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## Introduction to the systematics and biodiversity of sharks, rays, and chimaeras (Chondrichthyes) of Taiwan

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### Abstract

All 13 orders of chondrichthyan fishes occur in Taiwanese waters, representing 52 chondrichthyan families (31 shark, 19 batoid, 2 chimaeroid) and 98 genera (64 shark, 31 batoid, 3 chimaeroid). A total of 119 shark, 58 batoid, and 4 chimaera species may occur in the waters surrounding Taiwan, pending taxonomic resolution of some groups. Of the 34 nominally described species from Taiwan, 17 are currently considered valid. The majority of named species occurred during two peak periods in Taiwanese chondrichthyan research; the first between 1959–63, when 13 nominal species were described, of which 7 remain valid today, and a second peak period between 2003–13 when 9 nominal species were described, of which 6 remain valid. The overall species diversity of Taiwan's chondrichthyan fauna is comparable to that of other adjacent marine zoogeographic hotspots, e.g. Japan (126 shark, 75 batoid, 11 chimaeroid species) and the Philippines (81 shark, 46 batoid, 2 chimaeroid species). The Carcharhiniformes, Squaliformes, Myliobatiformes, and Rajiformes are the most dominant orders in terms of abundance and species-richness within this region. Each of these groups may increase in relative diversity with improved taxonomic resolution resulting from the incorporation of molecular tools and renewed morphological studies. Improved identification of Taiwan's chondrichthyan fauna will aid in developing better conservation and management practices.

**Key words:** Biodiversity, Sharks, Batoids, Chimaeras, Taiwan

### Introduction

Taiwan has one of the five richest and most diverse chondrichthyan faunas in the world with at least 181 known species (Ebert *et al.*, this volume), ranking behind Australia, southern Africa, and Japan, and close to the western Central Atlantic (e.g. Gulf of Mexico and Caribbean), each with approximately 322, 220, 212 and 188 species, respectively (Last & Stevens, 2009; Ebert, 2013; Nakabo, 2013; Compagno, 2002; Didier, 2002; McEachran & Carvalho, 2002). These other regions, however, encompass a much greater geographic dimension than the seas surrounding Taiwan; for its geographic area no other comparable region has a chondrichthyan fauna as diverse. All 13 chondrichthyan orders are found in Taiwanese seas, representing 52 families and 98 genera, numbers that compare favorably to the 57 families and 201 genera worldwide (Table 1). The sharks are well represented as 31 (91.2%) of 34 families and 64 (59.8%) of 107 genera are found in Taiwanese waters. The batoids are also well represented with 19 (82.6%) of 23 families and 31 (35.3%) of 88 genera occurring there. Two of the three

chimaeroid families and three of the six chimaeroid genera have been reported from Taiwan. The total number of chondrichthyan species occurring in Taiwanese waters represents about 15% of all known species, with 119 sharks, 58 batoids, and at least four chimaera species (Ebert *et al.*, this volume).

**TABLE 1.** Biodiversity of Taiwan chondrichthyans by order, family, genera, and species. Global numbers in parenthesis as of December 2013 from database maintained by authors.

Order	Family	Taiwan Chondrichthyes	
		Number Genera	Number Species
Sharks			
Hexanchiformes	Chlamydoselachidae	1 (1)	1 (2)
	Hexanchidae	3 (3)	4 (4)
Squaliformes	Echinorhinidae	1 (1)	1 (2)
	Squalidae	2 (2)	6 (29)
	Centrophoridae	2 (2)	8 (14)
	Etmopteridae	3 (4)	8 (45)
	Somniosidae	2 (7)	3 (17)
	Oxynotidae	0 (1)	0 (5)
	Dalatiidae	3 (7)	3 (9)
Pristiophoriformes	Pristiophoridae	1 (2)	1 (8)
Squatiniiformes	Squatinae	1 (1)	4 (20)
Heterodontiformes	Heterodontidae	1 (1)	2 (9)
Orectolobiformes	Parascyllidae	1 (2)	1 (9)
	Brachaeluridae	0 (1)	0 (2)
	Orectolobidae	1 (3)	2 (12)
	Hemiscyllidae	1 (2)	2 (20)
	Ginglymostomatidae	1 (3)	1 (3)
	Stegostomatidae	1 (1)	1 (1)
	Rhincodontidae	1 (1)	1 (1)
Lamniformes	Mitsukurinidae	1 (1)	1 (1)
	Odontaspidae	2 (2)	2 (3)
	Pseudocarchariidae	1 (1)	1 (1)
	Megachasmidae	1 (1)	1 (1)
	Alopiidae	1 (1)	3 (3)
	Cetorhinidae	1 (1)	1 (1)
	Lamnidae	3 (3)	4 (5)
Carcharhiniiformes	Scyliorhinidae	7 (17)	17 (149)

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TABLE 1. (Continued)

Order	Family	Taiwan Chondrichthyes	
		Number Genera	Number Species
	Proscyllidae	2 (3)	2 (6)
	Pseudotriakidae	1 (3)	1 (4)
	Leptochariidae	0 (1)	0 (1)
	Triakidae	4 (9)	6 (49)
	Hemigaleidae	4 (4)	5 (8)
	Carcharhinidae	8 (12)	22 (57)
	Sphyrnidae	2 (2)	4 (9)
Batoids			
Torpediniformes	Narcinidae	2 (4)	3 (32)
	Narkidae	1 (6)	1 (12)
	Hypnidae	0 (1)	0 (1)
	Torpedinidae	1 (2)	2 (24)
Pristiformes	Pristidae	1 (2)	1 (5)
Rajiformes	Rhinidae	1 (1)	1 (1)
	Rhynchobatidae	1 (1)	4 (7)
	Rhinobatidae	2 (7)	4 (48)
	Arhynchobatidae	2 (13)	2 (102)
	Rajidae	2 (18)	10 (166)
	Anacanthobatidae	1 (3)	2 (21)
Myliobatiformes	Platyrhinidae	1 (2)	1 (4)
	Zanobatidae	0 (1)	0 (2)
	Plesiobatidae	1 (1)	1 (1)
	Hexatrygonidae	1 (1)	1 (1)
	Urolophidae	1 (2)	1 (28)
	Urotrygonidae	0 (2)	0 (16)
	Potamotrygonidae	0 (4)	0 (25)
	Dasyatidae	6 (9)	11 (92)
	Gymnuridae	1 (1)	2 (13)
	Myliobatidae	3 (4)	5 (22)
	Rhinopteridae	1 (1)	1 (11)
	Mobulidae	2 (2)	5 (11)
Chimaeras			
Chimaeriformes	Callorhynchidae	0 (1)	0 (3)
	Chimaeridae	2 (2)	2 (36)
	Rhinochimaeridae	1 (3)	2 (8)

The high diversity of chondrichthyans in Taiwanese waters is likely due to the complexity of habitats and ocean currents that surround the island, which can be subdivided into five potentially distinct regions (Figure 1): the relatively shallow waters of the (1) Taiwan Strait to the west and (2) East China Sea to the north, the deeper waters to the south comprising the (3) South China Sea and to the east (4) the Philippine Sea, and the slightly more distant (5) Ryukyu Island chain to the northeast. All regions theoretically contribute to the diversity, novelty and level of endemism of Taiwan's chondrichthyan fauna. In addition, two ocean current flow patterns, the warm Kuroshio Current flowing from south to north along the Taiwanese east coast (Tang *et al.*, 2000) and the predominantly warm waters flowing north through the Taiwan Strait (Liang *et al.*, 2003), also exert a strong influence on the marine biodiversity of this region (e.g. Nakabo *et al.*, 2001).



**FIGURE 1.** Map of Taiwan showing principal collection localities. A: Keelung. B: Au-di. C: Fu-gui-jiao. D: Da-xi. E: Su-ao. F: Nan-fang-ao. G: Hualien. H: Chang-bin. I: Cheng-gong. J: Fu-gang. K: Da-wu. L: O-luan-bi. M: Hsiao-liu-chiu. N: Fong-gang. O: Dong-gang. P: Kaohsiung. Q: Ke-tzu-liao. R: Tainan. S: Budai. T: Dong-shi. U: Ma-gong (Penghu). V: Wu-chi (Taichong). Refer to Table 5 for details.

### Historical perspective

The first chondrichthyan species reported from Taiwan were by Günther (1870) based on a collection of fish specimens by Robert Swinhoe (Ho & Shao, 2011), and included four sharks (*Chiloscyllium indicum*, *Stegostoma fasciatum*, *Halaelurus buergeri*, and *Sphyrna zygaena*) and one batoid (*Rhinobatos schlegelii*) species. Jordan & Evermann (1902) reported on a collection of fishes from Taiwan (as Formosa) that included six shark and two batoid species. However, it was not until Hilgendorf (1904) that the first new chondrichthyan species (*Proscyllium habereri*) was described from Taiwanese waters. Jordan & Richardson (1909) increased the number of species known from Taiwan to 14, and included descriptions of two new species, *Galeus sauteri* and *Okamejei hollandi*. Norman (1926) described the next new species, *Rhinobatos formosensis*, followed by Nakamura (1935) who described two new thresher sharks, *Alopias pelagicus* and *Alopias profundus* [= *A. superciliosus* (Lowe, 1841)]. Nakamura (1934, 1936) reported on the sharks occurring in the waters around Taiwan, including 37 species. Okada (1938) and Fowler (1941) reported 16 and 15 species, respectively, from Taiwan. Chen (1948) recorded eight species and described the next new species, *Dasyatis micropthalmus*. The number of chondrichthyan species recorded from Taiwan subsequently rose to 67 (Chen, 1951, 1954, 1956), but it was not until a series of papers by

H.-T. Teng (1958–1959a-f), followed by his seminal work “*Classification and distribution of the chondrichthyans of Taiwan*” (Teng, 1962), that the first detailed revision on these fishes was published. Teng’s (1962) seminal monograph included 110 species of chondrichthyans (67 sharks, 42 batoids, and one chimaera species). Overall, Teng’s publications described 11 new species. The following year J.T.-F. Chen (1963) published his monograph on the sharks of Taiwan that included 70 species, two of which were described as new. Chen & Chung (1971) published a monograph on the batoids of Taiwan, recording 54 species. Since the early 1970s there have been several books and monographs on the fishes of Taiwan and most of these have included checklists on the chondrichthyans, but few have provided the comprehensive details of these earlier publications. Most notable among the various publications over the past 40 years has been Chen & Joung (1993) who reported 146 chondrichthyans (90 sharks, 55 batoids, and one chimaera), and Shen & Wu (2011) who reported on a similar number of species at 148 (97 sharks, 47 batoids, and four chimaeras). These latter two monographs were part of much larger volumes on the fishes of Taiwan.

The annotated checklist included in this Special Issue (Ebert *et al.*, this volume) increases the number of chondrichthyan species known to occur in Taiwanese waters to 181 (119 sharks, 58 batoids, and four chimaeras), and is the result of an international workshop held in the National Museum of Marine Biology and Aquarium in Checheng, Taiwan, in March 2012. The workshop's purpose was to describe and detail the rich diversity of the Taiwanese chondrichthyan fauna, providing a state-of-the-art perspective and complementing ongoing revisionary studies being undertaken by various specialists. An abbreviated chronology of chondrichthyan species added to the Taiwanese fauna is provided in Table 2; the references include only major or significant works and exclude shorter papers that first report a species occurrence (see Ebert *et al.*, this volume, for further details and synonymies).

**TABLE 2.** An abbreviated chronology of chondrichthyans added to the Taiwanese fauna from 1870 to 2013. References cited are only major or significant works and does not include shorter contributions reporting first occurrence of species (see Ebert *et al.*, this volume, for details and synonymies).

Family	Species	Günther (1870)	Jordan & Evermann (1902)	Hilgendorf (1904)	Jordan & Richardson (1909)	Norman (1926)	Nakamura (1936)	Chen (1948)	Teng (1958-1959a-f)	Teng (1962)	Chen (1963)	Chen & Chung (1971)	Chen & Joung <i>in</i> Shen <i>et al.</i> (1993)	Shen & Wu (2011)	Ebert <i>et al.</i> 2013, this volume
CHLAMYDOSELACHIDAE	<i>Chlamydoselachus anguineus</i> Garman, 1884														X
HEXANCHIDAE	<i>Hepranchias perlo</i> (Bonnaterre, 1788)								X						
	<i>Hexanchus griseus</i> (Bonnaterre, 1788)						X								
	<i>Hexanchus nakamurai</i> Teng, 1962										X				
	<i>Notorynchus cepedianus</i> (Péron, 1807)								X						
ECHINORHINIDAE	<i>Echinorhinus cookei</i> Pietschmann, 1928							X							
SQUALIDAE	<i>Cirrhigaleus barbifer</i> Tanaka, 1912														X
	<i>Squalus brevirostris</i> Tanaka, 1917							X							
	<i>Squalus formosus</i> White & Iglesias, 2011														X
	<i>Squalus japonicus</i> Ishikawa, 1908										X				
	<i>Squalus montalbani</i> Whitley, 1931		X												
	<i>Squalus suckleyi</i> (Girard, 1855)										X				
CENTROPHORIDAE	<i>Centrophorus atromarginatus</i> Garman, 1913										X				
	<i>Centrophorus granulosus</i> (Bloch & Schneider, 1801)														X
	<i>Centrophorus isodon</i> (Chu, Meng & Liu, 1981)														X

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TABLE 2 (continued)

Family	Species	Günther (1870)	Jordan & Evermann (1902)	Hilgendorf (1904)	Jordan & Richardson (1909)	Norman (1926)	Nakamura (1936)	Chen (1948)	Teng (1958-1959a-f)	Teng (1962)	Chen (1963)	Chen & Chung (1971)	Chen & Joung in Shen <i>et al.</i> (1993)	Shen & Wu (2011)	Ebert <i>et al.</i> 2013, this volume
	<i>Centrophorus cf. lusitanicus</i>								X						
	<i>Centrophorus moluccensis</i> Bleeker, 1860												X		
	<i>Centrophorus squamosus</i> (Bonnaterre, 1788)														X
	<i>Deania cf. calcea</i>									X					
	<i>Deania cf. profundorum</i>								X						
ETMOPTERIDAE	<i>Centrosyllium kamoharai</i> Abe, 1966													X	
	<i>Etmopterus brachyurus</i> Smith & Radcliffe, 1912								X						
	<i>Etmopterus burgessi</i> Schaaaf-Da Silva & Ebert, 2006												X		
	<i>Etmopterus jounqi</i> Knuckey, Ebert & Burgess, 2011												X		
	<i>Etmopterus cf. molleri</i>								X						
	<i>Etmopterus sheikoi</i> (Dolganov, 1986)														X
	<i>Etmopterus splendidus</i> Yano, 1988												X		
	<i>Trigonognathus kabeyai</i> Mochizuki & Ohe, 1990														X
SOMNIOSIDAE	<i>Somniosus pacificus</i> Bigelow & Schroeder, 1944														X
	<i>Zameus ichiharai</i> (Yano & Tanaka, 1984)														X
	<i>Zameus squamulosus</i> (Günther, 1877)														X
DALATIIDAE	<i>Dalatias licha</i> (Bonnaterre, 1788)								X						
	<i>Isistius brasiliensis</i> (Quoy & Gaimard, 1824)												X		
	<i>Squaliohus aliae</i> Teng, 1959								X						
PRISTIOPHORIDAE	<i>Pristiophorus japonicus</i> Günther, 1870						X								
SQUATINIDAE	<i>Squatina formosa</i> Shen & Ting, 1972													X	
	<i>Squatina japonica</i> Bleeker, 1858										X				
	<i>Squatina nebulosa</i> Regan, 1906								X						
	<i>Squatina tergocellatoides</i> Chen, 1963										X				
HETERODONTIDAE	<i>Heterodontus japonicus</i> Macleay and Macleay, 1884							X							
	<i>Heterodontus zebra</i> (Gray, 1831)						X								
PARASCYLLIIDAE	<i>Cirrhoscyllium formosanum</i> Teng, 1959							X							
ORECTOLOBIDAE	<i>Orectolobus japonicus</i> Regan, 1906													X	
	<i>Orectolobus leptolineatus</i> Last, Pogonoski & White, 2010													X	
HEMISCYLLIIDAE	<i>Chiloscyllium plagiosum</i> (Anonymous [Bennett], 1830)	X													
	<i>Chiloscyllium punctatum</i> Müller & Henle, 1838														
GINGLYMOSTOMATIDAE	<i>Nebrius ferrugineus</i> (Lesson, 1831)								X						
STEGOSTOMATIDAE	<i>Stegostoma fasciatum</i> (Hermann, 1783)	X													
RHINCODONTIDAE	<i>Rhincodon typus</i> Smith, 1828								X						

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TABLE 2 (continued)

Family	Species	Günther (1870)	Jordan & Evermann (1902)	Hilgendorf (1904)	Jordan & Richardson (1909)	Norman (1926)	Nakamura (1936)	Chen (1948)	Teng (1958-1959a-f)	Teng (1962)	Chen (1963)	Chen & Chung (1971)	Chen & Joung in Shen <i>et al.</i> (1993)	Shen & Wu (2011)	Ebert <i>et al.</i> 2013, this volume
MITSUKURINIDAE	<i>Mitsukurina owstoni</i> Jordan, 1898														X
ODONTASPIDIDAE	<i>Carcharias taurus</i> Rafinesque, 1810								X						
	<i>Odontaspis ferox</i> (Risso, 1810)														X
PSEUDOCARCHARIIDAE	<i>Pseudocarcharias kamoharai</i> (Matsubara, 1936)								X						
MEGACHASMIDAE	<i>Megachasma pelagios</i> Taylor, Compagno & Struhsaker, 1983														X
ALOPIIDAE	<i>Alopias pelagicus</i> Nakamura, 1935						X								
	<i>Alopias superciliosus</i> (Lowe, 1841)						X								
	<i>Alopias vulpinus</i> (Bonnaterra, 1788)							X							
CETORHINIDAE	<i>Cetorhinus maximus</i> (Gunnerus, 1765)								X						
LAMNIDAE	<i>Carcharodon carcharias</i> (Linnaeus, 1758)								X						
	<i>Isurus oxyrinchus</i> Rafinesque, 1810						X								
	<i>Isurus paucus</i> Guitart, 1966													X	
	<i>Lamna ditropis</i> Hubbs & Follett, 1947														X
SCYLIORHINIDAE	<i>Apristurus gibbosus</i> Meng, Chu & Li, 1985														X
	<i>Apristurus herklotsi</i> (Fowler, 1934)														X
	<i>Apristurus longicephalus</i> Nakaya, 1975														X
	<i>Apristurus macrostomus</i> Meng, Chu & Li, 1985										X				
	<i>Apristurus platyrhynchus</i> Tanaka, 1909														X
	<i>Atelomycterus marmoratus</i> (Anonymous [Bennett], 1830)								X						
	<i>Cephaloscyllium fasciatum</i> Chan, 1966														X
	<i>Cephaloscyllium formosanum</i> Teng, 1962									X					
	<i>Cephaloscyllium sarawakensis</i> Yano, Ahmad & Gambang, 2005									X					
	<i>Cephaloscyllium umbratile</i> Jordan & Fowler, 1903													X	
	<i>Galeus eastmani</i> (Jordan & Snyder, 1904)													X	
	<i>Galeus nipponensis</i> Nakaya, 1975														X
	<i>Galeus sauteri</i> (Jordan & Richardson, 1909)					X									
	<i>Halaehurus buergeri</i> (Müller & Henle, 1838)	X													
	<i>Parmaturus melanobranchus</i> (Chan, 1966)														X
	<i>Parmaturus pilosus</i> Garman, 1906														X
	<i>Scyliorhinus tokubee</i> Shirai, Hagiwara & Nakaya, 1992														X
PSEUDOTRIAKIDAE	<i>Pseudotriakis microdon</i> de Brito Capello, 1868								X						
PROSCYLLIDAE	<i>Eridacnis radcliffei</i> Smith, 1913													X	
	<i>Proscyllium habereri</i> Hilgendorf, 1904				X										
TRIAKIDAE	<i>Hemitriakis complicofasciata</i> Takahashi & Nakaya, 2004														X

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TABLE 2 (continued)

Family	Species	Günther (1870)	Jordan & Evermann (1902)	Hilgendorf (1904)	Jordan & Richardson (1909)	Norman (1926)	Nakamura (1936)	Chen (1948)	Teng (1958-1959a-f)	Teng (1962)	Chen (1963)	Chen & Chung (1971)	Chen & Joung in Shen <i>et al.</i> (1993)	Shen & Wu (2011)	Ebert <i>et al.</i> 2013, this volume
	<i>Hemitriakis japonica</i> (Müller & Henle, 1839)	X													
	<i>Hypogaleus hyugaensis</i> (Miyosi, 1939)									X					
	<i>Mustelus griseus</i> Pietschmann, 1908						X								
	<i>Mustelus manazo</i> Bleeker, 1854						X								
	<i>Triakis scyllium</i> Müller & Henle, 1839	X													
HEMIGALEIDAE	<i>Chaenogaleus macrostoma</i> (Bleeker, 1852)						X								
	<i>Hemigaleus microstoma</i> Bleeker, 1852							X							
	<i>Hemipristis elongata</i> (Klunzinger, 1871)														X
	<i>Paragaleus randalli</i> Compagno, Krupp & Carpenter, 1996														X
	<i>Paragaleus tengi</i> (Chen, 1963)										X				
CARCHARHINIDAE	<i>Carcharhinus albimarginatus</i> (Rüppell, 1837)						X								
	<i>Carcharhinus altimus</i> (Springer, 1950)														X
	<i>Carcharhinus amblyrhynchos</i> (Bleeker, 1856)														X
	<i>Carcharhinus brachyurus</i> (Günther, 1870)														X
	<i>Carcharhinus brevipinna</i> (Müller & Henle, 1839)														X
	<i>Carcharhinus falciformis</i> (Müller & Henle, 1839)						X								
	<i>Carcharhinus leucas</i> (Müller & Henle, 1839)														X
	<i>Carcharhinus limbatus</i> (Müller & Henle, 1839)							X							
	<i>Carcharhinus longimanus</i> (Poey, 1861)						X								
	<i>Carcharhinus macloiti</i> (Müller & Henle, 1839)						X								
	<i>Carcharhinus melanopterus</i> (Quoy & Gaimard, 1824)									X					
	<i>Carcharhinus obscurus</i> (Lesueur, 1818)														X
	<i>Carcharhinus plumbeus</i> (Nardo, 1827)						X								
	<i>Carcharhinus sorrah</i> (Müller & Henle, 1839)						X								
	<i>Carcharhinus tjujot</i> (Bleeker, 1852)						X								
	<i>Galeocerdo cuvier</i> (Péron & Lesueur, 1822)						X								
	<i>Loxodon macrorhinus</i> Müller & Henle, 1839														X
	<i>Negaprion acutidens</i> (Rüppell, 1837)														X
	<i>Prionace glauca</i> (Linnaeus, 1758)						X								
	<i>Rhizoprionodon acutus</i> (Rüppell, 1837)	X													
	<i>Scoliodon macrorhynchos</i> (Bleeker, 1852)	X													
	<i>Triacnodon obesus</i> (Rüppell, 1837)								X						
SPHYRNIDAE	<i>Eusphyrna blochii</i> (Cuvier, 1816)														X
	<i>Sphyrna lewini</i> (Griffith & Smith, 1834)								X						

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TABLE 2 (continued)

Family	Species	Günther (1870)	Jordan & Evermann (1902)	Hilgendorf (1904)	Jordan & Richardson (1909)	Norman (1926)	Nakamura (1936)	Chen (1948)	Teng (1958-1959a-f)	Teng (1962)	Chen (1963)	Chen & Chung (1971)	Chen & Joung in Shen <i>et al.</i> (1993)	Shen & Wu (2011)	Ebert <i>et al.</i> 2013, this volume
	<i>Sphyrna mokarran</i> (Rüppell, 1837)								X						
	<i>Sphyrna zygaena</i> (Linnaeus, 1758)	X													
TORPEDINIDAE	<i>Torpedo formosa</i> Haas & Ebert, 2006												X		
	<i>Torpedo tokionis</i> (Tanaka, 1908)													X	
NARCINIDAE	<i>Benthobatis yangi</i> Carvalho, Compagno & Ebert, 2003												X		
	<i>Narcine brevilabiata</i> Bessednov, 1966									X					
	<i>Narcine lingula</i> Richardson, 1846									X					
NARKIDAE	<i>Narke japonica</i> (Temminck & Schlegel, 1850)									X					
PRISTIDAE	<i>Anoxypristis cuspidata</i> (Latham, 1794)						X								
RHINIDAE	<i>Rhina ancylostoma</i> Bloch & Schneider, 1801						X								
RHYNCHOBATIDAE	<i>Rhynchobatus australiae</i> Whitley, 1939														X
	<i>Rhynchobatus palpebratus</i> Compagno & Last, 2008												X		
	<i>Rhynchobatus springeri</i> Compagno & Last, 2010														X
	<i>Rhynchobatus immaculatus</i> Last, Ho & Chen, this volume														X
RHINOBATIDAE	<i>Glaucostegus granulatus</i> (Cuvier, 1829)													X	
	<i>Rhinobatos formosensis</i> Norman, 1926					X									
	<i>Rhinobatos hynnicephalus</i> Richardson, 1846						X								
	<i>Rhinobatos schlegelii</i> Müller & Henle, 1841	X													
PLATYRHINIDAE	<i>Platyrrhina tangi</i> Iwatsuki, Zhang & Nakaya, 2011									X					
ARHYNCHOBATIDAE	<i>Bathyraja trachouros</i> (Ishiyama, 1958)														X
	<i>Notoraja tobitukai</i> (Hiyama, 1940)														X
RAJIDAE	<i>Dipturus gigas</i> (Ishiyama, 1958)														X
	<i>Dipturus kwangtungensis</i> (Chu, 1960)								X						
	<i>Dipturus macrocauda</i> (Ishiyama, 1955)												X		
	<i>Dipturus tengu</i> (Jordan & Fowler, 1903)											X			
	<i>Dipturus wuhanlingi</i> Jeong & Nakabo, 2008														X
	<i>Okamejei acutispina</i> (Ishiyama, 1958)											X			
	<i>Okamejei boesemani</i> (Ishihara, 1987)											X			
	<i>Okamejei hollandi</i> (Jordan & Richardson, 1909)				X										
	<i>Okamejei kenojei</i> (Müller & Henle, 1841)							X							
	<i>Okamejei meerdervoortii</i> (Bleeker, 1860)											X			
ANACANTHOBATIDAE	<i>Sinobatis borneensis</i> (Chan, 1965)												X		
	<i>Sinobatis melanosoma</i> (Chan, 1965)											X			
PLESIOBATIDAE	<i>Plesiobatis daviesi</i> (Wallace, 1967)											X			

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TABLE 2 (continued)

Family	Species	Günther (1870)	Jordan & Evermann (1902)	Hilgendorf (1904)	Jordan & Richardson (1909)	Norman (1926)	Nakamura (1936)	Chen (1948)	Teng (1958-1959a-f)	Teng (1962)	Chen (1963)	Chen & Chung (1971)	Chen & Joung in Shen <i>et al.</i> (1993)	Shen & Wu (2011)	Ebert <i>et al.</i> 2013, this volume
HEXATRYGONIDAE	<i>Hexatrygon bickelli</i> Heemstra & Smith, 1980												X		
UROLOPHIDAE	<i>Urolophus aurantiacus</i> Müller & Henle, 1841												X		
DASYATIDAE	<i>Dasyatis cf. akajei</i> (Müller & Henle, 1841)	X													
	? <i>Dasyatis microphthalmus</i> Chen, 1948						X								
	<i>Dasyatis ushieii</i> Jordan & Hubbs, 1925								X						
	<i>Dasyatis zugei</i> (Müller & Henle, 1841)														
	<i>Himantura gerrardi</i> (Gray, 1851)								X						
	<i>Himantura leoparda</i> Manjaji-Matsumoto & Last, 2008											X			
	<i>Himantura uarnak</i> (Gmelin, 1789)													X	
	<i>Neotrygon kuhlii</i> (Müller & Henle, 1841)											X			
	<i>Taeniura lymma</i> (Forsskål, 1775)						X								
	<i>Taeniurops meyeri</i> (Müller & Henle, 1841)													X	
	<i>Urogymnus asperrimus</i> (Bloch & Schneider, 1801)								X						
GYMNURIDAE	<i>Gymnura japonica</i> (Temminck & Schlegel, 1850)											X			
	<i>Gymnura zonura</i> (Bleeker, 1852)											X			
MYLIOBATIDAE	<i>Aetobatus ocellatus</i> (Kuhl, 1823)											X			
	<i>Aetomylaeus maculatus</i> (Gray, 1832)											X			
	<i>Aetomylaeus nichofii</i> (Bloch & Schneider, 1801)											X			
	<i>Aetomylaeus vespertilio</i> (Bleeker, 1852)								X						
	<i>Myliobatis tobijei</i> Bleeker, 1854						X								
RHINOPTERIDAE	<i>Rhinoptera javanica</i> (Müller & Henle, 1841)											X			
MOBULIDAE	<i>Manta alfredi</i> (Anonymous [Kreff], 1868)													X	
	<i>Manta birostris</i> (Walbaum 1792)											X			
	<i>Mobula japonica</i> (Muller & Henle, 1841)						X								
	<i>Mobula tarapacana</i> (Philippi, 1892)								X						
	<i>Mobula thurstoni</i> (Lloyd, 1908)													X	
CHIMAERIDAE	<i>Chimaera phantasma</i> Jordan & Snyder, 1900											X			
	<i>Hydrolagus mitsukurii</i> (Dean, 1904)												X		
RHINOCHIMAERIDAE	<i>Rhinochimaera africana</i> Compagno, Stehmann & Ebert, 1990													X	
	<i>Rhinochimaera pacifica</i> (Mitsukuri, 1895)													X	

A total of 34 chondrichthyan species have been described from Taiwan since Hilgendorf (1904) first described *Proscyllium habereri* (Table 3). Most of these new species were described during two peak periods in Taiwanese chondrichthyan research, the first between 1959 and 1963 (n = 13), and again from 2003 to 2013 (n = 9), including the new species described herein (Last *et al.*, this volume). H.-T. Teng described 11 of 13 new species between 1959–1962, and J.T.-F. Chen (1963) subsequently added another two new species. S.-C. Shen described five new

species from 1972–1986, including three new sixgill stingrays (*Hexatrygon* spp.) that were later provisionally synonymized with *H. bickelli* Heemstra & Smith, 1980, an apparently wide-ranging species (e.g. Compagno & Last, 1999). The authors of the present volume contributed to 8 of the 9 new species named during the period from 2003–2013. In summary, a total of 21 sharks and 13 batoid species, but no chimaeras, have been described from Taiwan, of which 12 sharks and five batoids are still considered valid species. However, several of these species are currently under investigation to clarify their status. Interestingly, six of these species (*Etmopterus burgessi*, *E. jounqi*, *Squatina formosa*, *Cirrhoscyllium formosanum*, *Tetronarce formosa*, and *Benthobatis yangi*) are presently known only from Taiwanese waters, but may have a wider geographic range. Two of these species (*C. formosanum* and *B. yangi*) are only known to occur off a very narrow stretch of coastline, less than 100 km, off southwestern Taiwan.

**TABLE 3.** Elasmobranch species (and their current status) described as new from Taiwan.

Family	Species	Current status
HEXANCHIDAE	<i>Hexanchus nakamurai</i> Teng, 1962	valid
SQUALIDAE	<i>Squalus formosus</i> White & Iglesias, 2011	valid
CENTROPHORIDAE	<i>Centrophorus armatus barbatus</i> Teng, 1962	= <i>Centrophorus atomarginatus</i> Garman, 1913
	<i>Centrophorus niaukang</i> Teng, 1959	= <i>Centrophorus granulosis</i> (Bloch & Schneider, 1801)
ETMOPTERIDAE	<i>Etmopterus burgessi</i> Schaaf-Da Silva & Ebert, 2006	valid
	<i>Etmopterus jounqi</i> Knuckey, Ebert & Burgess, 2011	valid
DALATIIDAE	<i>Dalatias tachiensis</i> Shen & Ting, 1972	= <i>Dalatias licha</i> (Bonnaterre, 1788)
	<i>Squaliolus aliae</i> Teng, 1959	valid
SQUATINIDAE	<i>Squatina formosa</i> Shen & Ting, 1972	valid
	<i>Squatina tergocellatoides</i> Chen, 1963	valid
PARASCYLLIIDAE	<i>Cirrhoscyllium formosanum</i> Teng, 1959	valid
PSEUDOCARCHARIIDAE	<i>Carcharias yangi</i> Teng, 1959	= <i>Pseudocarcharias kamoharai</i> (Matsubara, 1936)
ALOPIIDAE	<i>Alopias pelagicus</i> Nakamura, 1935	valid
	<i>Alopias profundus</i> Nakamura, 1935	= <i>Alopias superciliosus</i> (Lowe, 1841)
SCYLIORHINIDAE	<i>Cephaloscyllium formosanum</i> Teng, 1962	valid
	<i>Cephaloscyllium maculatum</i> Schaaf-Da Silva & Ebert, 2008	= <i>Cephaloscyllium fasciatum</i> Chan, 1966
	<i>Cephaloscyllium pardelotum</i> Schaaf-Da Silva & Ebert, 2008	= <i>Cephaloscyllium fasciatum</i> Chan, 1966
	<i>Cephaloscyllium parvum</i> Inoue & Nakaya, 2006	= <i>Cephaloscyllium sarawakensis</i> Yano, Ahmad & Gambang, 2005
	<i>Galeus sauteri</i> (Jordan & Richardson, 1909)	valid
PROSCYLLIDAE	<i>Proscyllium habereri</i> Hilgendorf, 1904	valid
HEMIGALEIDAE	<i>Paragaleus tengi</i> (Chen, 1963)	valid
TORPEDINIDAE	<i>Torpedo formosa</i> Haas & Ebert, 2006	valid
NARCINIDAE	<i>Benthobatis yangi</i> Carvalho, Compagno & Ebert, 2003	valid
RHYNCHOBATIDAE	<i>Rhynchobatus immaculatus</i> Last, Ho & Chen, 2013, this volume	valid
RHINOBATIDAE	<i>Glaucostegus microphthalmus</i> Teng, 1962	possibly a junior synonym of <i>G. typus</i> Bennett, 1830
	<i>Rhinobatos formosensis</i> Norman, 1926	valid
RAJIDAE	<i>Okamejei hollandi</i> (Jordan & Richardson, 1909)	valid
HEXATRYGONIDAE	<i>Hexatrygon brevirostra</i> Shen, 1986	= <i>Hexatrygon bickelli</i> Heemstra & Smith, 1980
	<i>Hexatrygon taiwanensis</i> Shen, 1986	= <i>Hexatrygon bickelli</i> Heemstra & Smith, 1980
	<i>Hexatrygon yangi</i> Shen & Lui, 1984	= <i>Hexatrygon bickelli</i> Heemstra & Smith, 1980
DASYATIDAE	<i>Dasyatis cheni</i> Teng, 1962	= <i>Dasyatis zugei</i> (Müller & Henle, 1841)
	? <i>Dasyatis microphthalmus</i> Chen, 1948	validity currently under investigation
MYLIOBATIDAE	<i>Aetomylaeus reticulatus</i> Teng, 1962	= <i>Aetomylaeus vespertilio</i> (Bleeker, 1852)
MOBULIDAE	<i>Mobula formosana</i> Teng, 1962	= <i>Mobula tarapacana</i> (Philippi, 1892)

## Conservation of Taiwanese chondrichthyans

Analysis of the IUCN Red List of Threatened Species for Taiwanese chondrichthyans (<http://www.iucnredlist.org/>; accessed November 24, 2013; also N. Dulvy, pers. comm. to DAE) reveals that most species (42.4%) have been assessed as *data deficient*, a number comparable to the global estimate of data deficient species at 46.8% (Table 4). The number of Taiwanese species listed as *least concern* (10.0%) is less than one-half (23.2%) the global number of species in this category. However, the number of Taiwanese chondrichthyans assessed as *near threatened* or higher (47.6%) is nearly one-half of all assessed species known to occur in this region (Ebert *et al.*, this volume). This compares to a global number of 30.1% of all chondrichthyans assessed as near threatened or higher. Even more striking is the disproportionately high percentage of the Taiwanese fauna that has been assessed as *vulnerable* (25.3% versus only 10.9% of the global species assessments). The relatively high percentage of species assessed as vulnerable is not surprising since Taiwan is one of the top five shark fishing countries in the world (Lack & Sant, 2011). Threatened species that have been so assessed include not only commercially targeted species but those prone to capture by longline and as trawl bycatch, all of which are linked by their vulnerability to exploitation due to their restricted ranges or less productive life-history characteristics. We also note that only 6.1% of Taiwanese chondrichthyans have not been assessed as compared to 13.3% globally. Finally, conservation assessments for many species at potential risk, especially those not considered to be “charismatic”, may be underestimated relative to higher profile, more charismatic or commercially sought after species. Many of these uncharismatic species have relatively restricted geographic ranges (e.g. *Benthobatis yangi*) that may be subject to intense anthropomorphic disturbances. Over the years, many of the authors of the present volume have witnessed strong declines in the capture of many species of elasmobranchs, such as thresher sharks, guitarfishes and angelsharks, from numerous localities throughout Taiwan. An overarching assessment of the taxonomic status of Taiwanese chondrichthyans is therefore timely.

**TABLE 4.** IUCN Red List Assessment of Chondrichthyans found in Taiwanese waters (see Ebert *et al.*, 2013, this volume for details).

IUCN Redlist Category	Taiwan %	Global %
Critically Endangered	0.6	2.4
Endangered	2.9	4.1
Vulnerable	25.3	10.9
Near Threatened	18.8	12.7
Least Concern	10.0	23.2
Data Deficient	42.4	46.8

## The present volume

The contributions included here stem from the aforementioned Taiwanese Chondrichthyes workshop as well as from revisionary studies presently underway, covering a wide range of chondrichthyan taxa. Of the 14 included papers, one brings new information on chondrichthyan type specimens in the South China Sea Fisheries Research Institute (SCSFRI) in Guangzhou, China (White & Last, 2013), with implications for species occurring in Taiwanese waters; another presents new records of chondrichthyan species from Taiwan (Hsu *et al.*, 2013); and yet another contribution is a broad and detailed survey (with much novel information) of the entire Taiwanese chondrichthyan fauna based on examined material (Ebert *et al.*, 2013). The latter contribution forms more than half the bulk of the present volume, amounting to an extensive collaborative effort with input by specialists on different taxa, and led by DAE. The contribution by Straube *et al.* (2013) is a list of Taiwanese chondrichthyans based on DNA sequences of the mitochondrial NADH2 gene from more than 250 well-identified and recently collected specimens; their results highlight population differences that may be indicative of undetected cryptic diversity. The remaining 10 papers address the systematics of particular chondrichthyan groups from Taiwan or adjacent seas, including sawsharks, long-snouted skates, eagle rays, wedgefishes, sixgill sharks, gulper sharks, and angelsharks, as well as full taxonomic revisions of the Taiwanese species of the complex genera *Apristurus* and *Cephaloscyllium* based on much new material. A table of standard names of sampling localities in Taiwan used throughout this volume is provided in Table 5.

**TABLE 5.** Standard names of sampling localities in Taiwan used throughout this volume.

Name used in this volume	Chinese name	Longitude & latitude (ca.)	Other name(s) used	Remarks
Ao-di (Taipei County)	澳底	25°10'N, 121°42.5'E	Audi, Aodi	Fishing port
Bu-dai (Chiayi county)	布袋	23°22'N, 120°6'E		Landing ground/fish market
Chang-bin (Taitung)	長濱	23°18.5'N, 121°17.5'E		Fishing port
Cheng-gong (Taitung county)	成功	23°5.5'N, 121°23'E	Chengkong, Chengkung	Auction/landing ground
Da-wu (Taitung county)	大武	22°21.5'N, 120°55.5'E		
Da-xi (Yilan county)	大溪	24°56.4'N, 121°54.3'E	Tashi, Ta-Shi, Ta-Chi, Tachi, Dashi, Daxi	Landing ground/ fish market
Dong-sha Islands	東沙群島	20°40'N, 116°43'N	Tong-sha Islands	In South China Sea
Dong-shi (Chiayi county)	東石	23°26.5'N, 120°08'E	Tongshi	Landing ground/fish market
Dong-gang (Pingtung county)	東港	22°27'N, 120°25'E	Tungkang, Tung-Kang, Tongkang, Tongkong	Landing ground/fish market
Fong-gang (Pingtung county)	楓港	22°15'N, 120°38.5'E	Fongkang	Fishing port
Fu-gang (Taitung)	富岡	22°47.4'N, 121°11.6'E	Fukang	Auction
Fu-gui-jiao (Taipei)	富貴角	25°18'N, 121°32'E		Fishing port/fish market
Hsiao-liu-chiu (Pingtung)	小琉球	22°20'N, 120°22.5'E	Hsiaoliuchiu, Liuchiu	Fish market
Hualien (Hualien city)	花蓮	23°59.5'N, 121°38.5'E		Auction/landing ground/ fish market
Kaohsiung (Kaohsiung city)	高雄	22°32.5'N, 120°17'E		Usually refer to Chian-jen harbor, a fish auction or Chong-zhou, a fish market
Ke-tzu-liao (Kaohsiung city)	蚵仔寮	22°43.5'N, 120°15'E		Landing ground/fish market
Keelung (Keelung city)	基隆	25°9'N, 121°45.5'E	Keelong, Geelong, Geelung	Fish market with fishes from all around Taiwan and other countries
Ma-gong (Penghu county)	馬公	23°33.5'N, 119°34'E	Makong, Makung, Ma-Kung	Same as Penghu
Nan-fang-ao (Yilan county)	南方澳	24°35.5'N, 121°54'E	Nanfangao, Nanfango, Nanfang'ao	Landing ground/fish market (near Su-ao)
O-luan-bi (Pingtung county)	鵝鑾鼻	21°53.5'N, 120°51.5'E		
Penghu	澎湖	23°33.5'N, 119°34'E	Penghu Islands, Penghow, Pengho	Fish market, usually referred to Magong
Su-ao (Yilan county)	蘇澳	24°35.5'N, 121°54'E	Suao, Su-Ao, Su-O	Auction on large fishes
Tainan (Tainan city)	台南	22°58.5'N, 120°7.5'E		Usual refer to An-ping fishing port
Wu-chi (Taichung city)	梧棲	24°18'N, 120°29'E	Wuchi, Wuqi	Landing ground/fish market

In publishing this volume we wish to reinforce our belief that geographically focused revisions employing wide-ranging comparisons, and that take into account all types of data, are crucial to untangle the global biodiversity and systematics of such ecologically important, but still greatly misunderstood, fishes. Our ultimate goal is to spark a greater interest in the highly diverse sharks, rays and chimaeras of Taiwan and surrounding areas.

[Note: Because citation of papers in edited volumes published in *Zootaxa* vary significantly, we offer the following suggestion in the hopes of obtaining a more uniform citation of the papers contained in the present Special Issue: White, W.T. & Harris, M. (2013) Redescription of *Paragaleus tengi* (Chen, 1963) (Carcharhiniformes: Hemigaleidae) and first record of *Paragaleus randalli* Compagno, Krupp & Carpenter, 1996 from the western North Pacific. In: Carvalho, M.R. de, Ebert, D.A., Ho, H.-C. & White, W. (eds.), *Systematics and biodiversity of sharks, rays, and chimaeras (Chondrichthyes) of Taiwan*. *Zootaxa* 3752, 172–184]

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