times.
3.2. Fish specimen data collection

Based on the results of fish specimen data collection, 61,262 specimen data were records were collected that consisting of 18,954 (30.94%) online data, 14,792 (24.15%) visual census data, 13,034 (21.28%) checklist data, 9,097 (14.85%) specimen collection and others 14,164 (8.79%). The compiled specimen data shows that the locality of the collected specimens is from almost all Indonesian waters (Figure 3). The figure shows that Indonesia’s parts most frequently visited by the various expeditions are North Maluku, Central Maluku, Sulawesi, North Kalimantan, West Kalimantan, East Kalimantan, South Sumatera, West Jawa, Jakarta, Bali, and Lombok.
3.3. Fish biodiversity

A total of 61,262 data records of specimens were compiled from various localities consisting of 5 class, 47 order, 311 families, and 4510 species. According to its locality data, the highest fish biodiversity was found in Sulawesi (2882 species), Kalimantan (1703 species), and Papua (1585 species), and those and other localities are as shown in Table 1. The biodiversity in Kalimantan seems higher than the localities in eastern Indonesia (except Sulawesi). This is due to the inclusion of fish data from the South China Sea into the compilation of fish data in Indonesian waters [12]. Several reasons to be considered, including that some of these waters are Indonesian waters, the similarity of habitats, and the primary consideration that the taxonomic study of fish in this area has been done very well.

Table 1. Number of family, genera, species and fish specimen collected from a variety localities of Indonesian waters

| Province       | Class | Order | Family | Genera | Species |
|----------------|-------|-------|--------|--------|---------|
| Bali           | 3     | 26    | 94     | 298    | 664     |
| Java           | 2     | 24    | 120    | 345    | 754     |
| Kalimantan     | 3     | 35    | 197    | 691    | 1703    |
| Moluccas       | 2     | 31    | 169    | 527    | 1245    |
| Nusa Tenggara | 4     | 32    | 148    | 485    | 1202    |
| Papua          | 3     | 32    | 156    | 541    | 1585    |
| Sulawesi       | 5     | 43    | 256    | 952    | 2882    |
| Sumatera       | 2     | 26    | 130    | 406    | 844     |

Over half of total number of specimens collected on the present study were represented by the ten families of Pomacentridae, Labridae, Gobiidae, Apogonidae, Chaetodontidae, Serranidae, Acanthuridae, Lutjanidae, Carangidae, and Scaridae. These families comprise about 48.9% of the total
species reported (Table 2). This domination essentially by the Gobiidae, Pomacentridae, Apogonidae is almost the same as at the other localities in the Indo Pacific.

| Family               | Number of specimens | %    |
|----------------------|---------------------|------|
| Pomacentridae        | 6777                | 11.06|
| Labridae             | 5800                | 9.47 |
| Gobiidae             | 2915                | 4.76 |
| Apogonidae           | 2743                | 4.48 |
| Chaetodontidae       | 2743                | 4.48 |
| Serranidae           | 2401                | 3.92 |
| Acanthuridae         | 2138                | 3.49 |
| Lutjanidae           | 1549                | 2.53 |
| Carangidae           | 1484                | 2.42 |
| Scaridae             | 1420                | 2.32 |
| **Total**            |                     | **48.92** |

The data’s species habitat shows that studies conducted in Indonesian waters from the pre-colonial period to the present are still concentrated in coastal areas, primarily in the coral reef, seagrass, pelagic, and freshwater ecosystems. In comparison, specimens from mangroves and deep-sea ecosystems were presented in a small percentage. The collections of deep-sea specimens came from previous international expeditions carried out along Indonesian waters. The collections of deep-sea specimens show that specimens resulted from previous international expeditions carried out in all Indonesian waters, especially those using foreign research vessels with special equipment such as trawl nets or other equipment.

In terms of zoogeographic, geographic fish distribution in the Indonesian waters is dominated by zoogeographic fish from the Western Pacific Ocean, Indo West Pacific Ocean, Indo-Australia archipelago, and Eastern Indian Ocean. The fish recorded outside the zoogeographic distribution but found in Indonesian waters has proven that Indonesian waters are the center of fish biodiversity in the Indo-West Pacific (Figure 4).

![Figure 4. Distribution of fish species reported from Indonesia waters.](image)
The high level of fish diversity in Indonesian waters is not only higher than the fish diversity in the waters of neighboring countries, but it is also higher than the fish diversity in the Western Pacific Ocean (WPO), such as the Andaman Sea with 1746 species [16] and Cocos Islands with 533 species [17]. The Reunion Islands with 885 species [18]; Chagos Islands with 784 species [19]; and Red Sea with 1078 species [20] in the West Indian Ocean (WIO) and also the South China Sea with 3,315 species [12]. This data shows that fish diversity in Indonesian waters was higher.

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