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The diversity of sharks, rays and chimaeras

By Terence I. Walker



The eastern fiddler ray (*Trygonorrhina* sp., order Rajiformes) (© Ken Hoppen, oceannotations@primus.com.au)

THE DIVERSITY OF SHARKS, RAYS AND CHIMAERAS

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Introduction

The class Chondrichthyes consists of sharks, rays and chimaeras. Scientific nomenclature includes selachii for sharks, neoselachii or batoidea for rays, and holocephali for chimaeras.

The cartilaginous skeletal structures of chondrichthyans do not preserve as well as the bony and dermal structures of other fishes in the fossil record. Paleontologists have to rely on fossilised teeth, small dermal scales and calcified vertebrae, rather than complete skeletons, to piece together their evolutionary history. These limitations have caused the early phylogenetic relationships and origins of chondrichthyan fishes to remain uncertain.

The chondrichthyan fauna is present in the fossil record from the Silurian and lower Devonian periods, and is clearly diverse by the middle to upper Devonian periods. Some scientists argue that these animals were present even earlier. Much of the controversy arises from definitions adopted for chondrichthyan fishes as many of their characters are shared with other fish groups. For example, while it is known that all living chondrichthyans animals have cartilaginous skeletons and lack bone, it appears that the earliest sharks originated from fish with bone in their skeletal structures. Bone was probably lost during the early evolution of sharks to reduce body weight and improve buoyancy.

The earliest sharks appeared on earth more than 400 million years ago and soon after gave rise to the earliest holocephalans. Holocephalan species were diverse during their early history and it was not until 340 million years ago that the chimaeroid group of holocephalans arose; this is the group to which all living species of holocephalans belong. There are only 33 described living species of chimaera with several additional species known to science and yet to be described. It is expected that there are no more than 45 living species of chimaera. The earliest rays appeared about 200 million years after the earliest sharks. The first rays are thought to have derived from flattened sharks that are close relatives of the present-day guitarfishes. There are nearly 400 species of living shark species and nearly 600 living ray species described worldwide. More species are likely to be discovered as the deep waters of the world's oceans are better explored.

Cartilaginous fishes occur in a range of habitats. They are present from near shore to the deep abyss, from the equator to the poles, and a few species are found in freshwater and hypersaline waters. They are most abundant in tropical and temperate marine waters. Species diversity of rays is highest in coastal waters, whereas species diversity of sharks and chimaeras is highest in the cool waters of the outer shelf and continental slope environments.

Sharks

The sharks are mostly fusiform in shape but some have a flattened ray-like shape. They have mostly five pairs of gill openings, but some have six or seven. Most have two dorsal fins, but a few species have only one. The dorsal fins of some groups of sharks have spines on the leading edges. Sharks have a well-developed caudal fin (tail) for swimming.

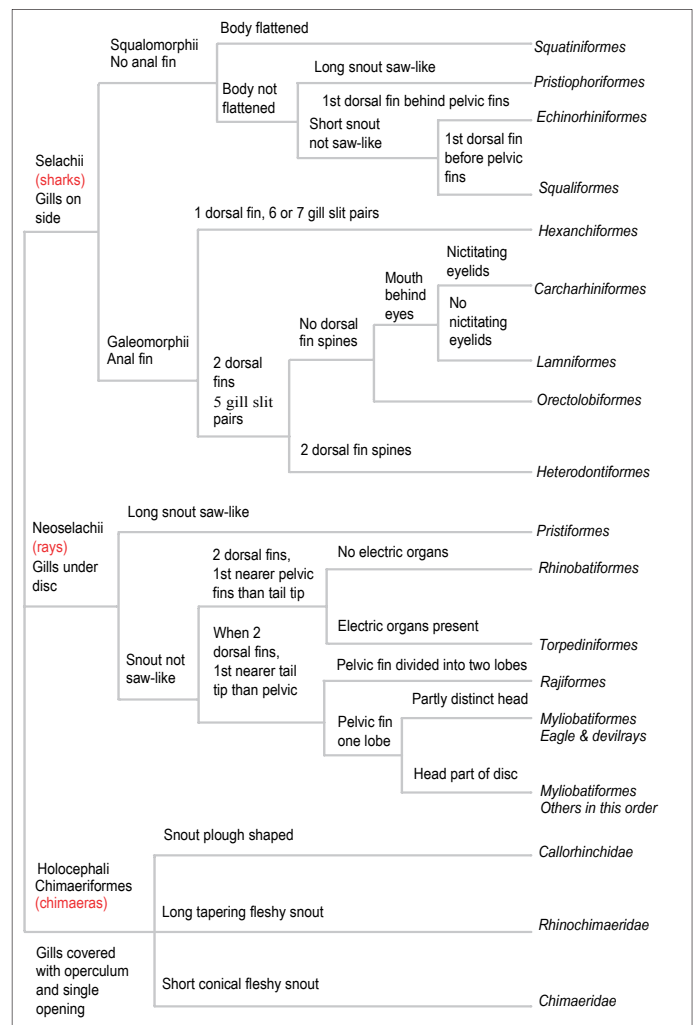


Figure 1. Taxonomic key for major Chondrichthyan groups.

Taxonomically, sharks (*Selachii*) form two broad groups (*Galeomorphii* and *Squalimorphii*), which can be further divided into nine orders (figure 1). The galeomorph sharks possess an anal fin and form five orders (Hexanchiformes, Carcharhiniformes, Lamniformes, Orectolobiformes and Heterodontiformes), whereas the squalimorph sharks lack an anal fin and form four orders (Squatiniiformes, Pristiophoriformes, Echinorhiniformes and Squaliformes). Within these nine orders there are 30 families of shark.

Squatiniiformes

This group includes the angel sharks (figure 2), also known as monkfish. Like the rays, they have dorsoventrally flattened bodies with very broad pectoral fins. However, unlike the rays, the gill openings are on the sides of the head. There are 14 species worldwide and all belong to the one genus *Squatina* (family Squatidae). They are mostly distributed on the continental shelf, but have been found on the continental slope at 1300 metres depth. They are often found buried in mud and sand waiting to ambush small fish and invertebrates.



Figure 2. The Australian angel shark (*Squatina australis*, order Squatiniiformes). Unlike the rays, the gill openings are on the sides of the head (© Ken Hoppen, oceannotions@primus.com.au).

Pristiophoriformes

This group is referred to as the sawsharks, named from the blade-like snout (rostrum) with long sharp lateral denticles (rostral teeth) and two sensory barbels attached on the underside of the rostrum. All living species fall within the one family (Pristiophoridae). They have five or six pairs of gill openings and a spiracle. Three species in the genus *Pristiophorus* occur in southern and eastern Australia.

Echinorhiniformes

These are the bramble sharks (family Echinorhinidae) and there are only two known species (*Echinorhinus brucus* and *E. cookei*), both of which occur in Australia, as well as in other parts of the world. Both dorsal fins are near the caudal fin behind the pelvic fins and are small without spines. They have large thorn-like denticles. They have a viviparous, aplacental mode of reproduction and are known to eat fish and squid. *E. brucus* is known to reach more than 4 metres total length.

Squaliformes

This group includes a large number of species of dogfishes (family Squalidae) and a small number of prickly dogfishes (family Oxynotidae) (figure 3). They have varied morphology, possess a large spiracle, and mostly have spines on the leading edge of the dorsal fins. The species reach very different maximum sizes: 22 cm total length for the smalleye pygmy shark (*Squaliolus aliae*) and 6 metres total length for the Pacific sleeper shark (*Somniosus pacificus*). They are most abundant on the continental slope, where the assemblage of species varies with depth.



Figure 3. The piked spurdog (*Squalus megalops*, order Squaliformes). Note the large spiracle behind the eye (© Ken Hoppen, oceannotions@primus.com.au).

Hexanchiformes

Referred to as cow sharks, sixgill sharks or sevengill sharks (family Hexanchidae) or frilled sharks (family Chlamydoselachidae), these sharks have either six or seven pairs of gill openings (figure 4). Members of this group of sharks can be distinguished by the presence of a single dorsal fin; all other sharks have two dorsal fins. They are found on the continental shelves and slopes of the world.



Figure 4. The frilled shark (*Chlamydoselachus anguineus*, order Hexanchiformes) (© Ken Hoppen, oceannotions@primus.com.au).

Carcharhiniformes

This group has a large number of species in eight families (figure 5). These are the catsharks (Scyliorhinidae), finback catsharks (Proscylliidae), false catsharks (Pseudotriakidae), barbeled hound sharks (Leptochariidae), hound sharks (Triakidae), weasel sharks (Hemigaleidae), requiem sharks (Carcharhinidae), and hammerhead sharks (Sphyrnidae). The eyes are lateral to dorsolateral with true nictitating lower eyelids. The mouth is moderately large, arched, and extending behind the anterior ends of the eyes.



Figure 5. The grey spotted catshark (*Aymbolus analis*, order Carcharhiniformes). The eyes are lateral to dorsolateral with true nictitating lower eyelids, and the mouth extends behind the anterior ends of the eyes (© Ken Hoppen, oceannotions@primus.com.au).

Lamniformes

Although the number of species in this group is relatively low, it is a diverse group with seven families. It includes the mackerel sharks (Lamnidae), grey nurse sharks (Odontaspidae), thresher sharks (Alopiidae), goblin shark (Mitsukurinidae), crocodile shark (Pseudocarchariidae), megamouth shark (Megachasmidae), and basking shark (Cetorhinidae). Spiracles are usually present, but very small, and nictitating eyelids are absent. The mouth is large and extends well behind the eyes. The group includes sharks that reach large maximum sizes; e.g., basking sharks 10 metres, white sharks 6 metres, and thresher shark 5.5 metres.

Orectolobiformes

This is the largest and most diverse group of sharks and includes seven families (figure 6). The group includes the collared carpet sharks (Parascyllidae), longtail carpet sharks (Hemiscylliidae), blind sharks (Brachaeluridae), wobbegong sharks (Orectolobidae), zebra sharks (Stegastomidae), and nurse sharks (Ginglymostomatidae). The group also includes the world's biggest living fish the whale shark (*Rhincodon typus*; family Rhincodontidae), feeds on plankton and undertakes long migrations. Members of this group of sharks are found in intertidal water, at all depths on the continental shelf and the upper region of the continental slope. They are not found in the mid-slope or deep-slope regions of the continental slope.



Figure 6. Juvenile brown-banded bamboo shark (*Chiloscyllium punctatum*, order Orectolobiformes) (© Ken Hoppen, oceannotions@primus.com.au).

Heterodontiformes

These are the bullhead sharks and characterised by big heads with heavy ridges over the eyes and dorsal spines on the leading edges of the dorsal fins (figure 7). Worldwide, this group has only nine species, which belong to the one genus *Heterodontus* (family Heterodontidae) and is absent from the Atlantic and most of the Pacific. These species are small to medium in size, benthic, and coastal on the continental shelves. They feed on invertebrates.



Figure 7. Crested Port Jackson sharks (*Heterodontus galeatus*, order Heterodontiformes) have a large head with heavy ridges over the eyes, and dorsal spines on the leading edges of the dorsal fins (© Ken Hoppen, oceannotions@primus.com.au).

Rays

Rays have five or six pairs of gill openings underneath their flattened body. The pectoral fins are attached to the back of the skull and body, which are greatly enlarged to form a body disc. Most ray species have small dorsal and caudal fins and many species lack them completely. The dorsal fins lack spines. Rays have a thin, often whip-like, tail and lack an anal fin. The eyes and spiracles are usually on top of the head; the eyes are covered with skin and indistinct in a few blind electric rays.

More than half the species have maximum sizes exceeding 50 cm in length. The smallest ray is a shortnose electric ray with a maximum length of 10 cm total length. The largest ray recorded, the wide sawfish (*Pristis pectinata*), is 7.6 metres total length and the largest manta ray (*Manta birostris*) recorded is 6.7 metres. Most species of ray prey on invertebrates and small fish, but some are plankton feeders. Most rays are bottom dwellers and feed by trapping prey against the substratum with their disc.

Features used for identifying species of ray are colour, disc and tail shape, nasal and mouth structure, and distribution and shape of dermal thorns and denticles. Taxonomically, rays (neoselachii) form a single broad group (batoidea) and are often referred to as batoids. Within five orders (figure 1), there are 16 families of living rays.

Pristiformes

This group is referred to as the sawfish because of the blade-like snout (rostrum) with lateral rostral teeth. They share the feature of the rostrum with sawsharks, but lack the barbels present in sawshark. Living sawfish belong to a single family (Pristidae). Sawfishes occur throughout the tropics and are rarely found in temperate waters.

Rhinobatiformes

This group includes the shovelnose rays (family Rhinobatidae) and sharkfin guitarfishes (family Rhynchobatidae). The latter is thought to be among the oldest ray groups. These rays have large dorsal fins and the sharkfin guitarfishes resemble sharks.

Torpediniformes

Referred to as the electric rays, this group has four families (figure 8). These are the torpedo rays (Torpedinidae), coffin rays (Hypnidae), numbfishes (Narcinidae), and shortnose electric rays (Narkidae). They are all capable of delivering an electric shock. Electric charges are produced by kidney-shaped electric organs located on each side near the centre of the disc. There is only one species of coffin ray and this is endemic to Australia. This group is thought to have evolved from the sawfish.



Figure 8. The coffin ray (*Hypnos monoptyerygium*, order Torpediniformes) is capable of delivering an electric shock (© Ken Hoppen, oceannotions@primus.com.au).

Rajiformes

This group consists of more than 280 species of skate (family Rajidae) (figure 9). A small group of leg skates with notched pelvic fins resembling small legs are also in this group (family Anacanthobatidae). They are widespread on the continental shelves of the world's landmasses and oceanic islands, but are absent from the coral islands in the Pacific. The earliest fossilised skates date back about 70 million years to the upper Cretaceous.



Figure 9. The eastern fiddler ray (*Trygonorrhina* sp., order Rajiformes) (© Ken Hoppen, oceannotions@primus.com.au).

Myliobatiformes

This group consists of seven families: the stingrays (Dasyatidae), stingarees (Urolophidae), butterfly rays (Gymnuridae), sixgill stingrays (Hexatrygonidae), eagle rays (Myliobatidae) (figure 10), devilrays (Mobulidae), and river rays (Potamotrygonidae). Representatives of all families except the river rays occur in Australia. Most species have one or more serrated stinging spines.



Figure 10. The southern eagle ray (*Myliobatis australis*, order Myliobatiformes.) has a stinging spine
 (© Ken Hoppen, oceannotions@primus.com.au).

Chimaeras

Chimaeras differ from sharks and rays by having the upper jaw fused to the underside of the skull. The head is large with prominent eyes. Their teeth are fused into plates that are often beak-shaped. All chimaeras have six ever-growing non-replaceable, beak-shaped tooth plates: two pairs in the upper jaw and one pair in the lower jaw. Unlike the sharks and rays they have only a single opening for their gills. They have a large strong spine in front of the first dorsal fin, a pair of large pectoral fins and a long, usually filamentous, tail. Unlike the sharks and rays they have a smooth skin lacking denticles.

They range in size from 50 cm to 200 cm total length. All species are egg laying and they feed on invertebrates. Chimaeras are found mainly on the continental slopes of the world in deep water. Most species of chimaera prey on invertebrates.

Species of chimaera are identified from colour, head shape, position and shape of fins, size of the spine in relation to the first dorsal spine, and tooth plate structure. All living chimaeras belong to the one order Chimaeriformes; other orders have extinct species. Living chimaeras are classified into three separate families: Callorhynchidae, Rhinochimaeridae and Chimaeridae (Figure one).

Callorhynchidae

This family is known as the plow-nosed chimaeras or elephant fishes. This family contains a single genus with only three species worldwide. One of these is the elephant fish (*Callorhynchus milii*) found in south-eastern Australia and



Figure 11. Juvenile elephant shark (*Callorhynchus milii*, family Callorhynchidae) (© Ken Hoppen, oceannotions@primus.com.au).

New Zealand (figure 11). The other species occur off eastern South America and southern Africa. All species occur in coastal waters on the continental shelf.

Rhinochimaeridae

This family is known as the longnose chimaeras or spookfishes. They have a long pointed snout. The first dorsal fin is triangular and the second dorsal fin is long and low. Most inhabit the continental slope and abyssal plains.

Chimaeridae

This family is referred to as the shortnose chimaeras, ratfishes or ghostsharks (figure 12). They have compressed, elongate bodies tapering to a whip-like tail and a short conical snout. Most are benthopelagic and inhabit the continental slope and abyssal plains.



Figure 12. Southern chimaera (*Chimaera* sp., family Chimaeridae) have a compressed, elongate body tapering to a whip-like tail and a short conical snout (© Terence I. Walker).

Further information

For terms in this text that may be unfamiliar to you please visit fishbase:

<http://www.fishbase.org/search.cfm>

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