BIOGEOGRAPHY AND DATABASE OF MARINE FISHES IN TAIWAN WATERS

by

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ABSTRACT. - The total number of fishes in Taiwan consists of 2,331 species in 233 families. Most of these are marine fish, totaling 2,245 species. Their distribution in Taiwan waters have been recorded in two databases and can be accessed on the internet at [http://fishdb.sinica.edu.tw]. The databases were constructed using the GRASS and INFORMIX ONLINE softwares with dbsSQL interface. Users can check the actual distribution areas of each species on the map (in a 10' grid system) or obtain a species list for each grid. Faunistic similarity measures and clustering results have shown that the distribution pattern of Taiwanese fishes are mainly affected by temperature, i.e., ocean current (warm Kuroshio coming up from south and cool China coastal waters come down from north) and substratum. Fish faunas are quite different between the north and south, especially among dominant reef species. The overlapping areas are in Penghu on the west and in north-eastern Taiwan on the east.

RÉSUMÉ. - Biogéographie et base de données des poissons marins de Taïwan.

A ce jour, 2 331 espèces de poissons, appartenant à 233 familles, ont été recensées dans les eaux taiwanaises, dont 2 245 sont marines. Leur distribution a été enregistrée dans deux bases de données qui sont accessibles par Internet sur le site [http://fishdb.sinica.edu.tw]. Ces bases de données ont été élaborées avec les logiciels GRASS et INFORMIX ONLINE, et les interfaces dbsSQL. Les utilisateurs peuvent consulter la distribution géographique de chaque espèce sur des cartes (étalons avec un système de quadrillage de 10') ou bien obtenir une liste des espèces pour chaque carré de la grille. Des mesures de similitude faunistique et les résultats d'analyses hiérarchiques montrent que la distribution des poissons de Taiwan est principalement fonction de la température, i.e., des courants océaniques (les eaux chaudes du Kuroshio venant du sud et les eaux froides côtières chinoises venant du nord) et du substrat. Les faunes ichthyologiques du nord et du sud sont bien différentes, notamment en ce qui concerne les espèces récifales dominantes. Les zones de recouvrement sont au Penghu, à l'ouest et au nord-est de la partie orientale de Taïwan.

Key-words. - Ichthyofauna, Taiwan, Database, Biogeography.

The island of Taiwan has abundant fishery resources. Shen et al. (1993) listed 237 families and 2,028 species of fish and estimated more than 2,500 species, altogether. The senior author was granted by the National Science Council a five-year project during 1989-1994 to do a faunistic survey in each region, every year. The data were mostly collected by visual census and specimen collections via scuba diving, including Kenting National Park, Orchid Is., Green Is., Hsiaoliihchu, Penghu, the reef zone from Chinsan in the northern coast to Maoao in the north-eastern coast, and the rocky substratum along eastern and western coast of Taiwan. For non-reef species, the data were collected from the

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harvests of near shore fisheries including long-liner, bottom trawler or set-net, impingement sample of nuclear power plants, and fish anglers. The fish specimens deposited at several museums or research institutes were also verified and included in the list. So far, only three papers have been published on these areas: Hsiaoaliuchiw with 608 species (Chen et al., 1992), western Taiwan with 664 species (Shao et al., 1993), and Penghu with other 648 species (Shao et al., 1994). Other species numbers are 663 (north), 332 (northeastern), 715 (eastern), 601 (Green Is.), 558 (Orchid Is.) and 1,104 (South, i.e., Kenting). Most of these fish are coral reef fishes. Additionally, the authors updated the species number to 392 at Tung-Sha (Pratas Is.) (Chen et al., 1995) and to 421 at Nansha (Spratly Is.) (Chen et al., 1997).

Additions to the Taiwanese fish fauna after 1994

After the book of “Fishes of Taiwan” (Shen et al., 1993) was published, we have reported many new additions of fishes to the Taiwanese fish fauna. To date, the following new species were added: Pseudochromis striatus Gill et al., 1984; Schismatogobioides ampluvinculus Chen et al. 1995; Pseudocoris ocellatus Chen & Shao, 1995; Cirrimumaxilla formosa Chen & Shao, 1995; Gymnothorax niphogenus Chen et al., 1996; Enneapterygus cheni Wang et al., 1996; and 3 new species of Rhinogobius (Chen and Shao, 1996). Another new species of Gymnophallus and one species of Callogobius in prep-aration. As to the Taiwanese new records of fishes since 1994, the following fishes were reported: 12 species of Muraenidae (Chen et al., 1994); 1 species of newly recorded family (Microdesmidae), Gunnellichthys curiousus (Chen et al., 1994); 5 species collected from western coast (Lin et al., 1994); 4 species of Labridae (Wang et al., 1994); 2 species of the genus Asterorhombus from the Spratly Island (Lin et al., 1995); 5 species of the genus Diaphus (Kao and Shao, 1996); 12 species of gobies living in coral reefs (Chen et al., 1997); 5 species of Carangidae (Lin and Shao, 1998), and 7 species of Amblyeleotris (Chen et al., 1998).

Other new species or new records published by Taiwanese fish taxonomists since 1994 include 5 new species of Myxinidae (Kuo and Mok, 1994; Kuo et al., 1994); 5 new species of Tripterygiidae (Shen and Wu, 1994); 2 new species of Rhinogobius (Aonuma and Chen, 1996); 1 new species of Synaphobranchidae, Dysomma opisthopterus (Chen and Mok, 1995); 1 new species of Congridae, Ariosoma nancyae (Shen, 1998); and 1 new record of a moray eel (Chen and Böhlke, 1996); 2 new records of gobies (Chen et al., 1995), and a long-nosed chimaera (Shao and Huang, 1997).

Biogeographical distribution of marine fishes in Taiwan

The updated checklist of fish species in Taiwan contains a total number of 233 families and 2,331 species. About three-fifth among them are coral reef fishes, i.e., 72 families and 1,425 species. The highest diversity region is in Kenting, then east, north, west, Penghu, Green Is., Hsiaoaliuchiw, and Orchid Is.

Chaetodontidae, Scaridae and Acanthuridae are common in the south, Hsiaoaliuchiw, Orchid Is. and Green Is. However, these reef fishes are rare in the north, Penghu and western Taiwan, where the corals are not so prosperous. The geographical distribution of reef fishes in Taiwan is highly correlated with the distribution of corals.

Table I lists the species numbers of 21 families of important reef fishes occurring in Taiwan. Four categories, i.e., abundant (A), common (C), occasional (O), and rare (R) were used to represent their abundance based on diving observation. The results show that the majority (56%) of reef fishes is rare, i.e., only one or two individuals could be found during one year survey on the basis of about 20 diving hours in average; 27% are occa-
Table I. - Abundance of exotic marine fish species in the waters around Taiwan. Asterisks (*) represent edible or economical species.

<table>
<thead>
<tr>
<th>Family (common names)</th>
<th>Total species in the world</th>
<th>Total species in Taiwan</th>
<th>Percentage in the world</th>
<th>Current species numbers in Taiwan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Abundant</td>
</tr>
<tr>
<td>Acanthuridae (surgeonfishes) *</td>
<td>72</td>
<td>40</td>
<td>55.6</td>
<td>3</td>
</tr>
<tr>
<td>Apogonidae (cardinalfishes)</td>
<td>207</td>
<td>80</td>
<td>38.6</td>
<td>2</td>
</tr>
<tr>
<td>Balistidae (triggerfishes)</td>
<td>40</td>
<td>18</td>
<td>45.0</td>
<td>0</td>
</tr>
<tr>
<td>Chaetodontidae (butterflyfishes)</td>
<td>114</td>
<td>46</td>
<td>40.4</td>
<td>3</td>
</tr>
<tr>
<td>Cirrhitidae (hawkfishes)</td>
<td>32</td>
<td>10</td>
<td>31.3</td>
<td>2</td>
</tr>
<tr>
<td>Gobiidae (gobies)</td>
<td>#2000</td>
<td>195</td>
<td>9.8</td>
<td>1</td>
</tr>
<tr>
<td>Holocentridae (squirrel-fishes) *</td>
<td>65</td>
<td>28</td>
<td>43.1</td>
<td>0</td>
</tr>
<tr>
<td>Labridae (wrasses)</td>
<td>&gt;500</td>
<td>127</td>
<td>25.4</td>
<td>14</td>
</tr>
<tr>
<td>Lutjanidae (snappers)</td>
<td>97</td>
<td>48</td>
<td>49.5</td>
<td>3</td>
</tr>
<tr>
<td>Monacanthidae (filefishes)</td>
<td>95</td>
<td>23</td>
<td>24.2</td>
<td>2</td>
</tr>
<tr>
<td>Muraenidae (moray eels) *</td>
<td>200</td>
<td>51</td>
<td>25.5</td>
<td>0</td>
</tr>
<tr>
<td>Ostraciidae (boxfishes)</td>
<td>33</td>
<td>10</td>
<td>30.3</td>
<td>0</td>
</tr>
<tr>
<td>Pomacanthidae (angelfishes)</td>
<td>74</td>
<td>31</td>
<td>41.9</td>
<td>0</td>
</tr>
<tr>
<td>Pomacentridae (damselfishes)</td>
<td>315</td>
<td>101</td>
<td>32.1</td>
<td>10</td>
</tr>
<tr>
<td>Pseudochromidae (dottybacks)</td>
<td>98</td>
<td>13</td>
<td>13.3</td>
<td>1</td>
</tr>
<tr>
<td>Scaridae (parrot fishes) *</td>
<td>83</td>
<td>28</td>
<td>33.7</td>
<td>0</td>
</tr>
<tr>
<td>Serranidae (groupers) *</td>
<td>449</td>
<td>116</td>
<td>25.8</td>
<td>2</td>
</tr>
<tr>
<td>Siganidae (rabbitfishes) *</td>
<td>27</td>
<td>10</td>
<td>37.0</td>
<td>0</td>
</tr>
<tr>
<td>Solenostomidae (ghost pipefishes)</td>
<td>3</td>
<td>2</td>
<td>66.7</td>
<td>0</td>
</tr>
<tr>
<td>Syngnathidae (pipefishes)</td>
<td>215</td>
<td>29</td>
<td>13.5</td>
<td>0</td>
</tr>
<tr>
<td>Tetraodontidae (puffers)</td>
<td>121</td>
<td>29</td>
<td>24.0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total (%)</strong></td>
<td>4229</td>
<td>1035</td>
<td>24.5</td>
<td>43</td>
</tr>
</tbody>
</table>
Fig. 1. - UPGMA phenogram showing the faunistic relationships of fish communities among eight different regions in the waters around Taiwan.

seasonal species, with a few individuals or occurrences 2-3 times per year. The common and abundant species comprise only 14.5% and 4.2% respectively. Thus, although the total number of important coral reef fish species in Taiwan is almost one-quarter (24.5%) of those in the world, the number of individuals is quite low.

Two large distinct groups could be recognized from UPGMA clustering result (Fig. 1). One contains eastern and southern Taiwan, Hsiaoliuchi, Orchid and Green Is. The other contains Penghu, northern and western Taiwan. This pattern coincides with that of the ocean currents and surface temperature (Fig. 2), modified by substratum types. In other words, two major zoogeographical distribution zones in the waters around Taiwan could be distinguished:

Kuroshio affected zone

The main current and its branch come from south of the equator up to the southern tip of Taiwan. The strong main current flows to the east coast passing through the islets of Orchid and Green Is. A weak side-branch flows through the Taiwan Strait up to Hsiaoliuchi and south Penghu. In winter it flows along the Penghu Channel or even penetrates into more northern parts. In summer it flows along the western shoreline, crossing the Tropic of Cancer. This zone is the major area of coral reef fishes in Taiwan. Some of them, at least 10 species, are distributed here as their northernmost boundary, such as *Samariscus triocellatus*, *Sillago chondropus*, *Thysanophrys otaitensis*, *Pseudopleiops knighti*, *Apogon taeniophorus*, *Scolopsis trilineatus*, *Paracheilinus carpteneri*, *Canthigaster solandri* and *Siganus javus*. Eastern Taiwan, because of its strong currents and deep waters contains mostly deep water or oceanic meso-pelagic fish species.

Fig. 2. - Distribution pattern of sea water temperature around Taiwan (A), this surface temperature pattern is actually determined by the northward warmer Kuroshio current and South China Sea Waters, as well as the southward colder China Coastal Waters (B).
Southwestern monsoon affected zone

In the summer season, the southwesterly summer monsoon drives the South China Sea surface waters into Taiwan Strait through the Penghu Channel. These lighter surface waters can flow over the Changyuen ridge and then along the west coast of Taiwan to the East China Sea. However, the flows change during the northeasterly winter monsoon, which drives the colder and fresher China coastal waters into the southern Taiwan Strait (Jan, 1995). In other words, the warmer and more brackish waters of the South China Sea are retarded by the wind stresses and turned northwestward at south of the Changyuen ridge during the winter. Some reef fishes originating from the South China Sea could be transported to Penghu, northern or western Taiwan from this southwestern monsoon current. However, the low water temperature of the China coastal waters will inhibit the distribution of more tropical reef fish species so that the number of reef species in this zone is less than that of the Kuroshio affected zone. Penghu Islands at the Tropic of Cancer is the boundary or overlapping area between these two zoogeographical zones. Thus, the number of coral reef fish species is higher in southern Penghu than northern Penghu and northern Taiwan. Besides those non-coral fishes such as Sciaenidae or Chaetodactylidae, which are associated with China coastal waters, there are some coral reef fishes in this region that have not yet been found in Japan, such as Halichoeres dassumeri, H. timorensis, Apogon holotaenia, A. nigripinnes, Valenciennea immaculata, Parascorpaena picta and Epinephelus bleekeri. Except for H. timorensis, all are common species in this area but are not found in other areas of Taiwan. It is believed that these species are originally Indian Ocean species that expanded to the western Pacific.

Other similar species which have been reported from Japan, but not yet been discovered in the Kuroshio affected zones include: Ecsenius lineatus, E. namiyi, Upeneus moluccensis, Chromis cinerascens and Parapercis snyderi. Finally, the most distinctive fish species composition was on the western coast, which was mainly due to different types of substratum and topography, i.e., shallow and sandy or muddy habitat.

Fish database of Taiwan and its access on the Web

In Taiwan, only curatorial databases of fish at both Academia Sinica (AS) and National Taiwan University (NTU), existed previously. The specimens deposited at other museums have not yet been computerized. The only distributional database of marine organisms in Taiwan was established by the authors at AS. This fish database was established by using ACCESS 7.0 and now can be accessed on the Web at [http://fishdb.sinica.edu.tw]. This database is briefly introduced below.

There are three distributional databases: Inshore economic fishes, coastal fishes, and freshwater and estuary fishes. They were constructed using GRASS (Geographic Resources Analysis and Support System) and INFORMIX ONLINE with dbSQL interface. Users can easily check the actual distribution areas of each fish species on the map or get a species list for each 10' grid of coastal waters around Taiwan. The database contains a fish's scientific name, Chinese names, both English and Chinese common names, localities, seasons (months), fishery methods, and abundance data. Four categories of abundance (abundant, common, occasional or rare) for each month can be plotted in different colors on a map for each fish species. There are specimen photos and detailed descriptions (in Chinese language) of each species including morphological character, ecological habitats, and geographical distribution.

Original fish data were collected region by region every year. For inshore economic fishes, the project was supported by the Council of Agriculture in order to promote
the utilization, management, and conservation of coastal fishery resources in Taiwan. For coastal marine fishes of Taiwan, the project was supported by the NSC. The basic differences of this coastal fish database from a previous inshore economical one is that this database includes non-economical smaller fishes, such as coral reef fishes. All data of coastal fishes were recorded from field work, not indirectly from fishermen’s questionnaires.

We are planning to put the most updated fish checklist and the reason (citation) for each change (new addition, deletion or name change) on the Web to provide the most updated fish taxonomic information in Taiwan. The most updated erratum of “Fishes of Taiwan” (Shen et al., 1993) was provided in this database as well to serve all users in the world.

Actively provide our local fish faunistic data in order to merge Taiwanese data into some global databases is very important because users can easily obtain updated fish information of Taiwan through, e.g., the global FishBase (CD-ROM) (Froese and Pauly, 1996). There are several different approaches to export our country data to FishBase: file transfer, forms, reprints or unpublished data, and photos. Species 2000, a project for indexing the world’s known species on the internet, also links to FishBase for taxonomic information. Finally, we hope that our experiences of building a fish database in Taiwan could help fish taxonomists in other Asian-Oceanic countries to build up similar databases. Ultimately, everyone should be able to get the most update fish distribution data from all of the world through the internet.

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