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Distribution Pattern of Coral Reef Fishes in China

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Abstract: Coral reefs are known as "tropical rain forests" in the ocean. Fish diversity is extremely high, accounting for one-third of marine fishes. To better protect and manage coral reef fishes, this study systematically compiled documents and databases published in China. We counted 2855 species of coral reef fishes in China, which belong to 3 classes, 41 orders, 252 families, and 1017 genera. Among these, Perciformes was the dominant order, accounting for 57.31% of the total species. Gobiidae (7.43%), Labridae (5.36%), Pomacentridae (4.52%), and Serranidae (4.38%) were the main families, while other families accounted for less than 4%. Furthermore, 5.56% of coral reef fish species have entered the IUCN Red List. The present study found that coral reef fishes can be divided into nearshore and offshore. This was mainly because the nearshore coral reef fishes were more affected by human disturbance and runoff from the mainland, whereas offshore coral reef fishes were in areas with high salinity and temperature far from the mainland, where human disturbance was less. Coral reef fish species' diversity had a significant positive correlation with coral species diversity ($p < 0.05$), mainly because corals provide habitat and shelter. This study is the first systematic compilation and analysis of coral reef fishes in China and provides a basic reference for global protection management and biological geographical analysis.

Keywords: coral reef fishes; species composition; endangered status; coral fish diversity index; coral reef ecosystems

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1. Introduction

Coral reef ecosystems are among the most productive ecosystems in the ocean, with rich biodiversity and economic value, and are known as the "tropical rain forests" of the ocean [1]. Coral reefs provide living areas for many marine organisms and, to a large extent, affect the physical and ecological conditions of the surrounding environment [2]. However, in recent years, coral reef ecosystems have faced land pollution, destructive fishing, overexploitation, climate change pressure, and other factors, and 19% of coral reefs have disappeared globally [3–5]. Owing to various forms of water pollution, such as sewage and industrial and aquaculture wastewater, the coral coverage rate continues to decline, affecting the long-term stability of the coral reef system [6–8]. Since the 1980s, 80% of coral reefs around mainland China and Hainan Island have been destroyed by human activity [7]. In particular, destructive fishing has affected the stability of the ecological environment of coral reefs, and habitats that many species depend on for survival have been destroyed [3,9,10]. These incidents also directly or indirectly have an important impact on coral reef ecosystems, biological diversity, indigenous coastal residents, and fishery economies [11]. At present, various organizations and institutions around the world have proposed initiatives to start the restoration of coral reefs and try to rebuild coral reef

ecosystems that have been slow to recover naturally [12,13]. The commonly used methods for coral reef restoration include transplantation of coral fragments, culture and release of coral larvae or juveniles, establishment of marine reserves, grazing of herbivorous fishes, and migration of corallivorous fishes [14]. It is worth noting that coral reef restoration should focus not only on coral conservation but also on the important ecological functions of various fishes, benthic organisms, and microorganisms in coral reef waters.

Among marine fishes, 5000–8000 fish species live in coral reef waters, exceeding 1/3 of the total number of marine fishes [15–17]. Coral reef fish are economically important, and 6 million people around the world live by fishing coral reef fishes. The annual fishing was 1.4~4.2 million tons [18] and has basically stabilized at about 80 million tons since the 1990s [19], providing direct food sources and income for hundreds of millions of people. Coral reef fishes play an important role in material circulation and energy flow, which can promote the sustainable development of coral reef ecosystems [20]. As an important nutritional library, its excrement can improve primary productivity, promote coral growth, and regulate the nutritional ratio of the ecosystem [21]. In addition, it can diagnose and repair degenerate coral reefs through downward control in the food network [22].

The biological diversity of coral reef fishes is often used as an indicator of the health status of coral reefs [23–25]. However, in recent years, the function of the coral reef ecosystem has declined significantly, and the coral reef fish community structure has undergone tremendous changes, attracting widespread attention from many scholars [26–28]. Strona et al. [29] proposed that if corals disappear, the global tropical reef fish biomass will be reduced by half. Coral die-off and bleaching may reduce the environmental carrying capacity of coral reef ecosystems, and coral reef fishes may adapt to habitat changes by changing their community structure [30]. As a result, the diversity of coral reef fishes is reduced or even lost, which has led to countless direct or indirect nutritional relationships, ecosystem functions and services, and other effects [31]. Carreonpalau [32] assessed the coral reef ecosystem of the Parque Nacional Sistema Arrecifal Veracruzano national park in Mexico and found that the input of terrestrial pollutants and anthropogenic organic carbon were the main causes of coral growth damage. Akita et al. [33] stated that overfishing leads to a decline in the diversity of herbivorous fishes, aggravates the deposition of sediments, and destroys the survival and growth of coral reefs. Therefore, research and protection of coral reef fishes is currently the top priority for marine workers [34].

To better protect and manage coral reef fishes in Chinese waters, the purposes of this study were: (1) to systematically summarize the species composition of coral reef fishes in China; (2) to analyze the geographical distribution characteristics of coral reef fishes in China; (3) to understand the endangered status of coral reef fishes in China; and (4) to explore the reasons affecting the diversity of species.

2. Materials and Methods

2.1. Study Area

The total coral reef area in China is about 3.8×10^4 km^2 and ranks eighth in the world, and the reef area along the coast of southern China has a small distribution area due to the influence of temperature and latitude. Coral reefs can be divided into three types: shore and barrier reefs, and atolls [35]. The coral reefs in Xuwen, Daya Bay, Weizhou Island, Hong Kong, and other areas along the coast of the South China Mainland are shore reefs. The coral reefs in the surrounding waters of Hainan and Taiwan Island are barrier reefs, while the coral reefs in the South China Sea are atolls. Figure 1 shows the species number and distribution regions of coral reef fishes in China, including Xuwen (110.4° E, 20.3° N), Daya Bay (114.6° E, 22.5° N), Weizhou Island (109.0° E, 21.0° N), Hong Kong (114.3° E, 22.3° N), Taiwan Island waters (120.7° E, 22.2° N), Hainan Island (110.4° E, 18.7° N), Dongsha (116.7° E, 20.7° N), Nansha (116.1° E, 10° N), Xisha (111.9° E, 16.3° N), and Zhongsha Islands (114.3° E, 15.8° N).

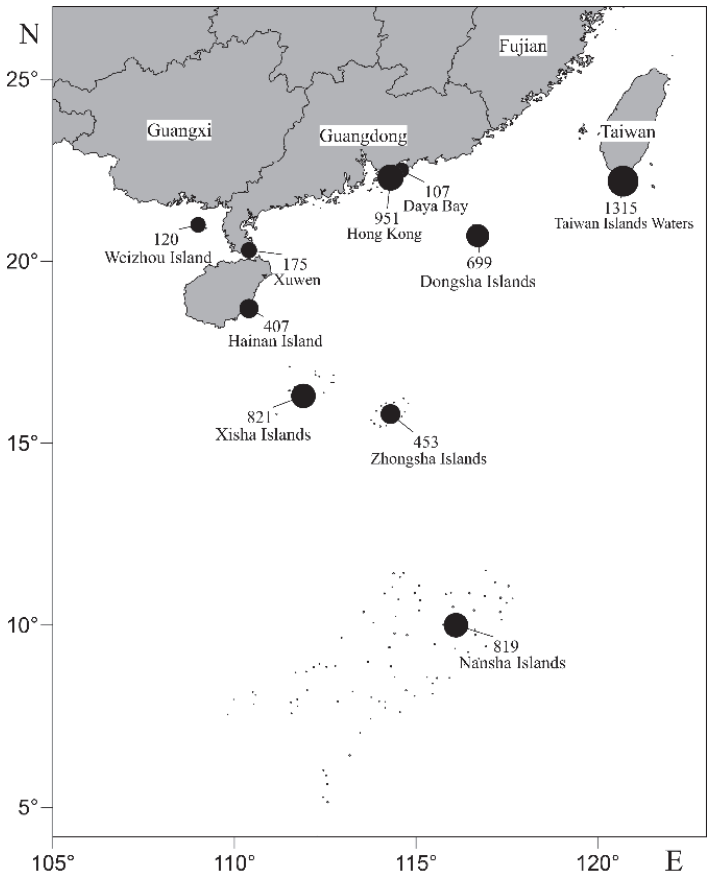

Figure 1. Distribution characteristics of coral reef fishes in China.

2.2. Data Collection

Our data are all research data on reef fishes in China up to October 2022 and are presented in different orders, families, genera, and species, which are mainly quoted from relevant literature, books, and databases on coral reef fishes published on academic research websites. The sources of each species are presented in the Supplementary Material (Table S1). Each of the fish habitat types and diets were based on information from the fishbase database (https://www.fishbase.se/search.php, accessed on 13 August 2022), and the endangered state was derived from the International Union of Conservation of Nature and Natural Resources Red List (IUCN Red List) (https://www.iucnredlist.org/, accessed on 13 August 2022), and the part of the "*" species indicated that they were not found in the database. Habitat types can be classified as reef-associated (RFA), demersal (DEM), pelagic (PEL), brackish (BRA), amphidromous (AMP), oceanodromous (OD), bathydemersal (BAD), benthopelagic (BEP), bathypelagic (BAP), pelagic-neritic (PE), and pelagic-oceanic (PELO). According to the fishbase database, there are four types of feeding types: detrivore, herbivore, omnivore, and carnivore. Since the 1960s, the MACe-lande Endangered Species rating has been used as a criterion for classifying endangered species and classifying animals in terms of rate of population decline, range of distribution, number of populations, predicted rate of population decline, and probability of extinction [36]. According to the IUCN Red List, the endangered status of coral reef fishes is queried, with a total of nine grades: Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), and Not Evaluated (NE).

2.3. Data Analysis

2.3.1. Coral Fish Diversity Index (CFDI)

The CFDI was proposed by Allen [37] to assess the diversity of reef fishes. The CFDI selected six important families: Chaetodontidae, Pomacanthidae, Pomacentridae,

Labridae, Scaridae, and Acanthuridae, as indicators for calculation. The CFDI value was used to estimate reef fish fauna using a regression formula. The total area coefficient of the sea area over 5000 km^2 was calculated using the following formula: total fish fauna $= 4.234 \times (\mathrm{CFDI}) - 114.446$.

2.3.2. Cluster Analysis

To analyze the differences in the composition of coral reef fish species in different waters of China, this paper took the coral reef fish species in the waters around Xuwen, Daya Bay, Weizhou Island, Hong Kong, Taiwan, Hainan Island, Dongsha, Nansha, Xisha, and Zhongsha Islands as the objects of analysis. Square root transformation was used for data processing, and the Bray–Curtis similarity coefficients of different waters were calculated to construct the similarity matrix. Analysis of similarity (ANOSIM) was used to test the significance of similarity among coral fish species in different waters. The global R indicates whether there was a significant difference between groups. The closer the value was to 1, the more significant was the difference. Primer 5 software was used for data analysis and mapping.

3. Results

3.1. Species Composition

A total of 2855 species belonging to 3 classes, 41 orders, 252 families and 1017 genera are listed, including 175 species from Xuwen, 107 species from Daya Bay, 120 species from Weizhou Island, 951 species from Hong Kong, 1315 species from Taiwan Island waters, 406 species from Hainan Island, 699 species from Dongsha Islands, 819 species from Nansha Islands, 821 species from Xisha Islands, and 453 species from Zhongsha Islands. There were 45 species classified as undetermined and were not included in the statistical analysis.

As shown in Figure 2, the biomass of Perciformes fish was dominant, with 1631 species accounting for 57.13% of the total. This was followed by Scorpaeniformes and Anguilliformes, with 156 (5.46%) and 140 (4.90%) species, respectively. At the family level, the number of fish in Gobiidae was the highest, with 212 species, accounting for 7.43% of the total, followed by Labridae (153 species, 5.36%), Pomacentridae (129 species, 4.52%), Serranidae (125 species, 4.38%), Apogonidae (96 species, 3.36%), Scorpaenidae (90 species, 3.15%), Blenniidae (68 species, 2.38%), and Carangidae (63 species, 2.21%).

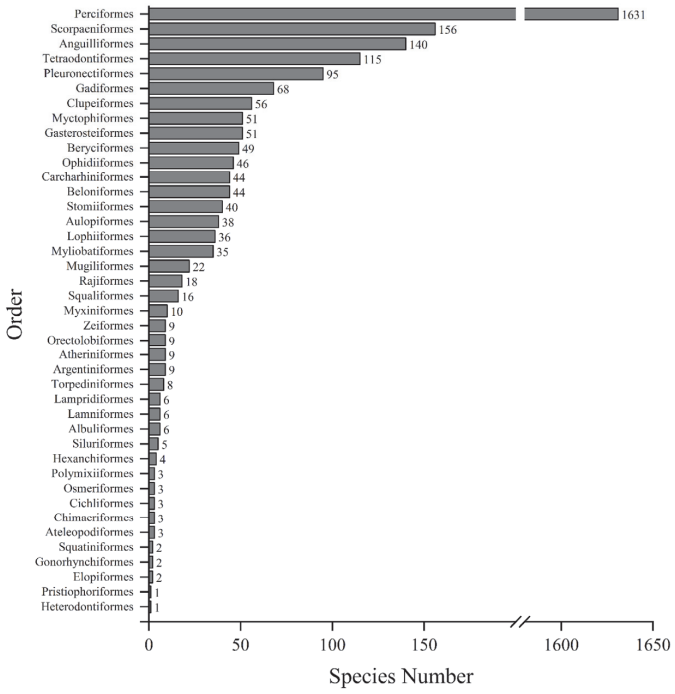

Figure 2. Total species number of listed coral fishes by order.

3.2. Community Characteristics of Coral Reef Species

3.2.1. Endangered Status

Of the 2855 fish species, 2823 belong to the IUCN category. There were 157 species (5.56%) of 2823 coral fish species, including 12 species (0.43%) in CR, 41 species (1.45%) in EN, 64 species (2.27%) in VU, and 40 species (1.42%) in NT. In addition, there were 1715 species (60.75%) in LC, 127 species (4.50%) in DD, and 824 species (29.19%) were NE (Figure 3).

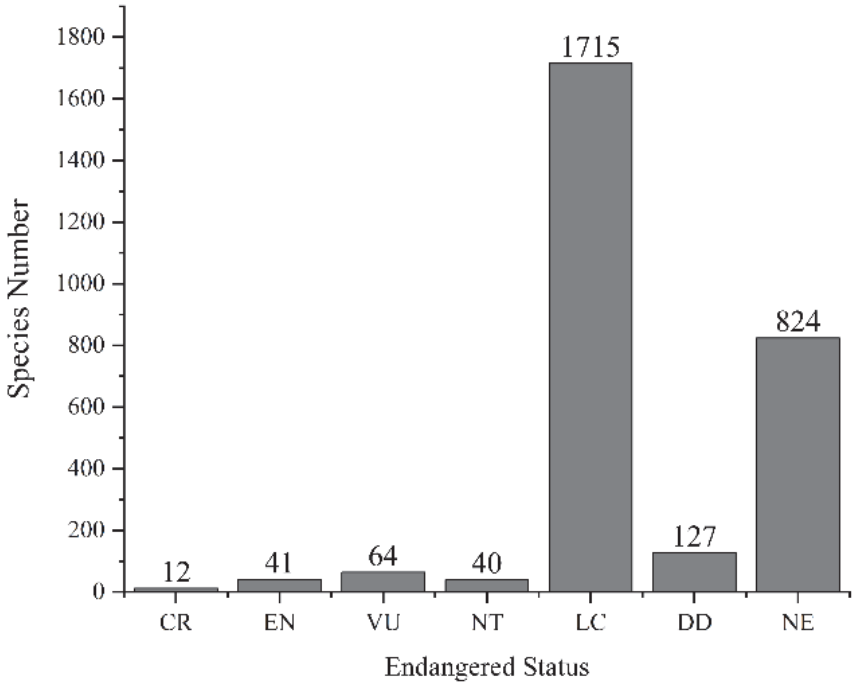

Figure 3. Endangered status and number of listed coral reef fishes.

3.2.2. Types of Feeding Habit

Most of the feeding types belonged to carnivores and omnivores, with 1369 and 1145 species, accounting for 47.95% and 40.11% of the total fish population, respectively. Detrivores and herbivores accounted for only a small proportion with 159 (5.57%) and 122 (4.27%) species, respectively. As shown in Figure 4, carnivorous fishes occupy a significant advantage in many coral reef waters in China, followed by omnivorous fishes. This indicates that the diet of coral reef fishes in China is mainly carnivorous and omnivorous.

3.2.3. Type of Habitat

Regarding habitat type, the largest number of species was RFA, with 1515 species, accounting for 53.06% of the total number of fishes. As shown in Figure 5, RFA fishes were widely distributed in coral reef waters, accounting for more than 50%. Especially in the Dongsha, Nansha, Xisha, and Zhongsha Islands, species of RFA fishes dominated.

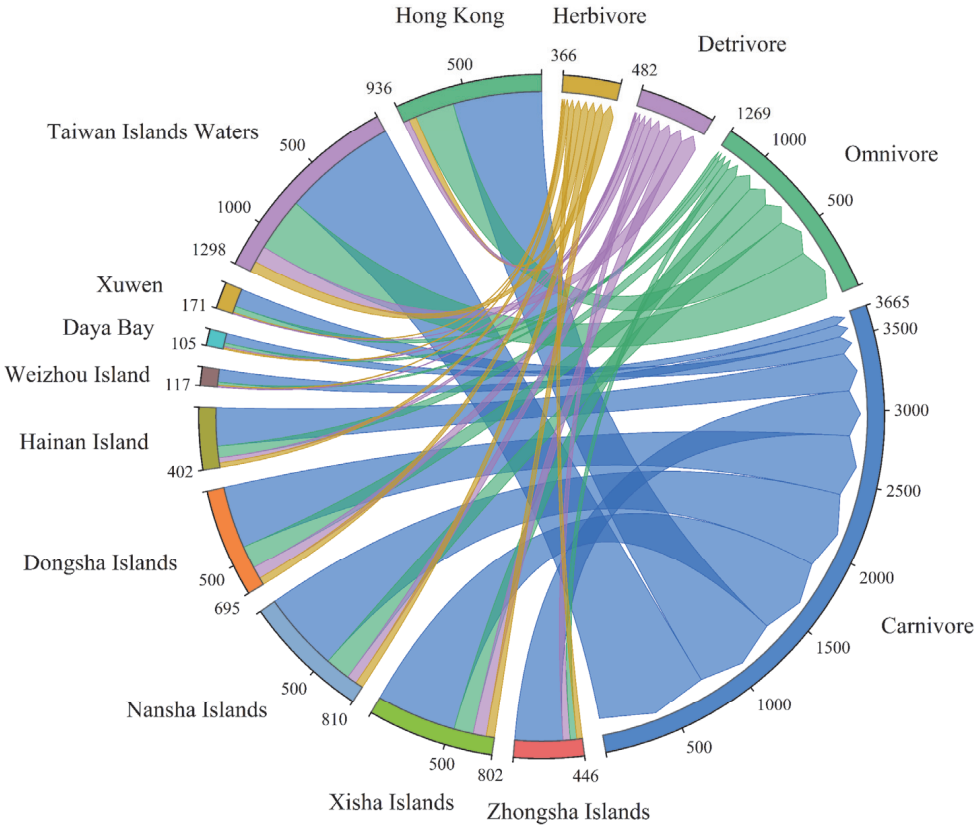

Figure 4. Feeding characteristics of coral reef fishes in various waters.

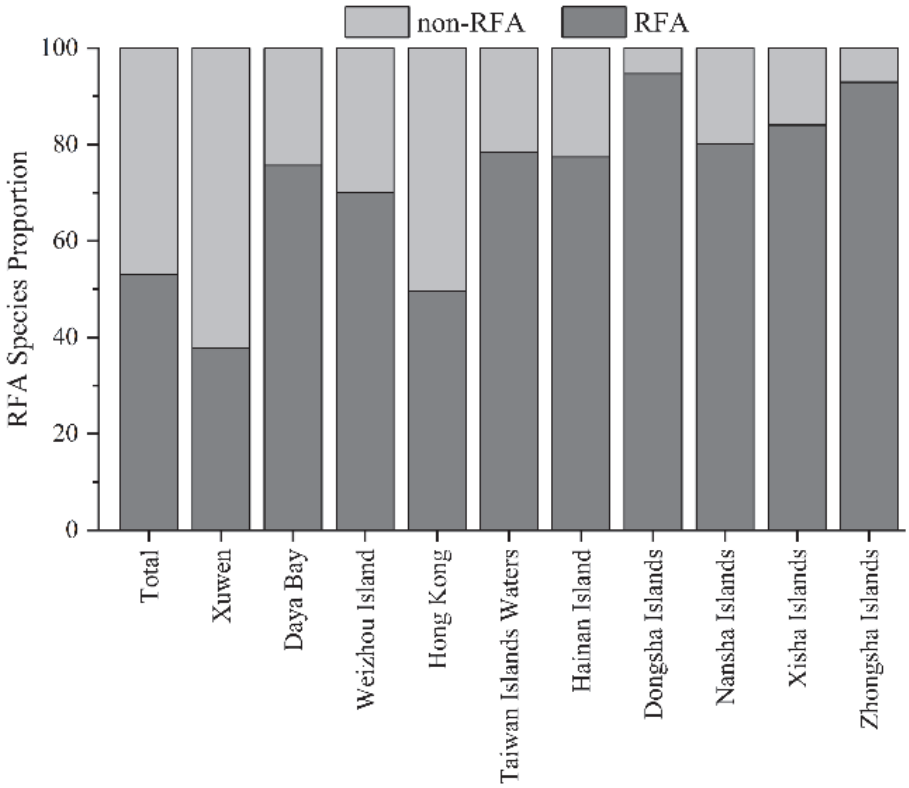

Figure 5. Characteristics of reef-associated (RFA) fishes in various coral areas.

3.3. Distribution Patterns of Coral Reef Fish Species

As shown in Figure 6, the number of coral reef fish species in each coral reef area in China can be divided into two groups with a similarity of 12.92%. Among them, Daya Bay, Xuwen, and Weizhou Island off the coast of the mainland are grouped into one branch, while the other branch includes Hong Kong, Taiwan Island waters, Hainan Island and Dongsha, Nansha, Xisha, and Zhongsha Islands in the South China Sea. ANOSIM results showed that the global R value was 0.972, $p < 0.01$, indicating a significant difference between the two groups.

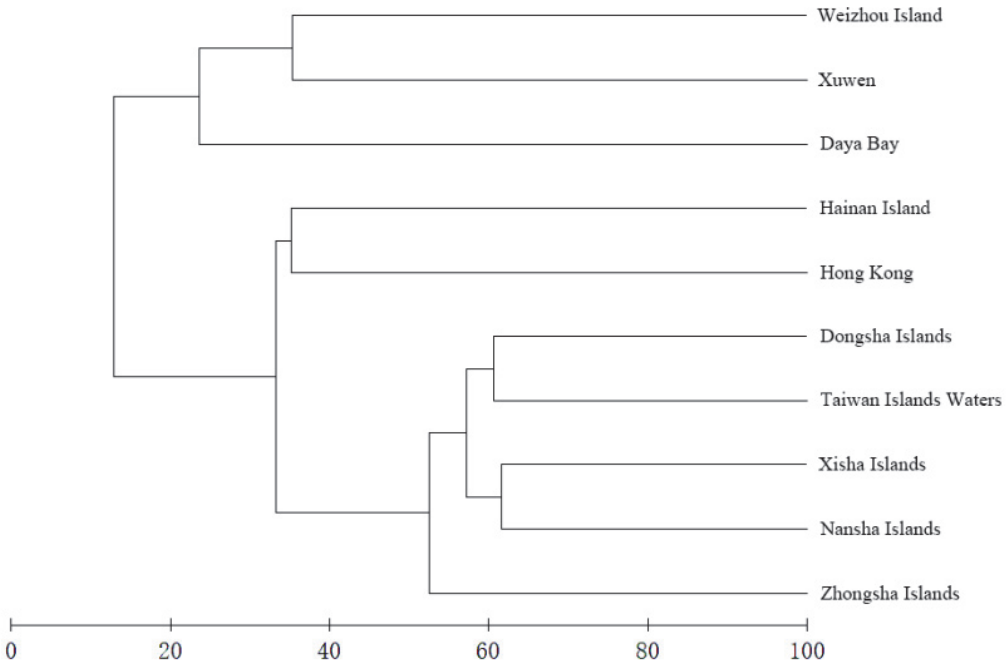

Figure 6. Cluster analysis of coral reef fish species in different coral reef waters of China.

3.4. Correlation between Coral and Coral Reef Fishes

Refer to the State of Coral Reefs in China (2010–2019) [38], which counts the number of reef-building corals in different regions of China. There were 66 species, 29 genera, and 12 families in Xuwen; 83 species, 23 genera, and 11 families in Daya Bay; 82 species, 33 genera, and 12 families in Weizhou Island; 97 species, 32 genera, and 14 families in Hong Kong; 328 species, 71 genera, and 16 families in Taiwan; 186 species, 57 genera, and 16 families in Hainan Island; 297 species, 64 genera, and 14 families in Dongsha Islands; 251 species, 60 genera, and 15 families in Xisha Islands; and 386 species, 73 genera, and 16 families in Nansha Islands. The correlation analysis between the number of reef-associated corals (x) and coral reef fish (y) in each area showed that there was a significant positive correlation between them, $y = 2.4392x + 120.11$ ($r = 0.703861$, $p = 0.034328 < 0.05$) (Figure 7).

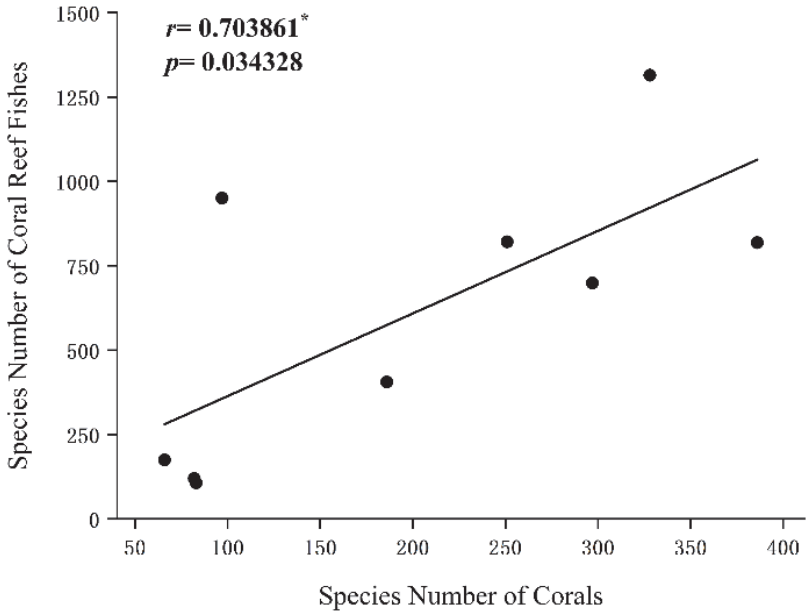

Figure 7. Relationship between coral reef fishes and coral numbers in coral reefs of China. (*: Significant, $p < 0.05$).

4. Discussion

4.1. Coral Reef Fish Species Composition

The Chinese coral reef fish species (2855 species) were extremely abundant and were significantly higher than those in other countries and areas, such as the Philippines (2200 species) [39], Indonesia (2057 species) [40], Malaysia (1428 species) [10], Vietnam (1049 species) [41], the Northern Territory in Australia (1474 species) [42], Andaman Nicobar Islands in the Bay of Bengal (1434 species) [43], Ouvea Atoll in New Caledonia (653 species) [44], Rapa Island in French Polynesia (383 species) [45], and Bootless Bay in Papua New Guinea (488 species) [46]. Therefore, it could be speculated that the coral reef area in China is the main activity area of coral reef fishes between the Indian and Pacific Oceans. According to the "Island Effect" theory, coral reef species diversity is closely related to coral reef cover area, a well-known concept in coral reef ecology [30]. The total area of coral reefs in the South China Sea is approximately 3×10^4 km^2, accounting for 5% of the global coral reef area (60×10^4 km^2) [28,47]. It can provide more available resources for coral reef fishes, such as food and hidden environments, so the area has plenty of coral ecological resources and coral reef fish species diversity.

More than 100 families of coral reef fish are found in Indo-Pacific coral reefs, but only a small portion comprises the majority of species [48]. Most fishes consist of 29 families, namely: Serranidae, Mullidae, Siganidae, Nemipteridae, Lutjanidae, Haemulidae, Lethrinidae, Chaetodontidae, Labridae, Apogonidae, Pomacentridae, Pseudochromidae, Acanthuridae, Scaridae, Cirrhitidae, Pomacanthidae, Carangidae, Gobiidae, Blenniidae, Holocentridae, Tetraodontidae, Balistidae, Monacanthidae, Scorpaenidae, Muraenidae, Syngnathidae, Pinguipedidae, Caesionidae, and Microdesmidae. This study is consistent with this result; with the exception of Microdesmidae, the remaining families were distributed, accounting for 54.85% of the coral reef fishes in China. In Malaysian waters, 29 families accounted for 68.8% [10]. In Vietnam's coral reef waters, survey data only disclosed the number of fishes contained in the first 19 families, all of which belong to the aforementioned 29 families, and the proportion reached 67.9% [41]. Even when compared with coral reefs, such as the Ouvea Atoll in New Caledonia (79.6%) [44], Redang Islands in Malaysia (63.5%) [49], and Mayotte Island in the southwestern Indian Ocean (73.8%) [50], the species number of the 29 coral reef fish families in China was low. This may be because the coral reefs in China are located on the northern edge of the "coral triangle" with low latitude and high temperature and affected by the cold flow of the mainland's estuary and

the South China Sea tropical warm currents, forming a unique coral reef ecosystem that integrates multiple physical, chemical, geological, energy, and material flow properties [28]. Many studies have shown that the composition of coral reef fishes is closely related to the status of coral reefs, human interference, environmental factors, and sampling time and methods [27,30,51–53].

Gobiidae account for an important proportion (7.43%) of reef fishes in China, which is consistent with the results of Malaysia [10] and Vietnam [41]. Goridae, also known as amphibians [54], are found in coral reef ecosystems owing to their feculence and environmental adaptation [55]. With more than 1700 species distributed across 200 genera, it is a major part of the diversity of coral reef ecosystems [56]. However, in a study by foreign scholars [3,57,58], Labridae was the family with the largest number of species. In fact, the Labridae family is also rich in the number of species in China's coral reef, second only to the number of Gobiidae. As a common species in coral reef areas, they are common in all sea areas, particularly in countries in the Indo-Pacific region (Table 1). However, owing to the influence of various geographical environments and human factors, the families in each region are slightly different.

Table 1. The number of species at the dominant family level in other sea areas.

References	Areas	Family
This study	Coral reefs of China waters	Gobiidae (212), Labridae (153), Pomacentridae (129), Serranidae (125), Apogonidae (96), Scorpaenidae (90), Blenniidae (68), Carangidae (63), Macrouridae (56), Muraenidae (56)
Samoilys et al. (2022) [3]	Madagascar, Comoros, Mozambique, and Tanzania	Labridae (6), Chaetodontidae (4), Pomacentridae (3), Scaridae (2), Epinephelidae (2), Acanthuridae (1), Lutjanidae (1), Haemulidae (1), Pomacanthidae (1), Ostraciidae (1)
Andradi-Brown et al. (2021) [57]	Raja Ampat, West Papua	Labridae (5), Nemipteridae (3), Chaetodontidae (3), Acanthuridae (2), Balistidae (2), Pomacanthidae (2), Pomacentridae (2), Serranidae (2), Lethrinidae (2), Lutjanidae (1)
Muallil et al. (2020) [59]	Tawi-Tawi Islands, south Philippines	Epinephelinae (48), Lutjanidae (40), Acanthuridae (33), Scarinae (31), Lethrinidae (26), Nemipteridae (19), Balistidae (16), Mullidae (16), Siganidae (14), Haemulidae (13)
Nguyen and Mai (2020) [41]	Coastal waters of Vietnam	Pomacentridae (110), Gobiidae (107), Labridae (100), Apogonidae (60), Serranidae (47), Blenniidae (46), Chaetodontidae (41), Scaridae (36), Scorpaenidae (32), Acanthuridae (30)
Jayaprabha et al. (2018) [51]	Southeast coast of India	Carangidae (22), Serranidae (16), Lutjanidae (13), Mullidae (7), Haemulidae (6), Acanthuridae (5), Apogonidae (5), Siganidae (4), Nemipteridae (4), Synodontidae (4)
Arai (2015) [10]	Malaysian South China Sea	Gobiidae (133), Pomacentridae (108), Labridae (85), Serranidae (65), Apogonidae (57), Carangidae (53), Chaetodontidae (45), Lutjanidae (38), Blenniidae (36), Tetraodontidae (34)
Satapoomin (2000) [60]	Gulf of Thailand	Pomacentridae (37), Gobiidae (28), Labridae (26), Serranidae (17), Apogonidae (16), Scaridae (10), Carangidae (9), Lutjanidae (9), Nemipteridae (8), Siganidae (7)
Low and Chou (1992) [53]	Coral reefs of Singapore	Pomacentridae (28), Labridae (16), Apogonidae (8), Nemipteridae (7), Serranidae (6), Chaetodontidae (4), Blenniidae (3), Lutjanidae (3), Monacanthidae (3), Pomacanthidae (3)

4.2. Distribution Patterns of Coral Reef Fish Species

In nature, each organism has a unique community structure and spatial distribution in response to the environment. Coral reef fish in China can be divided into two groups: nearshore and offshore coral reef fishes. This is mainly due to the differences in geographical location [8,27,61,62] (Figure 1). Xu Wen, Daya Bay, and Weizhou Island are located along the mainland coast. The turbidity and low salinity created by the water at the estuary, as well as lower water temperature, hindered the growth and development of corals along the mainland waters [63]. The three sites had similar ecological environments and formed unique coral reef fish areas; therefore, the fish species composition had the highest similarity, all belonging to the nearshore coral reef fishes. However, the coral reefs of Taiwan, Hainan Island, Dongsha, Nansha, Xisha, and Zhongsha Islands in the South China Sea are barrier reefs or atolls [35]. Offshore fishes mostly live in environments of high temperature and salt and are affected by the diffusion of ocean currents [3,35,64]; therefore, they have similar and high coral reef fish species diversity, and all belong to offshore coral reef fishes.

It is worth mentioning that Hong Kong is on the coast of the mainland, but the number of reef fish species was significantly higher than that of Xu Wen, Daya Bay, and Weizhou Island, which is mainly due to the high coverage of coral reefs in Hong Kong. According to the results of the Hong Kong Coral Reef Census in 2015 [65], the coral cover of 19 of the 33 locations was higher than 50%, up to 79.5%. Many studies have shown that coral reef cover is important in explaining the high abundance of fish in coral reefs [66–68]. Coral reefs with high cover often have higher species diversity of coral reef fishes [69], especially small fishes [70] and corallivorous fishes [71] (such as Scaridae, Chaetodontidae, etc.). The reduction in coral coverage is often accompanied by an increase in algae [72,73] or changes in the coral reef structure complexity [69,74], which has a significant impact on the ecosystem, such as a decrease in the species diversity of coral reef fishes. This is similar to the results reported by Tanzania [75] and the Seychelles [76]. Jones et al. [73] showed that coral cover in Papua New Guinea decreased from 66% in 1996 to 7% in 2002, and more than 75% of coral reef fish species declined during the survey period. In addition, the geographical location of Hong Kong is unique, belonging to three coastal streams (along the coast of China, drifting, and black tide), Pearl River runoff, and rising flow and decline [77], resulting in its near-tropical reef fish species diversity. Therefore, although Hong Kong is located along the mainland coast, such as Daya Bay and Xuwen, its coral reef fishes are offshore.

The coral reef fish diversity around the Taiwan waters is also high, mainly due to the passing of Taiwan's warm current and black tide. Controlled by the east boundary current with high temperature and salinity and influenced by the western boundary current dominated by the coastal current, the sea area has a rich food biological basis, and the composition and fauna of fish communities are characteristic of the transitional sea area between the East China Sea and the South China Sea [78].

4.3. Relationship between the Species of Coral and Coral Reef Fishes

The present study found that the number of coral reef fish species in China increased with an increase in coral species, with a significant positive correlation. This is similar to Australia [79], Malaysia [10], Indonesia [80], and Tanzania [81]. Komyakova et al. [67] reported that the species diversity of fish from Lizard Island had a strong linear relationship with the diversity of coral species, mainly because a large number of fish, especially juveniles, depend on living corals and choose to settle near them. Coker et al. [17] found that there are a large number of fishes in coral reef areas that rely on living corals to survive, some fishes associate with a single coral species, and some fishes can be found on more than 20 different species of corals. Messmer et al. [82] found that fish diversity increased with an increase in coral species diversity. This correlation is mainly related to changes in habitat and food sources. Like the "tropical rain forest" on land, coral reefs can provide food and habitat for related fish biological communities. The high coverage and species diversity of corals have greatly improved the survivability and species coexistence of individuals by providing shelter and moderating key processes [17]. Some scholars [67] reported that in areas focusing on corals dominated by upright branches [83], the reduction or even loss of coral will expose the fragile skeleton under the action of weathering and waves [75,84,85], causing fishes to lose asylum. Jones et al. [73] proposed that coral reefs that lack corals will no longer support diverse fish areas but will be replaced by small parts of the species that prefer algae or the bottom layer of gravel. Moreover, existing research results clearly prove that the mortality rate of corals will reduce the diversity and biomass of coral reef fishes [29,73,85,86]. In coral reef waters, about 65% of the fishes settle on live coral [73], and as different coral types support different fish communities, the difference can reach 50–90% [79]. There are strong or obligate associations between coral reef fishes and specific corals [82].

4.4. Endangered Status of Coral Reef Fish in China

In China, 157 species (5.56 %) are endangered (CR, EN, VU, and NT). This was similar to the species in India [51] (5.56%), lower than that in Malaysia [10] (7.01%), but much higher than that in the Philippines [87] (1.63%), Thailand [60] (2.49%), and Papua New Guinea [46] (2.25%). This demonstrates the seriousness of endangered coral reef fish species in China, mainly due to overfishing [36,88] and habitat degradation [89,90] and highlights the need for conservation action for coral reef fish species. As an institution that directly influences the protection actions and legislation of coral reef fishes [91], the Chinese government has paid great attention to the protection and management of endangered species and adopted some corresponding measures. On one hand, the summer fishing moratorium was implemented in China in 1999, effectively alleviating the recession of fishery resources and creating a favorable soft environment for the sustainable utilization of fishery resources [92]. On the other hand, by 2019, 271 marine protected areas (MPAs) with a total area of 124,000 km^2 had been established in China [93], which was of great significance for regulating the ecological balance between species and environment in MPAs, maintaining marine fish biodiversity and sustainable development of resources [28,94].

5. Conclusions

At present, the degradation of coral reefs and decrease in fish diversity have attracted widespread attention. To conserve endangered coral reef fishes and rebuild the ecological function of coral reefs, it is necessary to strengthen coral reef fishery management and ecological restoration [89]. In recent years, various natural resource agencies have protected and managed coral reef resources through fishery regulations, marine reserves, endangered species protection, and other methods [95]. This study is the first to systematically summarize the composition of coral reef fish species in China, analyze the distribution characteristics and factors affecting their distribution, and analyze the endangered status of coral reef fishes in China. These studies will provide basic data for the protection and restoration of coral reef ecosystems in China in the future, a basic reference for research on coral reef fisheries, and reliable data on the distribution and study of coral reef fishes worldwide.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su142215107/s1, Table S1: The Checklist of coral reef fishes in China. References [30,63,77,96–134] are cited in the Supplementary Materials.

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