Research Article

Taxonomic update and illustrated key of Zeiformes from Chile
(Pisces: Actinopterigii)

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ABSTRACT. The Chilean fishes of the order Zeiformes are rare in museum collections, the lack of scientific expeditions to the submarine ridge and the scarcity of new specimens records in Chilean shelves, as well as the lack of biological studies, probably accounts for its apparent rarity. In the last two decades, fishes of the order Zeiformes in Chile have undergone major changes in their taxonomic categories and in the record of new species. In Chile, there are five families, 7 genera and 11 species. They live in benthic and bathypelagic realms and are distributed at depths of 30 to 1500 m. Also, the literature of these species, is scattered, hindering their taxonomic and systematic knowledge, which makes difficult their study and better understanding as a group. It also prevents progress in such important aspects like their phylogenetic relationships, the state of vulnerability of their populations and other biological aspects. In order to contribute to the knowledge and its identification, a bibliographical compilation and a tentative illustrated identification key that unifies all the existing information in a single document, is presented. This may constitute a new tool to contribute to the growing interest in biodiversity studies in the south eastern Pacific Ocean.

Keywords: Zeiformes, fishes, taxonomy, illustrated key, Chile.

INTRODUCTION

The fishes of the order Zeiformes are marine, cosmopolitan, bathy- and bathypelagic, with preference of cold and temperate waters and found at various depths in the southeastern Pacific and Atlantic Ocean (Heemstra, 1980; Lloris, 1981, 1986; James et al., 1988; Pequeño et al., 1992; Yearsley & Last, 1998; Tyler et al., 2003; Pequeño & Matallanas, 2004; Nakabo et al., 2006; Nelson, 2006; Nolf & Tyler, 2006).

Many species of this order are deep-sea fishes, found at depths that may exceed 1000 m. Some species, however, especially in the family Zeidae, live at depths of 100-300 m (Nelson, 2006; Nolf & Tyler, 2006). The Zeiformes are characterized by having a high and compressed body, with the dorsal and anal profile bordered by the presence or absence of small thorns or shields. They possess five to eight branchiostegal rays, being gas-bladder and orbited-sphenoid bone absent. Eyes are large and well apparent; mouth is widely protractile. The single dorsal fin has spines and supplemenal soft rays. Anal fin has 0 to 4 spines with soft rays. The pectoral fins are short and rounded. The pelvic fin, which can be very apparent, possesses one spine and five to 10 soft rays. The caudal fin, usually with 11 rays (with the only exception of the family Grammicolespididae with 13 rays), may be rounded, truncated or split (Heemstra, 1980; Nelson, 2006; Nolf & Tyler, 2006).

In Chile, information about of Zeiformes species is scarce, probably due to the casual captures and the limited access of the seamounts (Pequeño, 1989; Meléndez et al., 2001; Pequeño et al., 1992; Pequeño & Matallanas, 2004). The members of this order are rare in museum collections, the lack of scientific expeditions to the submarine ridge and the scarcity of new specimens records in Chilean shelves, as well as the scarcity of biological studies, probably accounts for its apparent rarity.

Due to this lack of knowledge, the present work attempts to create a bibliographical compilation to display the current taxonomic status of the species in this order, together with a tentative illustrated identification key that unifies all the existing information in a single document.
MATERIALS AND METHODS

For the revision and updating of the order Zeiformes of Chile, the classification criteria provided by Nelson (2006) and Eschmeyer (2015) were considered. For the validation of the nomenclature, the criterion of Eschmeyer (2015) was used.

Due to the difficulty to obtain fresh specimens or in museum collection, the description of figures as well as the morphological, environmental, geographical distribution and bathymetric parameters, has been compiled from the following sources: Heemstra (1980, 1986a, 1986b); Lloris (1981); Karrer (1986); Karrer & Heemstra (1986); Parin (1989, 1991); Pequeño et al. (1992); Parin et al. (1997); Yearsley & Last (1998); Bianchi et al. (1999); Vasconcelos et al. (2003); Pequeño & Matallanas (2004); Nakabo et al. (2006); Nolf & Tyler (2006); Santini et al. (2006); Schwartz (2008); Carvalho-Filho et al. (2012); Martins & Schwingel (2012) and Froese & Pauly (2015).

The acronyms referred in the text are (Levito et al., 1985): BMNH British Museum of Natural History. BSKU Kochi University, Department of Natural Science, Faculty of Science, Kochi, Japan. CSIRO The Australian National Fish Collection, Common Wealth Scientific and Industrial Research Organization, Division of Marine and Atmospheric Research, Hobart, Tasmania, Australia. RMNH Naturalis (Nationaal Natuurhistorisch Museum; formerly Rijksmuseum van Natuurlijke Historie), Postbus 9517, 2300RA Leiden, The Netherlands. SAM South Australia Museum, North Terrace, Adelaide, South Australia 5000, Australia. SU Stanford University. USNM National Museum of Natural History, Washington D.C., USA. ZIN Zoological Institute, Academy of Sciences, St. Petersburg, Russia. ZMB Universität Humboldt, Zoologisches Museum, Invalidenstrasse 43, 1040 Berlin N-4, Alemania. ZMMU Uppsala Universitet, ZoologiskaMuseet, Uppsala, Sweden.

IUCN classification nomenclature (Red List IUCN 2013.2): DD Data Deficient, LC Least Concern, NT Near Threatened, NE Not Evaluated and VU Vulnerable.

RESULTS


The species appear in systematic order according to Eschmeyer (2015) criteria.

Family: OREOSOMATIDAE
Subfamily: OREOSOMATINAE

Neocytus psilorhynchus Yearsley & Last, 1998 (Fig. 1)


Distribution: Southeastern Pacific: Chile (James et al., 1988; Parin, 1991; Yearsley & Last, 1998).

Habitat: Benthopelagic (James et al., 1988; Parin, 1991; Yearsley & Last, 1998; Froese & Pauly, 2015).

Depth: 750-1170 m (James et al., 1988; Parin, 1991; Yearsley & Last, 1998; Froese & Pauly, 2015).

IUCN information (Red List 2013):
- Classification: NE
- Population trend: Unknown
- Biological parameters: Scarcely known (Table 1) (Froese & Pauly, 2015).

Figure 1. Oreosomatidae: Neocytus psilorhynchus (Modified from Yearsley & Last, 1998).

Neocytus rhomboidalis Gilchrist, 1906 (Fig. 2)

Distribution: Southern Circumglobal; Southeastern Pacific: South of Chile, Canal Bárbara and seamounts
Zeiformes from Chile


Depth: 200-1240 m (usually 450-800 m) (James et al., 1988; Parin, 1991; Yearsley & Last, 1998; Froese & Pauly, 2015).


IUCN information (Red List 2013):
- Classification: NE
- Population trend: Unknown
- Biological parameters: Known basic biological data (Table 1) (Froese & Pauly, 2015).

Table 1. Basic biological parameters analyzed in Chilean Zeiformes species. TL = total length; SL = standard length (male specimens only).

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Maximum age (years)</th>
<th>Maturity length (cm)</th>
<th>Maximum length (cm)</th>
<th>Fecundity rate</th>
<th>Resilience</th>
<th>Vulnerability</th>
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<tbody>
<tr>
<td>Oreosomatidae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neocytus psilorhynchus</td>
<td>X</td>
<td>X</td>
<td>22.4</td>
<td>X</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Neocytus rhomboidalis</td>
<td>100</td>
<td>34 (29-34)</td>
<td>40</td>
<td>Low</td>
<td>Very low</td>
<td>High to very high</td>
</tr>
<tr>
<td>Pseudocytus maculatus</td>
<td>100</td>
<td>40-41</td>
<td>68</td>
<td>Low</td>
<td>Very low</td>
<td>High to very high</td>
</tr>
<tr>
<td>Parazeniidae</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>?</td>
<td>Low</td>
</tr>
<tr>
<td>Stethopristes eos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zenionidae</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Cyttomimus stelgis</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>?</td>
<td>Low</td>
</tr>
<tr>
<td>Zenion hololepis</td>
<td>X</td>
<td>X</td>
<td>12</td>
<td>X</td>
<td>?</td>
<td>Low</td>
</tr>
<tr>
<td>Zenion japonicum</td>
<td>X</td>
<td>X</td>
<td>10</td>
<td>X</td>
<td>?</td>
<td>Low</td>
</tr>
<tr>
<td>Grammicolepididae</td>
<td>X</td>
<td>X</td>
<td>64 LT</td>
<td>X</td>
<td>Low</td>
<td>Moderate to high</td>
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<td>Grammicolepis brachiatus</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Zeidae</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Zenopsis conchiifer</td>
<td>X</td>
<td>X</td>
<td>80 LT</td>
<td>X</td>
<td>Low</td>
<td>Moderate to high</td>
</tr>
<tr>
<td>Zenopsis nebulosa</td>
<td>45</td>
<td>25-40</td>
<td>70</td>
<td>X</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Zenopsis oblonga</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Low</td>
<td>Moderate to high</td>
</tr>
</tbody>
</table>
Subfamily: PSEUDOCYTTINAE

*Pseudocyttus maculatus* Gilchrist, 1906 (Fig. 3)


Distribution: Southwest Atlantic: off Suriname, off Uruguay to Argentina and the Falklands; Southeast Atlantic: Namibia to South Africa, including the northern part of Walvis Ridge; Bellingshausen and Australian-Antarctic Basin to New Zealand, New South Wales and Tasmania, Australia and the Kerguelen Islands; Southeastern Pacific: off southern Chile (Heemstra, 1980; James *et al.*, 1988; Eschmeyer, 2015). Habitat: Benthopelagic (James *et al.*, 1988; Froese & Pauly, 2015).

Depth: 400-1500 m (usually 900-1100 m) (James *et al.*, 1988; Froese & Pauly, 2015)

IUCN information (Red List 2013):
- Classification: DD
- Population trend: Decreasing
- Biological parameters: Scarcely known (Table 1) (Froese & Pauly, 2015).

Family: PARAZENIDAE

Subfamily: CYTTOPSINAE

*Stethopristes eos* Gilbert, 1905 (Fig. 4)


Depth: 343-686 m (Parin, 1991; Froese & Pauly, 2015)

IUCN information (Red List 2013):
- Classification: NE
- Population trend: Unknown
- Biological parameters: Unknown (Table 1) (Froese & Pauly, 2015).

Family: ZENIONIDAE

*Cyttomimus stelgis* Gilbert, 1905 (Fig. 5)


Depth: 351-644 m (Parin, 1991; Froese & Pauly, 2015)

IUCN information (Red List 2013):
- Classification: NE
- Population trend: Unknown
- Biological parameters: Unknown (Table 1) (Froese & Pauly, 2015).
Zenion hololepis (Goode & Bean, 1896) (Fig. 6)


Distribution: Western Indian Ocean: Tanzania and off Delagoa Bay, Mozambique; Western Central Pacific, Western Atlantic: Antilles and Venezuela; Northwest Atlantic: Canada; Eastern Atlantic; South China Sea; Southeastern Pacific: Nazca and Salas y Gomez submarine ridges. (Parin et al., 1997; Pequeño & Matallanas, 2004).

Habitat: Benthopelagic (Parin, 1991; Froese & Pauly, 2015)
Depth: 180-700 m (Parin, 1991; Froese & Pauly, 2015)
IUCN information (Red List 2013):
- Classification: NE
- Population trend: Unknown
- Biological parameters: Scarcely known (Table 1) (Froese & Pauly, 2015).

Zenion japonicum Kamohara, 1934 (Fig. 7)


Habitat: Benthopelagic (Froese & Pauly, 2015)
Depth: 200-400 m (Froese & Pauly, 2015)
IUCN information (Red List 2013):
- Classification: NE
- Population trend: Unknown
- Biological parameters: Scarcely known (Table 1) (Froese & Pauly, 2015).

Grammicolepis brachiusculus Poey, 1873 (Fig. 8)


Distribution: Eastern Atlantic: Spain to the Gulf of Guinea and southward to Durban, South Africa; Western Atlantic: Georges Bank to off Suriname; North Pacific: Japan and Hawaii Brazil, Southeastern Pacific: Chile, San Felix Island (Pequeño & Matallanas, 2004; Eschmeyer, 2015).

Habitat: Bathypelagic (Froese & Pauly, 2015)
Depth: 300-1026 m (usually 500-700 m) (Pequeño & Matallanas, 2004; Froese & Pauly, 2015)
IUCN information (Red List 2013):
- Classification: NE
- Population trend: Unknown
- Biological parameters: Scarcely known (Table 1) (Froese & Pauly, 2015).
**Figure 8.** Grammicolepididae: *Grammicolepis brachiusculus* (Modified from Vasconcelos et al., 2003).

**Family: ZEIDAE**

**Zenopsis nebulosa** (Temminck & Schlegel, 1845) (Fig. 9)


Distribution: Indo-Pacific: Japan, northwest shelf of Australia to Broken Bay in New South Wales, New Zealand, and elsewhere in the region; Eastern Pacific: off central and southern California, USA, Southeastern Pacific Ocean, seamounts of the Nazca Ridge (Parin et al., 1988; Eschmeyer, 2015).

Habitat: Benthopelagic (Parin et al., 1988; Froese & Pauly, 2015)

Depth: 30-800 m (usually 50-600 m) (Parin et al., 1988; Froese & Pauly, 2015)

IUCN information (Red List 2013):
- Classification: NE
- Population trend: Unknown
- Biological parameters: Scarcely known (Table 1) (Froese & Pauly, 2015).

**Figure 9.** Zeidae: *Zenopsis nebulosa* (Taken from Bray, 2011).

**Zenopsis conchifer** (Lowe, 1852) (Fig. 10)


Distribution: Cosmopolitan (Heemstra, 1980); Southwestern Pacific Chile: Juan Fernández Archipelago (Pequeño & Matallanas, 2004).

Habitat: Benthopelagic (Froese & Pauly, 2015)

Depth: 50-600 (usually 150-300 m) (Froese & Pauly, 2015)

IUCN information (Red List 2013):
- Classification: NE
- Population trend: Unknown
- Biological parameters: Scarcely known (Table 1) (Froese & Pauly, 2015).

**Figure 10.** Zeidae: *Zenopsis conchifer* (Modified from de Silvestre & Schwingel, 2012).

**Zenopsis oblonga** Parin, 1989 (Fig. 11)


Distribution: Eastern Pacific, seamounts of the Nazca and Salas y Gómez submarine ridges (Parin, 1989; Eschmeyer, 2015).

Habitat: Benthopelagic (Parin, 1989; Froese & Pauly, 2015)

Depth: 210 m (Parin, 1989; Froese & Pauly, 2016)

IUCN information (Red List 2013):
- Classification: NE
- Population trend: Unknown
- Biological parameters: Scarcely known (Table 1) (Froese & Pauly, 2015).

**Figure 11.** Zeidae: *Zenopsis oblonga* (Modified from Parin, 1989).
Zeiformes from Chile

Tentative identification key for the Zeiformes fishes from Chile

The term "tentative" is applied in this key due to the limited information of these taxa (juvenile or adult, male or female), to carry out an accurate diagnosis.

1a. Preorbitary distance greater than the eye diameter. Dorsal fin with 7 to 11 spines. Pelvic spine present or absent and 5 to 10 soft rays. Presence of dorsal and ventral bony bony bucklers ………ZEIDEA (2)

2a. With 2-5 dorsal bony bucklers and 1-9 ventral bony bucklers; dorsal fin with 10 spines ………Zenopsis conchifer.

2b. With 5-9 dorsal bony bucklers and 2-12 ventral bony bucklers; dorsal fin with 8 spines ………(3)

3a. With 5-7 dorsal bony bucklers and 5-12 ventral bony bucklers ………Zenopsis nebulousa.

3b. With 6-9 dorsal bony bucklers and 2-11 ventral bucklers ………Zenopsis oblonga.

1b. Preorbitary distance shorter than the ocular diameter. The base of dorsal and anal fins without bony shields…………………………………………………………………………………(4)

4a. Preorbitary distance subequal to ocular diameter. Dorsal fin with 7 spines. Spiny keel of preanal shields. Pelvic fins large, contained 2 times in the standard length. PARAZENIDA. Monotypic family ………

4b. Preorbitary distance shorter than the ocular diameter……………………………………(5)


5b. Mouth large or moderate. Upper jaw length subequal or 2 times smaller than the eye diameter. Scales little or absent. Caudal fin with 11 rays ……………………………………..(6)

6a. Height of the body, subequal to cephalic length. Dorsal fin with 5 to 10 spines. Anal fin with one spine weak or absent. Pelvic fins with one serrate spine and 6 soft rays……………………….ZENIONIDAE (7)

7a. Eye contained two times in head. Mouth terminal; hight body; dorsal fin with 8 spines ………Cyttomimus stelgis.

7b. Eye contained more than two times in head. Mouth supera, dorsal fin with 5 to 7 spines …………………(8)


8b. Anal fin with 1 spine and 23-24 rays. First spine of dorsal fin larger than to second spine silver colored body leaden; top of the spines blackish………Zenion japonicum.

6b. Body height, greater than cephalic length. Dorsal fin with 4 to 8 spines. Anal fin with 1 to 4 spines. Pelvic fins with 1 spine and 5 to 7 rays …OREOSOMATIDAE (9)

9a. Body profile oval, with dark spots in juveniles specimens. First dorsal fin with six spines ………………………….Pseudocyttus maculatus.

9b. Body profile rhomboidal, without spots. First dorsal fin with 8-9 spines ……………………..(10)

10a. Caudal peduncle, thin and long. Pectoral fin with 19-21 rays. Maxilar edge reach the anterior eye edge. Rostrum without scales between the lacrimal and supraorbital crest…………….Neocyttus psilorrhyncus.


DISCUSSION

The fishes of the Order Zeiformes fishes contains six families and 322 species. They are widespread in all oceans, in the southeastern Pacific and Atlantic Ocean, and the species live near the bottom at 2 to more than 1000 m. The most species live on the continental slope often around the seamounts (Heemstra, 1980; Pequeño et al., 1992; Nelson, 2006).

In Chile, this order is represented by five families: Oreosomatidae, Parazenidae, Zenionidae, Grammicoledipidae and Zeidae. The family Oreosomatidae is known primarily from off South Africa and southern Australia (Nelson, 2006). Most of the species of Oreoso-
matidae are found in the southeastern Pacific, inhabiting continental slopes down to about 1000 m deep. However, there are records of the catch of a *Neocyttus rhomboidalis* in southern Chile (Canal Barbara), which would mean an extension of its distribution in the Pacific Ocean (Pequeño *et al.*, 1992).

The second, Parezenidae, is a monotypic family. This taxon is distributed in the Atlantic and Pacific oceans. In Chile, it is found in the Salas y Gomez submarine ridge (Parin *et al.*, 1997; Eschmeyer 2015).

Another family of Zeiformes, is Zenionidae. This family is found primarily off southern Africa and tropical western Pacific. In Chile, three species are found in the Salas y Gomez submarine ridge (Parin, 1989; Parin *et al.*, 1997; Pequeño & Matallanas, 2004; Eschmeyer, 2015).

The monotypic family Grammicolepidae, is found in Eastern Atlantic, Western Atlantic, north Pacific and Hawaii. In the Atlantic is found in Brazil. In South Pacific is found in Chile (San Felix Island) (Pequeño & Matallanas, 2004; Eschmeyer 2015).

The last family Zeidae inhabits in the Atlantic and South Pacific Ocean of Perú and Chile, Salas y Gomez submarine ridges (Tyler *et al.*, 2003; Eschmeyer, 2015).

Another relevant aspect of the Order Zeiformes in Chile is its taxonomy that differs from that presented by Pequeño (1989, 1997). The six species considered in the literature have increased to 11, due to new captures (Parin *et al.*, 1997; Yearsley & Last, 1998; Pequeño & Matallanas, 2004). The exclusion of the family Caproidae from the Zeiformes, and its incorporation in Perciformes, based on the proposals by Tyler *et al.* (2003), is another relevant change in these taxa (Nelson, 2006; Nolf & Tyler, 2006; Eschmeyer, 2015).

The best known family is Oreosomatidae, with three species (Karrer, 1986; Lloris, 1986; James *et al.*, 1988; Parin *et al.*, 1997; Meléndez *et al.*, 2001). A fourth species *Allocyctus verrucosus* (Gilchrist, 1906) is uncertain, being presumably present in Chilean waters (SPRFMO, 2007). However, no evidence supporting the latter is available. This family has been enriched with a third species, *Neocyttus psilorhynchus*, that is found in the southwest and southeastern Pacific (Yearsley & Last, 1998).

Species of the family Zeidae have increased their nominal number, with two new species: *Zenopsis conchifer* captured in the seamounts of Juan Fernandez Archipelago and *Z. oblonga* captured in seamounts of Nazca and Salas y Gomez (Parin, 1989; Parin *et al.*, 1997; Pequeño & Matallanas, 2004; Santini *et al.*, 2006; Martins & Schwingel, 2012).

Another family that adds to the order Zeiformes is Grammicolepididae with *Grammicolepis brachiusculus* Poey, 1873 captured at the west of Desventuradas Islands (Pequeño & Matallanas, 2004).

The synonyms used in some species may be confused. This is the case of *Zenion hololepis* with *Zenion japonicum*. Both were considered as synonymous for a long time, but now they are accepted as independent species (Pequeño & Matallanas, 2004; Eschmeyer, 2015).

Another relevant taxonomic change is *Stethopristes eos* Gilbert, 1905, previously included in the family Zeidae (Pequeño, 1989; Parin *et al.*, 1997). This taxon is included as part of the family Parazenidae (Tyler *et al.*, 2003; Eschmeyer, 2015).

The last species included in the family Parazenidae, Zenionidae and Zeidae, remain all as slightly studied taxa, without new reports of captures in Chilean waters. Consequently, the biological information of these taxa is scarce and incomplete.

The species of the family Oreosomatidae (as well as the other members of zeiform families), have been partially known and studied. For their nominal species *Neocyttus rhomboidalis, Pseudocyttus maculatus* biological information has been recorded, while for the third species *Neocyttus psilorhynchus* only the maximum length is currently known. 90% of the species are not evaluated, 9.1% are classified as Data Deficient (DD), with a decreasing population or unknown trend (Red List, 2014). The present lack of information could be covering up a potential vulnerability of these species. For instance, seamounts are unique ecosystems, but is little known about them. They are extremely fragile to disturbance caused by fishing, so they have been classified as Vulnerable Marine Ecosystems (SUBPESCA, 2015). To protect these ecosystems and to propose protective actions to be taken, it is necessary to know its ichthyofauna.

In general, fishes of the order Zeiformes in Chile have been poorly studied. For this reason, it is not enough to have new records of capture, but more biological studies (maximum age, size of maturity, maximum size, fertility rate) and new explorations to seamounts, are necessary also to know the current and actual state of this group of fishes in Chilean waters.

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