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To my wife......Zainab Issa...
I would like to thank my dear for standing beside me throughout my life and career and for your unlimited patience. You have been my inspiration and motivation for continuing to improve my knowledge and move my career forward.

To my daughters Hend, Nora, and Warda...
You gave me much joy to life. I do not know what the taste of life without you is.

To my granddaughters Zainab 'Zuzu,' Leirah 'Lulu,' and Habibah 'Hubhub'...
Our new addition for bringing the joy to our life and our home

..............................I dedicate this book

Preface

Twenty years ago, I came across Halstead's book, *Poisonous and Venomous Marine Animals of the World*. This incident triggered inside myself the idea of collecting articles about the dangerous fishes in general including the poisonous and venomous fishes. Later, the idea of writing a book about these fish groups flourished in my mind and I chose the eastern and southern coasts of the Arabian peninsula as the region for the background of these fishes. Two reasons were behind my choice of the region, these are: the high biodiversity of fishes in the selected area and the unawareness of the locals to the hazards of the different groups of dangerous fishes living in their environment.

Dangerous aquatic organisms may be confronted during recreational or fishing activities in coastal environments. Such organisms vary widely and are generally of local or regional importance. The possibility and nature of human exposure often depend significantly on the type of the activity concerned. Because of the wide diversity of organisms that may be encountered, the coverage of these fishes in the present book is limited to only the common fish species of which locals are fully aware.

In each dangerous group, the information given is a historical background about the fish group, the causative agent, symptoms, treatment, and prevention. The account of the species includes identification, world distribution, distribution in the study area, habitat and ecological role, biology, economic value, and conservation status. To draw the attention of the readers and to make them aware of the dangers of the species dealt with in this book, a section about the distribution of the species in the study is included. Thanks to the fully informative species account used in the Fishbase, I decided to adopt this format in the present book.

Two types of risks can be distinguished in relation to dangerous aquatic species: the risk of infectious disease transmitted by species with lifecycles linked to the aquatic environment, and injury or intoxication (e.g., ciguatera, histamine poisoning, etc.) resulting from direct encounters with large animals or venomous species. Apparent risks involving dangerous fishes may have important economic consequences in areas that depend to a large extent on recreational tourism and fisheries as a source of income.

Among the aims of the present book is to educate locals about the danger of this group of fishes as part of a public education and awareness program that should be initiated in the coastal areas. It is therefore important to identify and assess the hazards posed by various fishes in a given region and bring the results to public attention. In addition, at locations where hazards involving dangerous fishes have been identified, procedures should be developed for treating any injuries sustained.

I would like to express my thanks to all the amateur and professional photographers who gave their permission to use their pictures of various dangerous fish species in the wild and in the laboratory.

Manukau, Auckland, New Zealand Laith A. Jawad

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Part II Poisonous and Venomous Fishes

1 Introduction

Dangerous marine fishes have always created a challenge for coastal human societies such as fishing communities. These fishes are typically classified into five main categories, with subdivision of some categories: predators, biting, harmful, venomous, and poisonous. Venomous fishes are those capable of producing venom in specialised tissues or glands that are connected with application structures (e.g., stings), unlike poisonous fishes that usually produce poisons in nonspecialised tissues or accumulate them after ingestion of prey or algae and may be dangerous to people who consume them (Spanier 1987; Russell 1996). The number of attacks, envenomation, and toxication by dangerous fishes has increased in recent years; the increased use of skin and scuba diving as leisure activities has led to an increase in the number of admissions to emergency departments (Atkinson et al. 2006). Yet, very limited research has been done around the world to estimate the magnitude of these injuries inflicted by marine fishes. In countries such as Australia, it was found that fish (including stingrays) constituted the taxonomic group causing the highest rate of injury (62.9%). In the Australian study 8.3% of the cases required hospitalisation, and most of the injuries occurred as a result of sport and leisure activities (65.9%; Taylor et al. 2002). Such a survey has not been applied in many other countries thus far. Such studies will assess the prevalence of injuries caused by dangerous marine fishes along the coastal areas to describe the medical aspects of the injuries in order to identify causes of hazard and recommend prevention strategies.

The eastern and southern coasts of the Arabian peninsula are surrounded with three seas, the Arabian-Persian Gulf, the Sea of Oman, and the Arabian Sea. Each of these seas is geographically, geologically, oceanographically, and climatologically different from the others. Such factors make each sea have its own fish fauna which are considered unique to each of the three environments.

1.1 Geography

Arabian-Persian Gulf

The Arabian-Persian Gulf is a semi-enclosed marginal sea located between 24° to 30°30′ N latitude and 48° to 56°25′ E longitude and oriented northwest to southeast. This Gulf is connected to the Indian Ocean through the 56 km wide Hormuz Strait and the Sea of Oman. Its length is about 1000 km, has a maximum width of 350 km, average depth of 40 m, and maximum depth of 120 m at the Strait of Hormuz; the straits open on the Gulf of Oman with surface area of about 239,000 km^2 and its volume is 8780 km^3 (Britannica 2016). It is bounded to the north by flat land (the delta of Iranian and Iraqi rivers), to the northeast by the

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Zagros Mountains, and to the southwest by the desert of Saudi Arabia. From the east and from the west it receives the Shatt al-Arab River (formed by the Euphrates and Tigris in Iraq) and the Karoon River in Iran running in the Khuzestan province of Iran. Its total length from the Hormuz Strait to the last point in the west is around 805 km.

Sea of Oman

The Sea of Oman (Gulf of Oman) is a northwest extension arm of the Arabian Sea and is located between 22° and 26°N and 56° and 62°E. The total area is 94,000 km^2 and it is found in the semi-arid zone stretching from the Strait of Hormuz in the northwest to Ras al Hadd on the eastern tip of the Arabian peninsula. The boundary between the Gulf of Oman and the Arabian Sea lies at the imaginary line stretching from Jiwani on the Iran–Pakistan border to Ras al Hadd (Price et al. 2012). This sea borders Iran, Oman, and the United Arab Emirates. It is distinctive in being funnel-shaped, 480 km long, 320 km wide, and 3350 m deep. The width starts to increase from the eastern end of the Strait of Hormuz and becomes wider at Muscat and then is at its widest point when joining the Arabian Sea. The top of this sea is tapered and it is has a strategic importance as the Strait of Hormuz is situated there. The strait guards the entrance of the Arabian Gulf, the petrol-richest area in the world (Price et al. 1993).

Southern Coast of the Arabian Peninsula

The southern coast of the Arabian peninsula is represented by the Arabian Sea. This sea has a surface area of about 3,862,000 km^2, the maximum width is approximately 2400 km, and it has a maximum depth of 4652 m (Morgan 2016). The Arabian Sea has two important branches, the Gulf of Aden in the southwest, connecting with the Red Sea through the strait of Bab-el-Mandeb; and the Sea of Oman to the northwest, connecting with the Arabian-Persian Gulf. The Omani coast of the Arabian Sea is narrow, ranging between 16 and 32 km with hills and mountains of maximum elevation of 760 m along the length of the coast.

1.2 Geology

Arabian-Persian Gulf

The geological history of the Gulf goes back 15,000 years or so and its complete evaporation occurred in the Pleistocene. The period between 110,000 years BP and 30,000 years BP was characterised by considerable sea-level fluctuations within the range of 30–60 m below the present. During the Last Glacial Maximum, the sea-level set between 120 and 150 m below the present, which means that the entire Gulf was dry during this period. Flooding of the Gulf was probably initiated shortly prior to 12,000 years BP as the ocean transgressed into the basin via the Strait of Hormuz and then a rapid rise in sea level between 12,000 and 9000 years BP from less than 90 m to less than 30 m below the present level occurred. This was followed by a more gradual rise until today's sea level was reached (Lambeck 1996).

The coastal strip of the Gulf is represented by the southern part of the Mesopotamian depression which includes the Arabian Gulf and a narrow coastal strip of the Arabian peninsula. This coastline is irregular, low, and sandy and the water has many shoals, therefore tidal changes have a remarkable effect on its stability. Among the common features on this part of the coast are the Sabkhat (salt flats); such environments are common all along the coast from Kuwait to the southern end of the Arabian Gulf. Other coastal features are the rolling plains which are found along the northwestern shores north of Jubail. These plains are covered with a thin mantle of sand. Other coastal characteristics are the wide gravel plains which are present in the southwest of Kuwait (Konyuhov and Maleki 2006).

Sea of Oman

During the continental drift and through the late Permian time (about 250 million years ago), the breaking of Pangaea marked the initial formation of the Sea of Oman. It is considered a remnant of the Neotethys Ocean (Robertson and Searle 1990; Pillevuit et al. 1997; Beydoun 1998).The basin of this is narrow and becomes shallower towards the Strait of Hormuz and then separates from the inner part of the Arabian-Persian Gulf where the depths are 70–110 m.

The coasts of the Sea of Oman are a part of the Arabian plate. This plate is bordered by the Owen fracture zone to the east. It marks the boundary to the Indian plate in the east. The Makran subduction zone is another geological formation in the Sea of Oman (Hoffmann et al. 2013). It is located east–west, stretching from the Minab Fault System in the Strait of Hormuz to the Ornach-Nal Fault in Pakistan, and has an along-strike extension of about 1000 km (Jacob and Quittmeyer 1979; Mokhtari et al. 2008). This zone has been active since the Miocene (Glennie et al. 1990) or possibly since the Early Cretaceous (Byrne et al. 1992).

The coast of the Sea of Oman contains hard-rock as well as soft-rock sections. Different wave energies act on the facing of the coast of this sea. Moderate wave energy and more energetic waves act on the northern and southern shores, respectively. In the area from Muscat to Sur at the south of the Sea of Oman, boulders and blocks are found (Hoffmann et al. 2012) and considered traumagenic (Watts et al. 2010; Etienne et al. 2011; Engel and May 2012). Similarly, on the Iranian coast of the Sea of Oman blocks and boulders are also present (Shah-Hosseini et al. 2011).

Southern Coast of the Arabian Peninsula

Ras al Hadd ('Ras' meaning 'headland,' and 'al Hadd' being the 'edge' or 'margin' in Arabic) is the easternmost point of Arabia and marks the transition from the Gulf of Oman to the Arabian Sea (Sheppard et al. 1992a, b). It is important in regard to its effect on the distribution of marine life in this area of the Indian Ocean.

The past roughly 50 million years mark the formation of the Arabian Sea as the Indian subcontinent collided with Asia. Southeastward from Socotra, the submarine Carlsberg Ridge is found, which coincides with the belt of seismic activity in the Indian Ocean that divides the Arabian Sea into two major basins, the Arabian Basin to the east and the Somali Basin to the west. There is a clear split in the Carlsberg Ridge with depths reaching up to 11,800 ft below the sea's surface. The coastal cliffs of the Gulf of Aden are formed by rift faults that converge towards the southwest to continue into Africa as the boundary scarps of the Eastern, or Great, Rift Valley, which forms part of the East African Rift System. The Arabian Basin is separated from the Gulf of the Sea of Oman basin by the Murray Ridge, a narrow, seismically active submarine ridge that extends northeast to southwest to meet the Carlsberg Ridge. West of Murray Ridge is the Malian subduction zone, an area where the ocean floor sinks below the adjacent continental crust (Morgan 2016).

Along the coast of the Arabian peninsula, the continental shelf is narrow and is even narrower along the Somali coast. No true coral reefs are found along the Arabian coast. At Ras al Hadd, where upwelling of deep water occurs, sediments found there consist of fine greenish mud with a high organic content containing hydrogen sulfide. This is known as the fish cemetery due to the presence of many fish remains. The thickness of the sediment decreases from 2500 m in the north to about 500 m in the south of the Arabian Basin.

The northern Arabian Sea is a semi-enclosed sea, which is characterised by having seasonal monsoon forcing. The Omani coasts of this sea consist of sandy beaches, littoral dunes, and mudflats with salt pans ('sabkhas'). These geological formations are discontinued by rocks. The bottom topography of the Arabian Sea in general shows the presence of the Carlsberg Ridge extending in a northwest–southeast direction. In the north, Murray Ridge is found located in a southeast–northeast direction. The continental shelf is 120 km wide and it is narrow along the Arabian coast to less than 50 km, especially at the entrance of the Red Sea. Along the eastern coast of Oman near Masirah Island there is a protected sedimentary region from the most direct effects of coastal upwelling (Ross 1985).

Masirah Island, a major island in the Omani waters of the Arabian Sea, has more obvious rock formations and is surrounded by a shallow continental shelf of mostly carbonate sediments. Coral patch reefs are also found in this area. The geology of the coastline of this island is quite different from that of southern mainland Oman, where rocky capes, steep cliffs, and hard substrates dominate the shoreline (Sheppard et al. 1992a, b).

1.3 Oceanography

Arabian-Persian Gulf

Because of its location and bathymetry, the Gulf's marine environment is characterised by environmental extremes. Evaporation is far greater than the combined rainfall and river discharge within the Gulf, leading to an inverse estuarine circulation and a counterclockwise circulation. Surface water flows into the Gulf in the northern part of the Strait of Hormuz as a wedge of less saline water that penetrates deep into the Gulf along the Iranian coast, increasing in salinity and exiting at depth through the Strait of Hormuz. Summer surface water temperatures (SST) average 33 °C, with an upper maximum reported being 37.7 °C. Salty water forming high evaporation over the Gulf is maintained, and is disseminated into the Sea of Oman, and compensated by an inflow of fresher Indian Ocean surface water.

The bathymetry study of the Gulf shows that it is shallow in the northwest and west coasts. An isolated trough extends northward from the Strait of Hormuz along the Iranian coast approximately 100 km. The trough collects denser bottomwater and impedes exiting bottom flow.

Evaporation in the Gulf exceeding the inflow of freshwater from rivers in its northeastern and northwestern parts and the net loss of water creates a reverse-flow, estuarine circulation. Most evaporation occurs in the wintertime, mainly because of the higher wind speeds, rather than in summertime when water temperature is considerably higher.

The average salinity of the Gulf is 37–40%, which is high relative to the ocean because of the high evaporative rate over this restricted basin; values of 40–50 or higher are reached in shallow waters along the United Arab Emirates (UAE) coast. This area is a region of intense evaporation, and a significant contribution to the deep circulation of the Gulf is made here. High-salinity water flows out of the Gulf and spreads at 200–350 m depth within the Sea of Oman. This amount of Gulf overflow water affects the stability of the Indian Ocean thermocline and introduces oxygen-rich water at a depth characterised farther east by extreme oxygen-depletion because of the decay of surface layer primary production.

The semi-diurnal and diurnal waves generate resonant interactions in the basin of the Gulf which lead to a system of amphidromic points of Kelvin–Taylor type. The energy in the water motion can be related to three forcing processes: tidal forces, wind forces, and density differences. Each of the different currents has a different scaling time: tides vary over a few hours at diurnal or semi-diurnal periods, wind-driven currents develop and subside over a few days, and density-driven currents take weeks to change in response to seasonal forcing. The circulation study within the Gulf indicates northwest flow with speeds greater than 10 cm/s along the Iranian coast with weaker flow to the west or south.

The strong northwest winds in the winter and spring produce southeast-flowing surface currents along both coasts in the northern Gulf, confine cyclonic circulation to the southern Gulf, and shift the surface current through the Strait to the south side of the channel.

The tides in the Persian Gulf co-oscillate with those in the narrow Strait of Hormuz, which opens into the deep Gulf of Oman. The tides in the Gulf of Oman co-oscillate with those in the Arabian Sea. The tides in the Persian Gulf are complex standing waves and the dominant pattern varies from being primarily semi-diurnal to diurnal. The tidal range is large, with values greater than 1 m everywhere (Lehr 1984). The dimensions of the Persian Gulf are such that resonance amplification of the tides can occur and the result is that the semi-diurnal constituents have two amphidromic points, in the northwest and southeast ends, and the diurnal constituents have a single amphidromic point in the centre near Bahrain.

In the Gulf region, there is an oscillation period between 21.6 and 27 h for tidal waves. Tides are important for stirring and mixing waters vertically and on a horizontal scale, but they do not make an important contribution to the residual circulation. Tides are important on smaller scales of horizontal length ($<$10 km) and time ($<$24 h). The main features of the residual circulation (wind-driven and density-driven) in the Gulf are: (a) circulation resulted from the high- and low-salinity water exchange in the Strait of Hormuz, (b) circulation resulted from density in the central and southern regions of the Gulf, (c) circulation created by the frictional-balanced and domination of wind in the northwest region of the Gulf, and (d) the bottom flow induced by evaporation. Water exchange with the Gulf of Oman dominates the circulation of the southern part of the Gulf. The surface inflow replaces the net freshwater loss to the atmosphere in the Strait of Hormuz. Regularly, and against prevailing Shamal winds, water with low salinity enters through the Strait of Hormuz to freshen the hypersaline water in the Gulf. The Gulf water increases in density because of the high evaporation and thus sinks to exit as a high-salinity undercurrent through the deeper portion of the Strait of Hormuz.

The estimates of residence times vary in the approximate range of 2–5 years. However, knowledge of the circulation in the Strait of Hormuz plays a key role in understanding the basinwide behaviour of the Gulf. The lower level of water in the northern part of the Gulf may remain in residence longer than that in the southern end where the north is shallow and dominated by wind friction and the effect of river outflow may considered as a good factor to affect the local circulation there.

Sea of Oman

Clockwise gyres in the west seem to be the main factor that affects circulation in the Gulf of Oman and clockwise gyres in the east. Upwelling happens in the region between the two types of gyres at the Iranian side of the Sea of Oman. The circulation of water is continuous and present in both winter and summer and its strength depends on the existing winds at that time.

The water temperature distribution pattern in the Sea of Oman tends to have a semi-annual mode of variability with alternate phases of warming and cooling. Such an event has been seen in Bandar Khyran Bay, south of Muscat City. The sea surface temperature exceeded 31 °C in June and the other temperature rising occurred during October (30 °C). On the other hand, the cooling phases occurred during December–April and August–September. During this phase, the temperature dropped to about 23 °C.

Similar to the water temperature distribution pattern, the annual distribution of salinity is also exhibited in a semi-annual mode of variability with two high saline and two low saline periods. One high-salinity period is present during April–June and the second is during October–December.

In the Sea of Oman, a mesotidal regime is present with the highest tide of 3 m occurring in spring. Low waves bathe the Omani coasts of the Sea of Oman from north of Ras al Hadd to the border of the United Arab Emirates with more energetic waves present south of Ras al Hadd.

The hydrological system in the Sea of Oman is unique as it falls between two high-salinity water masses, the Arabian-Persian Gulf and the Arabian Sea. Therefore, during winter, in the northeast monsoon, the currents usually carry the Arabian seawater mass from the oceanic regions into the Gulf, along the northern Iranian coasts of the Sea of Oman, whereas in summer and during the southwest monsoon, the Sea of Oman experiences an outflow of high-saline Gulf water mass. The exiting current from the Gulf is at about 100 m depth in the Strait of Hormuz and water runs along the Omani coast towards the open Arabian Sea. A boundary is found during summer time and disappears in the fall of the year at the meeting point between the current that propagates along the Omani coasts towards the Arabian Sea and that running along the Omani coast of the Arabian Sea from Somalia.

Southern Coast of the Arabian Peninsula

In the Arabian Sea coasts of Oman, there is a striking type of ocean circulation caused by wind. Such water movement is induced by the summer monsoon starting in June and ending in September and as result a clockwise circulation develops in the area. Upwelling starts at the end of May and reaches its peak in July–August and slows down at the end of September. The upwelling has a great effect on primary productivity in this area and therefore is increased tenfold because of the increase in the level of nutrient concentration.

In addition to the clear effect of monsoons on the movement of water bodies and heat fluxes in this region of the Arabian Sea, the surface currents can be largely accounted for by Ekman drift. The northern Arabian Sea is renowned for a complicated flow pattern consisting of several eddies and little is known at present about the bottom water circulation in the Arabian Sea.

1.4 Climate

Arabian-Persian Gulf

In the northern part of the Gulf, the climate is influenced by the effect of highlands or orography, the mountain series of Turkey, Iran, and the Arabian peninsula. In addition, it is also affected by the climate of the Tigris–Euphrates Valley. The general climate look in the Gulf area is affected mainly by the extra-tropical weather systems from the northwest. The most well-known, and notorious, weather phenomenon in the Gulf is the northwest wind that occurs year round and is known locally as 'shamal' (Reynolds 1993). The winter shamal is a wind that happens unexpectedly and with force. It seldom exceeds 10 m/s (<5% frequency) but lasts several days. On the other hand, the summer shamal affects the area continuously from early June through July. It is associated with the relative strengths of the Indian and Arabian thermal lows. Before spreading to the south, the shamal usually occurs first in the northwest (Delphi and Mosaddad 2010).

The usual weather that performs over the Gulf is the presence of high clouds and the skies are often clear, but fog can reduce visibilities in coastal regions. Except for this coastal fog, visibility is normally good.

Maximum air temperature at daytime along the immediate coast averages between 19 and 23 °C, and that of the inland areas rises to 21–29 °C. The minimum temperature along the coast falls between 7 and 19 °C. In spite of the warm water of the Gulf, dewpoints along even the immediate northern coastline range between −1 and 3 °C.

Sea of Oman

The Sea of Oman has a different climate than that present in the Arabian-Persian Gulf. Here, the Sea of Oman is situated at the northern edge of the tropical weather systems in the Arabian Sea and Indian Ocean. In this area, the monsoon circulation produces southerly winds in the summer and strong northerlies in the winter (Rezai et al. 2004).

The northwesterly winds dominate the atmosphere over the Sea of Oman with high and low pressure in winter and summer, respectively. Air temperature has been shown to vary between 32 and 34 °C in summer, and 18 and 20 °C in winter. Contrary to the Arabian-Persian Gulf, the shamal winds do not dominate over the Sea of Oman and are variable and light during winter; in summer they fall under the effect of the southwest monsoon. It is clear that the southwesterly winds are most pronounced at the eastern end of the Sea of Oman, but they are deflected at its centre to the south or southeast.

Water currents in the Sea of Oman move with a velocity of 0.4–0.6 knots in the winter month of January and the average speed during monsoon time is 0.5 knots which increases in its velocity reaching 10–11 knots near the Arabian Sea entrance. During the northeast monsoon, the wave heights increase to 60 cm to about 1.5 m (Coles 1997).

Water temperatures decrease from 250 °C in December to 21 °C in February, and then rise to 23 °C in March.

Southern Coast of the Arabian Peninsula

There are several aspects that can differentiate the northern part of the Indian Ocean from the rest of the oceans on earth: (1) its northmost boundary extends to 25N making this part a tropical ocean, (2) the presence of monsoons making the winds seasonal, and (3) such seasonal variation is not found in any other ocean. The regular and seasonal monsoon cycle consists of the northeast monsoon from December until February where winds usually blow from the northeast and the southwest monsoon running from June to September with strong winds gusting from the southwest. During the intermonsoon periods the winds have remarkable effects on the hydrography of the region with a significant influence on the distribution of fish and other marine fauna.

1.5 Biodiversity

In spite of the increased interest in biological diversity, knowledge of marine biodiversity remains significantly less than that of terrestrial systems (Ellingsen 2002). Oceans cover about 70% of the earth, and a diverse array of organisms inhabits their various regions (Snelgrove 1998). Such organisms are considered the source of a large number of organisms including humans (Snelgrove 1999; Thrush and Dayton 2002).

The marine flora and fauna in the area around the Arabian peninsula have distinctive biogeographic features (Smith et al. 1987; Kemp 1998) which separated them from those in the Red Sea and the remaining Indian Ocean regions (Price 1982; Sheppard 1987; Kemp 1998; Sheppard and Sheppard 1991; Sheppard et al. 1992a, b). Such distinction makes it possible to recognise three subregional communities for corals and fish communities, for example. This type of subregionalisation reflects the differences in distance and environmental conditions found in the three water bodies.

There are significant influences on fish community structure due to the differences in environmental and oceanographic conditions between the Persian Gulf, the Gulf of Oman, and the Arabian Sea, but thus far no direct comparative studies of fish assemblages among the regions exist. Numerous studies indicate the presence of relatively distinct communities of corals and other benthos in all three regions. Such dissimilarity is related to the differences in environmental factors in the three regions (Price 1982; Sheppard and Sheppard 1991; Sheppard et al. 2000; Coles 2003; Schils and Wilson 2006), and this conclusion possibly applies to fish too. Thus far, some studies of reef fish communities from each region indicate that such differences are likely (Smith and Saleh 1987; Smith et al. 1987; Coles and Tarr 1990; Krupp and Al-Marri 1996; Carpenter et al. 1997), but an ample comparison of reef fish communities among the regions is missing.

Arabian-Persian Gulf

It is known that the Arabian-Persian Gulf contains deprived organisms from the adjacent region (Coles 2003). Low species richness has been reported for the Gulf region (Price 2002). The diversity of the benthic communities, for example, has faced impact caused by the anthropogenic instabilities during the last decades (Riegl 1999, 2002, 2003; Purkis and Riegl 2005). The richness in fish species in the Arabian-Persian Gulf is far lower than the adjacent Sea of Oman (Feary et al. 2010). Such low richness is might be because of the presence of harsh environmental factors in the Gulf such as wide variation in temperature and salinity (Coles and Tarr 1990; Randall 1995). The differences in the extremity of the environmental factors in the two adjacent regions will result in a zoogeographic boundary for species distribution. A similar case is present between the southern part of the Red Sea and the Gulf of Aden (Roberts et al. 1992; Kemp 1998).The northern part of the Gulf, along the Iranian coast, has species richness higher than the south and it seems that such increase is related to the fact that the variation in environmental factors is less extreme than in the south of the Gulf. In the deeper water of the north part of the Gulf the fish species richness is high (Price et al. 1993) and coastal communities showed seasonality in adult movement (Burt et al. 2009).

In one region in the south of the Gulf, the offshore islands of Saudi Arabia, the species richness is noted to be high and it decreases north and east of this area. This area is deep and the extremity of the environmental factors is less than the adjacent east and north extents (Price et al. 1993). The average abundance of fish assemblages in the south of the Gulf is reduced and the result is reflected in the reduction of abundant piscivorous fishes (Stewart and Jones 2001). The abundance of another fish group, the planktivores, seems also to be negatively affected by the unfavourable physical factors in the south of the Gulf.

Sea of Oman

The fish diversity is higher in the Sea of Oman than that in the Arabian-Persian Gulf, but the fauna is deprived compared to the closeby Arabian Sea.

The Sea of Oman is considered among the areas of the northernmost parts of the Indian Ocean regarded as highly diverse regions, encompassing a large number of endemic species (Head 1987). It is assumed that the presence of such a high number of endemic species is due to the geological and hydrographical history of the area and the extreme values of abiotic factors such as high salinity and temperature (Klausewitz 1989; Sheppard and Sheppard 1991).

Therefore, Sheppard et al. (1992a, b) recognised the whole Arabian region as a subdivision of the Indo-West Pacific.

In the Sea of Oman the fish groups are different from those found in the Arabian-Persian Gulf and the Arabian Sea. This is true at least for the reef fish communities. The reef fauna react with environmental factors and produce a kind of habitat specialisation in which they divide into subgroups according to the nature of the environment (Burt et al. 2011; Sheppard 1987, 1998). The sea floor habitats might play an important role in choosing the fish group that can inhabit the area. Riegl (1999) and Burt et al. (2008) suggested that the seasonal changes in the benthic habitats will select which fish group can be present. This case is clear in the Sea of Oman as the benthic habitats change from the Arabian-Persian Gulf to the Sea of Oman. Substantial difference in the diversity of planktivore fish species occurs between the Arabian-Persian Gulf and the Sea of Oman as the former is dominated by high salinity and temperature (Munday and Jones 1998).

Southern Coast of Arabian

The Arabian Sea coasts of Oman are characterised by a short biogeographical transition area of 50 km in comparison with several hundreds of kilometres in other such areas around the world (Bolton et al. 2004), in southern Australia (Bolton 1996), in Florida (Humm 1969), and California (Thom 1980; Murray and Littler 1981). Therefore, it is considered as the sharpest biotic transition zone known in marine biology. In this area, certain centres of endemism are present (Sheppard and Salm 1988; Randall and Hoover 1995; Kemp 1998) and assemblages of flora and fauna are found to be distinct from those in the Sea of Oman and the Arabian-Persian Gulf. This is because of the presence of upwelling phenomena (Sheppard et al. 1992a, b).

There are three zoogeographical features by which the southern Arabian coasts are characterised. These include: (1) a major barrier stretching from the Horn of Africa northeastwards to the coasts of Iran and Pakistan (Klausewitz 1972, 1989; Ormond and Edwards 1987; Blum 1989; Sheppard et al. 1992a, b),

(2) the presence of a centre of endemism at the Arabian Sea coasts of Oman (Randall and Hoover 1995; Randall 1996) with a possibility of extension to the border of Yemen, and (3) the barrier located at the Bab-al-Mandab (Klausewitz 1972, 1989; Briggs 1974; Ormond and Edwards 1987). Those barriers at the Gulf of Aden and along the Somali coasts possibly define the western and southern boundaries of a distinct south Arabian region (Kemp 1998).

The ichthyofauna of the Arabian Sea is considered a typical tropical assemblage, with great taxonomic diversity. In the north Arabian Sea region, there is a trend of somewhat decreasing diversity from east to west, from India to the eastern coast of Somalia (Manilo and Bogorodsky 2003).

The fish species within the coastal ichthyofauna of the north part of the Arabian Sea originated from different distribution types such as the pantropical Indo-West Pacific groups with broad distribution in the Indian Ocean and in the West Pacific from the Red Sea to South Africa and from Japan to Australia; the tropical north Indian distribution group with presence in the Red Sea, the Arabian and the Andaman Seas, in the Gulf of Aden and the Bay of Bengal; the tropical northwestern Indian distribution group which inhabits the Arabian Sea and invades it from the Red Sea; the tropical north Indian West-Pacific distribution group which is found in the northern Indian Ocean and in the West-Pacific; the tropical western Indian distribution group with presence in the Indian Ocean from Cape Agulhas and along the eastern African coast, in the Arabian Sea, and in the Red Sea; the tropical Indo-Pacific distribution group found mainly in tropical regions of the Indian and Pacific Oceans to the west coast of America; the tropical Indo-West Pacific distribution group which has a limited distribution by tropical regions of the Indian and western.

Pacific oceans, and often having a mosaic distribution; the tropical Indian distribution group found in tropical and, partially, subtropical regions of the Indian Ocean; the tropical Atlantic-Indian distribution group which is distributed in the tropical zone of the Atlantic and Indian Oceans; the tropical Atlantic-Indo-West Pacific distribution group which is found in the Atlantic, Indian, and western Pacific oceans; the circumtropical distribution group which is found in the entire tropical zone of all oceans; and the circumglobal distribution group which is widely distributed in tropical, subtropical, and temperate regions of all oceans (Manilo and Bogorodsky 2003). With such different distribution groups of fishes the coastal ichthyofauna of the Arabian Sea includes rather heterogeneous zoogeographical components with a predominance of the Indo-West Pacific species.

In the northeastern Arabian Sea region, some of the reef fish groups found in distinct biogeographic units (Smith and Saleh 1987; Smith et al. 1987; Kemp 1998) were separated from those of the Red Sea and the southern Indian Ocean by a zoogeographic barrier found in the Gulf of Aden (Kemp 1998).

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Part I

Dangerous Fishes

2 Biting and Predator Fish Group

2.1 Chondrichthyes (Cartilagenous Fishes)

Order: Orectolobiformes
Family: Stegostomatidae
Stegostoma fasciatum (Hermann 1783)
Common name: Zebra shark
Arabic name: قرش عنابى، ثعلب البحر
Etymology: *Stegostoma*: Greek, stego = cover + Greek, stoma = mouth (Fig. 2.1)

Identification

- Body cylindrical and flexible with longitudinal ridges on dorsal and median side of body.
- Head broad and depressed with short and rounded snout.
- Last three gill slits located above base of pectoral fin.
- Small eyes and spiracles larger than eyes.
- Nostril with short barbel.
- Mouth transvers, situated in front of eyes with teeth in several close-set rows.
- Very long caudal fin, almost as long as rest of body, with deep subterminal notch but with lower lobe hardly developed.
- No longitudinal skin ridges in young (Randall 1995; Ebert et al. 2013; Froese and Pauly 2016).
- Body grey to yellow with dark brown spots of variable size. No spots anterior to eyes. Young have body with dark brown above and yellowish below. Vertical yellow stripes and spots separating dark saddles.

World Distribution It is distributed in the Indo-West Pacific region. It is reported from the Red Sea, East Africa, New Caledonia, and Fiji. It is also found from northern to southern Japan, and south to New South Wales and Australia (Froese and Pauly 2016).

Distribution in the Study Area This species is found in the waters of all the countries along the coasts of the Arabian-Persian Gulf, Sea of Oman, and the southern coast of the Arabian peninsula.

Habitat and Ecological Role The zebra shark inhabits a marine area and lives in areas associated with reefs. It is also found in brackish waters. It is found at a depth range 0–63 m (Reide 2004). Adults rest in coral reef lagoons (Ebert et al. 2013).

Biology This species lives in small groups of not more than 50 individuals, but in some areas such as southeast Queensland, a large group of zebra sharks were observed each summer (Pillans and Simpfendorfer 2003). Aggresion between males in such large groups is observed as some males bite pectoral fins of other males (Dudgeon et al. 2008).The zebra shark females usually lay large egg capsules measuring about 170 mm long,

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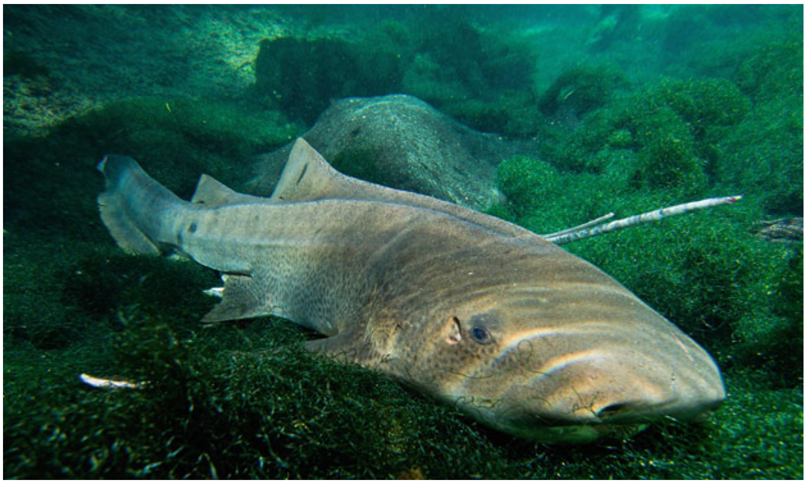

Fig. 2.1 Zebra shark, *Stegostoma fasciatum* (Hermann, 1783). Courtesy of Lewis Cocks, Saudi Arabia

80 mm wide, and 50 mm thick. The egg capsules can be distinguished by having dark brown colour and hairlike tentacles on their sides used to hold to the substrate (Compagno 2002). It takes about 4–6 months for the eggs to hatch in captivity depending on temperature (Dudgeon et al. 2009). This species can live up to 30 years in the wild (Bester 2009). Although this species is reported as a quiet and slow-moving shark, there are records of divers being bitten by zebra sharks who intimidated the fish by pulling their tails. In the International Shark Attack File and in 2008, an unthreatened attack was recorded on this shark (Bester 2009).

Economic Value This species is caught by commercial fisheries in several countries across its range (Compagno 2002). The oil extracted from its liver is used in pharmaceuticals to produce vitamins, the fins for fin soup, and the internal organs as fishmeal (Froese and Pauly 2016). In some parts of the Arabian-Persian Gulf, the liver is used for waterproofing dhows, and carcasses are retained and used as fertilisers (Jabado et al. 2015). In Iran there has been considerable recent research activity into the pharmaceutical applications of shark products, particularly for cartilage in anticancer treatment (Rabbani-Chadegani et al. 2008; Rabbani et al. 2007; Razmi et al. 2008; Shahrokhi et al. 2009) and also for liver oil in combating fungal infection (Hajimoradi et al. 2009). In addition, gelatin extraction from rays for industrial use has been examined (Jalili 2004). In some states of the Arabian-Persian Gulf, the vertebrae of shark are used as earrings (Moore et al. 2011).

Conservation Status IUCN Red List Status, Vulnerable**.** Because of the widely separated populations of this species and because of the nature of the shallow habitat that it lives in, the zebra shark is considered susceptible to localized depletion. In the coral reef habitats, human activity resulted in degradation of these habitats, and this species is significantly affected. A least threat to this species comes from the bycatch by prawn trawl nets (Pillans and Simpfendorfer 2003).

Family: Ginglymostomatidae
Nebrius ferrugineus (Lesson 1831)
Common name: Tawny nurse shark
Arabic name: قرش الممرض الأصفر
Etymology: *Nebrius*: Greek, nebris, -idos = skin of a fawn (Fig. 2.2)

Identification

- Body large and bulky.
- Small mouth; long barbels situated in front of eyes.
- Teeth in multiple rows, but only first three rows functional.

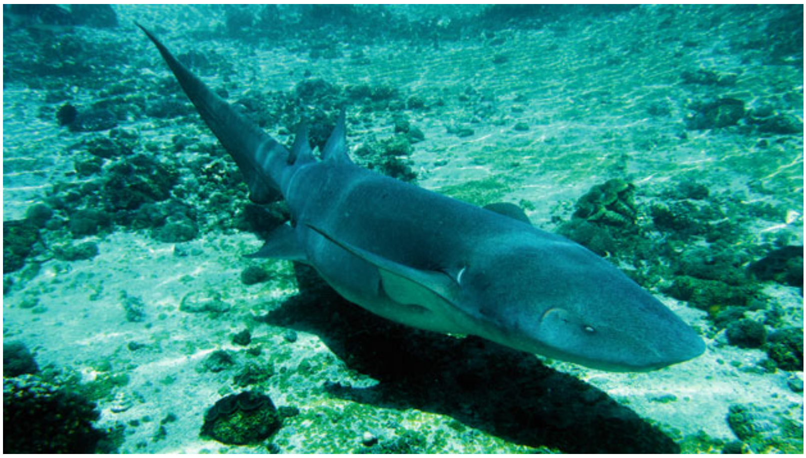

Fig. 2.2 Tawny nurse shark, *Nebrius ferrugineus* (Lesson, 1831). Courtesy of Lewis Cocks, Saudi Arabia

- Spiracle very small.
- Both dorsal and anal fins angular in shape. Caudal fin long and pectoral fins falcate.
- Colour varies within shades of brown to grey with pale ventral side. Fins dark in colour.

World Distribution This species is widely distributed in the tropical Indo-West and central Pacific. It is recorded from the Red Sea and east Africa and from the Tuamoto Islands to southern Japan and south to Australia.

Distribution in the Study Area This species is recorded from the southern coast of the Arabian peninsula. No records are present in both the Arabian-Persian Gulf and the Sea of Oman. Froese and Pauly (2016) reported, based on Compagno (1984), that this species is present in Iranian waters. Checking this reference it appears that Compagno (1984) has left a question mark on the Iranian waters in the distribution map of this species.

Habitat and Ecological Role The tawny nurse shark is a marine species that lives in association with reefs at depths not more than 70 m (Myers 1991). It is usually found in lagoons, channels, and along edges of rocky reefs (Ebert et al. 2013).

Biology This species is mainly nocturnal in habit with a limited activity during the day and aggregating on top of each other (Compagno 1984). It does not wander away from its home and returns to the same daytime resting area. It is ovoviviparous and usually there are four or more young 400 mm long at birth that are born per litter (Compagno 2001). With its muscular pharynx, it sucks its prey from crevices (Ebert et al. 2013). In spite of reports about this shark being a quiet creature, there are infrequent cases where this species is provoked by pulling its tail and severe bites with its strong, small, and sharp teeth were reported (Compagno 2002).

Economic Value The meat of this species is marketed both fresh and dried-salted and the fins usually dried for the famous shark fin soup. The liver is used for producing oil and vitamins and the remaining organs are good for fish meal. The hide is valuable for the leather trade.

Conservation Status IUCN Red List Status, Vulnerable. Due its preference in an area where fishing operations are heavy along its distribution, this species is facing the threat of population decline and total removal in some localities. Things that lead to such cases are the small litters and the limited dispersion (Ebert et al. 2013).

Order: Lamniformes
Family: Odontaspididae
Carcharias taurus (Rafinesque 1810)
Common name: Sand tiger shark
Arabic name: قرش نمر الرمل
Etymology: *Carcharias*: Greek, karcharos = sharpen (Figs. 2.3 and 2.4)

Fig. 2.3 Sand tiger shark, *Carcharias taurus* Rafinesque, 1810. Courtesy of Alessandro De Maddalena, Italy

Fig. 2.4 Sand tiger shark, *Carcharias taurus* Rafinesque, 1810, jaws. Courtesy of Pierre de Chabannes, France

Identification

- Large heavy body.
- Snout flat, short, conical, and pointed.
- Eyes small.
- Mouth long with spike-like teeth of single cusplet.
- Gill openings long situated in front of pectoral fin.
- Dorsal and anal fins large and similar in size.
- Tail asymmetrical with lower lobe very short with distinct notch.
- Dark spots scattered on brownish body and caudal fin. Ventral side white and fins plain (Bass et al. 1986a, b; Compagno et al. 1989; Randall 1995; Compagno and Niem 1998a, b; Ebert et al. 2013).

World Distribution The sand tiger shark has a circumtropical type of distribution. It is not recorded from the central and eastern Pacific (Ebert et al. 2013), but it is found in the Indo-West Pacific region from the Red Sea to off South Africa and east to Japan, Korea, and - Australia (Compagno and Niem 1998a, b). It is also recorded from the western, eastern, and northwest Atlantic (Froese and Pauly 2016).

Distribution in the Study Area In 1980, Gubanovand Shkeib reported this species from Kuwait, Arabian-Persian Gulf. Recently, a second record was reported from Iraqi marine waters (Ali 2013) and a third record was from the coasts of Abu Dhabi, United Arab Emirates (Jabado et al. 2013). This shark is not recorded from the southern coasts of the Arabian peninsula (Manilo and Bogorodsky 2003), but it is reported from the Sea of Oman (Henderson and Reeve 2011).

Habitat and Ecological Role This shark is a marine species that lives in association with a reef and also in coastal waters in depths ranging from <1 to 191 m. It is also reported to be present in underwater caves (Ebert et al. 2013).

Biology The sand tiger shark is a strong slow swimmer that gets its prey during the night. It is the only shark known to take air in and store it in its stomach to keep buoyant while swimming (Compagno and Niem 1998a, b). It lives singly or joins small and large groups (Compagno 1984). The embryos have the habit of what is known as uterine cannibalism where embryos feed on the yolk sac, ova, and other siblings in the womb (Dulvy and Reynolds 1997). The gestation period is between 9 and 12 months and usually the female gives birth to 2 pups (Froese and Pauly 2016). The sand tiger shark is shown to have some interesting social behaviours such as feeding and courtship attributed to their large brain size. There are some nonfatal attack records about the sand tiger shark that happened while spear fishing, line fishing, and shark feeding (Bass et al. 1986a, b). Usually, the normal behaviour of the sand tiger shark is affected by the approach of scuba divers and this might lead the shark to be aggressive and finally attack (Smith et al. 2010).

Economic Value The meat of this shark is used for human consumption. It is usually utilised fresh, frozen, and dried. Its liver is used for oil and vitamins, and other organs are used for fish meal and the skin for the leather industry (Compagno and Niem 1998a, b). In some parts of the Arabian-Persian Gulf, the liver is used for waterproofing dhows, and carcasses are retained and used as fertilisers (Jabado et al. 2013). In Iran there has been considerable recent research activity into the pharmaceutical applications of shark products, particularly for cartilage in anticancer treatment (Rabbani-Chadegani et al. 2008; Rabbani et al. 2007; Razmi et al. 2008; Shahrokhi et al. 2009) and also for liver oil in combating fungal infections (Hajimoradi et al. 2009). In addition, gelatin extraction from rays for industrial use has been examined (Jalili 2004). In some states of the Arabian-Persian Gulf, the vertebrae of shark are used as earrings (Moore et al. 2011).

Conservation Status IUCN Red List Status, Vulnerable. In several countries, the populations of this species are seriously depleted. In addition, a number of eggs are eaten by pups inside the uterus which reduces the number of eggs available for producing new individuals (Ebert et al. 2013). In South Africa, the mortality of this shark is high because of the erection of shark nets that captured about 200 sharks in 2000 (Brazier et al. 2012).

Order: Lamniformes
Family: Lamnidae
Carcharodon carcharias (Linnaeus 1758)
Common name: Great white shark
Arabic name: القرش الأبيض الكبير
Etymology: *Carcharodon*: Greek, karcharos = sharpen + Greek, odous = teeth; *carcharias*: From the Greek 'karcharios' which refers to man-eater sharks (Figs. 2.5 and 2.6)

Identification

- Body heavy, huge, and spindle-shaped.
- Snout large, blunt, and conical with black eyes (Compagno et al. 1989; Ebert et al. 2013).
- Gill slits large.
- First dorsal fin large and anal and second dorsal fins very small.
- Tail with crescent shape and conspicuous keel on caudal peduncle.
- Mouth subterminal with huge triangular teeth (Compagno 2001; Ebert et al. 2013).
- Body greyish-brown in colour with white abdomen. First dorsal fin with dark free rear edge as a result of presence of black spots (Humphries 1986; Ebert et al. 2013).

World Distribution This shark has a cosmopolitan type of distribution and is widely distributed in most oceans. It is found in the western and eastern Atlantic regions. It is also reported from the Seychelles, South Africa, Reunion, and Mauritius (Fricke 1999). In the western Pacific, it is recorded from Siberia in the north to New Zealand in the south (Smith 1997).

Fig. 2.5 Great white shark, *Carcharodon carcharias* (Linnaeus, 1758). Courtesy of Department of Conservation, New Zealand

Fig. 2.6 Great white shark, *Carcharodon carcharias* (Linnaeus, 1758). Courtesy of Alessandro De Maddalena, Italy

Distribution in the Study Area No record of this species from the eastern and southern coasts of the Arabian peninsula except that of Moore et al. (2007) from Kuwaiti waters of the Arabian-Persian Gulf.

Habitat and Ecological Role The great white shark is a marine species and inhabits pelagic oceans. It can stand a wide range of temperature from 5 to 25 °C (Ebert et al. 2013). It swims at depths ranging between 0 and 130 m. This species is epipelagic in nature and found swimming in areas where fur seals, sea lions, cetaceans, and other sharks and large bony fish species are present (Thomas 2010).

Biology The male of this shark reaches maturity at 3.5–4.0 m long, whereas females become mature at length 4.5–5.0 m. Both species reach maturity at age of 15 years and their life span is not more than 30 years, but recent studies showed that they may live up to 70 years (Wikipedia 2016). The adults have body mass of 680–1100 kg with females larger than males.

The maximum length and weight reached by the great white shark are 6.4 m and 3324 kg, respectively (Taylor 1993; Tricas and McCosker 1984; Wroe et al. 2008; Viegas 2010). This shark has intelligent, complex social interactions. With the presence of a large number of sensitive cells, this fish is enable to detect the electromagnetic field emitted by the movement of living animals up to half of billionth of a volt and can detect the faint electrical pulse (Wikipedia 2015). It is one of few sharks known to lift their head above water to locate prey and it is known to be a very curious animal (Martin and Martin 2013). The great white shark of 6.1 m long has the jaw power of 18,000 newtons (1814 kg) (Wroe et al. 2008). It has a hunting technique known as breaching behaviour which is the result of a high-speed approach to the surface with the resulting momentum taking the shark clear out of the water (Martins et al. 2012). The great white shark is responsible for the highest number of shark attacks on humans ever reported. In 2012, records of 272 of unprovoked attacks on humans are given (ISAF 2016). Peter Benchley's best-selling novel, *Jaws* and the subsequent 1975 film adaptation directed by Steven Spielberg, represent the best example of a vicious attack of this shark on humans. In the Mediterranean Sea and during the last two centuries, there were over 30 attacks reported against this shark, most of which were nonfatal. They were included under 'test-bites' where this shark usually test-bites different objects such as buoys and flotsam and might snatch a human or part of his or her body (Benchley 2000).

The fatalities might seem to be low in comparison with the size and vicious behaviour of this species. It has been hypothesised that such a low proportion of fatalities could be because humans are able to escape after the first bite unlike other mammals. This is clear in the great white shark attacks when divers appeared to be partially consumed. The shark usually waits for the prey to be weakened after the first attack and then continues consuming it. In this aspect, human ability to move out of the scene with the help of others will not complete the attack scenario. Death usually happens because of great blood loss from the initial bite rather than for any other reason (Tricas and McCosker 1984). This shark is reported to attack boats and sometimes sink them. Such attacks are usually performed on kayakers, but it has happened that it attacks boats up to 10 m and bumps the boat from the stern, knocking people overboard. The shark attacks on boats are attributed to the electrical field they produce (Tricas and McCosker 1984).

Economic Value Trading the parts of the great white shark such as its teeth and jaws as trophies and its fins for fin soup represent the main fishery exploitation of this species (Compagno 2001). In some parts of the Arabian-Persian Gulf, the liver is used for waterproofing dhows, and carcasses are retained and used as fertiliser (Jabado et al. 2013). In Iran there has been considerable recent research activity into the pharmaceutical applications of shark products, particularly for cartilage in anticancer treatment (Rabbani-Chadegani et al. 2008; Rabbani et al. 2007; Razmi et al. 2008; Shahrokhi et al. 2009) and also for liver oil in combating fungal infections (Hajimoradi et al. 2009). In addition, gelatin extraction from rays for industrial use has been examined (Jalili 2004). In some states of the Arabian-Persian Gulf, the vertebrae of shark are used as earrings (Moore et al. 2011).

Conservation Status IUCN Red List Status, Vulnerable. The increase in fishing, bycatch, beach meshing, and sport fisheries have led to a significant decline in the populations of this species which made it vulnerable according to the IUCN Red List status and it is considered the world's most protected species.

Family: Lamnidae
Isurus oxyrinchus (Rafinesque 1810)
Common name: Shortfin mako
Arabic name: ذيبه
Etymology: *Isurus*: Greek, isos = equal + Greek, oura = tail (Fig. 2.7)

Fig. 2.7 Shortfin mako, *Isurus oxyrinchus* Rafinesque, 1810. Courtesy of Alan Reeve, USA

Identification

- Shark with large, spindle-shaped body with long pointed snout.
- Eyes large and black.
- Mouth U-shaped with long, slender, smooth-edged anterior teeth. Posterior teeth smaller and triangular in shape.
- Head longer than pectoral fin. Caudal fin lunate in shape with strongly developed lower lobe. Second and anal fins very small.
- Body bright dark blue colour and white abdomen. Anterior half of pelvic fin dark (Compagno et al. 1989; Randall 1995; Compagno 1998; Ebert et al. 2013).

World Distribution This shark has a cosmopolitan type of distribution. It is found in the western Atlantic region from the Gulf of Maine to southern Brazil and Argentina (Menni and Lucifora 2007). It is reported from several areas in the eastern Atlantic from Norway to South Africa including the Mediterranean Sea. It is widely distributed in the Indo-Pacific region from the east of Africa to Hawaii and south to Australia and New Zealand. It is also found in the eastern Pacific (Froese and Pauly 2016).

Distribution in the Study Area There no clear record of this species from the Arabian-Persian Gulf. Froese and Pauly (2016) reported this species from the Arabian-Persian Gulf based on Compagno (1984). Checking this reference showed that the author did not mention particular Iranian waters, but instead gave a generalised distribution of this species from the Red Sea westward to Pakistan, India, and Japan. Therefore, the presence of this species in the Arabian-Persian Gulf cannot be acknowledged. It is has been recorded from both the Sea of Oman and the southern coasts of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003; Henderson and Reeve 2011).

Habitat and Ecological Role This shark is a marine species living in pelagic-oceanic areas and with oceanodromous habit (Reide 2004). It is found in warm water of depths of 0–600 m (Ebert et al. 2013). This species of shark uses the heat-exchange produced by the circulatory system to keep the temperature of its muscles and viscera higher than the surrounding seawater. In doing so, the shark obtains an increased level of activity (Carey et al. 1981; Bernal et al. 2001). The short fin mako shark is often found diving into water less than 10 °C. Such activity showed that this shark can explore a range of habitats (Cailliet et al. 2009).

Biology The maximum size of this species is about 4 m (Compagno 2001) and males mature at age of 7–9 years and females vary between 19–21 years for several populations including New Zealand (Bishop et al. 2006) and in the

Fig. 2.8 Pelagic thresher, *Alopias pelagicus* Nakamura, 1935. Courtesy of Alan Reeve, USA

western north Atlantic 18 years (Natanson et al. 2006). Shortfin mako can live up to 29–32 years (Bishop et al. 2006; Natanson et al. 2006). They are ovoviviparous and pups have the habit of oophagy where the grown-up pups eat younger ones and other ova (Mollet et al. 2000). Litters are not more than 25 with length ranging between 600 and 700 mm at birth (Garrick 1967; Compagno 2001). This shark has high attack records against humans. There are 42 records against it in the period from 1980 to 2010 (International Shark Attack File 2016). It is capable of causing injuries and killing humans because of its speed, power, and size. On other hand, some reports showed that this shark can attack only if it is provoked or being captured on a fishing line (Wikipedia 2016). Before attacking divers, this shark swims in a movement forming the number eight. It is usually attacks spear fishermen with cavitation of bubbles caused by a fast movement of its tail. Such cavitation will cause an intense shock wave (Wikipedia 2016).

Economic Value Like other sharks, the meat, oil, fins, hide, and jaws of the shortfin mako are utilised in different manners. The meat of this shark is a high-quality meat (Compagno 2001).

Conservation Status IUCN Red List Status, Vulnerable. This shark has been given a Vulnerable rank in the IUCN Red list because of the pressure it faces in different parts of the world especially from countries with big fishing fleets using the pelagic longline, drifting or set gill nets, and hook-and-line (Holts et al. 1998). Among the measures of conservation to save this species are: fishing pressure must be significantly decreased through the drop in effort, catch limits, and measures to enhance chances of survival after capture, when released, and the application of large-scale oceanic nonfishing areas (Baum et al. 2003).

Order: Lamniformes
Family: Alopiidae
Alopias pelagicus (Nakamura 1935)
Common name: Pelagic thresher
Etymology: *Alopias*: Greek, alopex = fox (Ref. 45335)
Arabic name: سمكة القرش الدرّاسه الساحليه (Figs. 2.8 and 2.9)

Identification

- Body nearly equal in length to upper lobe of tail which curves.
- Lower lobe short and strong.
- Head narrow with convex anterior side with moderately long snout.
- Pectoral fins broad and straight.
- Eyes large and no labial furrows.
- Teeth small with one or two small basal cusps on posterolateral side.
- Body colour mixed with grey and blue on back and on sides with white abdomen

Fig. 2.9 Pelagic thresher, *Alopias pelagicus* Nakamura, 1935, jaws. Courtesy of Hamid Osmany, Pakistan

(Compagno et al. 1989; Randall 1995; Compagno 1998; Ebert et al. 2013; Froese and Pauly 2016).

World Distribution This species has a circumglobal type of distribution. It is distributed widely in the Indo-Pacific region from the Red Sea to South Africa, the Arabian Sea to western Australia, and north to China, Taiwan, Japan, New Caledonia, the Hawaiian Islands, and Tahiti. It is recorded from the eastern Pacific in the Gulf of California and Galapagos (Anderson et al. 1998; Compagno 2001).

Distribution in the Study Area No record of this species from the Arabian-Persian Gulf. The record of Assadi and Dehghani (1997) is not clear as from where exactly in the Iranian waters this species was recorded. Such practice renders this record incomplete. It is reported from the Sea of Oman (Randall 1995; Henderson and Reeve 2011) and from the southern coast of the Arabian peninsula (Compagno 1984; Randall 1995; Manilo and Bogorodsky 2003; Ebert et al. 2013).

Habitat and Ecological Role The pelagic thresher is a marine, pelagic, oceanodromous species (Reide 2004). It sometimes visits the nearshore on narrow continental shelf areas. It lives at depths ranging between 1 and 152 m and sometimes swims farther down to be at the seamounts (Ebert et al. 2013). The distribution of this species seems to be affected by the temperature and oceanic currents and is found near the equator in winter (Dingerkus 1987).

Biology This species of shark is viviparous with a habit of oophagy with usually two litters varying in size between 1580 and 1900 mm in length (Liu et al. 1999). The maximum length reached by this species is 3300 mm and maturity is at age of 8–9.2 years (Reardon et al. 2009). In spite of its large size and predation habit, there are only few attack cases on humans and boats on report about the pelagic thresher (Wikipedia 2015). A single intimidated attack was reported in New Zealand against a spear fisherman (Froese and Pauly 2016).

Economic Value Meat, liver oil, hides, and fins are the several utilisations of this species by humans. The lower urea content in the muscle of this shark is preferred by longline fishermen in Japan over other shark species (Gilman et al. 2007). The fins of this species represent 2–3% of the fin auctions in Hong Kong, the world's largest shark fin trading centre, but they fetch lower value due to their low fin ray count (Clarke et al. 2006). In some parts of the Arabian-Persian Gulf, the liver is used for waterproofing dhows, and carcasses are retained and used as fertiliser (Jabado et al. 2013). In Iran there has been considerable recent research activity into the pharmaceutical applications of shark products, particularly for cartilage in anticancer treatment (Rabbani-Chadegani et al. 2008; Rabbani et al. 2007; Razmi et al. 2008; Shahrokhi et al. 2009) and also for liver oil in combating fungal infections (Hajimoradi et al. 2009). In addition, gelatin extraction from rays for industrial use has been examined (Jalili 2004). In some states of the Arabian-Persian Gulf, the shark vertebrae are used as earrings (Moore et al. 2011).

Conservation status IUCN Red List Status, Vulnerable. This species is ranked as Vulnerable status of the IUCN Red List as it is faces threats from several factors such as the slow life history which gives it a low ability to recover from exploitation, and for the large mortality of individuals of this species through targeted and bycatch fisheries mainly for its meat and fins. The pelagic thresher requires a close-up monitoring programme

Fig. 2.10 Snaggletooth shark, *Hemipristis elongata* (Klunzinger, 1871). Courtesy of Alan Reeve, USA

Fig. 2.11 Snaggletooth shark, *Hemipristis elongata* (Klunzinger, 1871). Courtesy of Tassapon Krajangdara, Thailand

because of the specificity of its life history and the documented evidence of decline in parts of its distribution range (Reardon et al. 2009).

Order: Carcharhiniformes
Family: Hemigaleidae
Hemipristis elongata (Klunzinger 1871)
Common name: Snaggletooth shark
Arabic common name: قرش غير مرتب الأسنان
Etymology: *Hemipristis*: Greek, hemi = half + Greek, pristis = saw (Figs. 2.10 and 2.11)

Identification

- Body slender with long rounded snout.
- Teeth in upper jaw curved with saw-edges and those in lower jaw protruding from mouth.
- Long gill slits.
- Fins strongly curved. First dorsal fin large and dorsally pointed.
- Body light grey colour with no markings (Compagno 1998; Randall 1995; Ebert et al. 2013).

World Distribution This species has an Indo-Pacific distribution. It is reported from the Red Sea down to southeast Africa, to the west to the Philippines, to the north to China, and to the south to Australia (Froese and Pauly 2016).

Distribution in the Study Area The snaggletooth shark has been reported from Bahrain, Iran, Iraq, Kuwait, Qatar, Saudi Arabia, the United Arab Emirates, and the Arabian-Persian Gulf (Compagno 1984; Moore et al. 2012). It is also recorded from the Sea of Oman (Henderson and Reeve 2011) and from the southern coasts of the Arabian peninsula from the coasts of Oman and Yemen (Randall 1995; Manilo and Bogorodsky 2003).

Fig. 2.12 Bignose shark, *Carcharhinus altimus* (Springer, 1950). Courtesy of Alan Reeve, USA

Fig. 2.13 Bignose shark, *Carcharhinus altimus* (Springer, 1950). Courtesy of Hamid Osmany, Pakistan

Habitat and Ecological Role This shark is a marine species preferring demersal habitats (Last and Stevens 1994) and living at depths from 1 to 132 m (Ebert et al. 2013).

Biology The snaggletooth shark is a rare to common species. It reaches 2400 mm in total length (Compagno 1998). Males reach maturity at 1200 mm total length, and females at 1100 mm. It is a viviparous species having 2–11 pups born at 450–520 mm total length with gestation period of 7–8 months (Compagno 1984; Last and Stevens 1994). This shark could be dangerous as it has been equipped with fearsome teeth, has a large body, and inhabits shallow water (Compagno 1984). Therefore, extreme care should be taken to not come close to this shark or intimidate it.

Economic Value The meat of this shark is utilised fresh by humans. The liver is used for its oil and for producing vitamins. The fins are used for the shark fin trade, and the remaining flesh is used for fish meal (Compagno 1984).

Conservation status IUCN Red List Status, Vulnerable. The different methods used in fisheries such as gillnet and trawl (prawn and fish) around the world and especially found in the range of distribution of this species form the main threat to the Snaggletooth shark. Therefore, the population of this shark is declining and it has been rated as Vulnerable on the Red List of the IUCN (White 2003).

Carcharhinus altimus (Springer 1950)
Common name: Bignose shark
Arabic name: قرش كبير الخطم
Etymology: *Carcharhinus*: Greek, karcharos = sharpen + Greek, rhinos = nose (Figs. 2.12 and 2.13)

Identification

- Heavy cylindrical body with large, broad, long snout.
- Nasal flaps long.
- Teeth in upper jaw broad and triangular with serration on posterolateral side; those in lower jaw narrow, erect, and finely serrated.
- Interdorsal ridge conspicuous with large dorsal and pectoral fins. Second dorsal fin smaller than anal fin.
- Dorsal side of body grey; ventral side white. No prominent marks on body, but tips of fins dark (Randall 1995; Ebert et al. 2013; Compagno et al. 1989; Compagno and Niem 1998a, b).

World Distribution The distribution of this shark is distinguished in being a circumtropical type, but there are only patchy records in some world areas. It is recorded in the western Atlantic from Florida to Venezuela, in the eastern Atlantic from Senegal to Ghana including the Mediterranaen Sea, in the western Indian Ocean from China to Australia, and in the central Pacific from Hawaii, and the eastern Pacific from the Gulf of California and south to Mexico and Ecuador (Last and Stevens 1994; Compagno and Niem 1998a, b; Ebert et al. 2013).

Distribution in the Study Area There is no record of this species in the Arabian-Persian Gulf (Moore et al. 2012), although it has been reported from the Sea of Oman (Randall 1995; Henderson and Reeve 2011) and from the southern coasts of the Arabian peninsula from the Gulf of Aden (Manilo and Bogorodsky 2003).

Habitat and Ecological Role This shark is a marine species and found associated with reefs (Mundy 2005). The recent study showed that this shark lives at depths ranging between 80 and 430 m (Ebert et al. 2013). Individuals of bignose sharks have been seen near the surface in some areas including Hawaii, Maldives, Australia, Brazil, and Sri Lanka. Therefore the species is thought to display diurnal vertical migrations (Anderson and Stevens 1996).

Biology The maximum size reached by this shark is 2820 mm in total length and the size at birth is 700–900 mm in total length. Males and females reach maturity at 2160 and 2260 mm in total length, respectively, and the average reproductive age is about 21 years (Compagno 1984; Kohler et al. 1995; Jensen 1996). The bignose is a dangerous shark and causes a fatal attack if a human comes in contact with it. This could happen if the shark comes up in shallow areas (Hennemann 2001).

Economic Value The bignose shark like other sharks has different parts of its body utilised in different aspects of human needs. The liver is used for its oil and for producing vitamins, the meat is consumed, the fins used for the famous fin soup, the skin is used for the shagreen industry, and the remainder of the body is used for fish meal (Pillans et al. 2008).

Conservation Status IUCN Red List Status, Data Deficient. This species of shark is causing concern as an inadequate population and fishery monitoring in addition to its being slow reproducing and heavily fished. For such reasons, this species is rated Data Deficient in the Red List of the IUCN (Pillans et al. 2009). Because of a major threat in the northwestern Atlantic, the IUCN has rated this shark as near threatened. On the other hand, it has been assessed of least concern in Australia where no significant threat is present (Pillans et al. 2008).

Carcharhinus amblyrhynchoides (Whitley 1934)
Common name: Graceful shark
Arabic name: قرش نحيف
Etymology: *Carcharhinus*: Greek, karcharos = sharpen + Greek, rhinos = nose (Figs. 2.14 and 2.15)

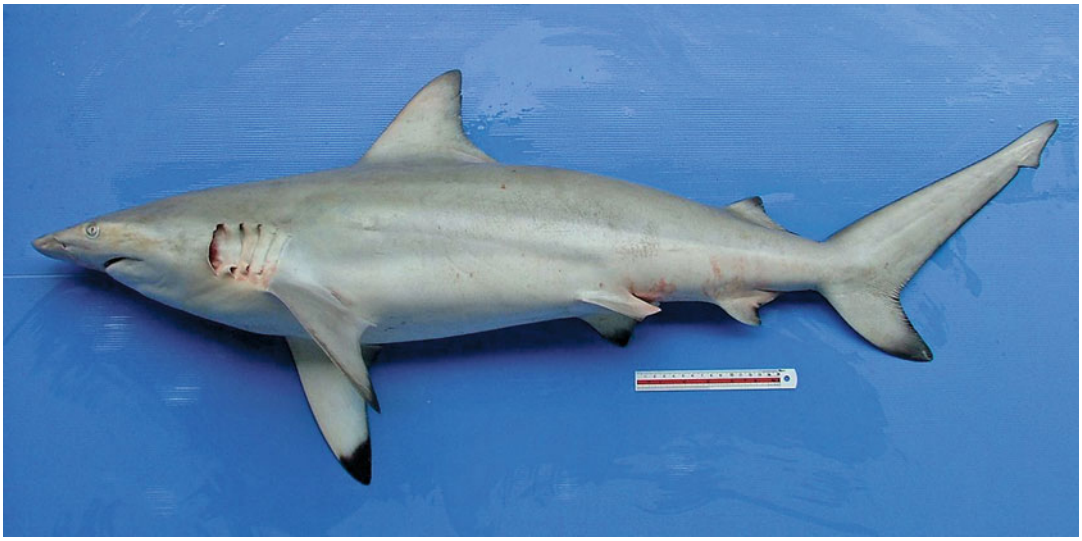

Fig. 2.14 Graceful shark, *Carcharhinus amblyrhynchoides* (Whitley, 1934). Courtesy of Tassapon Krajangdara, Thailand

Fig. 2.15 Graceful shark, *Carcharhinus amblyrhynchoides* (Whitley, 1934). Courtesy of Hamid Osmany, Pakistan

Identification

- Large stout body with short pointed snout.
- Eye and gill slits large.
- Interdorsal ridge absent; pectoral fin reasonably large. Both first and second dorsal fins have short posterior tip. First dorsal fin large and triangular, and second dorsal smaller.
- Body greyish-brown colouration with white colour below and a conspicuous white flank mark. Tips of dorsal, pectoral, and caudal fins black (Randall 1995; Compagno and Niem 1998a, b; Ebert et al. 2013).

World Distribution This species is distributed in the Indo-Pacific region only from the Gulf of Aden to southeastern India and to Papua New Guinea and to the north to Taiwan and south to Australia (Froese and Pauly 2016).

Distribution in the Study Area The only record of this shark from the Arabian-Persian Gulf is that of Moore et al. (2010, 2012) in Kuwait. No record from any other country in the Gulf has been revealed. It has been reported from the Sea of Oman (Henderson and Reeve 2011) and from the coasts of the southern Arabian peninsula at the Gulf of Aden and coasts of Oman (Manilo and Bogorodsky 2003).

Habitat and Ecological Role This shark is a marine species found on continental and insular shelves at depths not more than 50 m (Last and Stevens 1994; Simpfendorfer 2009a, b; Ebert et al. 2013).

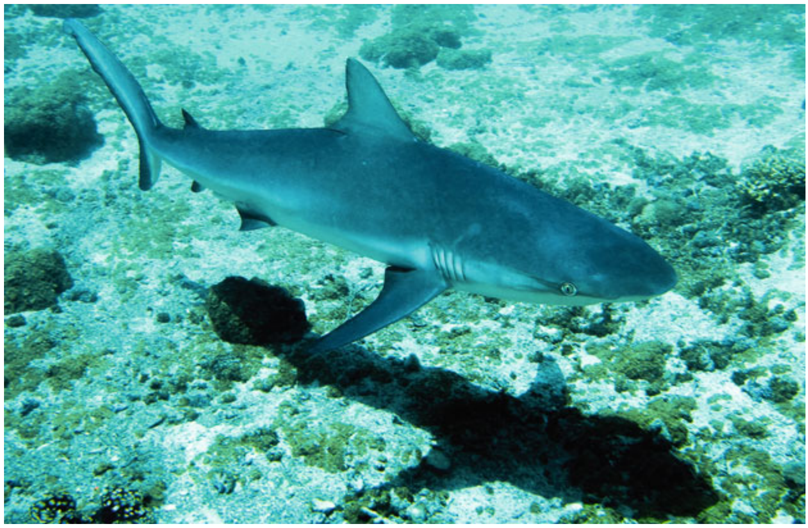

Fig. 2.16 Blacktail reef shark, *Carcharhinus amblyrhynchos* (Bleeker, 1856). Courtesy of Lewis cocks, Saudi Arabia

Biology The largest size reached by this species varies between localities. In the Gulf of Thailand, it reaches 1670 mm in total length (Garrick 1982), whereas in Australian waters, it reaches 1620 mm (Stevens and McLoughlin 1991). Size at maturity is 1100–1150 mm for males and females and the litter size ranges between 1 and 9 pups with sizes between 500 and 600 mm in total length. The gestation period is 9–10 months (Stevens and McLoughlin 1991). The shark uses its strong eyesight, sense of smell, and the organs around the head (Ampuli of Lorinzini) to locate the prey. The prey is usually captured by the sharp serrated teeth with a sudden snap of the crushing jaws (Bannister 1993). This species is dangerous to humans as it has body size and very sharp teeth that could easily cause a fatal attack especially if the shark is provoked.

Economic Value The Graceful shark is used for its meat, liver oil, fins, and skin. It is regularly caught by gill net and longline along its distribution line (Simpfendorfer 2009a, b).

Conservation Status IUCN Red List Status, Near Threat. Due to the high catch by gill net and longline along its distribution line, a major threat is facing this shark. Therefore, it has been rated Near Threat in the IUCN Red List and presently there are no measures whether conservation or management is placed for this species (Simpfendorfer 2009a, b).

Carcharhinus amblyrhynchos (Bleeker 1856)
Common name: Blacktail reef shark
Arabic name: قرش ذو الذيل الأسود
Etymology: *Carcharhinus*: Greek, karcharos = sharpen + Greek, rhinos = nose (Fig. 2.16)

Identification

- Body cylinder with round and broad snout.
- Eye area rounded.
- Teeth on upper jaw serrated with triangular cusp. Central upper teeth erect, lateral ones oblique.
- No interdorsal ridge.
- First dorsal fin large and second dorsal short rear tip. Pectoral fin falcate and narrow.
- Body dark grey dorsally and white ventrally. Caudal fin with clear black edge and dorsal fin with obvious white tip (Randall 1995; Compagno and Niem 1998a, b; Ebert et al. 2013).

World Distribution This shark is an Indo-Pacific species distributed from Madagascar and the Mauritius–Seychelles areas to the Tuamoto archipelago. It is distributed farther north to southern China and south to north Australia (Froese and Pauly 2016).

Distribution in the Study Area The only record from the Arabian-Persian Gulf is that of Moore et al. (2010) and it is based on an underwater photograph from Jana Island, Saudi Arabia (Moore et al. 2010). It has been reported from the Sea of Oman (Henderson and Reeve 2011) and from the southern coasts of the Arabian peninsula from Yemeni and the Omani coasts (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecological Role This marine shark species is found associated with reefs and with oceanodromous habit (Reide 2004). It lives in depths ranging between surfaces to around 1000, but is usually found at depth 0–280 m (Florida Museum of Natural History 2005; Ebert et al. 2013).

Biology It takes 7 years for the males and females of this species to attain their maximum size of 1850 and 1250 mm in total length, respectively (Wetherbee et al. 1997). Females reproduce every other year and give birth to six small embryos; (Compagno 1984; Last and Stevens 1994; Wetherbee et al. 1997) gestation lasts for 9 months in the southern hemisphere (Stevens and McLoughlin 1991). It is a dangerous shark that humans need to be careful of, especially when the shark is hassled. It is shown to have conventional threats (Johnson and Nelson 1973; Nelson 1981; Randall 1986) and divers are recommended to keep away from this shark and not take photos when the shark is in an unpredictable swimming movement (Smale 2009). The grey reef shark is a curious creature about what is happening around it especially with divers when they first enter the water (Compagno 1984). If they meet in open water, they become more dangerous than on the reef (Stafford-Deitsch 1999). This shark has records of attack against spearfishers when it raided the speared fish very close to the diver. The shark has also shown cases of attack when it is followed or confronted and in such cases, divers should go back, but keep facing the shark (Compagno 1984). The flash from a camera of the divers has encouraged at least one attack (Martin 2007). Noteworthy damage can be imposed by this shark in spite of its reasonable size. Bright (2000) wrote about this case saying, '[D]uring one study of the threat display, a grey reef shark attacked the researchers' submersible multiple times, leaving tooth marks in the plastic windows and biting off one of the propellers. The shark consistently launched its attacks from a distance of 6 m, which it was able to cover in a third of a second.' The Florida Museum of Natural History (2005) has recorded seven cases of unthreatened attack and another six provoked attacks against this shark since 2008.

Economic Value This shark is utilised for its meat, liver, fins, skin, and the remainder of the body for fish meal (Froese and Pauly 2016).

Conservation Status IUCN Red List Status, Near Threat. This species is ranked Near Threat in the IUCN Red List for these factors: limited habitats, site loyalty, small number of pups, relative late age at maturity, and increasing unmanaged fishing pressure (Ebert et al. 2013). In some important reef diving sites, this shark is protected as it lives in clear water that is used for tourism diving (Anderson and Ahmed 1993).

Carcharhinus amboinensis (Müller and Henle 1839)
Common name: Pigeye shark
Arabic name: قرش كبير العين
Etymology: *Carcharhinus*: Greek, karcharos = sharpen + Greek, rhinos = nose (Fig. 2.17)

Identification

- Body huge.
- Very big head with short, broad, blunt snout.
- Eyes small.

Fig. 2.17 Pigeye shark, *Carcharhinus amboinensis* (Müller & Henle, 1839). Courtesy of Alan Reeve, USA

- Teeth in upper jaw broadly triangular and coarsely serrated; those in lower jaw slightly oblique anteriorly.
- Absence of interdorsal ridge.
- First dorsal fin large with pointed dorsal tip. Second dorsal and anal fins equal in size. Pectoral fins large.
- Body greyish colour dorsally and white ventrally; fins with dark tips (Compagno et al. 1989; Randall 1995; Ebert et al. 2013).

World Distribution This shark is mainly distributed in the Indo-Pacific region from South Africa to Madagascar and the Gulf of Aden to the west to Pakistan, Indonesia, and Papua New Guinea (Last and Stevens 1994), and then to Australia. It is also reported from the Mediterranean Sea (Froese and Pauly 2016).

Distribution in the Study Area This species is reported from the Arabian-Persian Gulf in the Bahraini, Kuwaiti, and Qatari waters (Moore et al. 2012). It has been recorded from the southern coasts of the Arabian peninsula in the Yemeni and Omani waters (Manilo and Bogorodsky 2003; Henderson and Reeve 2011).

Habitat and Ecological Role This shark is a marine species associated with reefs and lives at depths ranging from surfaces to 150 m (Compagno and Niem 1998a, b).

Biology Males and females reach maturity at 2100 and 2150–2200 mm in total length, respectively (Stevens and McLoughlin 1991; Cliff and Dudley 1991). The young individuals are 600–750 mm in total length at birth (Fourmanoir 1961).The number of pups ranges between 3 and 13 and the gestation period in South Africa is 12 months, and 9 months in Australia (Stevens and McLoughlin 1991; Cliff and Dudley 1991). This shark is dangerous to humans with its huge and fearful teeth which can cause a fatal attack. This shark could be dangerous to humans in another way. Because this species is a predator, it accumulates ciguatera toxins produced by dinoflagellate algae within its tissues. A record from Madagascar in 1993 shows that about 500 people were poisoned by eating the meat of this shark and 98 of them died (Habermehl et al. 1994).

Economic Value As in other shark species, it has been taken for its meat, fins, liver, skin, and other body remains, but in small quantities along its distribution line.

Conservation Status IUCN Red List Status, Data Deficient. This shark is rated as Data Deficient in the IUCN Red List because of the decline in both catch rate and average size of sharks during the period 1978 and 1998 (Cliff 2009).

Fig. 2.18 Spinner shark, *Carcharhinus brevipinna* (Müller & Henle, 1839). Courtesy of Hiroyuki Motomura, Japan

Carcharhinus brevipinna (Müller and Henle 1839)
Common name: Spinner shark
Arabic name: القرش الدوار
Etymology: *Carcharhinus*: Greek, karcharos = sharpen + Greek, rhinos = nose (Fig. 2.18)

Identification

- Cylindrical body.
- Narrow, long, pointed snout.
- Eyes small with conspicuous labial furrow.
- Long gill slit.
- In both jaws, teeth small with broad base and narrow cuspid becoming oblique posteriorly.
- Interdorsal ridge absent.
- First, second, and anal fins small with first dorsal slightly pointed.
- General colour of body grey with clear white bands on sides. Second dorsal and anal fins and tip of lower caudal fin lobe dark grey-tipped. Colouration pattern not present in small individuals (Compagno et al. 1989; Randall 1995; Compagno and Niem 1998a, b; Ebert et al. 2013).

World Distribution This shark has a cosmopolitan type of distribution, but in temperate and tropical waters. It is reported from the Atlantic Ocean and the Mediterranean Sea and from the Indo-Pacific region (Froese and Pauly 2016; Ebert et al. 2013).

Dsitribution in the Study Area Moore et al. (2012) stated that this species is widely distributed in the Arabian-Persian Gulf, but without the availability of specimens (Basson et al. 1977; Goubanov and Shleib 1980; Bishop 2003). There are some variations in the report of this species from the Arabian-Persian Gulf. Sivasubramaniam and Ibrahim (1982) have misidentified this species with *C. sorrah* and Fischer and Bianchi (1984) included it with the other shark species found in this area, but Carpenter et al. (1997) did not consider it among the fish fauna of the Arabian-Persian Gulf area as did Compagno et al. (2005). Moore et al. (2012) has reported this species from Kuwait. The spinner shark has been reported from the Sea of Oman (Henderson and Reeve 2011) and for the southern coasts of the Arabian peninsula (Manilo and Bogorodsky 2003; Henderson and Reeve 2011).

Habitat and Ecological Role This is a marine shark species with reef-associated life and oceanodromous habit (Reide 2004). It lives in depths down to 100 m (Reiner 1996). It is also found in offriver mouths to about 75 m (Ebert et al. 2013).

Biology The most interesting behaviour of this species of shark is its habit of leaping out of the water. It has been seen rotating as many as three times in the air and falling back in the water on

Fig. 2.19 Silky shark, *Carcharhinus falciformis* (Müller & Henle, 1839). Courtesy of Hiroyuki Motomura, Japan

Fig. 2.20 Silky shark, *Carcharhinus falciformis* (Müller & Henle, 1839). Courtesy of Hamid Osmany, Pakistan

its back (Burgess 2009). It has a viviparous way of reproduction with a presence of placenta and a gestation period of 11–15 months. The number of pups from the female varies between 3 and 20 and it is usually 7–11; the whole reproductive cycle takes about 2 years (Castro 1993; Burgess 2009). Males reach maturity at about 1300 mm in total length and in 4–5 years, whereas females reach maturity at 1500–1550 mm in total length and in about 7–8 years. Maximum size reached by this species ranges between 2250 and 2500 mm in total length, and the maximum age is between 15 and 20 years (Branstetter 1987a, Burgess 2009). This species forms a potential danger to humans especially when spearfishing (Compagno 1984) and there are a number of attacks documented in the international Shark Attack File about this shark (ISAF 2009).

Economic Value This shark is usually taken by humans for its several usages such as by recreational commercial fisheries. The meat is utilised fresh or dried-salted and the fins are used for fin soup in the Far East. The skin is used by the leather industry and the liver to extract oils and produce vitamins (Burgess 2009).

Conservation Status IUCN Red List Status, Threatened. This shark is ranked as Threatened in the Red List of the IUCN because of the fishing pressure put on throughout its range of distribution. Thus far there are no conservation measures set for this species (Burgess 2009).

Carcharhinus falciformis (Müller and Henle 1839)
Common name: Silky shark
Arabic name: القرش الحريرى
Etymology: *Carcharhinus*: Greek, karcharos = sharpen + Greek, rhinos = nose (Figs. 2.19 and 2.20)

Identification

- Large, but slim with rounded, long, and flat snout.
- Eyes large.
- Jaws small. Teeth in upper jaw oblique and triangular, whereas those in lower jaw are erect and have cusps with smooth edges.

- Presence of narrow interdorsal ridge.
- First dorsal fin with rounded apex. It is the largest among the median fins and second dorsal is smallest. Long and narrow pectoral fin. Absence of caudal keel.
- Body dark grey to brownish grey above and white below. Absence of fin markings except for dark shade on tips of all fins except first dorsal (Compagno et al. 1989; Randall 1995; Smith 1997; Ebert et al. 2013).

World Distribution It has a circumtropical type of distribution. It is reported in the western and eastern Atlantic with scattered records in the Indo-Pacific region. It is found in the eastern Pacific as well (Lubbock and Edwards 1981; FAO Department of Fisheries 1994; Debelius 1998; Menni and Lucifora 2007; Ebert et al. 2013).

Distribution in the Study Area There is no record of this shark from the Arabian-Persian Gulf (Compagno 1984; Moore et al. 2012). It has been reported from the Sea of Oman (Randall 1995; Henderson and Reeve 2011) and from the southern coasts of the Arabian peninsula from the coasts of Yemen and Oman (Manilo and Bogorodsky 2003).

Habitat and Ecological Role It is a marine shark species found in association with reefs and with oceanodromous habit. It lives in depths ranging from surfaces to about 4000 m, but commonly water of less than 200 m depth and enters inshore areas of about 18 m depth (Last and Stevens 1994; Reide 2004; Florida Museum of Natural History 2005; Ebert et al. 2013).

Biology The silk shark follows the viviparous method of reproduction where females give birth to pups. The interesting point in its reproduction habit is the yolk sac will be converted to a placental connection to obtain food from the mother's body once the yolk is exhausted. This placenta is not similar to that of mammalian placenta as there is no interdigitation between the tissue of the fetus and that of the mother. Moreover, the red blood cells of the fetus are much smaller than those of the mother which is opposite to that present in mammals. The female has a functional right ovary only and with two functional uteruses which are separated into longitudinal partitions for each embryo (Gilbert and Schlernitzauer 1966). It reproduces year-round, but in some regions mating and birth take place in spring or early summer (Branstetter 1987a, b; Bonfil et al. 1993). The gestation period of 12 months happens either every year or every other year. The typical litter size is 6–12 (Bonfil 2008). Males reach maturity at age of 6–10 years with 2150–2250 mm total length and females at 7–12 years with 2320–2460 mm total length (Bonfil et al. 1993); the maximum life span is 22 years and the maximum size it reaches is 3300 mm in total length (Randall and Hoover 1995). This shark is an aggressive predator and has an explicit attack behaviour and the consequence of such behaviour is unknown until confronted (Perrine 2002). It is dangerous to humans as it becomes aggressive in the case of confronting spearfishing divers (Stafford-Deitsch 1999, 2000). The International Shark Attack File contains several attack records about this Shark Facts (2016).

Economic Value As is the case in other sharks, it is utilised for its meat fresh and dried-salted, liver for its oil and vitamin production, skin for leather manufacturing, and fins for the famous shark fin soup. Fins from about one and half million silky sharks are traded globally per year in the Hong Kong fin market (Bonfil 2008). In the tropics, the jaws of this shark are sold to tourists (Martin 2006).

Conservation Status IUCN Red List Status, Near Threatened. For the reasons of being heavily fished and the absence of management, this shark is rated as threatened in the Red List of the IUCN (Bonfil et al. 2009). However, it is at the state of vulnerable in regions and this status could stand globally in the near future for this species (Ebert et al. 2013).

Fig. 2.21 Galapagos shark, *Carcharhinus galapagensis* (Snodgrass & Heller, 1905). Courtesy of Pedro Niny Duarte, Portugal

Carcharhinus galapagensis (Snodgrass and Heller 1905)
Common name: Galapagos shark
Arabic name: قرش جزر الجلاباجوس
Etymology: *Carcharhinus*: Greek, karcharos = sharpen + Greek, rhinos = nose (Fig. 2.21)

Identification

- Large body with long, broadly-rounded snout.
- Anterior nasal flaps low with large eyes and large erect teeth.
- Interdorsal ridge.
- Pectoral fin large and wide.
- Body dark grey with white abdomen. No visible marking on fins, but fin tips dusky (Compagno and Niem 1998a, b; Ebert et al. 2013).

World Distribution This shark has a circumtropical type of distribution with patchy occurrence. It is reported from the eastern Atlantic, western Indian Ocean, and western and eastern Pacific (Lavenberg et al. 1994; Ebert et al. 2013).

Distribution in the Study Area There is no record of this species from the Arabian-Persian Gulf, but it has been reported from the Sea of Oman (Henderson and Reeve 2011). This record is considered the first in the north Indian Ocean.

Habitat and Ecological Role This shark is a marine species that lives in association with reefs and is found at depths ranging from the surface down to 286 m, but is usually seen at 30–180 m. It prefers areas with strong currents (Myers 1999; Mundy 2005; Ebert et al. 2013).

Biology Individuals of this shark are found in small aggregations, but not forming organised schools (Ebert et al. 2013). It reaches a maximum size of 3500 mm in total length with males reaching maturity at 2050–2500 mm in total length with age of 6.5–9 years and females at 2150–2500 mm in total length with age of 6–8 years (Bass et al. 1973a, b; De Crosta et al. 1984; Last and Stevens 1994; Wetherbee et al. 1997). Number of pups at birth ranges from 4 to 16 with 600–810 mm in total length (Bennett et al. 2003). Mating occurs during winter to spring and females breed every other year (Smith et al. 1998). This shark is aggressive and has been shown to have a hunch display habit once divers come close to its territory (Ebert et al. 2013). Unprotected divers should not attempt to enter areas where individuals of this shark are abundant. This shark is attracted to fishing activities

Fig. 2.22 Bull shark, *Carcharhinus leucas* (Müller & Henle, 1839). Courtesy of Hiroyuki Motomura, Japan

(Wikipedia 2015). It might start a feeding frenzy if a weapon is used against it by divers (Compagno 1984). This shark has attack records with at least one fatality (ISAF 2009).

Economic Value This shark like other shark species is taken for its meat, liver oil, skin, and its jaws to sell as a tourist commodity.

Conservation Status IUCN Red List Status, Near Threatened. This shark has been given the Near Threatened rank in the IUCN Red list because of its life history parameters and the decline of the population along its geographical distribution. The aggressive nature and its presence in shallow areas increase the pressure to eradicate this species from the local populations Bennett et al. (2003).

Carcharhinus leucas (Müller and Henle 1839)
Common name: Bull shark
Arabic Name: القرش الثور
Etymology: *Carcharhinus*: Greek, karcharos = sharpen + Greek, rhinos = nose (Fig. 2.22)

Identification

- Huge body with broad, short, and blunt snout.
- Eyes small.
- Teeth in upper jaw serrated with broad triangular shape, whereas those in lower jaw slender and pointed.
- No interdorsal ridge and no spiracle.
- Posterior lateral gill-slit situated at origin of pectoral fin. First and second dorsal fins large with first dorsal having pointed top and both dorsal fins having short rear tips. Pectoral fins broad and large. Anal fin nearly similar in size to second dorsal fin.
- Body grey in colour with white abdomen. Young individuals have black tips on their fins, which is faded in adults (Compagno et al. 1989; Van der Elst 1993; Randall 1995; Smith 1997; Compagno and Niem 1998a, b; Séret 2003; De Carvalho et al. 2007; Ebert et al. 2013).

World Distribution This shark is widespread in world oceans, rivers, and lakes and prefers warm water. It is recorded from the eastern Atlantic and Indo-Pacific regions (Menni and Lucifora 2007; Séret 2003).

Distribution in the Study Area The bull shark is recorded from the Arabian-Persian Gulf in the waters of Iran (Coad and Papahn 1988), Iraq (Coad and Al-Hassan 1989), and Qatar (Moore et al. 2012). The record of this species from Kuwait given by Froese and Paully (2014) based on Compagno (1984) is not correct as Compagno (1984) did not mention its presence in Kuwaiti waters. It has been reported from the Sea of Oman (Randall 1995; Henderson and

Reeve 2011) and from the southern coasts of the Arabian peninsula (Manilo and Bogorodsky 2003; Henderson and Reeve 2011). It is reported to ascend rivers in Iran (Coad and Papahn 1988) and in Iraq (Coad and Al-Hassan 1989). Recently, this species has been reported to be present at Nasiriyah City, 170 km north of the nearest marine water point (Hussain et al. 2012). This record represents the northmost extension for this species.

Habitat and Ecological Role This shark is a marine species, but sometimes ascends rivers and is found in brackish waters. It is found living in association with reefs and at depth range 1–152 m (Sommer et al. 1996; Reide 2004). The bull shark is a euryhaline species including its juveniles as they migrate into freshwater areas. They favour warm water, but they migrate again once water temperature changes (Ebert et al. 2013). This shark has an unusual degree of tolerance to both fresh and high-saline waters (Randall 1995). The movement of the bull shark to brackish or freshwater areas is to give birth (Springer 1963) and the young use these localities as a nursery area and have no predators in such areas (Snelson et al. 1984). The recent bull shark specimen captured at Nasiriya, Iraq, 170 km north of the nearest marine water point, was shown to be a female, 2060 mm in total length (Hussain et al. 2012). This record of this female supports the suggestion of Snelson et al. (1984).

Biology This shark prefers swimming near the seabed in water less than 20 m deep, but it is fast when attacking prey (Ebert et al. 2013). Females are often seen with courtship scars. This shark can grow up to 3400 mm in total length and its young are usually born at 560–810 mm in total length. Males and females mature at 1570–2260 and 1800–2300 mm in total length, respectively (Compagno 1984). It has a placental viviparity type of reproduction and the gestation period will last for 10–11 months; the female reproduces every other year (Clark and von Schmidt 1965; Bass et al. 1973a, b; Branstetter 1981; Compagno 1984). It was estimated that males and females can live up to 12 and 16 years, respectively, and the oldest male and female found were 21.3 and 24.2 years, respectively (Thorson and Lacy 1982). Males mature at age of 14–15 years, and females at age of 18+ (Branstetter and Stiles 1987). This shark can distinguish between colours of mesh netting present underwater and was found to be attracted to bright yellow survival gear rather than ones that were painted black (Bres 1993). This shark is able to conserve energy during the changing of tidal flow as it moves downriver and also through decreasing the amount of energy required for osmoregulation (Ortega et al. 2009). The movement into freshwater gives another benefit to this shark, one that is related to evolution. The majority of shark species are not be able to live in a freshwater habitat and this shark has evolved their offspring in freshwater. This habitat acts as a protector for the young ones from the attacks of larger sharks (Heupel et al. 2007). Because of its habit of dwelling in very shallow waters, more than any other species of shark, this shark is considered among the most dangerous creatures to humans (National Geographic 2016). There are plenty of records of attacks of this shark against humans in both marine and freshwater habitats (Frantz 2011; Wikipedia 2016). In the Middle East and in the rivers found in southern Iran, an attack of the bull shark has been documented. It includes 11 attacks with 3 fatalities recorded for the period 1953–1985. The Iranian records are considered as a substantial proportion of about 28% of the documented cases worldwide for an activated freshwater attack at the time of writing this information (Coad and Papahn 1988). Similar attacks by this species of sharks have occurred in Shatt Al-Arab River, Basrah City, Iraq (Coad and Al-Hassan 1989), where 11 attacks on humans in Al-Ashar Canal, the centre of Basrah City and Abu Al-Khasib, Basrah City, 15 km downriver from Basrah on Shatt Al-Arab River, Iraq. Two of the 11 attacks were fatal. The attacks appear to be accidental confrontations between sharks and victims as they use the river for washing or

Fig. 2.23 Blacktip shark, *Carcharhinus limbatus* (Müller & Henle, 1839). Courtesy of Hiroyuki Motomura, Japan

Fig. 2.24 Blacktip shark, *Carcharhinus limbatus* (Müller & Henle, 1839). Courtesy of Hamid Osmany, Pakistan

swimming. Among the cases reported by Coad and Al-Hassan (1989) was an attack that involved date palms. Blegvad and Løppenthin (1944) narrated that individuals of this species seen at Mohammara, southern Iran usually position themselves under palm trees to eat falling dates and thus they come in contact with people at the riverbank. The riverine attack of this shark numbered 34 in 1988 and with the addition of the 11 cases from Iraq brings the total to 45 cases in 1989 and it represents about 34% of the freshwater attacks worldwide at the time of writing (Coad and Al-Hassan 1989).

Economic Value This shark is commonly caught in both commercial and recreational fisheries. However, the bull shark is not a fishery target and is caught as bycatch. It is taken for its meat, skin, liver oil, and fins as they are important products driving major demand (Simpfendorfer and Burgess 2009a, b).

Conservation Status IUCN Red List Status, Near Threatened. This species of shark has been given the rank of Near Threatened in the IUCN Red List for their habit of living in shallow waters that makes it an easy target for humans, habitat loss and degradation, and heavy fishing. No conservation programmes are in place for this species of shark. It is managed in the US east coast shark fisheries (Simpfendorfer and Burgess 2009a, b).

Carcharhinus limbatus (Müller and Henle 1839)
Common name: Blacktip shark
Arabic name: قرش أسود طرف الزعنفه
Etymology: *Carcharhinus*: Greek, karcharos = sharpen + Greek, rhinos = nose (Figs. 2.23 and 2.24)

Identification

- Heavy body with long pointed snout and long gill slits.
- Eyes small.
- No interdorsal ridge.
- First dorsal fin large and falcate.
- Teeth in upper and lower jaws somewhat similar in shape, being moderately long, erect, and narrowly pointed with a broad base. Those of upper jaw coarsely serrated along

cusp and crown; those in lower jaw have fine serrations and tend to curve inwards.

- Body bronze in colour becoming grey after death; clear white band is present. Tips of fin have black colouration (Compagno et al. 1989; Randall 1995; Compagno and Niem 1998a, b; Ebert et al. 2013).

World Distribution The blacktip shark has a cosmopolitan type of distribution. It is reported to be present in the western and eastern Atlantic as well as the Mediterranean Sea. It is also recorded from the Indo-Pacific and eastern Pacific regions (Claro 1994).

Distribution in the Study Area This species of shark is present in the Arabian-Persian Gulf. It has been reported from Iran and Iraq (Compagno 1984) and from Kuwait and Qatar (Moore et al. 2012). It is also found in the Sea of Oman (Randall 1995; Henderson and Reeve 2011) and on the southern coasts of the Arabian peninsula (Manilo and Bogorodsky 2003; Henderson and Reeve 2011).

Habitat and Ecological Role This shark is a marine species found in brackish water and has a habit of living in association with reefs. It lives at depths from surfaces to 64 m (Reide 2004; Mundy 2005; Florida Museum of Natural History 2005). It is also recorded in estuaries and shallow muddy bays and has been shown to tolerate low salinity water (Ebert et al. 2013).

Biology The individuals of this shark live in loose aggregations (Castro 1996). Such segregation occurs by age and sex and is intense in early summer when there are a large number of young. Females are seasonally migratory and move inshore when they are pregnant to drop their young (Ebert et al. 2013). This shark has an unusual habit of leaping from the water, rotating in the air and falling on its back in the water and in doing so it resembles the spinner shark (Burgess and Branstetter 2009). The maximum size reached by this shark is 2550 mm in total length. The average adult size is 1500 mm in total length. Males and females mature at 4–5 and 6–7 years, respectively, and the maximum age reached by this shark is 12 years. The black tip shark has the placental viviparous method of reproduction and females give birth to 4–11 pups with a mean of 4–6. The gestation period is 11–12 months occurring every other year and the pups are born at 530–650 mm in total length (Killam 1987; Dudley and Cliff 1993; Castro 1996). This shark has an attack record against humans which includes unprovoked attacks, but none was fatal. The blacktip sharks are liable for roughly 16% of the attacks that occur in Florida waters, often smacking surfers. This shark becomes aggressive in the presence of food, therefore spearfishing divers should take extreme care (Compagno 1984).

Economic Value This shark is fished mainly for commercial fisheries, but also for recreational fisheries. The shark is taken for its meat, fins, liver oil, and skin as a leather commodity (Burgess and Branstetter 2009).

Conservation Status IUCN Red List Status, Near Threatened. This shark is rated Near Threatened in the IUCN Red List because of the great demand for its meat as it is considered among the best meat of the shark species. In addition, it is taken for recreational fishing. Therefore, it has been a target of both recreational and commercial fisheries which cause a depletion in its population along its geographical range. The black tip shark gained conservation measures in only two countries, Australia and the United States, where regulated steps of conservation have been taken (Burgess and Branstetter 2009).

Carcharhinus longimanus (Poey 1861)
Common name: Oceanic whitetip shark
Arabic name: قرش المحيط أبيض الخطم
Etymology: *Carcharhinus*: Greek, karcharos = sharpen + Greek, rhinos = nose (Figs. 2.25 and 2.26)

Fig. 2.25 Oceanic whitetip shark, *Carcharhinus longimanus* (Poey, 1861). Courtesy of Alan Reeve, USA

Fig. 2.26 Oceanic whitetip shark, *Carcharhinus longimanus* (Poey, 1861). Courtesy of Hamid Osmany, Pakistan

Identification

- Very big body with short and blunt snout.
- Eyes small.
- Teeth in upper jaw triangular with strong serration; lower jaw have narrow cusp, slightly serrated, and erect.
- Interdorsal ridge low.
- Pectoral fins large with rounded end. First dorsal fin rounded.
- Caudal keel present, but not clear.
- Body dark grey to black colouration with bronze shades. Ventral side whitish. Tips of first dorsal, pectoral fins, and lower lobe of caudal fin white or with white spots. Black spots at tip of anal and second dorsal fin and ventral lobe of caudal fin. Presence of dark saddle marks anterior to dorsal fin (Compagno and Niem 1989; Randall 1995; Compagno 1998; Ebert et al. 2013).

World Distribution The oceanic whitetip shark has a cosmopolitan type of distribution. It has been reported to be present in the western and eastern Atlantic regions. It is also found in the Indo-Pacific and the eastern Pacific (Claro 1994; Smith 1997; FAO Fisheries Department 1994).

Distribution in the Study Area There is no record of this shark from the Arabian-Persian Gulf and the sea of Oman (Henderson and Reeve 2011; Moore et al. 2012), but it is reported from the coasts of the south Arabian peninsula at the coasts of Yemen and Oman (Manilo and Bogorodsky 2003).

Habitat and Ecological Role This is a marine species shark that lives in the pelagic region of the world oceans. It is oceanodromous and found living at depth range from the surfaces down to 230 m, but usually found from surfaces down to

152 m (Reide 2004; Mundy 2005; Florida Museum of Natural History 2005). Individuals of this species like warm water and they tend to restrict their presence to the central equatorial belt, but probably go farther to include 45°N and 43°S. They have a habit of going up to the surface and putting their heads outside the water to locate prey (Shark Facts 2016).

Biology This shark has a solitary type of living and if it happens to be with other sharks, it prefers members of its species, but individuals of other species will join them once members of this species get excited. It is an active shark during day and night (Ebert et al. 2013). Males and females reach about 1.8 m and 1.9 m, respectively, and the maximum reported length of this shark is 4 m (Seki et al. 1998). This species is viviparous and the gestation period lasts for 1 year after which the females give birth to up to 15 pups at any one time. The young are 600 mm in total length at birth and they reach maturity at 6 or 7 years of age and can live for up to 22 years (Shark Facts 2016). This species of shark is considered the most dangerous of all sharks (Cousteau and Cousteau 1970). The whitetip shark is held responsible for many fatal attacks on humans together with the great white shark and other species of sharks that live in shallow waters as it is reported to attack survivors of shipwrecks or floored aircraft (Bass et al. 1973a, b; Marx 1990). It is responsible for the attack on the survivors of the USS Indianapolis on 30th July 1945 (Martin 2006). Many deaths of the 192 survivors from a steamship sunk by the Germans in Nova Scotia during World War II are assigned to this shark (Bass et al. 1973a, b). The whitetip shark is responsible for the famous Red Sea shark attack in 2010 where the diver's back and thigh were snatched by sharks while the diver was handfeeding them (Wikipedia 2016). It is always said that if you are in deep water and you come face to face with the whitetip shark, watch its white-tipped elongated dorsal fin, but if you are in such depth, your chances of escaping unharmed from this shark are very slim. This shark becomes very aggressive during the feeding frenzy and bites and snaps anything; the wounds from its continuous bites will be fatal (Sharkfacts 2014).

Economic Value This shark is taken for its meat, for its fins, for the vitamins in its liver oil, and for its skin which is used to make leather (Sharkfacts 2014).

Conservation Status IUCN Red List Status, Critically Endangered. Although this species of shark is ranked as Vulnerable in the IUCN Red List (Baum et al. 2007), it is considered Critically Endangered in the western north and central Atlantic, therefore the Red List assessment needs to be revised as a long-term decline up to 99% and a recent decline of 60–70% have been reported (Ebert et al. 2013). Such a decline in the population of this shark is mainly due to its curious nature which makes it easy to catch. In addition, the slow capability for reproduction and its presence in the bycatch all make this shark vulnerable and facing extinction (Baum et al. 2007; Ebert et al. 2013). Management action and conservation measures should be taken for this species. Up till now, the only such measures are taken in US Atlantic waters. Also international cooperation is required to have an effective conservation (Baum et al. 2007).

Carcharhinus melanopterus (Quoy and Gaimard 1824)
Common name: Blacktip reef shark
Arabic name: قرش الجزر المرجانيه أسود الزعنفه
Etymology: *Carcharhinus*: Greek, karcharos = sharpen + Greek, rhinos = nose (Fig. 2.27)

Identification

- Body small with blunt, short, rounded snout.
- Eyes oval; horizontally located on sides of head.
- Absence of interdorsal ridge.
- Teeth in upper jaw narrow-cusped, oblique, and serrated.
- First dorsal fin large with short posterior tip.

Fig. 2.27 Blacktip reef shark, *Carcharhinus melanopterus* (Quoy & Gaimard, 1824). Courtesy of Alan Reeve, USA

- Body brownish-grey above and whitish below. All fins have clear black tips and on anterior and posterior edges of pectoral fin and upper lobe of caudal fin. Dark bands on flanks extending to pelvic fins (Randall and Helfman 1973; Compagno et al. 1989; Randall 1995; Compagno and Niem 1998a, b; Ebert et al. 2013).

World Distribution This species of shark is restricted in its distribution to the Indo-Pacific region where it is found from the Red Sea to East Africa in the south and to Hawaii and the Tuamoto archipelago in the east. It is reported from Japan in the north and south down to Australia (Froese and Pauly 2016).

Distribution in the Study Area Compagno (1984) has reported this species to be present in the Arabian-Persian Gulf thus Froese and Paully's (2016) records of the Gulf depend on him. The recent study (Moore et al. 2012) and the previous studies (Blegvad and Løppenthin 1944; Randall and Helfman 1973) showed that this species is not present in the Arabian-Persian Gulf. It is reported from the Sea of Oman (Randall 1995; Henderson and Reeve 2011) and found in the southern coasts of the Arabian peninsula at the coasts of Yemen and Oman (Manilo and Bogorodsky 2003).

Habitat and Ecological Role This species of shark is a marine species and is also found in brackish water. It is associated with reefs and found living at depth range from 20 to 75 m (Myers 1999). Adults have been seen to swim in the shallow water areas with dorsal fin exposed. Usually, young sharks of this species are found in the shallow water and sandy flats, and the adults are seen around reef ridges (Compagno 1984).

Biology Individuals of this species have been shown to be in the range of 900 and 1100 mm in total length at maturity and the maximum length reached by adults is 1800 mm in total length (Compagno 1984; Stevens 1984a, b; Last and Stevens 1994). It is viviparous with a yolk sac placenta, giving birth to 2–4 pups with length range between 300 and 500 mm in total length, with gestation period between 8 and 9 months (Compagno 1984; Lyle 1987; Last and Stevens 1994; Heupel 2009). Compagno (1984), Melouk

(1957), and Randall and Helfman (1973) suggested that the gestation period for this species is 16 months and breeding takes place every other year (Stevens 1984a, b). The shallow habitat of this shark makes contact with humans possible and therefore it is considered dangerous (Compagno 1984). The interesting cases of attack of this shark on humans are given by Randall and Helfman (1973). They reported on 10 cases at Palau, Phoenix, Line, and Marshall Islands, Caroline atoll, and Tuamotu archipelago. Three of these attacks caused injuries, eight of them occurred during the afternoon, and nine in very shallow water not reaching the waist of humans. In only one of the 10 cases of these shark attacks, was the victim not wading and dead or injured fishes were at the scene of the incident. These incidences have led Randall and Helfman (1973) to believe that the blacktip shark is not to be regarded as a harmless species. On the contrary, it can cause severe injuries, but less serious than those caused by the larger species of carcharhinid species. This shark has 11 unprovoked attacks and 21 attack records in general in 2009 (ISAF 2009). The shark is responsible for attacking the legs and feet of waders. It becomes aggressive in the presence of food especially in the case of spearfishers catching a fish (Compagno 1984).

Economic Value This species is not targeted, but in India and Thailand, it usually caught by inshore fisheries and its meat used fresh and dry-salted. As with other sharks, the liver oil has little commercial importance (Heupel 2009).

Conservation Status IUCN Red List Status, Near Threatened. This shark is given the rank of Near Threatened in the IUCN Red List because it has been taken in inshore fisheries in shallow waters and the effect of depletion and destruction of reef on the population of this shark (Ebert et al. 2013). No conservation measures were in action about this species at the present time (Heupel 2009).

Carcharhinus obscurus (Lesueur 1818)
Common name: Dusky shark
Etymology: *Carcharhinus*: Greek, karcharos = sharpen + Greek, rhinos = nose
Arabic name: قرش غامق اللون (Fig. 2.28)

Fig. 2.28 Dusky shark, *Carcharhinus obscurus* (Lesueur, 1818). Courtesy of Hiroyuki Motomura, Japan

Identification

- Large body with broad and rounded snout.
- Teeth in upper jaw triangular in shape with serrated edges.
- Dorsal fin large and wide. Pectoral fin curved and moderate size.
- Interdorsal ridge.
- Body grey to blue colour above and white below. Tips of pectoral and pelvic fins dark as is lower lobe of caudal fin (Compagno et al. 1989; Compagno and Niem 1998a, b; Ebert et al. 2013).

World Distribution This shark has an almost worldwide distribution. It is found in the western and eastern Atlantic regions. It is also recorded from several localities in the Indo-Pacific region (Bass et al. 1986a, b; FAO Fisheries Department 1994; Menni and Lucifora 2007).

Distribution in the Study Area This species of shark has not been recorded at either the Arabian-Persian Gulf or the Sea of Oman (Compagno 1984; Randall 1995; Henderson and Reeve 2011; Moore et al. 2012; Ebert et al. 2013), but it has been reported as present in the southern coasts of the Arabian peninsula in the coasts of Yemen (Manilo and Bogorodsky 2003).

Habitat and Ecological Role This shark is a marine species found in association with reefs and lives at a depth range from surfaces down to about 400 m (Compagno 1984; Reide 2004). In some localities, it stays most of the time at depth 10–80 m and makes irregular incursions down to 200 m. It prefers water with temperature range of 19–28 °C and avoids estuaries (Ebert 2003; Hoffmayer et al. 2009).

Biology This shark chooses places to reside that are located in an intermediate position that overlaps with its nearest shark species (Compagno 1984). This shark is migratory and wandering and its recorded movement is 3800 km (Musick et al. 2009). The maximum size that this shark can attain is 4000 mm in total length, but the average is about 3200 mm in total length. The size and age are different in different areas. Males and females mature at about 2800 mm in total length, reach maturity at age 20, and are known to live for 45 years (Natanson et al. 1995; Sminkey 1996; Musick et al. 2009). The female of this species is placental viviparous and usually gives birth to 3–16 pups of 700–1000 mm in total length (Last and Stevens 1994; Dudley et al. 2005). Gestation will last 22 months and the reproductive cycle is at least 3 years (Branstetter and Burgess 1996; Romine 2004; Dudley et al. 2005). Females usually move to shallow areas to give birth where such areas provide shelter for the young ones (Smale and Goosen 1999; Ebert 2003). The large size of this shark makes it potentially dangerous to humans. Six attacks were reported for this shark for the year 2009. These attacks were performed on people and on boats and three of these six attacks were fatal (ISAF 2009).

Economic Value This shark is taken for its valuable fins and meat. Human consumption of the meat of this shark includes using it as fresh, dried-salted, frozen, and smoked. The skin is used for leather manufacturing and the liver to extract oil for vitamins (Compagno 1984; Musick et al. 2009).

Conservation Status IUCN Red List Status, Vulnerable globally, Endangered in the northwest and western central Atlantic (Musick et al. 2009). The conservation rank given for this shark is based on the fact that this shark is slow to reproduce, difficult to manage as it is usually caught in mixed species fisheries and, in some areas, a substantial number of this species are caught by shark nets set to protect beaches. Active protective measures should be in place for this shark. Such measures should target the bycatch fisheries. In some areas, the population of this shark was shown to respond to conservation measures as several recruitments were observed over the last few years (Romine 2004).

Fig. 2.29 Tiger shark, *Galeocerdo cuvier* (Péron & Lesueur, 1822). Courtesy of Hiroyuki Motomura, Japan

Fig. 2.30 Tiger shark, *Galeocerdo cuvier* (Péron & Lesueur, 1822), jaws. Courtesy of Tassapon Krajangdara, Thailand

Galeocerdo cuvier (Péron and Lesueur 1822)
Common name: Tiger shark
Arabic name: قرش النمر
Etymology: *Galeocerdo*: Greek, galeos = a shark + latin, cerdus = the hard hairs of pigs (Figs. 2.29 and 2.30)

Identification

- Big head.
- Anterior part of body narrower towards posterior end.
- Snout round, big, and blunt.
- Upper lateral furrow very long and lateral keel on each side low.
- Spiracles small and situated behind eyes.
- Gill slits small.
- Mouth big with teeth similar in both jaws, strongly serrated and convex anteriorly.
- Body grey dorsally with grey bars and spots, white ventrally (Compagno et al. 1989; Randall 1995; Ebert et al. 2013).

World distribution This shark has a circumtropical type of distribution and is found in temperate and tropical waters. It is reported from the western Atlantic regions. It is also recorded from the Indo-Pacific and eastern Pacific regions (FAO Fisheries Department 1994).

Distribution in the Study Area This shark is reported from several localities in the Arabian-Persian Gulf (Compagno 1984; Moore et al. 2012). It is also recorded from the Sea of Oman (Henderson and Reeve 2011) and from the southern coasts of the Arabian peninsula at the coasts of Yemen and Oman (Manilo and Bogorodsky 2003; Henderson and Reeve 2011).

Habitat and Ecological Role This shark is a marine species, but it moves into brackish waters with a benthopelagic habit. It is found living at a depth from the surface down to over 370 m (Reide 2004; Mundy 2005), but also found close to the coasts throughout the world (Knickle 2011). It is also noted that this shark travels long distances and visits different habitats (Ebert et al. 2013).

Biology This species of shark has the habit of swimming slowly. This type of swimming and its cryptic colouration make this shark very difficult to be seen by prey (Heithaus 2001). It can reach a length of 3250–4250 mm in total length and weigh over 600 kg with males and females reaching maturity at 2260–2900 mm and 2500–3250 mm in total length, respectively. The largest specimens of this shark are about 5500 mm in total length. The reproductive method followed by this shark is ovoviviparous

Fig. 2.31 Sicklefin lemon shark, *Negaprion acutidens* (Rüppell, 1837). Courtesy of Alan Reeve, USA

and is unique among members of the family Carcharhinidae in having such a manner of reproduction. Females have 10–82 embryos, but the mean number is 30–45 (Tester 1969; Bass et al. 1975; Simpfendorfer 1992). These embryos are 510–900 mm in total length at birth (Randall 1995; Simpfendorfer 1992). The female has a gestation period of 13–16 months (Clark and von Schmidt 1965). It is a dangerous species of shark that should be avoided and watched. The incidences of attacks on humans reported about this shark are ranked as second to those of the white shark. The large body size and its voraciousness make it one of the most dangerous sea creatures. All recorded attacks by this shark were performed on divers, swimmers, and boats and usually attacks on divers spearfishing or attracting sharks for photography (Randall 1995; Marine Species Identification Portal 2016).

Economic Value This shark is taken for its fins, flesh, and liver for its high content of vitamin A. The thick skin is used as a leather commodity.

Conservation Status IUCN Red List Status, Threatened. This shark is rated as a Threatened species in the IUCN Red List because its population has declined due to fishery activities and because it is easy to hook in addition to its economic importance. At the present time, there are no conservation measures to protect the tiger shark. In the US Atlantic and Gulf of Mexico, it has been included in a fisheries management plan (Simpfendorfer 2009a, b).

Negaprion acutidens (Rüppell 1837)
Common name: Sicklefin lemon shark
Arabic name: قرش الليمون ذو الزعنفه المنجلية (Fig. 2.31)

Identification
- Very large with narrow, blunt, and broad snout.
- No spiracle.
- Gill slits large.
- Teeth not serrated and those in upper jaw have long cusp and broad base and angular notch on each side. Those of lower jaw have narrower cusp and are more erect.
- Absence of interdorsal ridge.

- First dorsal fin broad and moderate in size and nearly similar in size to second dorsal. Anal fin smaller than second dorsal and its anterior insertion posterior to origin of second dorsal fin.
- Body yellowish brown on top and pale brown on the ventral side. Fins darker than body (Compagno et al. 1989; Randall 1995; Compagno and Niem 1998a, b; Myers 1999; Ebert et al. 2013).

World Distribution This species of shark is confined in its distribution to the Indo-Pacific regions. It is reported in the Red Sea down to South Africa and to the east to the Philippines and southeast to Australia (Froese and Pauly 2016).

Distribution in the Study Area Compagno (1984) and Ebert et al. (2013) did not report this species from the Arabian-Persian Gulf, but Moore et al. (2012) suggested that a single photograph of a specimen of this species was misidentified with *Negaprion brevirostris* obtained from Jana Island. Saudi Arabia is mentioned by Basson et al. (1977) and Moore et al. (2010). No other records of this species from the Arabian-Persian Gulf are present. Henderson and Reeve (2011) recorded this species from the Sea of Oman and Manilo and Bogorodsky (2003) from both southern coasts of the Arabian peninsula at Yemeni and Omani.

Habitat and Ecological Role This shark is a marine species found inshore or near bottom at depth from surfaces to 30 m. It lives in association with reefs (Compagno and Niem 1998a, b).

Biology This shark is characterised in swimming slowly near the bottom of the sea and is unable to pump water over its gills (Compagno 1984). Sometimes it moves for long distances (Stevens 1984a, b). The maximum size reached by this shark is 3000 mm in total length. Males and females reach maturity at 2200 mm in total length. The gestation period is between 10 and 11 months and the reproductive period is 2 years. The young are about 450–800 mm in total length at birth (Pillans 2003). With its fearsome body size and teeth, this shark is considered a potential danger to humans. There are several attack records of this shark on humans as this species is known to defend itself quickly and aggressively. Among the interesting attack records of this shark is to force swimmer to jump over a coral's head and it stayed swimming in circles around them for hours before it gave up. Usually, young sharks are more aggressive than adults (Compagno 1984).

Economic Value As with other shark species, this shark is taken for its meat, fins, skin, and liver oil (Compagno 1984).

Conservation Status IUCN Red List Status, Vulnerable. This shark is rated as Vulnerable on the IUCN Red List as it is susceptible to local overfishing and due to its slow reproductive rate and limited movement. In Southeast Asia, this shark comes under the pressure of expanding and unregulated fishery activities. No conservation measures are on record for this species of shark (Pillans 2003).

Prionace glauca (Linnaeus 1758)
Common name: Blue shark
Arabic name: القرش الأزرق
Etymology: *Prionace*: Derived from Greek, prio, prion, saw; *glauca*: Name comes from the Latin 'glauca' meaning blue (Fig. 2.32)

Identification
- Agile and slim body with conical long snout.
- Large eyes.
- No spiracles.
- No interdorsal ridge.
- Teeth in upper jaw serrated with narrow cusp and broad base; those in lower jaw less serrated and less oblique with narrow cusp.
- Low keel on both sides of caudal peduncle.
- Long, narrow, and slender pectoral fin. Second dorsal fin slightly smaller than anal fin.

Fig. 2.32 Blue shark, *Prionace glauca* (Linnaeus, 1758). Courtesy of Joo Park, Korea

- Body dark blue at dorsal side and bright blue ventrally with dark tips of pectoral and anal fins (Compagno et al. 1989; Randall 1995; Compagno and Niem 1998a, b; Ebert et al. 2013).

World Distribution This shark has a circumtropical type of distribution in temperate and tropical waters. It is found in the western and eastern Atlantic regions. It is also recorded from the Indo-Pacific and eastern Pacific regions too (Froese and Pauly 2016).

Distribution in the Study Area There are no records of this species from the Arabian-Persian Gulf (Compagno 1984; Moore et al. 2012; Ebert et al. 2013). The record of this species from Iranian waters given in Froese and Pauly (2016) is based on Compagno (1984). Checking this reference revealed that Compagno (1984) does not record this species from Iranian waters. It is not reported from the sea of Oman either (Henderson and Reeve 2011), but Manilo and Bogorodsky (2003) have reported this shark from the southern coasts of the Arabian peninsula at the coasts of Yemen and Oman.

Habitat and Ecological Role This shark is a marine species found in pelagic-oceanic habitats (Reide 2004). It is found in depths from surfaces to 1000 m, but usually lives at depths 80–220 m (McMillan et al. 2011; Florida Museum of Natural History 2005). It inhabits the shores and can see divers in temperate seas, but in tropical areas, it inhabits deeper water (Compagno 1984).

Biology The maximum size reached by this shark is slightly over 3800 mm in total length. Males and females reach maturity at 1820 and 2210–3230 mm in total length, respectively. Five and five to six years is the age of the individuals of this species at maturity and they live for more than 20 years. This shark is parentally viviparous and females give birth to about 35 pups with a gestation period of 9–12 months. The maximum number of pups recorded is 135. At birth, the pups are 350–500 mm in total length (Pratt 1979; Stevens 1984a; Nakano 1994). The females can stand the bites of the males during

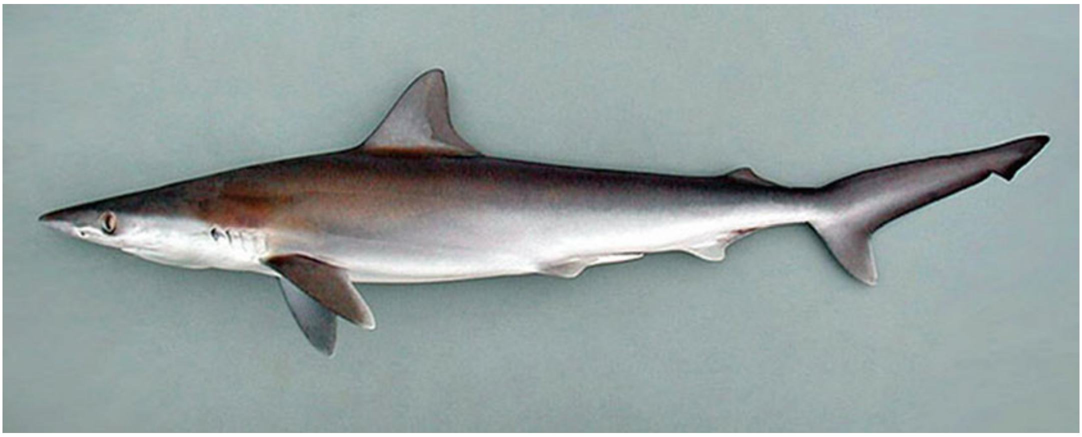

Fig. 2.33 Milk shark, *Rhizoprionodon acutus* (Rüppell, 1837). Courtesy of Pedro, Duarte, Portugal

Fig. 2.34 Milk shark, *Rhizoprionodon acutus* (Rüppell, 1837). Curtesy of Hamid Osmany, Pakistan

the hard courtship as they have skin three times thicker than that of the males (Pratt 1979). The blue shark is an aggressive species with records of 12 attacks on humans and 4 on boats. Among these records, there are three resulting from air or sea disasters and in addition, this shark is reported to attack sailors on floating ship wreckage. During its circulation, the shark plans for an exploratory bite as a feeding test.

Economic Value This shark is used for recreation. It is not possible to keep the meat of this shark for a long time as it ammoniates very quickly and the shark specimens have their fins cut and sold in the shark fin market for shark fin soup. The meat of the blue shark is of low value, but its fins are valuable and there is a great demand for them.

Conservation Status IUCN Red List Status, Near Threatened. This shark has been granted Near Threatened status in the IUCN Red List because it is heavily fished in several areas along its range of distribution. Such action is the main cause for the depletion of the population of this shark. A management plan is in place in some countries where this shark is taken by commercial fishery activities (Stevens 2009).

Rhizoprionodon acutus (Rüppell 1837)
Common name: Milk shark
Arabic name: قرش الحليب
Etymology: *Rhizoprionodon*: Greek, rhiza = root + Greek, prion = saw + Greek, odous = teeth (Figs. 2.33 and 2.34)

Identification

- Small slender body with narrow, long snout.
- Eyes big.
- Upper and lower labial furrows long.

- Teeth in upper jaw have blade-like cusp and are strongly oblique; those of lower jaw similar to those of upper jaw, but with anteromedial edge concave.
- No interdorsal ridge.
- Second dorsal fin small, originated behind large anal fin.
- Body greyish brown above and white below. Fins usually pale, but sometimes dark (Compagno et al. 1989; Randall 1995; Compagno and Niem 1998a, b; Ebert et al. 2013).

World Distribution This species of shark is recorded from the eastern Atlantic from Mauritania to Angola and in the Indo-Pacific region from the Red Sea down to East Africa and to the west to Indonesia and north to Japan and south to Australia (Fischer et al. 1987).

Distribution in the Study Area This species of shark has been reported from the Arabian-Persian Gulf (Compagno 1984; Moore et al. 2012). Recently, Ali (2013) reported this species from Iraqi waters of the Arabian-Persian Gulf, but this publication came well after Compagno (1984). Therefore it is not possible to consider it as a valid reference for the distribution of this species. It has been recorded from the Sea of Oman (Henderson and Reeve 2011) and from the southern coasts of the Arabian peninsula at the coasts of Yemen and Oman (Randall 1995; Manilo and Bogorodsky 2003; Henderson and Reeve 2011).

Habitat and Ecological Role This shark is a marine species and sometimes found in estuaries (Reide 2004). It lives in depths from surfaces down to 200 m (Compagno 1984).

Biology There is not much known about the behaviour of this shark (Ebert et al. 2013). The exceptional maximum size recorded is 1780 mm in total length; most individuals are less than 1100 mm in total length. Males and females mature at 680–720 and 700–810 mm in total length, respectively. This shark is viviparous and has a litter size of 1–8 (Compagno 1984). The females have a gestation period of 12 months and produce young yearly. At birth the young are between 250 and 390 mm in total length (Stevens and Mcloughlin 1991). In India, the locals believe that the meat of this shark promotes lactation in women therefore the name milk shark is used (Randall 1995). Trape (2008) reported on two cases of shark attack performed by this species on humans in the Cap-Vert peninsula, Senegal. This shark in certain places such as Bahrain and other Arabian-Persian Gulf states is considered dangerous to humans based on attack incidences reported from there (Al-Baharna 1992).

Economic Value Because it is abundant in the areas where it occurs, this shark is the target of artisanal, small-scale commercial fisheries and offshore fishing fleets. It is utilised for fresh and possibly dried-salted for food and for fishmeal. The liver is used for oil, fins for soups, and skin for leather manufacturing.

In some parts of the Arabian-Persian Gulf, the liver is used for waterproofing dhows, and carcasses retained and used as fertilisers (Jabado et al. 2013). In Iran there has been considerable recent research activity into the pharmaceutical applications of shark products, particularly for cartilage in anticancer treatment (Rabbani-Chadegani et al. 2008; Rabbani et al. 2007; Razmi et al. 2008; Shahrokhi et al. 2009) and also for liver oil in combating fungal infection (Hajimoradi et al. 2009). In addition, gelatine extraction from rays for industrial use has been examined (Jalili 2004). In some states of the Arabian-Persian Gulf, the vertebrae of shark are used as earrings (Moore et al. 2011).

Conservation Status IUCN Red List Status, Least Concern. The conservation rank given for this shark by the IUCN in the Red List is Least Concern because this shark is targeted heavily by fisheries of different sorts, but it is productive as the female produce young every year, is common

Fig. 2.35 Whitetip reef shark, *Triaenodon obesus* (Rüppell, 1837). Courtesy of Hiroyuki Motomura, Japan

Fig. 2.36 Whitetip reef shark, *Triaenodon obesus* (Rüppell, 1837), jaws. Courtesy of Jean Lou Justine, France via Wikimedia commons BY-SA 3.0

in several places, and widely distributed (Simpfendorfer 2003a, b; Ebert et al. 2013).

Triaenodon obesus (Rüppell 1837)
Common name: Whitetip reef shark
Arabic name: قرش الجزر المرجانيه أبيض الخطم
Etymology: *Triaenodon*: Greek, triaena = trident, odon = tooth, obesus = devour (Figs. 2.35 and 2.36)

Identification

- Small slender body.
- Broad very short snout.
- Eyes oval.
- Spiracles very small or absent.
- No interdorsal ridge.
- Teeth in both jaws small.
- First dorsal fin moderate size, larger than second dorsal, and located behind pectoral fins. Anal fin similar in size to that of second dorsal fin. Short and broad pectoral fins.
- Body brownish grey colour above and whitish below with scattered dark spots on sides sometimes. Very clear white tips on first dorsal fin and upper portion of caudal fin, but second dorsal-fin lobe and ventral caudal-fin lobe often white-tipped (Compagno et al. 1989; Compagno and Niem 1998a, b; Ebert et al. 2013).

World Distribution The distribution of this shark is confined to the Indo-Pacific region from the Red Sea down to east Africa, east to Indonesia, and south to New South Wales. It is also recorded in the eastern Pacific (Russell and Houston 1989).

Distribution in the Study Area This shark is not recorded from the Arabian-Persian Gulf (Moore et al. 2012). Froese and Pauly (2016) have mentioned that this shark is present in Iranian waters, but they did not state clearly in which Iranian body it is found, whether the Arabian-Persian Gulf or the Sea of Oman. Froese and Pauly (2016) based their suggestion on Compagno (1984) who showed in the geographical distribution of this species that it is present in the Sea of Oman, but he did not mention this presence in the text. This shark is recorded from the southern coasts of the Arabian peninsula at the coasts of Yemen and Oman (Manilo and Bogorodsky 2003).

Habitat and Ecological Role This shark is a marine species found in association with reefs and lives in depths ranging from surfaces down to 330 m, but it usually swims in water depth of 8–40 m (Compagno 1984).

Biology This shark has a habit of living in clear waters and is primarily active at night, seeking shelter in caves during the day (Randall 1977). The maximum length attained by this shark is 2100 mm in total length and the maximum recorded weight is 18,300 g (Compagno 1984). Both males and females reach maturity at 1050 mm total length, however, a mature male and pregnant female were found in the Maldives at 950 and 1020 mm total length, respectively (Anderson and Ahmed 1993). Females have a gestation period of at least 5 months. The number of pups is 2–3 in Madagascar (Fourmanoir 1961; Last and Stevens 1994) and 1–5 in other areas (Randall 1977; Last and Stevens 1994). The newborn young are 520–600 mm in total length (Fourmanoir 1961; Last and Stevens 1994). Randall (1977) supported Garrick and Schultz (1963) in their claim about this being a potentially dangerous shark species if provoked. Randall (1977) wrote about his underwater experience with the speared shark of this species in the Marshall Islands. He was about to get a big bite from this shark, but he decided to retreat at the end of the confrontation. Nelson and Johnson (1970) have reported that this shark may respond to vibratory or olfactory stimuli. Randall (1977) also talked about another several incidences of shark attacks performed by this species. Among these is the one that happened to a scuba diver who speared two or three fishes when a large-size whitetip reef shark reached him from behind and bit his leg. The diver did not have an extensive wound, but got away with a few stitches. This shark might be a threat to humans aside from attacking. Humans eating the meat of this shark might get ciguatera poisoning (Randall 1977) especially if the liver is used as food as the liver contains 50 times the concentration of ciguatera toxin than the muscle tissue (Randall 1977). In 2008, there were two provoked and three unprovoked cases of attacks on humans by this shark reported by the International Shark Attack File (ISAF 2008).

Economic Value As with other species of shark, it is taken for its meat, liver oil, fins, and skin; the meat, as mentioned above, might be toxic due to the presence of ciguatera toxin.

Conservation Status IUCN Red List Status, Near Threatened. This shark has been granted a near threat rank on the IUCN Red List due to the increasing fishing, restriction of its presence in certain depth ranges, and small number of young. No particular conservation measures have been in place for this shark. A marine reserve could help in protecting this species from exploitation (Randall 1977; Smale 2005).

Family: Sphyrnidae
Eusphyra blochii (Cuvier 1816)
Common name: Winghead shark
Arabic name: قرش ذو الرأس المجنح
Etymology: *Eusphyra*: Greek, eu = good + Greek, sphyra = hammer (Figs. 2.37 and 2.38)

Identification

- Head expanded laterally with edges directed posteriorly.
- Nostrils large, well apart from eyes.
- Teeth in jaws similar, not serrated oblique.
- Several small bumps in front of nostrils.
- First dorsal fin originates over pectoral fin base.
- Upper precaudal pit longitudinal and transverse.
- Body greyish above and whitish below without conspicuous markings (Randall 1995; Ebert et al. 2013; Froese and Pauly 2016).

Fig. 2.37 Winghead shark, *Eusphyra blochii* (Cuvier, 1816). Courtesy of Hamid Osmany, Pakistan

Fig. 2.38 Winghead shark, *Eusphyra blochii* (Cuvier, 1816). Courtesy of Hamid Osmany, Pakistan

World Distribution This species is confined in its distribution to the Indo-Pacific region only. It is found from the Arabian-Persian Gulf east to the Philippines, north to China, and south to Australia (Froese and Pauly 2016).

Distribution in the Study Area This species is reported from the Arabian-Persian Gulf (Randall 1995; Ebert et al. 2013; Froese and Pauly 2016), but Moore et al. (2012) have not recorded it from this area. Randall (1995) reported this species as *Sphyrna blochii* as did Froese and Pauly (2016), but Compagno (1984) and Ebert et al. (2013) called it *Eusphyrna blochii*. It has been reported from the Sea of Oman (Randall 1995; Ebert et al. 2013; Froese and Pauly 2016), but Henderson and Reeve (2011) have not reported it from this area. Manilo and Bogorodsky (2003) reported it as *Eusphyrna blochii* from the southern coasts of the Arabian peninsula at the coasts of Yemen and Oman.

Habitat and Ecological Role This shark is a marine species found sometimes in brackish

Fig. 2.39 Scalloped hammerhead, *Sphyrna lewini* (Griffith & Smith, 1834). Courtesy of Alan Reeve, USA

habitats and preferring benthopelagic habitat (Reide 2004).

Biology The maximum size reached by this shark is 1520 mm in total length. Adult males reach 1320 mm in total length and pregnant females are 1040–1440 mm in total length. It is a viviparous species with yolk sac and placenta. Females give birth to 6–11(usually 6) pups after a gestation period of 8 months. The yolk is one of the nourishment sources in the body of the female. Once this resource runs low, the yolk sac is connected to the uterus and the embryos continue receiving nourishment from the mother's body. The lateral blades of the head are usually developed in the embryo, but they are folded along the body. At birth, the embryo emerges tail first and the lateral blades are folded along the body side until it completely emerges outside the female body (Appukuttan 1978; Devadoss 1988; Smart et al. 2012).This shark uses the lateral blades of its head as manoeuvring organs. They might play a role in increasing the surveyed surface area scanned by the sense organs present in this shark (Compagno 1984). Although there are no attack records about this shark against humans, Al-Baharna (1992) considered this species as dangerous due to some undocumented attack cases on humans in Bahrain and some other Arabian-Persian Gulf states.

Economic Value This shark is taken for its meat which is usually consumed fresh, its liver for the oil to produce high-potency vitamins, and the remainder of the flesh as fishmeal.

Conservation Status IUCN Red List Status, Near Threatened. This species of shark is rated Near Threatened in the IUCN Red List because it is heavily fished and exploited in several places along its range of distribution. No conservation measures are in place for this species (Simpfendorfer 2003a, b).

Sphyrna lewini (Griffith and Smith 1834)
Common name: Scalloped hammerhead
Arabic name: قرش أبو مطرقه
Etymology: *Sphyrna*: Greek, sphyra = hammer (Figs. 2.39 and 2.40)

Identification

- Body large with head having narrow arched blades with rear margins swept backward. One central and two other smaller notches on anterior edge of head.
- Eyes slightly anterior to mouth.
- Teeth in upper jaw have broad base and are slightly oblique; those of lower jaw have narrow base and are less oblique.
- First dorsal fin high and second dorsal fin small. Anal fin larger than second dorsal fin.

Fig. 2.40 Scalloped hammerhead, *Sphyrna lewini* (Griffith & Smith, 1834). Curtesy of Hamid Osmany, Pakistan

- Body uniform greyish colour above and paler below. Tip of pectoral fin black with dark blotch on lower lobe of caudal fin (Compagno et al. 1989; Randall 1995; Smith 1997; Compagno 1998; Ebert et al. 2013).

World Distribution This species has a circumglobal type of distribution and is found in warm temperate and tropical seas (Compagno 1998). It is recorded from the western and eastern Atlantic and from the Indo-Pacific region (McEachran and Capapé 1984; Springer 1990; Menni and Lucifora 2007).

Distribution in the Study Area The only references that show the presence of this species in the Arabian-Persian Gulf is that of Compagno (1984) and Moore et al. (2012) where they reported it from Qatari waters. Al-Daham (1974) gave a description of the head of a hammerhead shark which is consistent with this species, but the presence of this species in the north part of the Arabian-Persian Gulf needs confirmation. It has been reported from Iranian waters by Assadi and Dehghani (1997), but no specific instance in Iranian waters was given. From these records the presence of this species is confirmed only from Qatari waters and unsubstantiated for other regions of the Gulf. It is reported from both the Sea of Oman and the southern coasts of the Arabian peninsula at the coasts of Yemen and Oman by Manilo and Bogorodsky (2003) and Henderson and Reeve (2011). Randall (1995) mentioned this species, but he did not confirm its presence in any seas that surround Omani coasts.

Habitat and Ecological Role This shark is a marine species that enters brackish water and with pelagic-oceanic habitats (Reide 2004). It is usually found at depths from surfaces down to 512 m, but usually swims from surfaces down to 25 m (Sanches 1991). Pups of this species prefer to stay in shallow coastal waters and near the bottom (Clarke 1971; Bass et al. 1975; Castro 1983).

Biology The maximum size reached by males and females ranges from 2190 to 3400 mm and 2960 to 3460 mm in total length, respectively (Clarke 1971; Bass et al. 1975; Schwartz 1983; Klimley and Nelson 1984; Stevens 1984a, b; Branstetter 1987a, b; Chen et al. 1988; Stevens and Lyle 1989; Chen et al. 1990). Males and females reach maturity at 1400–1980 and 2100–2500 mm in total length with ages of 10 and 15 years, respectively (Compagno 1984; Branstetter 1987a, b; Chen et al. 1990; Carrera and Martinez in prep.; White et al. 2008). The maximum age reported for this species is 35 years. The adult individuals of this species usually form small schools or are found in pairs. Segregation by sex is observed in this species where females move to shallow areas (Clarke 1971; Bass et al. 1975; Klimley and Nelson 1984; Branstetter 1987a, b; Klimley 1987; Chen et al. 1988; Stevens and Lyle 1989). The newborn of this species usually remain with juveniles in the coastal nursery area for up to 2 years before joining adults in their habitats (Holland et al. 1993). This species is viviparous and reproduction occurs in May to July and has a yolk-sac placenta; only the right ovary is functional (Ruiz-Alvarado and Ixquiac-Cabrera 2000; Torres-Huerta 1999). Females give birth to 12–41 pups after a gestation period of 9–12 months. The newborn is 310–570 mm in total length (Castro 1983; Compagno 1984; Branstetter 1987a, b; Chen et al. 1988, 1990; Stevens and Lyle 1989; Oliveira et al. 1991; Oliveira 1997; Amorim et al. 1994; White et al. 2008). This species has a number of attacks both provoked and unprovoked

Fig. 2.41 Great hammerhead, *Sphyrna mokarran* (Rüppell, 1837). Courtesy of Tassapon Krajangdara, Thailand

on humans given in the International Shark Attack File. Among these are 17 of nonfatal nature and 20 fatal cases (Marine life 2016). In the Arabian-Persian Gulf and in Bahrain, this species is considered dangerous due to reports of attacks on humans (Al-Baharna 1992).

Economic Value This shark is taken for its meat which is usually consumed fresh, but it is not in demand for its fins. Its liver is used for oil to produce vitamins and the remainder of the flesh as fishmeal.

Conservation Status IUCN Red List Status, Endangered. This species is ranked as an endangered species due to the heavy fishing that its population faces in different habitats where it lives. The predation of pups and juveniles by other members of the family Carcharhinidae and even by adults of the same species is considered a natural pressure put on the development of this species and causing a decline in the number of individuals. This may explain why this species has high fecundity in comparison with other shark species (Clarke 1971; Branstetter 1987a, b, 1990; Holland et al. 1993).

Sphyrna mokarran (Rüppell 1837)
Common name: Great hammerhead
Arabic name: قرش أبو مطرقه الكبير
Etymology: *Sphyrna*: Greek, sphyra = hammer (Figs. 2.41, 2.42 and 2.43)

Fig. 2.42 Great hammerhead, *Sphyrna mokarran* (Rüppell, 1837), jaws. Courtesy of Hamid Osmany, Pakistan

Fig. 2.43 Great hammerhead, *Sphyrna mokarran* (Rüppell, 1837). Courtesy of Ross Robertson; www.stri.org/sfgc, Papua New Guinea

Identification

- Body very large with head of nearly straight front edge; notch in centre gently curved in juveniles.
- Posterior end of eye well before the mouth opening.
- 34 teeth in upper jaw, 17 each side; 32–34 in lower jaw, 16–17 each side.
- First dorsal fin high, curved, and pointed. Second dorsal and anal fins deeply curved posterior edge.
- Body greyish–brown and paler below. Fins have no distinctive marking (Compagno et al. 1989; Randall 1995; Smith 1997; Ebert et al. 2013).

World Distribution This shark has a circumtropical pattern of distribution. It is found in both the western and eastern Atlantic. Also, it is distributed in the Indo-Pacific region and found throughout the Indian Ocean. In the eastern Pacific, it is reported from southern Baja California, Mexico to Peru (Compagno 1998; Froese and Pauly 2016; Ebert et al. 2013).

Distribution in the Study Area This shark is reported from different localities in the Arabian-Persian Gulf, from Kuwait (Moore et al. 2012), Bahrain (Moore and Peirce 2013), Qatar, Saudi Arabia, and the Iranian coasts of the Arabian-Persian Gulf (Compagno 1984). There is no report of this species from the southern part of the Arabian-Persian Gulf. It is also recorded from the Sea of Oman and the southern coasts of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003; Henderson and Reeve 2011; Ebert et al. 2013).

Habitat and Ecological Role This species of shark inhabits marine and brackish waters and is found at depth range 1–300 m. It is also found in association with corals in inshore and offshore areas (Reide 2004; Myers 1999).

Biology This shark can reach a maximum size of about 6 m, but the common size is 400 mm (Last and Stevens 1994). Males and females reach maturity at about 270 and 300 mm total length, respectively. *Sphyrna mokarran* has a viviparous type of reproduction with a yolk-sac placenta and females can give birth of up to 42 pups with size range 50–70 mm in total length. After a gestation period of 11 months, pups are born in late summer in the northern hemisphere and between December and January in Australia (Last and Stevens 1994; Compagno 1998; Mundy 2005; Smith et al. 2007; Denham et al. 2007). This shark can live up to 20–30 years (Bester 2008). One female shark from the Boca Grande was estimated to be 40–50 years old (Martin 2007). This shark has the ability to inflict fatal injuries to humans as it is characterised as having a large body size and sharp cutting teeth. The species is also known for its aggression and extreme care should be taken around them (Stafford-Dietsch 2000; Thornley et al. 2003). Several reports suggest that the great hammerhead shark was seen to attack divers once they entered the water (Stafford-Dietsch 1999, 2000). In the accounts with the International Shark Attack File, there are 34 cases of attack registered for the members of the genus *Sphyrna*, but it is unknown how many are allocated for the great hammerhead shark due to the difficulty in identifying the species (ISAF 2009). In Bahrain, this species has been reported to be responsible for several authenticated attacks on divers (Al-Baharna 1992).

Economic Value The great hammerhead shark is fished for its meat which is usually consumed fresh, frozen, dried-salted, and smoked, for its liver to produce oil, fins for soup, hides for leather manufacturing, and the body waste for fishmeal (Compagno 1998).

Conservation Status This species was given Endangered status in the IUCN Red List due to the overfishing operations and its long generation time. No conservation plans were put forward for this shark although it has been listed in the Annex I, Highly Migratory Species, of the UN Conservation of the Law of the Sea which recommends management of its catch (Denham et al. 2007).

Fig. 2.44 Smooth hammerhead, *Sphyrna zygaena* (Linnaeus, 1758). Courtesy of Alan Reeve, USA

Fig. 2.45 Smooth hammerhead, *Sphyrna zygaena* (Linnaeus, 1758), *side view*. Courtesy of Hiroyuki Motomura, Japan

Sphyrna zygaena (Linnaeus 1758)
Common name: Smooth hammerhead
Arabic name: قرش أبو مطرقه الأملس
Etymology: *Sphyrna*: Greek, sphyra = hammer (Figs. 2.44 and 2.45)

Identification

- Large body with absence of notch at centre of curved head.
- First dorsal fin high and second dorsal low.
- Head wide and very broadly arched with lateral indentation, but short longitudinally. Prenarial grooves well developed and situated anterior to nostrils.
- Posterior edge of eye behind upper symphysis of broadly arched mouth.
- Long, serrated anterior teeth; posterior ones molariform.
- Upper part of body olive-grey to grey-brown with white abdomen (Compagno 1984; Compagno et al. 1989; Compagno 1998; Ebert et al. 2013).

World Distribution The hammerhead shark has been reported from the western Atlantic from Canada to Brazil and Argentina, from the eastern Atlantic at the coasts of Côte d'Ivoire including the Mediterranean Sea and in the

Indo-Pacific from South Africa to Sri Lanka to southern Australia and New Zealand (Compagno et al. 1989; Ebert et al. 2013).

Distribution in the Study Area Compagno (1984) and Ebert et al. (2013) have reported this species to be present in the Arabian-Persian Gulf, but not Moore et al. (2012). It is present in the Sea of Oman (Henderson and Reeve 2011) and in the southern coasts of the Arabian peninsula at the coasts of Oman (Henderson and Reeve 2011).

Habitat and Ecosystem Role This species of shark is mainly marine, but it enters brackish waters. It is found at depth range 0–200 m, but usually found at depth 0–20 m (Compagno et al. 1989; Compagno 1998; Florida Museum of Natural History 2005; Ebert et al. 2013). It migrates northward to the pole during summer to stay in cooler water and returns to the equator in wintertime (Ebert 2003).

Biology The smooth hammerhead reaches maximum size of 3700–4000 mm in total length (Compagno 1984). Males and females mature at 2500–2600 and 2650 mm in total length, respectively, in the eastern coasts of Australia. Females and males reach maturity at 2700 and 2500 mm in total length, respectively, but this depends on the location (Bester 2008). It is a viviparous species and uses the yolk sac to get nutrition from the mother's body. Once the yolk is finished, the yolk sac changes into a placental connection and delivers food to the young. The gestation period is about 11 months, then females give birth up to 50 pups (Ebert 2003). At birth, the young measure up to 610 mm in total length and this shark reaches 20 years of age (Bester 2008). It is considered dangerous to humans as there are several attack records against this species in the International Attack File (2009). This species has been reported to feed on fish specimens captured by sportfishers in California (Compagno 1984).

Economic Value This species is usually obtained for its meat which can be used fresh, dried, salted, and smoked. The fins are used for shark fin soap. The liver is used for its valuable oil content. The skin is used for leather manufacturing and the remaining meat as fish meal (Bester 2008).

Conservation Status This shark has been considered Vulnerable in the IUCN Red List due to the heavy fishing activity that targets it along its geographical distribution line. Also, it gets entangled as a bycatch in shrimp trawlers. There are several conservation plans to protect this species in several countries (Casper et al. 2005).

Order: Heterodontiformes
Family: Heterodontidae
Heterodontus omanensis (Baldwin 2005)
Common name: Oman bullhead shark
Arabic name: قرش رأس الثور العماني
Etymology: *Heterodontus*: Greek, heteros = other + Greek, odous = teeth (Figs. 2.46 and 2.47)

Identification

- Supraorbital ridge high, situated anterior to eye.
- Dorsal fin spine short, not reaching dorsal edge of fin. Origin of dorsal fin over middle of pectoral fin. Posterior tip of anal fin reaches anterior end of lower lobe of caudal fin.
- Body with brown background and four dark bands equally distributed. First dark band passes across interorbital space and forms large dark spot below eye. Posterior side of two dorsal fins with disperse brown spots (Randall 1995; Baldwin 2005; Ebert et al. 2013).

World Distribution The distribution of this species is confined to the southern coasts of Oman at the Arabian Sea.

Distribution in the Study Area No records of this species are available from the Sea of Oman and the Arabian-Persian Gulf. It is only found in the Arabian Sea area.

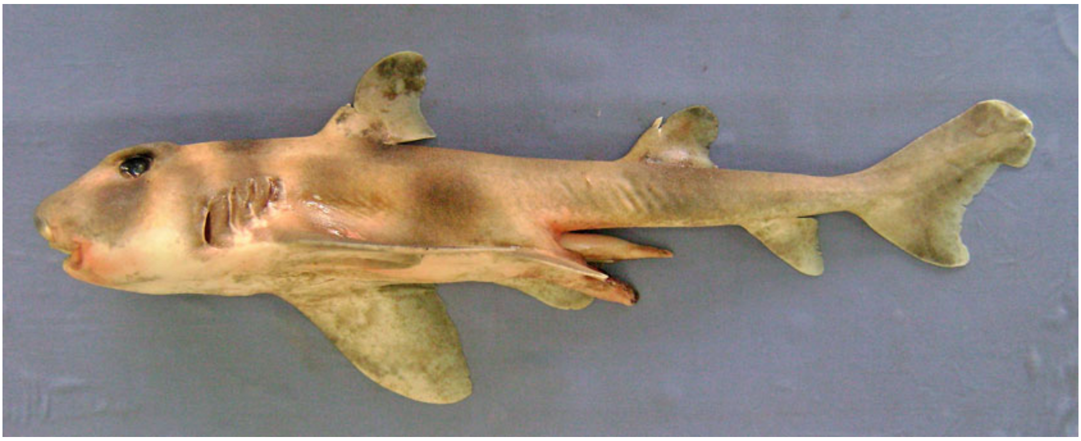

Fig. 2.46 Oman bullhead shark, *Heterodontus omanensis* Baldwin, 2005. Courtesy of Moazam Khan, Pakistan

Fig. 2.47 Oman bullhead shark, *Heterodontus omanensis* Baldwin, 2005, teeth. Courtesy of Moazam Khan, Pakistan

Habitat and Ecosystem Role This shark is a marine species found living at depths of 70 m. It prefers the continental shelf (Baldwin 2005).

Biology There are not many reports about the behaviour of the bullhead shark, but the females reach a maximum size of 610 mm in total length. This shark has strong molariform teeth that cause bad injuries to humans if provoked.

Economic Value No commercial value is reported for this species, but the locals at the south coasts of Oman usually consume meat of this shark.

Conservation Status Data Deficient status in the IUCN Red List is given to this shark. It is not a targeted species, but it usually is caught included within the demersal fisheries activities operating in its geographical range (Valenti 2009).

Order: Pristiformes
Family: Pristidae
Anoxypristis cuspidata (Latham 1794)
Common name: Pointed sawfish
Arabic name: سمكة أبو منشار مدبب
Etymology: *Anoxypristis*: Greek, ana = up + Greek, oxy = sharp, pointed + Greek, pristis = saw (Figs. 2.48, 2.49, 2.50 and 2.51)

Identification

- Shark-like body shape with separated pectoral fin and flattened head.
- Snout tapering to blade-like shape.
- 18–32 pairs of lateral teeth. Basal part of rostral blade lacks teeth.
- Small flaps on narrow nostrils.
- Body covered with denticles.
- Large and pointed dorsal fin. Lower lobe of caudal fin conspicuous.
- Dorsal body side greyish in colour and white ventrally with pale fins (Randall 1995; Froese and Pauly 2016).

Fig. 2.48 Pointed sawfish, *Anoxypristis cuspidata* (Latham, 1794). Courtesy of Hamid Osmany, Pakistan

Fig. 2.49 Pointed sawfish, *Anoxypristis cuspidata* (Latham, 1794). Courtesy of Hamid Osmany, Pakistan

Fig. 2.50 Pointed sawfish, *Anoxypristis cuspidata* (Latham, 1794). Courtesy of Hamid Osmany, Pakistan

World Distribution This species is found from the Red Sea to New Guinea, Japan, and southern Australia (Compagno 1999) and it is recorded from the western central Pacific (Compagno et al. 2005).

Distribution in the Study Area The pointed sawfish is reported from the northwest of the Arabian-Persian Gulf in the marine waters of Iraq (Hussain et al. 1988) and from coasts of Abu Dhabi (Beech 2004). No records of this species are available from the Sea of Oman (Henderson and Reeve 2011). It is recorded from the southern coasts of the Arabian peninsula at the coasts of Yemen and Oman (Compagno 1999; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role This is a marine species and enters both fresh and brackish waters with benthopelagic and amphidromous habitat (Compagno and Last 1999). It is found in depths from the surface down to 40 m (Compagno et al. 2005; Florida Museum of Natural History 2005).

Biology The most distinctive behaviour of this species is the way in which it obtains its food. It moves its rostrum side to side in order to uncover the sea substratum looking for prey or to knock out individual fishes in fish schools. Juveniles and pupping females prefer inshore areas, whereas adults are found offshore (Peverell 2005). In some areas such as Australia, it reaches a maximum size of 3500 mm in total length. Like other sharks and rays, this species has

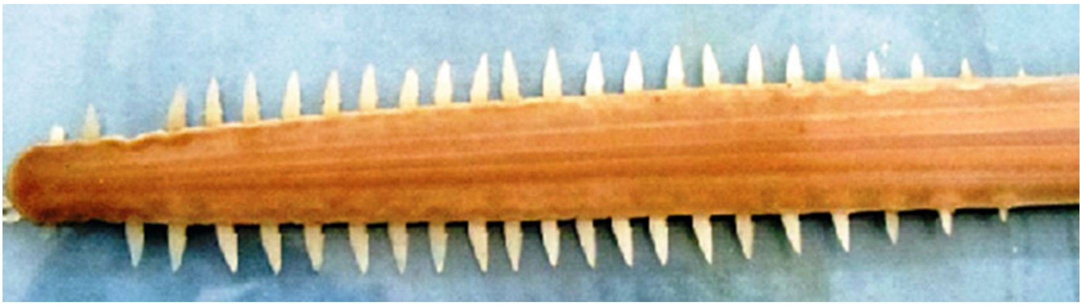

Fig. 2.51 Pointed sawfish, *Anoxypristis cuspidata* (Latham, 1794). Courtesy of Hamid Osmany, Pakistan

internal fertilisation. The embryos follow a sac viviparity mode of feeding where they get food from the yolk sac through the yolk stalk. Both yolk sac and yolk stalk are fully absorbed before the birth of the young (Florida Museum of National History 2014). The pointed sawfish mature at the second or third year of life and attain a total length of about 2000 and 2300 mm at maturity for males and for females, respectively (Peverell 2005). The average lifespan of this species is 9 years (Peverell 2005; Tobin et al. 2010; Moreno Iturria 2012). The young while they are inside the female's body have their saw teeth not extended and covered with tissue thus to not injure the mother. Once born, the tissue disappears and the rostrum starts to grow in proportion to the body. This species is considered dangerous and should not be reached in any circumstances. With this behaviour of moving the saw side to side, this movement might cause serious injuries to humans. Care should be taken if this species is present in the catch of a trawler. Several cases of attacks by this species against divers in Iraqi marine waters were reported to the local hospital at Fao City, southern Iraq and the victims gave a clear description of the species (Personal observation).

Economic Value This sawfish is taken for its meat, rostra, fins, liver oil, and skin (Compagno et al. 2005; Lack and Sant 2009). They are also caught as a bycatch by the fishery activities through its geographical distribution in the Indo-Pacific region. The fins of this species are considered more valuable elasmobranch products than any other species of shark as they have a high density of fin needles (Simpfendorfer 2013). Parts of the body of this sawfish are also in use in decorations and for medical purposes (McDavitt 1996; McDavitt and Charvet-Almeida 2004).

Conservation Status This sawfish is considered an Endangered species in the IUCN Red List (D'Anastasi et al. 2013). This is due to the heavy demand for its meat and other products and it has been targeted by the fishery activity. On the other hand it is more productive than other sawfish species which may give it a better opportunity to persist longer under fishing pressure (D'Anastasi et al. 2013).

Pristis pectinata (Latham 1794)
Common name: Smalltooth sawfish
Arabic name: سمكة أبو المنشار صغيرالأسنان
Etymology: *Pristis*: Greek, pristis = saw (Fig. 2.52)

Identification
- Body large with shark-body shape, but head, trunk, and pectoral fins flattened.
- Long, flat, blade-like rostrum with 24–32 pairs of teeth along both sides.
- Mouth and gill openings located ventrally with rounded teeth.
- Skin with several denticles of variable size.
- Absence of ventral lobe of caudal fin. Pectoral fins with broad base and straight posterior margin (Simpfendorfer 2005). Both dorsal fins equal in size.
- Body grey in colour with white abdomen (Bigelow and Schroeder 1953; Smith 1997; NMFS 2000).

Fig. 2.52 Smalltooth sawfish, *Pristis pectinata* Latham, 1794. Courtesy of Bonfil, Italy

World Distribution This sawfish has a circumtropical type of distribution. It is reported from the western and eastern Atlantic and from the Indo-Pacific regions (Robins and Ray 1986; Smith 1997; Compagno and Last 1999; Menni and Lucifora 2007).

Distribution in the Study Area There are no records of this species in the Arabian-Persian Gulf and the sea of Oman (Randall 1995; Froese and Pauly 2016), but it has been reported from the southern coasts of the Arabian peninsula at the coasts of Oman (Compagno and Last 1999). Although there are no documented records of this species from the Arabian-Persian Gulf, there is evidence of the presence of different species of sawfish in Iraqi marine waters (Personal observation), Kuwait (Moore et al. 2011), United Arab Emirates (Beech 2004), Qatar (Moore et al. 2011), and Bahrain (Al-Baharna 1992) and this species may well be one of them.

Habitat and Ecosystem Role This sawfish is basically a marine species entering both fresh and brackish waters and has demersal and amphidromous habitats (Reide 2004). It usually found at depth range from the surface of the water down to 10 m (Stehmann 1990). It prefers close to shore and sandy areas, is seldom found in sheltered vicinities, and is known to ascend rivers (NOAA 2016).

Biology The interesting behaviour of this sawfish is the use of the rostrum as a sensor and to handle prey (Wikipedia 2016). An electric field is emitted from thousands of sensory cells found on the saw of the sawfish. This field will enable the fish to censor the movement of other organisms found in its vicinity (Wueringer et al. 2011). Then the fish with the help of other types of cells found in small pits called ampullary pores establishes an image of the area above its body even in turbid water (Wikipedia 2016). By having a lower position near the sea floor, the fish can create an image of the entire surrounding area (Wueringer et al. 2012). In captivity, this species involves in premating behaviour (Smith et al. 2004) and uses its sensory system in courtship behaviour as the males use this system to locate females and vice versa (Pratt and Carrier 2001). It has an ovoviviparous type of reproduction and the young feed on the yolk found in the yolk sac and finish it before birth. Females have two gestation periods and the average number of pups is 20 (Pratt and Carrier 2001). Males and females reach maturity at 2700 and 3600 mm in total length, respectively (Simpfendorfer 2005). This species is considered dangerous to humans when present in the catch of a trawler. Therefore, extreme care should be taken by persons working on clearing nets onboard trawlers as this species is very strong and can cause severe injuries through moving its saw side to side. In Bahrain, the sawfish species in general is considered hazardous to humans as several cases of attacks against divers and swimmers are on record (Al-Baharna 1992).

Economic Value As with other elasmobranch species and slightly different, this sawfish is utilised for six parts of its body which are used mostly as a commercial commodity, these are: fins, whole rostra, rostral teeth, meat, organs, and skin (McDavitt 2005). The rostra of the sawfish are used as ornaments, ritual weapons, and for local medicine in some parts of the world (NMFS 2009). In the Arabian peninsula, the flesh of this sawfish is eaten and is considered as a means to strengthen sexual power (Moore et al. 2011) and used as dry seafood in the desert (Al-Shamlan 2001). The oil from the liver is used to caulk boat hulls (Miles 1919) and the carcasses are used as fertiliser in date palm fields in Bahrain (Moore et al. 2011). The vertebrae of sharks are used as nose clips by pearl divers (Cousteau 1963).

Conservation Status This sawfish is considered Critically Endangered in the IUCN Red List (Carlson et al. 2013). Such a rank is given on the basis that this species is overexploited through the fishery activities in the regions along its geographical distribution. It is easy for this fish to get entangled in nets by the teeth of its saw. The degradation of the environment is considered another threatening factor to this species as it relies on specific habitat types including estuaries and mangroves which are all disturbed by humans (Carlson et al. 2013). Several countries around the world have conservation plans to preserve this sawfish. In the Arabian-Persian Gulf area, several countries are involved in a programme to save this species and it seems to be working thus far (Moore et al. 2011).

Pristis zijsron (Bleeker 1851)
Common name: Longcomb sawfish
Arabic name: سمكة أبو طويل المنشار
Etymology: *Pristis*: Greek, pristis = saw (Figs. 2.53 and 2.54)

Identification

- Large strong body with shark-like shape.
- Head flat anteriorly less flat posteriorly.
- Snout with blade-like saw equipped with teeth on both sides. 23–37 slender and sharply pointed teeth.
- Groove on blade side.
- Oval-shape spiracles located behind eyes.
- Wide and pointed tip dorsal fin with origin above mid-base of pelvic fins. Triangular pectoral fins. Lower lobe of caudal fin not conspicuous.
- Dorsal side of body greenish-brown colour and white ventral side. Rostrum with dark shade (Randall 1995).

World Distribution The distribution of this species is confined to the Indo-Pacific region. It is found from the Red Sea down to east Africa and to Papua New Guinea in the west. It is also found on the coasts of China and south to New South Wales, Australia (Froese and Pauly 2016).

Distribution in the Study Area In the Arabian-Persian Gulf area, this sawfish is reported from Kuwait, Bahrain, Qatar (Moore et al. 2011), and United Arab Emirates (Abu Dhabi; Beech 2004) and it is also recorded from Iran (Compagno and Last 1999). This species is recorded from the Sea of Oman (Randall 1995; Compagno and Last 1999) and from the southern coasts of the Arabian peninsula (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role The longcomb sawfish is a marine species and enters both fresh and brackish waters. It lives at depth range from the surface of the water down to 5 m (Compagno and Last 1999). The members

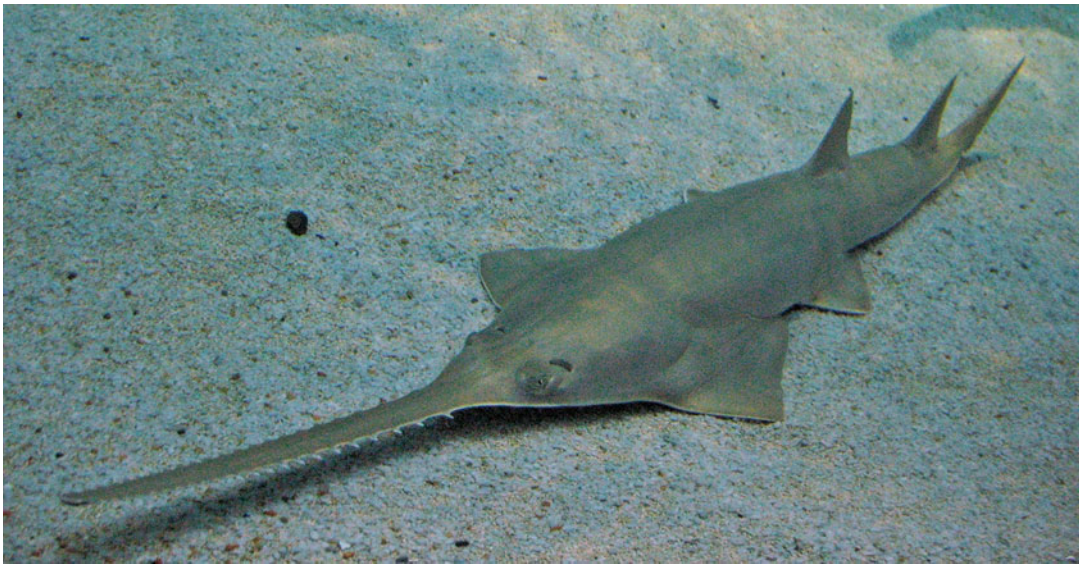

Fig. 2.53 Longcomb sawfish, *Pristis zijsron* Bleeker, 1851. Courtesy of Roberto Pillon, Italy

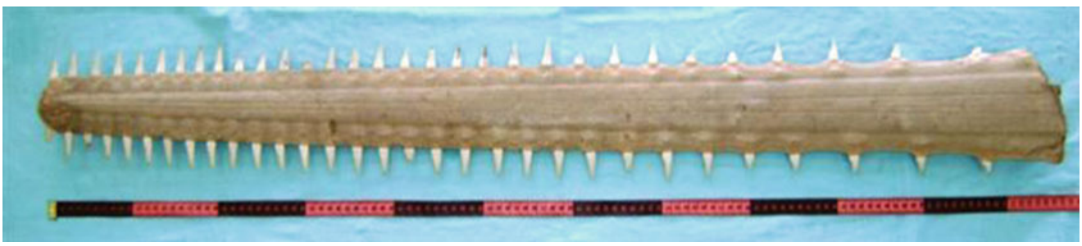

Fig. 2.54 Longcomb sawfish, *Pristis zijsron* Bleeker, 1851. Courtesy of Hamid Osmany, Pakistan

of this species prefer muddy bottoms when they are in an estuarine environment (NOAA 2016) and tolerate cooler waters more than any other sawfish species. Therefore, they are found in cold areas such as the south Australian waters (Compagno and Last 1999; EOL 2016). The young prefer the nearshore and estuarine sheltered areas, whereas adults move to deeper water (Stephenson and Chidlow 2003).

Biology This sawfish has an interesting behaviour: it moves the rostrum side to side to displace bottom dwellers when looking for suitable prey such as crustaceans, squid, or fish. It has been noticed that this fish usually raises the saw at an angle to the body axis. The common total length of the longcomb sawfish is within 6000 mm, but larger individuals with 7000 mm in total length have been reported (Simpfendorfer 2013) and reach maturity at 3400–3800 mm in total length (Peverell 2008; Last and Stevens 2009) at 9 years old (Peverell 2008). At birth, pups measure 600–1080 mm in total length after a gestation of 5 months. This sawfish has a nonplacental viviparous type of reproduction with number of pups reaching up to 12 (Moreno Iturria 2012). With the fish's large size and long rostrum armoured with sharp teeth, this sawfish is considered dangerous to humans in both water and on board fishing boats. No documented cases of attacks against humans were reported about this species, but in some places in the Arabian-Persian Gulf such as Bahrain it is considered dangerous (Al-Baharna 1992).

Fig. 2.55 African angelshark, *Squatina africana* Regan, 1908. Courtesy of Simon Weigmann, Germany

Economic Value As with other species of sawfish, the longcomb sawfish is taken for its flesh, fins, rostrum, liver, eggs, and skin. In the Arabian peninsula, and as with other elasmobranch fishes, the flesh is considered as a means to strengthen sexual power (Moore et al. 2011) and it is used as dry seafood in the desert (Al-Shamlan 2001). In addition to getting vitamins from the liver oil, it is used to caulk boat hulls (Miles 1919) and the carcasses are used as fertiliser in date palm fields in Bahrain (Moore et al. 2011). The vertebrae of sharks are used as nose clips by pearl divers (Cousteau 1963).

Conservation Status This sawfish is considered Critically Endangered in the IUCN Red List (Simpfendorfer 2013). The threat to this species is in the form of overfishing along its geographical distribution. As with other sawfish, it is easy for this fish to get entangled in nets by the teeth of its saw. In addition, this species requires special habitats with specific environmental characteristics. With the global changes in the marine environment, this species has lost the ability to find its preferred habitats (Simpfendorfer 2013). Conservation plans were put forward by several countries around the world including those countries in the Arabian-Persian Gulf area (Moore et al. 2011).

Order: Squatiniformes
Family: Squatinidae
Squatina africana (Regan 1908)
Common name: African angelshark
Arabic name: قرش الملاك الأفريقي
Etymology: *Squatina*: Latin, squatina, -ae = a kind of shark (Fig. 2.55)

Identification

- Flattened body.
- Pectoral fin large and separated from the body by a notch (Compagno et al. 1989).
- Simple and tapering anterior nasal barbels.
- No lobes on dermal folds of head.
- Snout and dorsal edge of eye with spines. Mid-dorsal line without spines.
- Broad pectoral fin.
- Dorsal side of body brownish with reticulated pattern and no ocelli. White ventral side (Compagno 1984).

World Distribution The angel shark is distributed in the western Indian Ocean from Tanzania to the Eastern Cape coast of South Africa (Froese and Pauly 2016).

Distribution in the Study Area This species is found in the southern coasts of the Arabian peninsula in the coasts of Yemen (Manilo and Bogorodsky 2003). It has not been recorded from the Arabian-Persian Gulf and Sea of Oman (Randall 1995; Henderson and Reeve 2011; Moore et al. 2012).

Habitat and Ecosystem Role The African angel shark is a marine species living at depth down to nearly 500 m, but it is usually found at depth range 60–300 m. It is a benthic inhabitant (Compagno et al. 1989).

Biology There is not much information about its behaviour, but it is known that it buries itself on the bottom of the sea and surprises its prey once they are close enough to have them as a meal (Froese and Pauly 2016). This species ranges in total length between 300 and 500 mm (Fennessy 1994). It follows the ovoviviparous type of reproduction with 7–11 litter size and body size of 280–340 mm in total length. Males and females reach maturity at 750–780 and 900–930 mm in total length, respectively (Compagno 1984). This species is considered dangerous to humans as it can cause a severe bite. Few cases of attack against divers were recorded. Also, fishery workers should take extreme care when clearing this species from trawler nets (Compagno et al. 2005).

Economic Value No commercial value is present for this species, but in south Yemen, people do eat the meat of this species and use the liver oil as a medicine (Personal observation).

Conservation Status Due to the lack of information on the ecology and the biology of this species, it has been listed in the IUCN Red List as Data Deficient. Although there is no significant commercial value and it is not a targeted species, this species faces a major threat from shrimp trawlers that operate in the necessary grounds of this species. No conservation plans are available in the countries where this species is found, but the practice of throwing the specimens of the angel shark back into the sea by the shrimp trawlers should be encouraged (Cliff 2004).

2.1.1 Relationship of Sharks to Humans

Humans are connected to sharks through the attempt of the latter to eat humans through the incidence of attacks which can take several forms. The mechanism of the shark attack is not fully known and the general understanding of this fact is the shark misidentify the sensory signals given by the human body as natural prey which in turn stimulates the predatory habit of the shark (Myrberg and Nelson 1991; Burgess 1990). The shark attack could be superficial or fatal and there are several cases of fatal shark attacks from around the world. Such cases have a direct impact on the countries where tourism is considered a major contribution to the national income such as Australia, Brazil, South Africa, and the United States (Burgess et al. 2010).

The shark attacks vary in both quantity and quality according to several factors. Burgess et al. (2010) have studied the shark attacks in Volusia County, Florida, United States, a place considered one of the most common areas of shark attacks. Burgess et al. (2010) have analysed the cases of shark attack and found they vary according to the following factors which are applicable to many localities.

1. The attack location: Sharks seem to make their attacks in certain areas that they choose for certain biological and environmental factors that lead them to trigger their predatory habit.
2. The attack timing in terms of month of the year, day of the week, and time of the day: The shark attacks usually happen in holiday months such as the summer and in those days when people practise sea sports. The attack is higher on surfers than swimmers. As to the days of the week, the attacks are higher from Wednesday till Sunday. Shark attacks happen in the early and late hours of the day, but frequent attacks occurred during late morning.
3. Effect of moon phase: The new moon period is preferable by sharks more than the other lunar phases.
4. Water depth and clarity: The majority of attacks happened in the near-shore and near-surface areas where people are engaged in swimming or other underwater activities.
5. Victim activity: Swimming is the most common activity when the attack occurred. To a

lesser extent, shark attacks happened through fishing activity.

6. Victim injury: The leg of swimmers and surfers seems to be the most affected body part by shark attack. However, other parts of the body such as the hand are also targeted by sharks.
7. Attacking shark species: Identifying the species of the attacking shark is a difficult task as the characteristics of the shark do not look clear at the time of the incident or the victim does not pay much attention.
8. Attacking shark behaviour: Usually, sharks have a single bite and leave the area, but repetitive bites are also reported but to lesser extent when sharks remain in the area of the incident.

The attacks by large species of sharks cause serious injuries if they are not fatal. The injuries caused by small-sized shark species are less severe and range from laceration to tooth impression wounds. There might be a significant loss of tissue or cut of a tendon that leads to inability to move the part (Burgess et al. 2010). According to Burgess (1990), the shark attack can be classified into three categories:

1. Sneak: In this type, the attack is unexpected and usually happens to a diver or swimmer in deep water.
2. Bump and bite: The victim is encircled by the shark and receives a series of bumps in which the shark tests how dangerous is the prey and at the same time causes injuries that might lead to the inability of the victim to escape (McCosker 1985; Baldridge 1988).
3. Hit and run: In this type of shark attack, the victim is just seized and released before being able to respond. This type of attack happens in shallow water and usually comes from juvenile sharks.

The attacks by large-size sharks fall under the first two categories where the shark repeatedly attacks the victim or the possibility of having another attack by the same shark is still present with high severity of injuries. On the other hand, the hit and run attack involves an initial bite followed by a direct retreat of the shark from the scene of the incident.

The sharks are usually attracted to shallow water areas where schools of mullet and herring use this area of the sea and the individuals of these schools are characterised in having movement similar to that generated by the moving hands and legs of swimmers and splashing water. Such activity confuses the shark and starts the attack. For surfers, the movement of hands and legs in an area away from the shore will attract large-size shark individuals. Also, surfers usually sit on the board waiting for the waves to come and their legs hang in the water. Such action will attract sharks to attack these hanging targets (Cliff 1991). If the surfing area is near a jetty where fishing activities are going on, then more sharks are attracted to this area to have their share of the captured fish. Surfers are more vulnerable to shark attack than waders as the former have their legs and hands moving whereas the latter have their legs standing in shallow water (Hazin et al. 2008).

The relationship between the lunar phase and the shark attack could be explained on the basis that during the new moon phase higher tides occur that bring more sharks to the coastal area. Such correlation between the lunar phases and the migration of sharks towards the coastal areas is also noted in other marine organisms such as different teleost fishes (Naylor 1999), invertebrates (Gliwicz 1986), and mammals (Wright 2005). With the new moon, light intensity is low and not much light penetrates the water. This leads organisms to follow the light to the surface and shore areas. Sharks usually use this fact and follow the prey to their new areas and stay there until the next moon phase when the moonlight becomes stronger and penetrates deeper into the water. Such changes in the moon intensity will lead to the movement of marine organisms to deeper areas and sharks will follow them there and leave the shallow and shore areas (Lowry et al. 2007).

Caldicott et al. (2001) have recognised several adaptations in the shark's body that make it a potential predator and also have allowed this creature to maintain its ecological position over the ages (Baldridge 1988). Knowledge of the biology and habits will make available information to help avoid receiving a shark attack. These adaptations are:

1. Skeleton made of cartilage that enables it to manoeuvre better than other fish species.
2. Absence of swim bladder, a case that gives the shark the ability to ascend to catch prey faster than any other fish species without the effect of depth pressure.
3. Sharks can see colour and their eyes are equipped with a light-reflecting layer which boosts their night vision. Unfortunately, sharks are attracted to the orange colour used for life-saving equipment (Welch and Martini 1981).
4. The sharks have an excellent sensation system. The chemoreceptors are very efficient and can trace any chemical or material. The ocean white-tip shark can even trace chemicals in the air. In addition, their hearing is tuned to low frequency (800 Hz) and their ability to locate a sound source is extremely accurate.
5. They have an electroreception sense via a special structure called 'ampullae of Lorenzi' by which they can smell the small electrical field transmitted from the body of every living creature.
6. They have well-built bodies with excellent groups of muscles that enable a single shark to throw an adult human out of the water (Davies and Campbell 1962).
7. Their jaws are equipped with large, sharp, and pointed teeth which help to hold their prey and are capable of biting through a surfboard, bones, and a small boat. Shark bites have been shown to exert as much as 18 tons per square inch pressure at the tips of the teeth (Guidera et al. 1991; Byard et al. 2000).

Prevention of Shark Attack

Caldicott et al. (2001) have suggested several concepts by which it is possible to reduce the risk of facing a shark attack. These are: (1) in understanding the behaviour and feeding habits of the shark which give an idea of what things trigger the shark for the attack; (2) keeping away from the feeding areas of the shark and reducing the body movements that the shark might think comes out of a natural prey will minimize the risk of an attack; (3) in the worst cases where one is faced with an imminent attack, the best decision in this case is to leave the water as soon as possible, but not to panic and show any movements that trigger the attack habit in the shark; (4) scuba divers may face large-size sharks therefore they should be aware of the signs of the attack and prepare to retreat; (5) if the shark insists on the attack, use any weapon that you can get to defend yourself. The most sensitive areas of the shark's body are the eyes and the gills so aim your hit to these areas if you need to strike.

2.2 Osteichthyes (Teleostean Fishes)

2.2.1 Moray eels

Order: Anguilliformes
Family: Muraenidae
Echidna nebulosa (Ahl 1789)
Common name: Snowflake moray
Arabic name: ثعبان السمك الثلجي
Etymology: *Echidna*: Greek, echidna = viper (Fig. 2.56)

Identification

- Body elongated, cylindrical at anterior end, compressed posteriorly towards tail.
- Short and blunt snout.
- Eyes small.
- Nostrils different in shape, anterior nostril tube-shaped, and posterior nostril is a simple hole.
- Teeth in two rows in both jaws. Vomerine teeth present.
- Dorsal fin originates from head anterior to gill opening. No pectoral and pelvic fins.
- No scales on body.

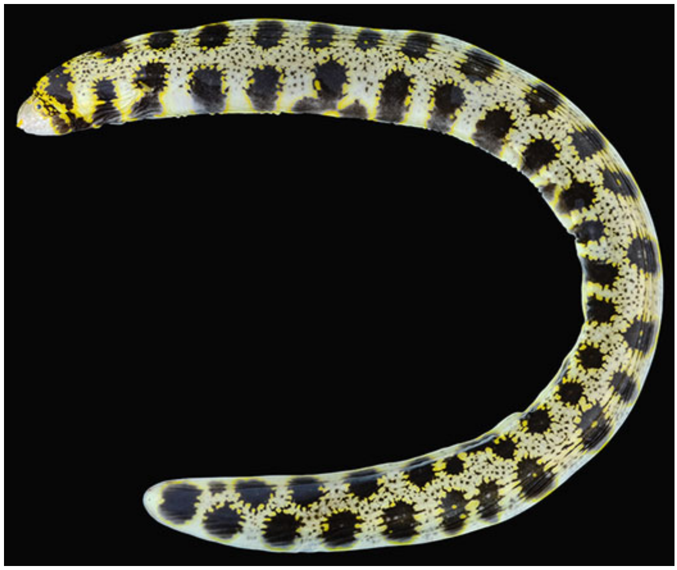

Fig. 2.56 Snowflake moray, *Echidna nebulosa* (Ahl, 1789). Courtesy of Hiroyuki Motomura, Japan

- Body whitish in colour with two large rows of black blotches and small black spots in between. Eyes yellow (Fischer and Bianchi 1984; Randall 1995; Kuiter and Tonozuka 2001).

World Distribution The distribution of the snowflake moray is confined to the Indo-Pacific region and found from the Red Sea down to East Africa (Fricke 1999) and east to Japan and south to Lord Howe Island and through Micronesia. It is recorded from the eastern and southeast Atlantic (McCosker and Rosenblatt 1995).

Distribution in the Study Area This moray eel is recorded from the Arabian-Persian Gulf in the waters of Kuwait (Bishop 2003), Iran (Owfi et al. 2014) and Oman (Randall 1995). It is also reported from the Sea of Oman at both the Omani and the Iranian coasts (Randall 1995; Owfi et al. 2014). In the southern coasts of the Arabian peninsula, it has been reported from the coasts of both Yemen and Oman (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species living in reef areas and found at depth range from the surface of the water down to about 50 m (Mundy 2005), but usually found at depth of 10 m. It prefers rocks and corals as a habitat but also visits shallow lagoons (Kuiter 1998).

Biology The snowflake moray reaches a total length of 1000 mm, but the common size is 500 mm in total length (Froese and Pauly 2016). It is a hermaphrodite fish and the habit of females changing sex to males (called protogynous) is not confirmed with a pelagic egg and larva (Sadovy de Mitcheson and Liu 2008). It is a solitary species (Froese and Pauly 2016). To keep this eel in an aquarium, a large, tight-fitting tank of 155–190 gallons is required to keep it in as this eel is able to escape. In an aquarium, this species can live up to 4 years (Aquarium community 2016). This species is considered dangerous to humans especially when divers go looking inside holes underwater. It can cause severe bites and bad injuries with its large teeth. In the aquarium, this species can attack people feeding animals especially in their first few days in captivity.

Conservation Status Not evaluated.

Enchelycore pardalis (Temminck and Schlegel 1846)

Common name; Leopard moray eel

Fig. 2.57 Leopard moray eel, *Enchelycore pardalis* (Temminck & Schlegel, 1846). Courtesy of Hiroyuki Motomura, Japan

Arabic name: ثعبان السمك الفهد
Etymology: *Enchelycore*: Greek, enchelys = eel + Greek, kore = pupil (Fig. 2.57)

Identification

- Body elongated.
- Mouth with hooked teeth. Canine teeth in single row in both jaws in addition to small conical teeth between rows. Three long canine teeth in front of upper jaw.
- Nostrils different in length with posterior nostril longer than anterior.
- Anus in anterior half of body.
- Dorsal fin originates anterior to gill opening.
- Body basic orange to brown colouration with white and black spots of various size. White spots on head are vertically elongated.

World Distribution The distribution of this eel is confined to the Indo-Pacific region. It is found from the Reunion Islands to Hawaii, Japan, and southern Korea (Masuda et al. 1984).

Distribution in the Study Area This eel is not reported from the Arabian-Persian Gulf, but it is rare in the Sea of Oman and the southern coasts of the Arabian peninsula and the coasts of Oman (Randall 1995).

Habitat and Ecosystem Role It is a fully marine species found in reef areas at depth range 8–60 m (Allen and Steene 1988).

Biology It is a nocturnal species and prefers cryptic habitats, therefore it is not seen very much (Lieske and Myers 1994). Its body might show changes in colouration and several colours and patterns during development (Salt Aquarium 2016). With the presence of long sharp canine teeth of different sizes in its mouth, this species is considered dangerous to humans and divers should take extreme care when approaching underwater holes as this species prefers such habitats.

Economic Values The meat has no economic value, but the species is an important commercial commodity for aquarium trade in the areas where it is found.

Conservation Status Not evaluated.

Echidna polyzona (Richardson 1845)
Common name: Barred moray
Arabic name: السمكه الثعبانيه المخططه
Etymology: *Echidna*: Greek, echidna = viper (Fig. 2.58)

Fig. 2.58 Barred moray, *Echidna polyzona* (Richardson, 1845). Courtesy of Pierre de Chabannes, France

Identification

- Body grey basic colour with pale bands. 23–30 dark bands in young become unclear with age. In adults, colour pattern becomes mottled brown. Corner of mouth dark brown. Head light color with dark blotching (Kuiter and Tonozuka 2001).

World Distribution It is distributed in the Indo-Pacific region from the Red Sea north to South Africa at the south (Fricke 1999) and eastward to the Hawaiian, Marquesan, and Tuamoto Islands, north to the Ryukyu Islands, and south to the Great Barrier Reef (Froese and Pauly 2016).

Distribution in the Study Area This species was recorded from the Arabian Sea coasts of Yemen only (Randall et al. 1990).

Habitat and Ecological Role This marine species lives in association with reefs at depth range 2–20 m (Allen and Erdmann 2012).

Biology Not much information is available about the biology of this species.

Economic Value No commercial value.

Conservation Status Not evaluated.

Gymnothorax favagineus (Bloch and Schneider 1801)

Common name: Laced moray

Arabic name: ثعبان السمك المزركش

Etymology: *Gymnothorax*: Greek, gymnos = naked + Greek, thorax, -akos = breast (Fig. 2.59)

Identification

- Robust body with anus in anterior half.
- Dorsal fin originates well before gill opening.
- Long canine teeth falling in row in front of mouth. Roof of mouth equipped with sharp teeth falling into two rows in adult.
- Body basically white colour and black blotches in intercept position across body forming honeycomb pattern. Shape and size of spots on head and jaws less variable, numerous, and encircled with white colour (Randall 1995; Kuiter 1998; Kuiter and Tonozuka 2001; Allen and Erdmann 2012).

World Distribution The distribution of this eel is confined to the Indo-Pacific region. It is found from the Red Sea down to East Africa and to the

Fig. 2.59 Laced moray, *Gymnothorax favagineus* Bloch & Schneider, 1801. Courtesy of Trevor Meyer, Australia

west to Papua New Guinea and north to Japan (Lieske and Myers 1994; Fricke 1999).

Distribution in the Study Area There is no record of this species from the Arabian-Persian Gulf, but it has been reported from the Sea of Oman (Randall 1995). It is common in the southern coasts of the Arabian peninsula (Randall 1995; Kemp 1998; Zajonz et al. 2000; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role The lace moray is a marine species that prefers living in reef areas and is found at depth range 1–50 m (Allen and Erdmann 2012).

Biology There is not much information about the behaviour of this species. Maximum size reached is 300 mm in total length (Lieske and Myers 1994). In crevices, it lives in association of cleaning wrasses or shrimp (Chen et al. 1994). This species is known for its aggressive behaviour, therefore extreme care should be taken by divers when they explore underwater caves and holes. Also, aquarium keepers should be careful when they feed this species especially the large adult specimens.

Economic Value This species has no economic value, but in some cases gets caught in bottom trawlers where it discards the dead back to the sea.

Conservation Status No IUCN evaluation has been made for this species.

Gymnothorax flavimarginatus (Rüppell 1830)
Common name: Yellow-edged moray
Arabic name: ثعبان السمك أصفر الحافات
Etymology: *Gymnothorax*: Greek, gymnos = naked + Greek, thorax, -akos = breast (Fig. 2.60)

Identification

- Body robust with big head.
- Anus in anterior half of body.
- Dorsal fin originates over gill opening.
- Posterior nostril not tubular with raised edge.
- Large canine and small-sized teeth in first row of upper jaw. Median row of upper jaw with 1–3 canine teeth. Side of upper jaw with short teeth.
- Body colouration yellowish with numerous dark brown spots. Front of mouth purple. Fins with yellow-green posterior margins. Black blotches on gill opening. Corner of

Fig. 2.60 Yellow-edged moray, *Gymnothorax flavimarginatus* (Rüppell, 1830). Courtesy of Hiroyuki Motomura, Japan

mouth black. (Myers 1991; Chen et al. 1994; Randall 1995; Kuiter and Tonozuka 2001; Allen and Erdmann 2012).

World Distribution The distribution of this eel is confined to the Indo-Pacific region. It is found from the Red Sea down to South Africa (Castle and McCosker 1986) and eastward to the Hawaiian Islands and south to New Caledonia. It is recorded from several places in the eastern Pacific (McCosker and Rosenblatt 1995).

Distribution in the Study Area In the Arabian-Persian Gulf, this species is reported from Kish Island, Iran and the only image of this species was deposited by Amir Ghazilou in the Fishbase (Froese and Pauly 2016). No other report is present from another part of the Gulf. Similarly, no record is present from the Sea of Oman. It has been reported from the southern coasts of the Arabian peninsula at the coasts of Yemen (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role The yellow-edged moray is a marine species found in association with reefs and lives at depth range from the surface down to 150 m (Myers 1991).

Biology This eel has a habit of being solitary and curious at the same time. It has been seen protruding its head out of the crevices where it lives (Froese and Pauly 2016). It is sensitive to the presence of injured fish in its environment and has been found at the site where fish are speared during daylight (Hobson et al. 1974). It attains a maximum total length of 1400 mm. The male and female have been seen in the wild dancing prior to spawning and releasing eggs and sperm. Larvae are ribbon-shape called Leptocephalus larva. The bites of this species are very painful and serious. If bitten by this species, do not pull your hand back as you will cut yourself further by the recurved teeth. The microbes in the moray eel mouth and in the water will cause an infection of the injured area (Wet Web media 2016).

Economic Value In general, this species has no economic value, but it has been reported to be eaten in some parts of the Pacific region (Wet Web Media 2016).

Conservation Status No IUCN evaluation has been made for this species.

Fig. 2.61 Grey moray, *Gymnothorax griseus* (Lacepède, 1803). Courtesy of Lewis Cocks, Saudi Arabia

Gymnothorax griseus (Lacepède 1803)
Common name: Grey moray
Arabic name: ثعبان السمك الرمادى
Etymology: *Gymnothorax*: Greek, gymnos = naked + Greek, thorax, -akos = breast (Fig. 2.61)

Identification

- Body elongated and cylindrical.
- Anus in its anterior half.
- Dorsal fin originates between gill opening and eye.
- Both jaws equipped with conical teeth falling in two rows in upper jaw and one row in lower jaw.
- Ground colour of body pale yellowish with dense dark spots. Pores on head with dark spots (Castle and McCosker 1986; Randall 1995).

World Distribution The distribution of this species is confined to the western Indian Ocean area including the Red Sea (Froese and Pauly 2016).

Distribution in the Study Area No record of this species from the Arabian-Persian Gulf. Randall (1995) reported this species from Omani waters, but it is not clear whether it has been taken from the Sea of Oman or the Arabian Sea coasts of Oman. It is reported from the southern coasts of the Arabian peninsula at the coasts of Yemen and Oman (Zajonz et al. 2000; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species preferring reef areas and found at depths down to 40 m (Sommer et al. 1996).

Biology The species can attain 650 mm in total length. This species is considered dangerous to humans especially when divers go looking inside holes underwater. It can cause severe bites and bad injuries with its large teeth. In the aquarium, this species can attack people feeding animals especially in the first few days in captivity.

Economic Value No economic value.

Conservation Status Not evaluated.

Gymnothorax herrei (Beebe and Tee-Van 1933)
Common name: Herre's moray
Arabic name: ثعبان السمك هير
Etymology: *Gymnothorax*: Greek, gymnos = naked + Greek, thorax, -akos = breast (Fig. 2.62)

Identification

- Body small, but robust.
- Anus in anterior half of body.
- Dorsal fin originates slightly anterior to gill opening.
- Side of upper jaw with two rows of teeth with inner teeth longer than outer. Lower jaw with long teeth at front of jaw. Presence of nodular teeth on roof of mouth falling in one row.
- Body with light brown colouration. Area below eyes free of marks and snout white

Fig. 2.62 Herre's moray, *Gymnothorax herrei* Beebe & Tee-Van, 1933. Courtesy of Richard Winterbottom, Canada

(Randall 1995; Nakabo 2002; Allen and Erdmann 2012).

World Distribution This eel has an Indo-West Pacific distribution from the Red Sea to Taiwan and the Philippines in the east and South China Sea to Papua New Guinea (Froese and Pauly 2016).

Distribution in the Study Area No record of this species from either the Arabian-Persian Gulf or the Sea of Oman. It has been reported from the southern coasts of the Arabian peninsula in Omani waters (Randall 1995).

Habitat and Ecosystem Role This eel is a marine species found at depth range from the water surface down to 12 m (Allen and Erdmann 2012).

Biology There are no available data on the behaviour of this eel. This eel is considered dangerous to humans for its robust body and its sharp teeth which may cause severe injuries.

Economic Value In general, this species has no economic value, but it has been reported to be eaten in some parts of the Pacific region (Wet Web Media 2016).

Conservation Status No IUCN evaluation has been made for this species.

Gymnothorax javanicus (Bleeker 1859)
Common name: Giant moray
Arabic name: ثعبان السمك الكبير
Etymology: *Gymnothorax*: Greek, gymnos = naked + Greek, thorax, -akos = breast (Fig. 2.63)

Identification
- Body large and deep.
- Anus in middle of body.
- Dorsal fin originates in front of gill opening. Anal and dorsal fin covered with skin.
- Anterior nostril simple tube and posterior nostril simple hole.
- Lower jaw straight. Teeth in general are large. Front of upper jaw with 5–6 long teeth. Sides

Fig. 2.63 Giant moray, *Gymnothorax javanicus* (Bleeker, 1859). Courtesy of Hiroyuki Motomura, Japan

of upper jaw with 2–3 teeth. Lower jaw with small sharp teeth and 3–4 inner canine teeth.
- Ground colour of body brown with irregular dark spots. Abdomen and lower jaw pale. Corner of mouth dark (Chen et al. 1994; Allen and Erdmann 2012; Froese and Pauly 2016).

World Distribution The distribution of the giant eel is restricted to the Indo-Pacific region. It is found from the Red Sea down to east Africa and eastward to the Hawaiian Islands and New Caledonia (Fricke 1999; Froese and Pauly 2016).

Distribution in the Study Area No records of this eel from either the Arabian-Persian Gulf or the Sea of Oman. It has been reported from the southern coasts of the Arabian peninsula on the coasts of Yemen (Manilo and Bogorodsky 2003) and Socotra (Zajonz et al. 2000).

Habitat and Ecosystem Role This eel is a marine species preferring reef areas and found at depths down to 50 m (Sommer et al. 1996).

Biology This species can attain a maximum total length of 2500 mm. It prefers to live solitary in crevices and holes (Allen and Erdmann 2012). The giant moray eel has a feeding mechanism in which the teeth play an important role. The teeth of this moray eel are mobile to assist in swallowing prey. Usually, the eel bites and catches the prey with its oral jaws. Immediately, the pharyngeal jaws move forward and bite the prey to secure the grip. Then they retract pulling the prey down the eel's gullet with them and preparing the prey for swallowing (Animalia Enthusiasts 2016). The giant eel has several attack cases against humans; most of them are unprovoked (Siliotti 2002; Lieske and Myers 2004; Bshary et al. 2006; Froese and Pauly 2016).

Economic Value In general, this species has no economic value, but it has been reported to be eaten in some parts of the Pacific region (Animalia Enthusiasts 2016).

Conservation Status Not evaluated.

Gymnothorax meleagris (Shaw 1795)
Common name: Turkey moray
Arabic name: ثعبان السمك المرقط
Etymology: *Gymnothorax*: Greek, gymnos = naked + Greek, thorax, -akos = breast (Fig. 2.64)

Identification
- Body elongated and cylindrical with tail tapering posteriorly.
- Dorsal fin originates between gill opening and corner of mouth.
- Anus in anterior part of body.

Fig. 2.64 Turkey moray, *Gymnothorax meleagris* (Shaw, 1795). Courtesy of Hiroyuki Motomura, Japan

- Anterior nostril tubular-shaped and posterior nostril a simple hole.
- Upper jaw with 1–2 rows of teeth with canine teeth in front row. Canine teeth in front of upper jaw. Side of upper jaw with inner canine teeth.
- Body dark colour with small white spots. Inside mouth white. Anterior nostrils and gill openings black (Chen et al. 1994; Kuiter 1998; Kuiter and Tonozuka 2001).

World Distribution The distribution of this species is confined to the Indo-Pacific region. It is found from East Africa to the Marquesas and Mangareva, north to the Hawaiian Islands, and south to Lord Howe Island. It is also reported from South Africa (Fricke 1999).

Distribution in the Study Area There are no records of this species from either the Arabian-Persian Gulf or the Sea of Oman. It has been reported from the southern coasts of the Arabian peninsula at the coasts of Socotra (Zajonz et al. 2000) and coasts of Yemen (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role This eel is a marine species sometimes entering brackish and freshwater. It prefers reef areas and is found at depths from the surface down to 51 m (Mundy 2005).

Biology This species can attain a maximum total length of 1000 m. Eggs and larvae are pelagic. It lives in holes and has a habit of emerging suddenly to grasp passing fish (Froese and Pauly 2016). This species is considered dangerous to humans especially when divers go looking inside holes underwater. It can cause severe bites and bad injuries with its large teeth. In the aquarium, this species can attack people feeding animals especially in the first few days in captivity.

Economic Value No economic value.

Conservation Status Not evaluated.

Gymnothorax nudivomer (Günther 1867)
Common name: Yellowmouth moray
Arabic name: ثعبان السمك أصفر الفم
Etymology: *Gymnothorax*: Greek, gymnos = naked + Greek, thorax, -akos = breast (Fig. 2.65)

Identification

- Body large and robust with blunt snout.
- Anus in anterior half of body.

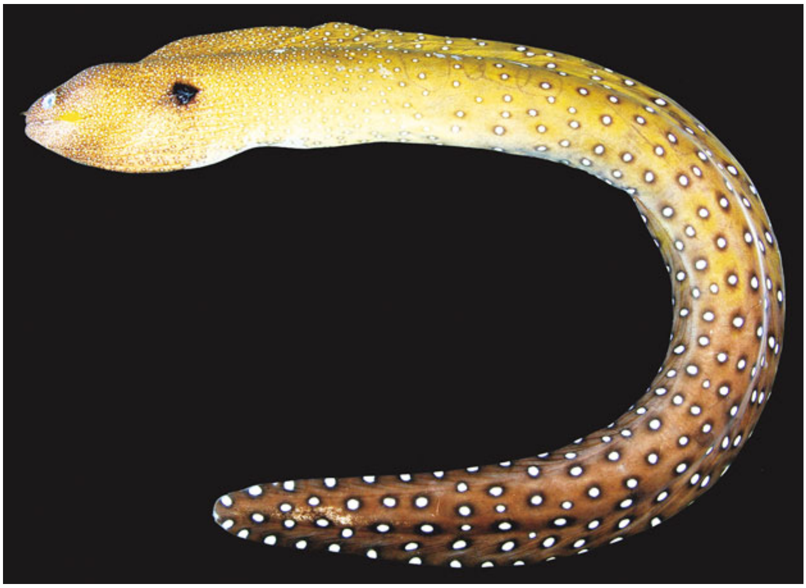

Fig. 2.65 Yellowmouth moray, *Gymnothorax nudivomer* (Günther, 1867). Courtesy of Hiroyuki Motomura, Japan

- Dorsal fin originates at point between corner of mouth and gill.
- Jaws equipped with teeth falling in one row. Absence of canine teeth. Inner row of upper jaw with three long teeth. Sides of upper jaw with two long teeth at internal row. All teeth serrated at their posterior edge. No teeth on roof of mouth (Smith et al. 2008).
- Body dark with yellow basic colour and numerous small spots increasing in number at anterior part of body (Kuiter and Tonozuka 2001). Inside mouth yellow (Kuiter 1998; Kuiter and Tonozuka 2001). Gill opening encircled in black colour spot (Chen et al. 1994).

World Distribution This species of eel has an Indo-Pacific distribution from the Red Sea to South Africa (Castle and McCosker 1986) and to the east to the Marquesas Islands and to the south to New Caledonia (Froese and Pauly 2016).

Distribution in the Study Area There is no record of this species from the Arabian-Persian Gulf. It has been reported by a single photo from the Fahal Island, Sea of Oman deposited in Fishbase by Richard Field (Froese and Pauly 2016). It is found in the southern coasts of the Arabian peninsula in the waters of Yemen (Kemp 1998; Manilo and Bogorodsky 2003) and Oman (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role The yellowmouth moray is a marine species preferring reef areas and living at depth range 2–270 m (Mundy 2005).

Biology There is no information about the behaviour of this species. It is dangerous for its large and strong body and sharp teeth.

Economic Value In general, this species has no economic value and no report on its use as food by humans.

Conservation Status Not evaluated.

Gymnothorax phasmatodes (Smith 1962)
Common name: Ghost moray
Arabic name: ثعبان السمك الشبح
Etymology: *Gymnothorax*: Greek, gymnos = naked + Greek, thorax, -akos = breast (Fig. 2.66)

Identification

- Slender long body.
- Anus near middle of body.

Fig. 2.66 Ghost moray, *Gymnothorax phasmatodes* (Smith, 1962). Courtesy of Moazam Khan, Pakistan

- Dorsal fin originates prior to gill opening.
- In both jaws, teeth triangular in shape and in one row. Front of mouth with 2–3 canine teeth.
- Body pale in colour. Dorsal fin with shaded narrow edge. Pores on side of jaw encircled with white spot (Randall 1995; Allen and Erdmann 2012).

World Distribution The distribution of this species is confined to the Indo-West Pacific region. It is found in Mozambique and Mauritius (Fricke 1999) and to the east to the Philippines and south to Australia (Froese and Pauly 2016).

Distribution in the Study Area The only record of this species from the Arabian-Persian Gulf is that of Randall (1997) from the coasts of Jana Island, Saudi Arabia. The record of this species from Oman by Randall (1995) is not clear whether it is from the Sea of Oman or from the southern coasts of the Arabian peninsula.

Habitat and Ecosystem Role It is a demersal marine species. Little is known about the habitat of this species.

Biology There is no information about the behaviour of this species. This species is considered dangerous to humans especially when divers go looking inside holes underwater. It can cause severe bites and bad injuries with its large teeth. In the aquarium, this species can attack people feeding animals especially in the first few days in captivity.

Economic Value No economic value.

Conservation Status Not evaluated.

Gymnothorax pictus (Ahl 1789)
Common name: Paintspotted moray
Arabic name: ثعبان السمك أسود النقاط
Etymology: *Gymnothorax*: Greek, gymnos = naked + Greek, thorax, -akos = breast (Fig. 2.67)

Identification

- Body elongated and cylindrical.
- Dorsal fin originates above gill opening.
- Anus at middle of body.
- Anal and dorsal fins covered with skin.
- Posterior nostril simple hole with slightly raised rim.

Fig. 2.67 Paintspotted moray, *Gymnothorax pictus* (Ahl, 1789). Courtesy of Hiroyuki Motomura, Japan

- Jaws with short and conical-shaped teeth falling in one row. Teeth on side of jaw compressed and triangular. About three teeth in front of upper jaw. Roof of mouth with long teeth directed anteriorly and falling in two rows.
- General body colouration grey with dark and irregular spots (Castle and McCosker 1986; Myers 1999; Allen and Erdmann 2012).

World Distribution The distribution of this species is confined to the Indo-Pacific region. It is found from East Africa to the Galapagos and north to Hawaii and south to Australia and Kermadec Islands (Weitkamp and Sullivan 2003; Froese and Pauly 2016).

Distribution in the Study Area There are no records of this species from both the Arabian-Persian Gulf and the Sea of Oman. The record of Randall (1995) from Oman cannot be confirmed as it is not clear where exactly in Oman it has been captured. This species is reported from the southern coasts of the Arabian peninsula on the coasts of Yemen and Oman (Manilo and Bogorodsky 2003) and from the coasts of Socotra (Zajonz et al. 2000).

Habitat and Ecosystem Role It is a marine species that prefers reef areas and is found at depth range 5–100 m (Weitkamp and Sullivan 2003).

Biology There is no information about the behaviour of this species, but it is known that it is a solitary species (Froese and Pauly 2016) and it is a simultaneous hermaphrodite (adult fish with both male and female sexual organs at the same time, but does not self-fertilise (Barrows 2001; Sadovy and Liu 2008). Eggs and larvae are pelagic. It attains a maximum total length of 1200 mm (Allen and Erdmann 2012). This species is considered dangerous to humans especially when divers go looking inside holes underwater. It can cause severe bites and bad injuries with its large teeth. In the aquarium, this species can attack people feeding animals especially in the first few days in captivity.

Economic Value No economic value.

Conservation Status No IUCN evaluation has been made for this species.

Gymnothorax pseudothyrsoideus (Bleeker 1853)
Common name: Highfin moray
Arabic name: ثعبان السمك مرتفع الزعنفة
Etymology: *Gymnothorax*: Greek, gymnos = naked + Greek, thorax, -akos = breast (Fig. 2.68)

Fig. 2.68 Highfin moray, *Gymnothorax pseudothyrsoideus* (Bleeker, 1853). Courtesy of Hiroyuki Motomura, Japan

Identification

- Body robust and cylindrical with big head.
- Anus at middle of body.
- Dorsal fin originates behind gill opening.
- Short, smooth, and strong teeth in both jaws falling in two rows. Teeth in outer row smaller than inner ones. Teeth in front of mouth in three rows. One row of small teeth in roof of mouth.
- Body colouration pale yellow with dark blotches aggregated to form irregular rows of larger spots along body (Randall 1995; Allen and Erdmann 2012; Froese and Pauly 2016).

World Distribution It is an Indo-West Pacific species and is reported from India, Japan, and Australia (Froese and Pauly 2016).

Distribution in the Study Area There is no record of this species from the Arabian-Persian Gulf and for the southern coasts of the Arabian peninsula. The record of this species from Oman by Randall (1995) is not clear whether it is from the Sea of Oman or from the Arabian Sea coasts of Oman.

Habitat and Ecosystem Role This species of eel is a marine species which prefers living in reef areas (Froese and Pauly 2016).

Biology The species can attain 800 mm in total length. It is rare and seldom seen in the environment. There is no information about its behaviour. This species is considered dangerous to humans especially when divers go looking inside holes underwater. It can cause severe bites and bad injuries with its large teeth. In the aquarium, this species can attack people feeding animals especially in the first few days in captivity.

Economic Value No economic value.

Conservation Status Not evaluated.

Gymnothorax richardsonii (Bleeker 1852)
Common name: Richardson's moray
Arabic name: ثعبان السمك ريتشارد
Etymology: *Gymnothorax*: Greek, gymnos = naked + Greek, thorax, -akos = breast (Fig. 2.69)

Fig. 2.69 Richardson's moray, *Gymnothorax richardsonii* (Bleeker, 1852). Courtesy of Hiroyuki Motomura, Japan

Identification

- Body medium in size, compressed.
- Dorsal fin originates in front of gill opening.
- Anus at middle of body.
- In both jaws, teeth triangular, compressed, and directed backward. Teeth in front of mouth with 1–3 teeth in medium row. Roof of mouth with short conical teeth.
- Ground colour of body pale yellowish with dark spots. Pores on lips encircled with white colour (Chen et al. 1994; Allen and Erdmann 2012; Froese and Pauly 2016).

World Distribution The distribution of this eel is confined to the Indo-Pacific region. It is found in the Red Sea down to East Africa and to Micronesia (Fricke 1999).

Distribution in the Study Area There is no record of this species from both the Arabian-Persian Gulf and the Sea of Oman. It has been reported from the southern coasts of the Arabian peninsula in the coasts of Socotra (Zajonz et al. 2000).

Habitat and Ecosystem Role It is a marine species which prefers reef areas and is found at depth range from the surface of water down to 12 m (Allen and Erdmann 2012).

Biology The species can attain 340 mm in total length (Allen and Erdmann 2012). It has an aggressive behaviour in the wild and is active during the day. In captivity, it is difficult for this species to breed. It requires a specious aquarium as it needs large areas for swimming and hiding. It is also aggressive in the tank and it should be kept alone (Froese and Pauly 2016).

Economic Value No economic value.

Conservation Status Not evaluated.

Gymnothorax undulatus (Lacepède 1803)
Common name: Undulated moray
Arabic name: ثعبان السمك الملتوى
Etymology: *Gymnothorax*: Greek, gymnos = naked + Greek, thorax, -akos = breast (Fig. 2.70)

Identification

- Body long and cylindrical.
- Anus in anterior half.
- Dorsal fin originates in front of gill opening.
- Both jaws have long canine mixed with smaller teeth. Front of mouth with three canine teeth and inner side of jaw with smaller teeth.

Fig. 2.70 Undulated moray, *Gymnothorax undulatus* (Lacepède, 1803). Courtesy of Hiroyuki Motomura, Japan

- Inconstant colour with recognised light undulating lines on green and dark background (Randall 1995; Allen and Erdmann 2012; Froese and Pauly 2016).

World Distribution The distribution of this species is confined to the Indo-Pacific region. It is found from the Red Sea south to East Africa and to the east to Japan and the Hawaiian Islands and south to the Great Barrier Reef. It is also reported from the eastern central Pacific Ocean (McCosker and Rosenblatt 1995; Fricke 1999).

Distribution in the Study Area In the Arabian-Persian Gulf, this species has been reported from Kuwait (Bishop 2003), Bahrain, and Saudi Arabia (Randall 1997) and from the Iranian coasts (Owfi et al. 2014). It is reported from the Sea of Oman (Randall 1995; Owfi et al. 2014) and from the southern coasts of the Arabian peninsula (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species which prefers reef areas and is found at depth range 9–110 m (Mundy 2005).

Biology The species can attain 1500 mm in total length with pelagic eggs and larvae. This species is considered dangerous to humans especially when divers go looking inside holes underwater. It can cause severe bites and bad injuries with its large teeth. In the aquarium, this species can attack people feeding animals especially in the first few days in captivity.

Economic Value No economic value.

Conservation Status Not evaluated.

Gymnothorax zonipectis (Seale 1906)
Common name: Barredfin moray
Arabic name: ثعبان السمك مخطط الذنب
Etymology: *Gymnothorax*: Greek, gymnos = naked + Greek, thorax, -akos = breast (Fig. 2.71)

Identification

- Body short and cylindrical.
- Dorsal fin originates closer to gill opening than corner of mouth.
- Anus in anterior half of body.
- Pointed, elongated, and curved jaws, both with single row of canine teeth. Upper jaw with two median long canine teeth. Side of upper jaw with small sharp teeth.

Fig. 2.71 Barredfin moray, *Gymnothorax zonipectis* Seale, 1906. Courtesy of Hiroyuki Motomura, Japan

- Body light brown with several irregular dark bars running vertically on side. Oblique, thick, dark bands on tail. Pores on jaws covered with white bar. Several white bars on face (Chen et al. 1994; Kuiter and Tonozuka 2001; Allen and Erdmann 2012).

World Distribution This species of eel has its distribution confined to the Indo-Pacific region. It is found from East Africa to the Marquesas and Society Islands and north to the Philippines (Froese and Pauly 2016).

Distribution in the Study Area There are no records of this species from both the Arabian-Persian Gulf and from the sea of Oman. It has been reported from the southern coasts of the Arabian peninsula on the coasts of Socotra (Zajonz et al. 2000).

Biology The species can attain 470 mm in total length, but is usually 400 mm in total length (Chen et al. 1994). This species is considered dangerous to humans especially when divers go looking inside holes underwater. It can cause severe bites and bad injuries with its large teeth. In the aquarium, this species can attack people feeding animals especially in the first few days in captivity.

Economic Value No economic value.

Conservation Status Not evaluated.

Scuticaria tigrina (Lesson 1828)
Common name: Tiger reef-eel
Arabic name: السمكه الثعباني النمر
Etymology: *Scuticaria*: Latin, scutum = shield (Fig. 2.72)

Identification
- Snout rounded.
- Fins reduced (Myers 1999).
- Body yellowish-brown. Black spots on body edges (Castle and McCosker 1986). Jaw with black spots (Kuiter and Tonozuka 2001).

World Distribution It is distributed in the Indo-Pacific region from the coasts of east Africa to the Society Islands and to the north to the Philippines and Taiwan (Chen et al. 1994). It also recorded from the eastern and central Pacific Ocean (McCosker and Rosenblatt 1995).

Fig. 2.72 Tiger reef-eel, *Scuticaria tigrina* (Lesson, 1828). Curtesy of Joe De Vroe, France

Distribution in the Study Area This species is reported from the Arabian Sea coasts of Oman only (Randall 1995).

Habitat and Ecological Role This marine species lives in association with reefs at depth range 8–25 m (Allen and Erdmann 2012).

Biology Not much biological information is available.

Economic Value No commercial value.

Conservation Status Not evaluated.

2.2.1.1 Bites of Moray Eels

The family Muraenidae comprises over 100 species of the moray eel. These creatures differ from the remaining eels in having small gill openings and lacking pectoral fins. Their body has no scales, but is covered with thick mucus material. Their eyesight is weak, but their sense of smell is outstanding and they use it to trace food in their environment. Their jaws are equipped with strong muscles and carry strong and sharp teeth which give the ability of the fish to hold prey tight (Riordan et al. 2004).

Moray eels are known for their aggressive behaviour and several severe cases of attack against humans were reported, the most severe being that reported by Riordan et al. (2004). Such cases might be increased in the future with the increase of human population inhabiting the seashores (Riordan et al. 2004). Eels usually hide in crevices and holes during the day and come out during the night to get their food. They can catch the eye of divers and those people admiring them in an aquarium as they swim in an attractive way.

The bite of a moray eel is considered a serious injury that needs to be given extreme attention and medication. There are two consequences of the eel's bite (Wet Web Media 2016). If the eel is poisonous, then the victim will have a dose of toxin injected into his or her body. The toxic side of the eel's bite will be dealt with later in the section on poisonous and venomous fishes. The other concern of the eel's bite is the inflammation caused by the secondary infection which is more serious and puts health at risk.

The eel has numerous teeth of different shapes and sizes, some of them packed with no space between them and others with a gap separating them. Food usually rots in those spaces between the teeth and germs of different kinds grow in such an environment. The bacteria and other germs will transfer directly to the body of the victim once the bite occurs. Among these horrible bacteria is the *Vibrio* which can cause septicaemia (infection of a blood). Infections with this type of bacteria might lead to death. Another less dangerous, but still causing disease, is the possibility of being infected by *Pseudomonas* bacteria. Eels may cause a large wound with considerable loss of tissue and blood (Howard et al. 1985; Chang and Pien 1986).

All the eel species mentioned above and present in the eastern and southern Arabian peninsula can potentially make a severe attack. Species considered harmless to humans might suddenly attack as the behaviour of the moray eels is not predictable.

There are some general rules to follow by people who come in contact with moray eels such as divers and aquarium keepers (Wet Web Media 2016).

A. Try not to feed the eel by hand.
   There is a good possibility for people who have an eel as a pet in an aquarium at home, those people working as aquarium keepers, or some divers who feel they have enough courage to come closer to the eel and feed it to receive a severe bite from the eel they are feeding. The movement of the hand in the process of feeding the eel will provoke the latter and put it in an attack position. The eel keeps changing its mind about the method of getting its food. This information is very important for aquarium keepers as one day they feed eels in the tank by hand and no incident occurs, but the next day a bite is given by the same eel that received hand-feeding the day before.
B. Do not attempt to become closer to or feed large eel species.
   Eel bites vary in severity and depth with the size of the eel. A bite from a few centimetres-long eel is completely different and less severe than that caused by a 5-m eel. The latter can easily tear a large piece of tissue from any part of your body.
C. Use tools to handle the eels.
   New aquarium or fish keepers are always taught to keep their hands out of the tanks and water as much as possible. Several handy tools are available nowadays to help people have daily contact with dangerous aquatic animals. These tools can assist in delivering food with the human feeder standing a good distance away from the tank.
D. Never get involved in another job while feeding.
   This is the most difficult rule to keep. Divers usually carry their camera and other equipment while diving and at the same time they are trying to feed the eel protruding its head from a hole with the aim of getting it out of its hide. In doing so, the diver will be concentrating on the camera more than the spear that carries the dead fish. There is a good possibility that the eel might attack the diver's body instead of the lure fish (Auerbach 1984). For aquarium keepers, it is important to not get in a discussion with another person while feeding the eels or cleaning their tank. The eel attack only takes a few seconds and therefore it needs your full attention on where you are putting your hand.
   The injuries caused by moray eels fall in the second group of injuries caused by marine animals. This category is about an animal with the potential to cause a severe injury as it is equipped with sharp and long teeth. The grip that the eel has on its prey is very strong and in most cases you need to kill the eel to release the body part. In addition to the long teeth of different shape, the roof of the mouth is supplied with small sharp teeth that help in holding the prey.
   The best treatment of a moray eel bite starts at the site of the incident and the victim should be taken directly to the hospital to determine the tetanus status. At the site of the incident, direct pressure should be applied to the bleeding point until the patient is received by the hospital. A comprehensive assessment of the bite should take place to investigate if any teeth remains are still in the wound which might cause sepsis later on. Use of oxygen locally on the wound appears to be good

Fig. 2.73 Daggertooth pike conger, *Muraenesox cinereus* (Forsskål, 1775). Courtesy of Hiroyuki Motomura, Japan

therapy for healing (LaVan and Hunt 1990). Hyperbaric oxygen therapy will inhibit the activity of the anaerobic bacteria and certain toxin-forming pathogenic microorganisms (Ellis and Mandal 1983; Petzold et al. 1999).

An increased awareness among both emergency-treating personnel and ocean users should reduce the threat of encounters. All divers and especially people entering waters for recreation should be alerted to avoid direct contact with moray eels. As the information about how the moray is predictable as to when it attacks, the building of information from these encounters should continue. Such information will help for better understanding of the motivations of these creatures and successively reduce the hazard of dangerous encounters (Riordan et al. 2004).

Family: Muraenesocidae
Muraenesox cinereus (Forsskål 1775)
Common name: Daggertooth pike conger
Arabic name: ثعبان السمك خنجرى الأسنان
Etymology: *Muraenesox*: Latin, muraena = morey eel + Esox, old name for pike (Fig. 2.73)

Identification

- Body elongated with long snout.
- Head broad.
- Posterior nostril situated near eyes.
- Large mouth with large dagger-shape teeth in two rows on each side of mouth. Vomerine teeth.
- Anus in anterior half of body.
- Body greyish brown colouration. Ventral side white. Median fins with black border.

World Distribution The distribution of this species is confined to the Indo-West Pacific. It is found in the Red Sea, Arabian-Persian Gulf, and west coast of India to Fiji (JICA 1987). It is also found in waters of north of Japan and Korea (Russell and Houston 1989). It is recorded from the Mediterranean Sea (Bauchot and Saldanha 1986).

Distribution in the Study Area In the Arabian-Persian Gulf, this species is only reported from Iraq (Hussain et al. 1988), Iran (IFC and IFRO 2000), Bahrain (Al-Baharna 1986), Saudi Arabia (Krupp and Al-Marri 1991), the United Arab Emirates (Field 2005), and Kuwait (Bishop et al. 2006). Randall (1995) and Manilo and Bogorodsky (2003) have reported it from the Sea of Oman and the Arabian Sea coasts of Oman.

Habitat and Ecosystem Role Basically, it is a marine species, but found in both freshwater and brackish. It is oceanodromous and lives at depths of 740 m (Klausewitz 1994).

Fig. 2.74 Harlequin snake eel, *Myrichthys colubrinus* (Boddaert, 1781). Courtesy of Robert Patzner, Austria

Biology This species can attain a maximum length of 2200 mm in total length, but the common length is 800 mm (Masuda et al. 1984) with age reaching 15 years (Altman and Dittmer 1962). This species is considered dangerous to humans especially when divers go looking inside holes underwater. It can cause severe bites and bad injuries with its large teeth. In the aquarium, this species can attack people feeding animals especially in the first few days in captivity. This species becomes very aggressive when it is caught by net, whether trawl or gill net. The mishandling of the specimens of this species leads to severe injuries. There are several reported cases from Fao City, southern Iraq, about harmful bites caused by this fish to fishermen trying to release the fish from the net. They hold the fish by the tail and the fish turns and plants its large dagger-shaped teeth in the arm of the fishermen (Personal observation).

Eggs are pelagic and spherical in shape. Size at hatching is about 6 mm with bending posture. The larva swims in a horizontal position and rests in a head-up position (Umezawa et al. 1991).

Economic Value This species has low commercial value. In some parts of the Arabian-Persian Gulf the natives use the meat of this species for human consumption, whereas in China and Japan, it is considered a major commercial species with annual catches of about 350,000 tonnes in recent years (FAO 2012). The meat of this fish is used as a co-ingredient in making crab sticks (Davidson 2003).

Conservation Status The status of this species is not evaluated for the Red List of the IUCN. In some parts of the world such as SouthEast Asia, China, and Japan, the fishery status of this species needs to be regulated due to the heavy targeted fishing activities.

Family: Ophicthidae
Myrichthys colubrinus (Boddaert 1781)
Common name: Harlequin snake eel
Arabic name: ثعبان السمك المخطط
Etymology: *Myrichthys*: Greek, myros, -ou = male of morey eel + Greek, ichthys = fish (Fig. 2.74)

Identification

- Body long, thin, and rounded resembling a snake.
- Anus in posterior part of body.
- Teeth are small, falling in two series on jaws.
- Dorsal fin originates on head. Very small pectoral fin.
- General body colour whitish to yellowish with dark rings (Randall 1995; Kuiter and Tonozuka 2001).

World Distribution It is distributed only in the Indo-Pacific region from the Red Sea to Mozambique south and east to the Society Islands and French Polynesia (Lieske and Myers 1994).

Distribution in the Study Area The only report of this species from the Arabian-Persian Gulf area is that from the United Arab Emirates (Field 2005). There is no report of this species from the Sea of Oman (Randall 1995), but it has been reported from the Arabian Sea coasts of Oman (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species living in association with reefs and found at depths down to 35 m (Bacchet et al. 2006).

Biology This species lives in shallow sandy areas and in seagrass locations (Lieske and Myers 1994; Kuiter and Tonozuka 2001; Mundy 2005). It is also reported to live in benthic environments (Mundy 2005). It usually feeds in the day (Kuiter and Tonozuka 2001). This species resembles to a great extent the venomous sea snake, *Laticauda colubrine* (Randall 2005a, b), and other dark-ringed sea snakes (McCosker and Rosenblatt 1995).

In spite of this the species is reported as harmless (Froese and Pauly 2016), however, several cases where the species was shown to be aggressive to fishermen and divers were obtained from the southern coasts of Oman (Ali 2010a, b). In these cases, the fishermen were collecting fish specimens from the net and a sudden and unexpected attack on the arm of the fishermen occurred, producing severe small cuts. Also, a diver got a bad bite from this species on his hand when, for photography, he got very close to the crevice where this fish is found.

Economic Value No economic value is reported for this species.

Conservative Status Not evaluated.

Family: Congridae
Conger cinereus (Rüppell 1830)
Common name: Longfin African conger
Arabic name: ثعبان السمك طويل الزعنفه الأفريقى
Etymology: *Conger*: Latin, conger = conger (Fig. 2.75)

Identification

- Body cylindrical and robust.
- Dorsal fin originates anterior to origin of pectoral fin.
- Upper and lower lips with well-developed flanges. Mouth big with teeth falling in two rows in both jaws with large teeth in the outer rows. Teeth close to each other forming a cutting edge.
- Body brown in colour and yellow on ventral side and fins. Median fins with black edge. Black spots on lower edge of eye and on pectoral fins (Castle 1986). Different colour pattern at night with dark banding (Allen and Erdmann 2012).

World Distribution It is found in the Indo-Pacific region distributed from the Red Sea south to East Africa and to the Marquesan and Easter Islands. It is also found in Japanese waters and south to Australia and Lord Howe Island (Froese and Pauly 2016).

Distribution in the Study Area This species has been reported to be present in the waters of Abu Dhabi, United Arab Emirates (Shallard 2003). It is also reported to be present in the southern coasts of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003). Field (2005) mentioned, but is not sure of, the presence of this species in the United Arab Emirates waters.

Habitat and Ecosystem Role It is a marine species sometimes found in brackish waters which usually lives in association with reefs at depths down to 80 m (Lieske and Myers 1994).

Fig. 2.75 Longfin African conger, *Conger cinereus* Rüppell, 1830. Courtesy of Abner Bucol, Philippine

Biology Not much is known about the biology and the behaviour of this species, which has a solitary way of life and usually feeds at night (Myers 1991). Although this species is not reported as dangerous to humans, there are several reports of cases where this species has been involved in an unprovoked attack against fishermen. In the south of Oman, on the coasts of the Arabian Sea, several fishermen have been severely bitten while clearing their nets from a catch. This attack happened to their hands when the fishermen tried to clear the fish from the net (Personal observation).

Economic Value In east Asia, nearly all the eel species are edible including this species. Therefore, they have a good economic value there. Some locals living east and south of the Arabian peninsula have a habit of eating eel species especially the big individuals. Also, they use its skin mucous as a medicine to relieve knee and joint pain (Al-Absi 2012).

Conservative Status Not evaluated.

2.3 Wolf-Herring and Barracuda

Order: Clupeiformes
Family: Chirocentridae

Chirocentrus dorab (Forsskål 1775)
Common name: Dorab wolf-herring
Arabic name: حف الذئب أسود الزعنفه
Etymology: *Chirocentrus*: Greek, cheir = hand + Greek, kentron = sting (Fig. 2.76)

Identification

- Body long and compressed.
- Maxilla not reaching posterior edge of eye.
- Scales small or lost.
- No spines in fins, but with many sharp teeth.
- Body silvery colour with bright blue back side. It can be separated from congeneric species *C. nudus* in having a shorter pectoral fin and black colouration on upper part of dorsal fin (Whitehead 1985; Randall 1995; Myers 1999).

Distribution It is distributed in the Indo-Pacific region from the Red Sea south to east Africa and west to the Solomon Islands, north to Japan and south to Australia (Randall et al. 2003).

Distribution in the Study Area This species is reported from Iraqi marine waters (Hussain et al. 1988). It is also found in the remaining Arabian-Persian Gulf countries including Iran (Whitehead 1985). This species is recorded from the Sea of Oman and the southern coasts of the Arabian peninsula (Whitehead 1985; Manilo and Bogorodsky 2003).

Fig. 2.76 Dorab wolf-herring, *Chirocentrus dorab* (Forsskål, 1775). Courtesy of Sahat Ratmuangkhwang, Thailand

Habitat and Ecosystem Role The dorab wolf-herring is a marine species entering brackish waters and living in association with reefs. It is amphidromous living at depths down to 120 m. It also prefers turbulent waters (Luther and Dharma 1982; Sommer et al. 1996; Reide et al. 2004).

Biology This species can live 4 or 6 years, though some can live up to 13 years (Luther 1985). The mating system is similar to that of the other members of the suborder Clupeioidei in which they disperse pelagic eggs which eventually get fertilised and drift through the current or adhere to substrate. This species breeds once a year and this happens in April to June and produces many off-spring (Luther 1973; Whitehead 1985).

This species is considered as a potential danger to humans. The long, curved, and strong teeth of this creature will threaten humans that get close to it. Al-Baharna (1986) considered this species as dangerous to humans based on cases of attacks on fishermen. Severe cuts and wounds were caused by attacks of this species on young fishermen on boats while they cleared nets from the yield in Fao City, south of Iraq (Zakei 2010). The incident happened when the fishermen thought that the fishes were dead and held them from the tail as they usually do with other dead fish specimens and suddenly the fish turned and had a good hold on the hand of the fisherman with its strong teeth.

Economic Value This species has high economic value in the countries along its geographical distribution where its meat is used in several ways for human consumption (Rasoanandrasana et al. 1997).

Conservation Status Not evaluated.

Chirocentrus nudus (Swainson 1839)
Common name: Whitefin wolf-herring
Arabic name: حف أبيض الزعنفه
Etymology: *Chirocentrus*: Greek, cheir = hand + Greek, kentron = sting (Fig. 2.77)

Identification

- Body long and compressed.
- Tip of maxilla reaching posterior edge of eye.
- Scales are many and small.
- Body silvery in colour with bright blue stripe on back. No dark coloration on dorsal fin (Randall 1995; Froese and Pauly 2016).

World Distribution It is an Indo-Pacific fish species distributed from the Red Sea down to east Africa, but not reaching South Africa and to Solomon Islands (Randall 1995; Fricke 1999).

Fig. 2.77 Whitefin wolf-herring, *Chirocentrus nudus* Swainson, 1839. Courtesy of Hamid Osmany, Pakistan

Distribution in the Study Area This species is found in the waters of all countries of the Arabian-Persian Gulf (Whitehead 1985). It is also present in both the Sea of Oman (Randall 1995) and the southern coasts of the Arabian peninsula (Whitehead 1985; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It lives in a marine habitat and is confined to the pelagic-neritic zone at depths down to 150 m (Sommer et al. 1996).

Biology There is not much known about the biology and behaviour of this species, but it is known that the maximum size is 1000 mm in total length (Whitehead 1985). This species is considered dangerous in several localities in the Arabian-Persian Gulf area. Al-Baharna (1986) considered it dangerous to humans as it has been reported to cause severe bites to fishers. In Fao City, south of Iraq, several cases of attack were reported about fishermen who had severe bites caused by this species while clearing their nets (Zakei 2010).

Economic Value It has high commercial value.

Conservation Status Not evaluated.

Order: Perciformes
Family: Sphyraenidae
Sphyraena acutipinnis (Day 1876)
Common name: Sharpfin barracuda
Arabic name: بركوده حادة الزعنفه
Etymology: *Sphyraena*: Greek, sphyraina, -es = the name of a fish (Fig. 2.78)

Identification
- Body long and pointed at front.
- Eyes large.
- Single flexible spine at operculum.
- Maxilla reaching anterior edge of eye. Large, erect, and spaced teeth on both jaws.
- Body dark green with a narrow dark stripe on lower flank. Body with dark marks near pelvic fin base. Dark caudal fin (Randall 1995).

World Distribution The distribution of this species is confined to the Indo-Pacific region and found from east Africa to Hawaii and north to Japan (Senou 2001).

Distribution in the Study Area There is no record of this species from the Arabian-Persian Gulf, but it has been reported from the Sea of Oman (Randall 1995) and from the Yemeni coasts of the Arabian Sea (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species which enters brackish waters and is found in association with reefs at depths of 66 m (Bogutskaya 2007).

Biology There is no information about the biology of this species. As to the behaviour and human interaction, please see the Barracuda Attacks and Bites section below.

Economic Value The meat of all barracuda has an economic value. They are usually eaten as fillets or smoked. In the Arabian-Persian Gulf and in the

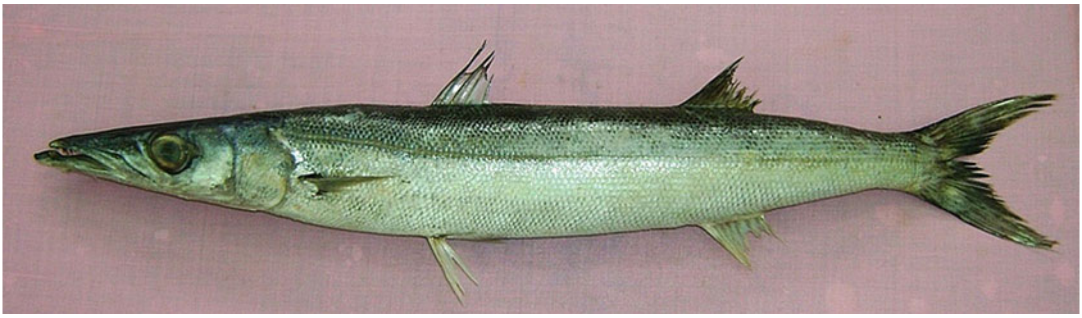

Fig. 2.78 Sharpfin barracuda, *Sphyraena acutipinnis* Day, 1876. Courtesy of Hamid Osmany, Pakistan

Fig. 2.79 Great barracuda, *Sphyraena barracuda* (Edwards, 1771). Courtesy of Hiroyuki Motomura, Japan

south Arabian peninsula, barracuda is considered an important commercial fish commodity.

Conservation Status Not evaluated.

Sphyraena barracuda (Edwards 1771)
Common name: Great barracuda
Arabic name: البركودا الكبيره
Etymology: *Sphyraena*: Greek, sphyraina, -es = the name of a fish (Fig. 2.79)

Identification

- Body long.
- No gill rakers; instead irregular plate-like structures found on gill arch.
- Small eyes in comparison with other members of genus *Sphyraena*.
- Lower jaw with bump located in front. Teeth strong, long, and erect.
- Dorsal fin originates behind pelvic fin. Caudal fin is distinguished with the presence of three marginations. Pectoral fin passes the base of pelvic fin.
- General body colour silvery with dark green blotches on back. Black blotches on both upper and lower lobs of caudal fin (Myers 1991; Randall 1995; Smith 1997).

World Distribution It is distributed in the Indo-Pacific region from the Red Sea south to east Africa and to Hawaii. It is also found in the western and eastern Atlantic (Froese and Pauly 2016).

Distribution in the Study Area This species is reported from the south Arabian peninsula at the coasts of Yemen and Oman (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role This barracuda is basically a marine species, but enters brackish water areas. It is also found living in reef habitats and usually inhabits depths down to 100 m, but

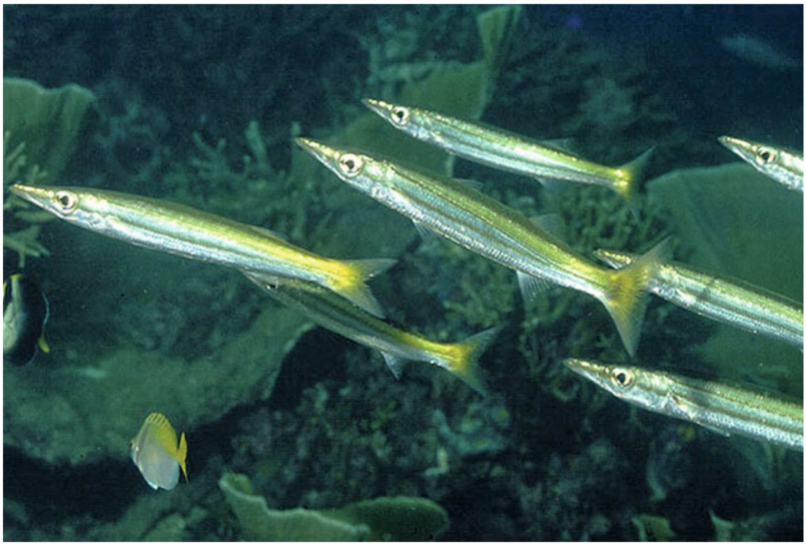

Fig. 2.80 Yellowtail barracuda, *Sphyraena flavicauda* Rüppell, 1838. Courtesy of David Cook, Australia

usually at 3–30 m (De Sylva 1990; Gasparini and Floeter 2001).

Biology Adults of this species have a solitary way of living, whereas young and young adults form small aggregations. It is a very fast fish when it starts its attack with speeds up to 43 km h^{-1} (Martin 2014). This species matures at the age of two and can live up to 13 years (Kristofferson 2015). For human interactions, see the Barracuda Attacks and Bite section below.

Economic Value As with other barracuda, this species is taken for its meat which is used for human consumption along its geographical distribution range.

Conservation Status Not evaluated.

Sphyraena flavicauda (Rüppell 1838)
Common name: Yellowtail barracuda
Arabic name: بركوده صفراء الذنب
Etymology: *Sphyraena*: Greek, sphyraina, -es = the name of a fish (Fig. 2.80)

Identification
- Body long and narrow.
- Eye large.
- Membranous flap at the corner of preoperculum and with one spine.
- Maxilla reaching mid-pupil.
- No cartilagenous pump at front of lower jaw. Teeth sharp and long.
- Dorsal fin originates behind tip of pectoral fin.
- Body general colour silvery with two brownish yellow longitudinal stripes. Caudal fin yellow (Randall 1995; Senou 2001).

World Distribution The distribution of this species is confined to the Indo-Pacific region. It is found from the Red Sea to Samoa in the east and south to the Great Barrier Reef (Senou 2001). It is also reported in the Mediterranean Sea as a Lessepsian migrant (Quignard and Tomasini 2000).

Distribution in the Study Area There is no record of this species from the Arabian-Persian Gulf and the Sea of Oman (Randall 1995), but it has been recorded from the south Arabian peninsula at the coasts of Yemen and Oman (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role This marine species lives in reef areas at depth ranges 2–25 m (Kuiter and Tonozuka 2001).

Biology There is not much information about the biology of this species other than it

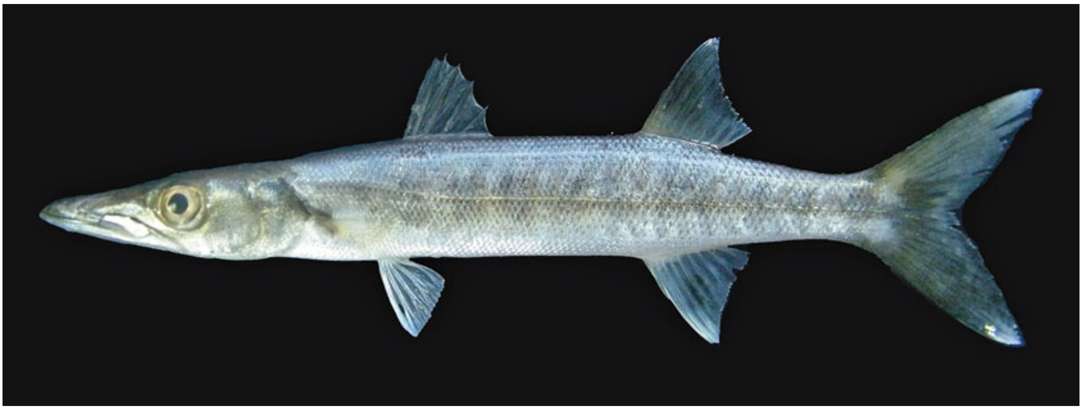

Fig. 2.81 Pickhandle barracuda, *Sphyraena jello* Cuvier, 1829. Courtesy of Sahat Ratmuangkhwang, Thailand

hunts during the night and lives in small groups, but the behaviour is similar to that of other species of barracuda. For human interactions, see the Barracuda Attacks and Bites section below.

Economic Value The meat of this species is considered among the high-quality fish meats that attract a large number of buyers.

Conservation Status Not evaluated.

Sphyraena jello (Cuvier 1829)
Common name: Pickhandle barracuda
Arabic name: البركوده الطويله
Etymology: *Sphyraena*: Greek, sphyraina, -es = the name of a fish (Fig. 2.81)

Identification

- Body elongated.
- Eyes moderate size.
- No gillrakers; instead plate-like structures with no spines on gill arches.
- Corner of preoperclum not membranous. Lower jaw lacking median cartilagenous bump. Maxilla reaching anterior edge of eye.
- Dorsal fin originates posterior to that of pelvic fins. Caudal fin forked and lacking lobes.
- Body silvery in colour with dark bars across lateral line. Caudal fin yellow (Randall 1995; Froese and Pauly 2016).

World Distribution The distribution of this barracuda is confined to the Indo-Pacific region. It is found from the Red Sea south to east Africa and to New Caledonia and Vanuatu (Randall et al. 2005b).

Distribution in the Study Area This species is reported from all the countries of the Arabian-Persian Gulf area (Rose 1984). It is also recorded from the Sea of Oman (Randall 1995) and the south Arabian peninsula (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species living in association with reefs at depth range 20–200 m and usually found down at 60 m (Al Sakaff and Esseen 1999; Reide 2004; Allen and Erdmann 2012).

Biology There is not much information about the biology of this species. In India, the common size is 400–500 mm in total length although some specimens were found to be 800–1300 mm in total length. This species spawns once a year and the spawning time is between March and April (Premalatha and Manojkumar 1990). For human interactions, please see below for the Barracuda Attacks and Bites section.

Economic Value This species has high commercial value in the east and south Arabian

Fig. 2.82 Sawtooth barracuda, *Sphyraena putnamae* Jordan & Seale, 1905. Courtesy of Hiroyuki Motomura, Japan

peninsula as do other species of barracuda. The fish is usually taken for its meat which is eaten grilled or with soup.

Conservation Status Not evaluated.

Sphyraena putnamae (Jordan and Seale 1905)
Common name: Sawtooth barracuda
Arabic name: بركوده منشارية الأسنان
Etymology: *Sphyraena*: Greek, sphyraina, -es = the name of a fish (Fig. 2.82)

Identification

- Body moderately long and broad.
- Eyes large.
- No gillrakers on gill arch. Spines on first gill arch.
- Operculum with no membranous flap. Operculum with two spines.
- Maxilla reaching anterior edge of eye. Lower jaw with median lump.
- Dorsal fin originates over posterior edge of pectoral fin.
- Body bright silvery colour with chevron dark marking across the lateral line. Caudal fin dark (Randall 1995; Froese and Pauly 2016).

World Distribution This species of barracuda is distributed in the Indo-Pacific region. It is found from the Red Sea, southeast Africa, and east to New Caledonia and Vanuatu and north to Japan (JICA 1987).

Distribution in the Study Area In the Arabian-Persian Gulf area, this barracuda is reported from the coasts of Kuwait (Bishop 2003), Bahrain (Froese and Pauly 2016), Saudi Arabia (Krupp et al. 2000), and Iran (Assadi and Dehghani 1997) only. It has been reported from the Sea of Oman (Randall 1995) and the south Arabian peninsula at the coasts of Yemen and Oman (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species found living in reef areas at depth range 3–20 m (Allen and Erdmann 2012).

Biology There is not much information about this species other than it occurs in schools, hunts at night, and reaches maximum size of 870 mm in total length (Randall 1995). As to human interaction, please see the Barracuda Attacks and Bites section below.

Economic Value As with other barracuda species, it is considered a valuable commercial commodity.

Conservation Status Not evaluated.

Sphyraena qenie (Klunzinger 1870)
Common name: Blackfin barracuda
Arabic name: بركوده سوداء الذنب
Etymology: *Sphyraena*: Greek, sphyraina, -es = the name of a fish (Fig. 2.83)

Fig. 2.83 Blackfin barracuda, *Sphyraena qenie* Klunzinger, 1870. Courtesy of Robert Patzner, Austria

Identification

- Body long with robust head and jaws.
- No gillrakers on gill arches.
- Eyes moderate size. No membranous flap on corner of preoperculum.
- No cartilagenous bump on median lower jaw. Maxilla passing the anterior edge of eye. Teeth erect, sharp, and close-set on both jaws.
- Dorsal fin originates slightly anterior to tip of pectoral fin. Caudal fin in adult with small lobe at inner side of each lobe.
- Body grey in colouration with several dark bars across lateral line (Randall 1995; Froese and Pauly 2016).

World Distribution This barracuda is distributed in the Indo-Pacific region from the Red Sea south to east Africa and to the central Indian Ocean. It is also found in the eastern Pacific at Mexico and Panama (Senou 2001).

Distribution in the Study Area There is no record of this species from the Arabian-Persian Gulf, but it is reported in both the Sea of Oman (Randall 1995) and the south coast of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003; Froes and Pauly 2016).

Habitat and Ecosystem Role It is a marine species found living in reef areas at depth range 1–100 m (Bacchet et al. 2006).

Biology This barracuda reaches maximum size of 1700 m min total length and maximum weight of 7140 g. The eggs and larvae are pelagic. It lives within schools that do not move during the day and are characterised in being in the same place for months or even years (Myers 1991; Senou 2001). During night, the individuals spread out for feeding (Myers 1991). As for human interaction, please see the Barracuda Attacks and Bites section below.

Economic Value This species has high economic value as the meat is used for human consumption.

Conservation Status Not evaluated.

2.3.1 Barracuda Attacks and Bites

Barracuda are ferocious, striking at anything that glows. They are dangerous to swimmers wearing shiny objects. As with sharks, barracudas have a bad reputation as causing a threat to humans. These fishes are scavengers and they follow the divers mistaking them for large predators to get some leftover food. Barracudas can defend themselves very well and such behaviour should be taken into account when diving. Handfeeding or touching them should not be attempted at all with barracudas. Also, spearfishing should not be operated in areas where barracudas are present as they are highly attracted to blood. Barracudas might stop biting after having the first bite (Wikipedia 2016).

Unlike the shark attacks, several unprovoked attacks by barracuda on humans go on without the media taking any notice. The case of Thomas Goreau from Cambridge, Massachusetts, United States represents an outstanding barracuda attack on humans. He was surface snorkelling with his family when a very big barracuda attacked him from below and cut his finger and caused severe injuries to his hand and other fingers. This incident was completely unprovoked as the snorkeler was neither spearfishing nor offering food for the barracuda or other fish in the vicinity. It also added new information to the barracuda attacks on humans as it was previously thought that barracuda usually attack humans only after being provoked (Goreau 2015).

Infecting organisms are involved in the bites of barracudas and cause later complications of the wound. There is a possibility of microorganisms such as *Vibrio vulnificus*, *V. parahaemolyticus*, and *V. alginolyticus* getting inside the wound and contaminating the affected area causing soft tissue infection and necrosis (Thomas and Brook 2011). Other bacteria including *Pseudomonas* spp., *Staphylococcus*, *Citrobacter*, and *Micrococcus* might also be present as they have been reported in the bite of different species of sharks (Buck et al. 1984).

In the case of barracuda bites, they are usually associated with a shearing type of injury (Auerbach 1984; Howard and Burgess 1993). As with other cases of aquatic animal bites, the patient should receive prophylactic antibiotics and any sign of wound infection should be treated as quickly as possible (Erickson et al. 1992). The usual antibiotic given in such cases are ciprofloxacin, cefuroxime, tetracycline, or trimethoprim/sulfamethoxazole (Riordan et al. 2004).

The general aim behind the treatment of barracuda bites is to prevent and treat the infection in order to minimize soft tissue damage. To achieve such a goal, several therapies may be adopted to cure the bite.

The smaller wound should be cleaned very well with cool clean water and mild soap may be used to clean the area. The flushing of the wound with water should continue for about 15 min in addition to the use of soap, detergent, or povidone iodine (Thomas and Brook 2011), but do not soak the wound as this might cause infection to the wound (Brinker et al. 2003). Application of ice is recommended to relieve the pain, but not alcohol or peroxide as they may cause further injury (Fleisher 1999).

The type of wound should be known (i.e., laceration, puncture, contusion, or crush-avulsion) as well as the depth of the wound and whether the underlying structures have been involved in the incident. Radiological examination is important in such cases as the radiograph will show whether there is air in the joint or a piece of broken tooth or any foreign bodies inside the wound (Thomas and Brook 2011).

2.4 Triggerfish

Order: Tetraodontiformes
Family: Balistidae
Abalistes stellatus (Anonymous 1798)
Common name: Starry triggerfish
Arabic name: سمكة الزناد النجمية
Etymology: *Abalistes*: Greek, a = without + Greek, ballo = to throw (Fig. 2.84)

Identification

- Body subdiagonal in shape.
- Large osseous scale posterior to gill opening.
- Deep and oblique groove anterior to eye.
- Dorsal and anal fins with unelevated soft part. Caudal fin double emarginate and lobes increase in size with age. Caudal peduncle with width greater than depth and usually depressed.
- Body greyish brown colouration with small white spots becoming brighter at the ventral side. Back with three large white spots and one on the dorsal side of caudal peduncle. Area posterior to gill opening with white streak (Randall 1995).

Fig. 2.84 Starry triggerfish, *Abalistes stellatus* (Anonymous, 1798). Courtesy of Hiroyuki Motomura, Japan

World Distribution This triggerfish is found distributed in the Indo-Pacific region from the Red Sea to South Africa and west to the western Pacific (Froese and Pauly 2016).

Distribution in the Study Area This species is found in all the waters of all countries of the Arabian-Persian Gulf except Iraq. It has been reported from Kuwait by Bishop (2003), Saudi Arabia (Krupp and Al-Marri 1991), Bahrain (Al-Baharna 1992), Qatar (Sivasubramaniam and Ibrahim 1982), the United Arab Emirates (Shallard 2003), and Iran (Sahafi 2000). It is recorded from the Sea of Oman (Randall 1995) and from the south coast of the Arabian peninsula (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species living in association with reefs at depths of 7–350 m (Khalaf and Zajonz 2007).

Biology The adult individuals of this species are usually found on deep coastal slopes, and the young are in sheltered coastal areas. It prefers mud and silt sand habitats (Kuiter and Tonozuka 2001). The maximum reached by this species is 600 mm in total length (Fischer and Bianchi 1984). This species is considered dangerous to humans as it can cause a severe bite. Cases of such incidents were obtained from several locations along the coasts of the Sea of Oman on both the Omani and the Iranian sides. In all these cases, this species has been seen attacking divers and fishermen clearing nets filled with freshly caught fishes. The hand and the arm are the two parts that this fish was aiming for in its attack (Ali 2010a, b; Hussaini 2009).

Economic Value This species is mainly used for the aquarium trade for its strange shape and colouration.

Conservation Status Not evaluated.

Canthidermis macrolepis (Boulenger 1888)
Common name: Largescale triggerfish
Arabic name: سمكة الزناد كبير القشور
Etymology: *Canthidermis*: Greek, kanthos = the outer or inner corner of the eye, where the lids meet, 1646 + Greek, derma = skin (Fig. 2.85)

Identification

- Body of this species elongated with anterior part oval in shape.
- Oblique groove anterior to eye.
- Soft parts of dorsal and anal fins much elevated. Caudal fin rounded in young and double emarginate in adult.
- Body greyish with pale ventral side. Second dorsal, anal, and caudal with black edges. Pectoral fin with black shading (Randall 1995).

Fig. 2.85 Largescale triggerfish, *Canthidermis macrolepis* (Boulenger, 1888). Courtesy of Hamid Osmany, Pakistan

World Distribution The distribution of this species is confined to the area from the Red Sea to the Sea of Oman (Randall 1995; Manilo and Bogorodsky 2003).

Distribution in the Study Area There is no record of this species from the Arabian-Persian Gulf (Randall 1995), but it is reported from the Sea of Oman and south coast of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species found in benthopelagic habitats.

Biology The maximum length reached by this species is 600 mm in total (Randall 1995). Not much is known about the biology and behaviour of this species. As with other triggerfish that can cause severe bites to humans, this species is also reported to have such incidents in the Sea of Oman. The cases report on the unprovoked attack by this species on a fisherman who thought that all the fish specimens he collected were dead and safe to catch when a large specimen of this species had a good bite of the small finger of his right hand (Majeed et al. 2010).

Economic Value No economic value is given for this species except that the meat is used by the locals in the south of Oman.

Conservation Status Not evaluated.

Melichthys indicus (Randall and Klausewitz 1973)
Common name: Indian triggerfish
Arabic name: سمكة الزناد الهنديه
Etymology: *Melichthys*: Greek, melis, -itos = honey, a sweet thing + Greek, ichthys = fish (Fig. 2.86)

Identification

- Anterior part of body slightly elongated.
- Caudal peduncle with longitudinal ridge on scales.
- Circular bony plates posterior to gill opening.
- Oblique groove anterior to eye. Soft parts of dorsal and anal fins not much elevated. Caudal fin rounded.
- Body black in general with six green stripes radiating from eye towards anterior and dorsal sides. Base of dorsal and anal fins and posterior edge of caudal fin white.

World Distribution The distribution of this triggerfish is confined to the Indian Ocean. It is found in the Red Sea south to east Africa and eastward to Thailand, Sumatra, and Indonesia (Froese and Pauly 2016).

Distribution in the Study Area There is no report of this species from the Arabian-Persian Gulf and the Sea of Oman. It is only reported

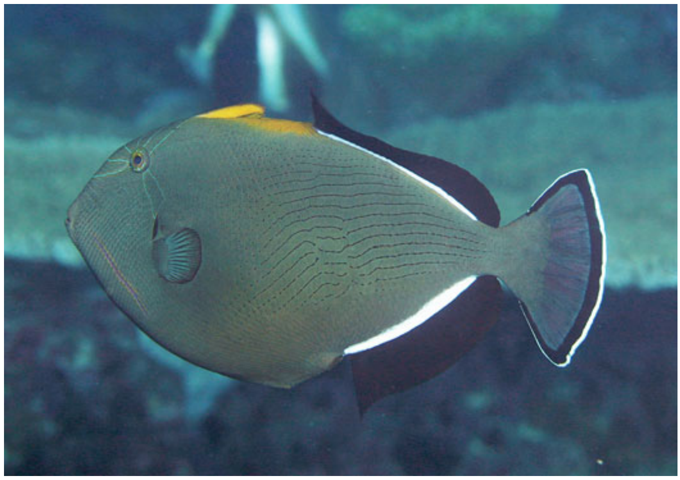

Fig. 2.86 Indian triggerfish, *Melichthys indicus* Randall & Klausewitz, 1973. Courtesy of Robert Patzner, Austria

from the south of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species living in reef areas and found at depth range 1–30 m (Lieske and Myers 1994).

Biology This species prefers to live singly. It usually digs holes below reefs for shelter. It reaches 250 mm in total length (Lieske and Myers 1994; Kuiter and Tonozuka 2001). There are some reports about attacks against humans by the species. The incidents happened in remote areas of south Oman at the fishermen's villages. (Personal observation). A severe bite was reported caused by this species to a young fisherman clearing his net when suddenly a fish jumped and had a good bite of his left hand.

Economic Value This species is characterised with its beautiful colouration which attracts aquarium traders to obtain small- and medium-sized individuals. They usually make regular diving trips to the reefs to collect these fishes to be sold in aquarium shops.

Conservation Status Not evaluated.

Order: Tetraodontiformes
Family: Balistidae
Odonus niger (Rüppell 1836)
Common name: Red-toothed triggerfish
Arabic name: سمكة الزناد ذو السن الأحمر
Etymology: *Odonus*: Greek, odous = teeth + Greek, onos = hake (Fig. 2.87)

Identification

- Body diagonal in shape with elongated anterior part.
- Mouth directed upward.
- Area posterior to gill opening with large bony scales.
- Rows of spines at posterior half of body.
- Upper jaw with large tooth that shows when mouth closed.
- Area anterior to eye with oblique groove.
- Soft parts of dorsal and anal fins elevated. Caudal fin lunate in shape with extended edge of each lobe.
- Basic colour of body blue with light blue colour at edges of soft parts of dorsal and anal fins. Teeth with distinguished red colour.

World Distribution The distribution of this triggerfish is confined to the Indo-Pacific region. It is found in the Red Sea and south to Durban, South Africa and eastward to the Marquesas and Society Islands. It is also found in Japanese waters and southward to the Greater Barrier Reef and New Caledonia (Smith and Heemstra 1986; Froese and Pauly 2016).

Distribution in the Study Area There is no record of this species from the Arabian-Persian

Fig. 2.87 Red-toothed triggerfish, *Odonus niger* (Rüppell, 1836). Courtesy Laith Jawad, New Zealand

Gulf, but it has been reported from the Sea of Oman (Randall 1995) and from the south coasts of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine oceanodromous species living in reef areas at depth range 5–40 m (Matsuura 2001; Reide 2004).

Biology It prefers areas of the reef where there is a strong current. Adults live in groups, and the young are found in patches in sheltered areas (Myers 1991; Kuiter and Tonozuka 2001; Matsuura 2001). This species is quite intelligent which is an unusual case among fishes and has the ability to learn from earlier encounters (Debelius 1993; McDavid 2007). As with other triggerfish species, the territory extends in a cone shape from the nest upward. Therefore, divers should not swim upward if facing a triggerfish, but horizontally (Wikipedia 2015). The male of this species usually mates with more than 10 females found in his territory in one day (Kawase 2003). Although this species has not registered as dangerous to humans, there are a few records about incidences of attacks on divers off the coasts of south Oman and were evident to the author.

Economic Value The meat of this species is used for human consumption and the young individuals are used in the aquarium trade worldwide.

Conservation Status Not evaluated.

Rhinecanthus assasi (Forsskål 1775)
Common name: Picasso triggerfish
Arabic name: سمكة الزناد بيكاسو
Etymology: *Rhinecanthus*: Greek, rhinos = nose + Greek, akantha = thorn (Fig. 2.88)

Identification

- Body diagonal in shape with elongated and pointed snout.
- Posterior part of body with three horizontal rows of scales.
- Absence of groove anterior to eye.
- Soft parts of dorsal and anal fins not elevated. Caudal fin rounded and slightly double emarginate.
- Body yellowish to white colouration. Ventral side pale. Blue and yellow lines anterior to a blue stripe passing down from eye to ventral edge of gill opening. Interorbital space with four blue bands separated by black line. Lips yellow. Anus surrounded by yellow spot.

World Distribution The distribution of this triggerfish is confined to the northern part of the Indian Ocean (Froese and Pauly 2016).

Distribution in the Study Area This species is recorded from all the countries of the Arabian-Persian Gulf except for Iraqi and Qatari waters. It has been reported from Kuwait (Bishop 2003), from Bahrain (Al-Baharna 1986), from Saudi Arabia (Lieske and Myers 1994), from the

Fig. 2.88 Picasso triggerfish, *Rhinecanthus assasi* (Forsskål, 1775). Courtesy of Robert Patzner, Austria

United Arab Emirates (Shallard 2003), and from Iran (Sahafi 2000). It is found in the Sea of Oman (Randall 1995) and the south coasts of the Arabian peninsula (Randall 1995; Zajonz et al. 2000; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species and found living in association with reefs.

Biology This species follows the same pattern of breeding that other members of the family Balistidae follow in depositing eggs in water during spawning time which attach to solid surfaces such as corals until they hatch. The hatched young individuals remain floating among the seaweeds. The name triggerfish came as all members of the family Balistidae have a mechanism of locking the spines of the first dorsal fin into an erect position. The first and second spines of the first dorsal fin are involved in this lock and the fish can only release them if the third spine is involved and presses the second spine to release the first spine. This mechanism is known as a trigger (Schultz 2004). This species has few reports of incidents of attacks against divers in some areas of the Arabian-Persian Gulf (Will 2007) and the Sea of Oman (Sally 2008).

Economic Value This species is valuable for the aquarium trade for its magnificent colouration. Divers usually go down looking for the young to trade them.

Conservation Status Not evaluated.

Sufflamen chrysopterum (Bloch and Schneider 1801)
Common name: Flagtail triggerfish
Arabic name: سمكة الزناد شراعية الذنب
Etymology: *Sufflamen*: Latin, sufflamen = clog (Fig. 2.89)

Identification

- Body more elliptical than diagonal with triangular ventral side.
- Lips thick and protruding.
- Snout elongated.
- Groove anterior to eye.
- Dorsal and anal fins with low soft parts. Truncated caudal fin.
- Adult colouration differs from that of juveniles. The latter usually dark brown with pale ventral side, and adult yellowish-grey. Yellow band from base of pectoral fin to posterior edge of eye. Caudal fin yellow with white border.

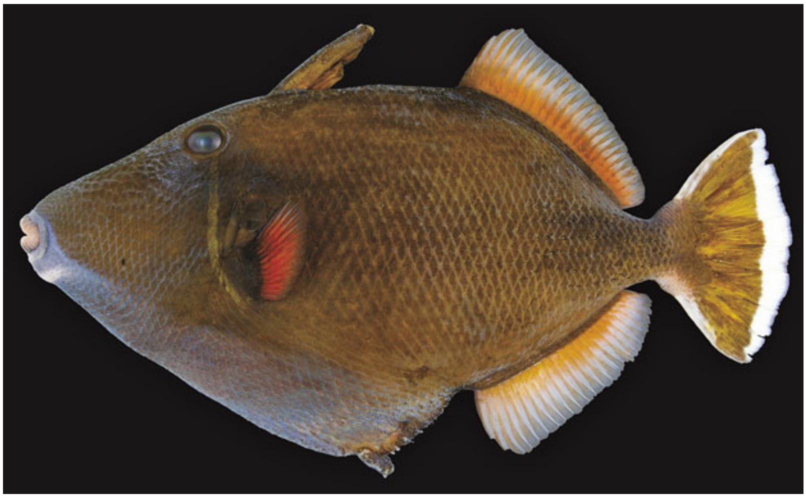

Fig. 2.89 Flagtail triggerfish, *Sufflamen chrysopterum* (Bloch & Schneider, 1801). Courtesy of Hiroyuki Motomura, Japan

World Distribution This species is found distributed in the Indo-West Pacific region from east Africa and eastward to Samoa and north of Japan and southward to Lord Howe Island (Myers 1991; Heemstra 1995).

Distribution in the Study Area In the Arabian-Persian Gulf, this species is reported to be present from Kuwait (Bishop 2003) and the United Arab Emirates (Burt et al. 2011). It has been recorded from the Sea of Oman (Randall 1995) and from the south coasts of the Arabian peninsula (Randall 1995; Zajonz et al. 2000; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species living in association with reefs at depths of 1–30 m (Myers 1991).

Biology Not much is known about the behaviour and biology of this species. It is usually the male who defends the territory, while the female stays on the nest. Females prepare sites for their eggs. Eggs are of a sticky material that enables them to adhere to the substratum which is usually corals. Females take the responsibility of defending the eggs, while males guard the area where females and eggs are (Kawase and Nakazono 1992). There are some reports from different parts of the Arabian-Persian Gulf area about this species being aggressive to divers who approach their territory and incidence of attacks on others (Malek 2007).

Economic Value Individuals, especially young of this species, have a high value as they are used for the aquarium trade around the world.

Conservation Status Not evaluated.

2.4.1 Reported Cases of Triggerfish Bites

Divers usually know the common hazards that they might encounter under the water. Such hazards are not confined to the dangerous fish species such as sharks and poisonous aquatic animals of various species. The bit of information that they are not usually aware of is the danger that might come from a triggerfish. All previous books that gave information about the dangerous organisms living in the sea have not thrown a light on the fact that the triggerfish might cause a threat to humans and give severe bites (Phillips and Brady 1953; Halstead 1959; Iversen and Skinner 1977).

The triggerfishes do not swim fast and usually cruise by moving the second dorsal and anal fins; when they need to swim fast, they move the caudal fin which gives them a good push forward. These fishes do not combat approaching divers unless they enter their territory without knowing where they are going or do not take notice of the presence of adult fish guarding the nest. In the holes in the reefs, these fishes usually lodge themselves by erecting the first dorsal spine and depressing the pelvic fin bone so the fish becomes immovable. In order to take these fishes out of their hiding, the diver should catch the fish and push the second dorsal spine down to release the lock and then pull the fish out.

Randall and Millington (1990) have reported seven cases of unprovoked attack by different species of triggerfish. The species mentioned are not present in the coasts of the east and south Arabian peninsula, but I thought it worth mentioning here to give an idea about how the triggerfish might be aggressive and divers should take extra care.

In most of these seven incidents, the divers approached or were near the triggerfish territory and they received slight bites except for one case where the diver had severe bites from a large adult triggerfish. The area in front of the ear and the parotid area were targeted. The fish continued to suck the skin and soft tissue and the fish was removed by a strong knock from the diver. The repeated bites caused lacerations and a slightly deep wound on the left cheek.

Randall and Millington (1990) have concluded that attention should be paid when divers come face to face with triggerfish as they have the potential of giving an unfavourable and unexpected bite. They also alert divers to be careful when they dive in the area where the two species *Pseudobalistes fuscus* and *Balistoides viridescens* are living as these two species do not move away when approached. Also, care should be taken to not feed the triggerfish by hand.

2.5 Ribbonfish

Family: Trichiuridae
Eupleurogrammus glossodon (Bleeker 1860)
Common name: Longtooth hairtail
Arabic name: سمكة الحزام كبيرة الأسنان

Etymology: *Eupleurogrammus*: Greek, eu = good + Greek, pleura = near, on the side + Greek, gramma = mark, signal (Fig. 2.90)

Identification

- Body long, compressed, and tapering towards tail.
- Large mouth with flap on each jaw. Large fangs on upper and lower jaws in addition to series of small teeth in both jaws.
- Eyes small.
- Anal fin very small reduced to small spinules and pelvic fins also reduced but to a small scale-like process. No caudal fin.
- Large and elongated anus.
- Body colouration shiny blue with metallic reflections. Black colouration on membrane of dorsal fin (Fischer and Bianchi 1984; Froese and Pauly 2016).

World Distribution Distribution of this species is confined to the Indo-Pacific region. It is found from the north of the Indian Ocean to Malaysia and Thailand (Froese and Pauly 2016).

Distribution in the Study Area This species is reported from all the countries of the Arabian-Persian Gulf (Nakamura and Parin 1993). Fischer and Bianchi (1984) gave a discontinuous distribution. They did not report from the Sea of Oman. On the other hand, Randall (1995) was not clear in his record of this species in his book. It has not been reported from the south coast of the Arabian peninsula (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species which inhabits benthopelagic environments at depths down to 80 m (Nakamura 1997).

Biology It usually comes to the surface at night. The post-larvae very closely resemble the adult in having a median lateral line. The caudal fin is present in the post-larva, but disappears in the adult. In India, maturity occurs when the fish reaches 380 mm in total length (Narasimham

Fig. 2.90 Longtooth hairtail, *Eupleurogrammus glossodon* (Bleeker, 1860). Courtesy of Fereidoon Owfi, Iran

Fig. 2.91 Smallhead hairtail, *Eupleurogrammus muticus* (Gray, 1831). Courtesy of Liu Jing, China

1983). For human interactions, please see Section 2.5.1 below.

Economic Value This species is an important commercial fish along its geographical distribution.

Conservation Status Not evaluated.

Eupleurogrammus muticus (Gray 1831)
Common name: Smallhead hairtail
Arabic name: سمكة الحزام صغيرة الرأس

Etymology: *Eupleurogrammus*: Greek, eu = good + Greek, pleura = near, on the side + Greek, gramma = mark, signal (Figs. 2.91 and 2.92)

Identification

- Body long, ribbon-shape tapering towards tail.
- Large mouth with large teeth in upper jaw and no fangs in lower jaw. Small teeth falling in series in both jaws.

Fig. 2.92 Smallhead hairtail, *Eupleurogrammus muticus* (Gray, 1831), fish market. Courtesy of Fereidoon Owfi, Iran

- Eye small.
- Anal fin and pelvic very small and represented by small spinules and small scale-like process respectively.
- Anus small.
- Body general colour shiny blue. Anterior part of jaws black (Fischer and Bianchi 1984; Randall 1995).

World Distribution The distribution of this species is confined to the Indo-West Pacific from the Arabian-Persian Gulf to the Korean peninsula (Froese and Pauly 2016).

Distribution in the Study Area It has been reported from the waters of all the countries in the Arabian-Persian Gulf (Fischer and Bianchi 1984; Nakamura and Parin 1993). It is reported from the Sea of Oman (Randall 1995) and the south coast of the Arabian peninsula (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species, but found sometimes in brackish water. It inhabits benthopelagic environments and is found at depths down to 80 m (Nakamura and Parin 1993).

Biology As with the previous trichiurid species, the post-larva closely resembles the adult in having the median lateral line. Also, these larvae contain a caudal fin unlike the adult individuals (Narasimham 1983). This species attains maturity at 510 mm total length. For human interactions, please see Section 2.5.1 below.

Economic Value This species is considered among the most commercial fishes along its geographical distribution line.

Conservation Status Not evaluated.

Trichiurus lepturus (Linnaeus 1758)
Common name: Largehead hairtail
Arabic name: سمكة الحزام كبيرة الرأس
Etymology: *Trichiurus*: Greek, thrix = hair + Greek, oura = tail (Fig. 2.93)

Identification
- Body long, compressed, and tapering towards tail.
- Large mouth and eye. Large teeth at front of both jaws in addition to series of small teeth in both jaws. Palatine with teeth.
- Anal fin reduced to small spinules.
- Absence of both pelvic and caudal fins. Lateral line oblique starts from upper margin of gill cover.
- Anus in anterior half of body.
- Body colouration shiny blue with transparent pectoral fins (Fischer and Bianchi 1984).

World Distribution This species has a circumtropical and temperate mode of distribution (Froese and Pauly 2016).

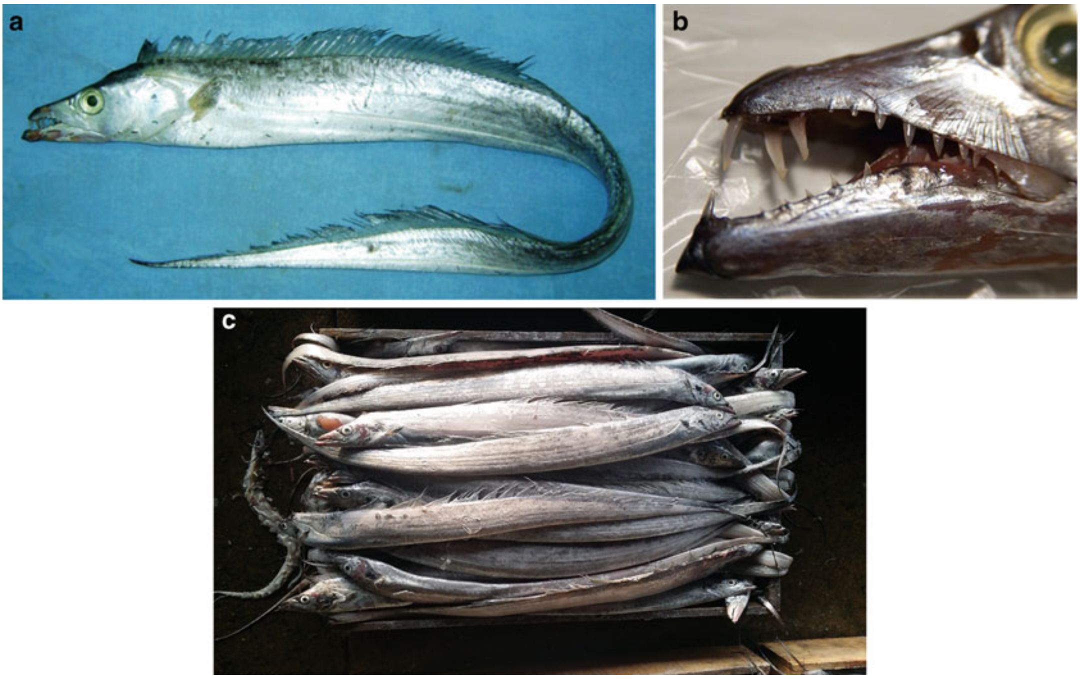

Fig. 2.93 Largehead hairtail, *Trichiurus lepturus* Linnaeus, 1758. (**a**) Whole fish, courtesy of Hamid Osmany, Pakistan; (**b**) barbed fangs, courtesy of David Yu, Canada; (**c**) fish market, courtesy of Joo Park, Korea

Distribution in the Study Area It has been recorded in the waters of all countries in the Arabian-Persian Gulf, Sea of Oman, and south of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003; Froese and Pauly 2016).

Habitat and Ecosystem Role It is a marine species, but enters brackish water and prefers benthopelagic environments. It is usually found at depth range 0–600 m (Reide 2004; Bogutskaya 2007).

Biology The feeding patterns of juveniles and adults are different. Juveniles feed on the bottom during the day and at the surface at night. Adults have a reverse pattern (Nakamura and Parin 1993). In a study on the population of this species in the Arabian Sea coasts of Oman, the females seem to dominate the population of this species in that area (Al-Nahdi et al. 2009). This study has also shown that the females are larger in size than males. Ripe ovaries are found year round except for the period July–September. This species is found to live up to 7 years in the Omani coasts of the Arabian Sea (Al-Nahdi et al. 2009). For human interactions, please see Section 2.5.1 below.

Economic Value This fish has high commercial value in the countries along its geographical distribution.

Conservation Status Not evaluated.

2.5.1 Bite of Ribbonfish and Its Mechanism

All three species of ribbonfish mentioned above have long fangs in either the upper or lower jaw or both. These fangs are long and very sharp and ready to cut and cause severe wounds. These species are rated among the high commercial demand fish species along their geographical distribution line.

The ribbonfishes living in the east and south Arabian peninsula are potential attackers and can cause severe injuries to humans. Every day, many fishermen from different countries in the studied area come in contact with these fishes either on fishing boats or through processing their daily catch. There have been several incidents of attack by these species on fishermen and people handling fresh fish specimens. The cases of attack originate from Fao City, southern Iraq (Salem 2010), Iran (Mehdi 2008), and south Oman (Ali 2008). In the incidents from the Iraqi marine waters, two fishermen pulled their fishing net from the water and when they started to clear the catch from the net, freed two large ribbonfish which bit the right hand of one of the fishermen and the arm of the other before the two men controlled the angry fishes. The cuts were very deep and the two men were evacuated to a nearby hospital for treatment. The Iranian incidents are similar to that of the Iraqi, but it happened to one fisherman working on the deck of a small trawler. He started to sort out the catch from the net when a large ribbonfish jumped and bit his forearm. The wound was very deep and the fisherman needed treatment urgently. The Omani incidents happened on the shore when the fish catch was brought back from the fishing boat and put on a plastic mat for sorting; suddenly a large ribbonfish jumped and had the young fisherman by his arm. The wound was deep and the affected person was taken to the hospital for treatment. In all these cases, the fishermen or the people handling the fresh fish thought that the fishes were dead and they felt free to handle them from any part of the fish body. Such practice is not correct especially with freshly caught fishes as some large specimens stay alive for longer periods and get aggressive once they have been touched.

At this point, it is appropriate to have some information about the mechanism that the ribbonfishes have in their jaws and mouth to accomplish such strong and severe bites.

The ribbonfishes are long-jawed, equipped with large and sharp teeth. In such a type of mouth, the fish needs to have maximal speed to snap and maximal force to press against the prey (De Schepper et al. 2008). The ribbonfishes depend on inflecting their teeth in the body of the prey (Sibbing and Nagelkerke 2001). During the dynamics of mouth closing in trichiurid fishes as seen in *T. lepturus* studied by De Schepper et al. (2008), there are several different muscles involved in this mechanism. Some of these muscles are responsible for closing the lower jaw and at the same time dragging the food towards the esophagous. De Schepper et al. (2008) have estimated that for the trichiurid individual to close its mouth from a gape angle of 50° to 10° takes 74.2 ms.

The trichiurids have the ability to close their mouth very quickly and leave very little chance for the prey to escape. Such character started with the development of the feeding habit and goes along with the type of food that these fishes feed on and with the development of a powerful bite (Wojciechowski 1972; Martins and Haimovici 1997; Friel and Wainwright 1998; Costa et al. 2000; Swan et al. 2003). These prerequisites are revealed in the morphology of the jaws of the trichiurid species which are shown to have elongated jaws. Moreover, the long jaws give the fish possessing them the ability to swallow large prey between the jaws (Norton and Brainerd 1993; Porter and Motta 2004).

The trichiurids have a streamlined head which allows them to approach their prey very close before raiding. The streamlined head does not generate momentum on water in front of the head which decreases prey recognition of the predator (Porter and Motta 2004). These species move towards their prey slowly holding their body rigid (Bone 1971). The less undulation there is, the less visual recognition there is by the prey for the predator (Porter and Motta 2004).

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3 Harmful Fish Group

3.1 Needlefish

Order: Beloniformes
Family: Belonidae
Strongylura leiura (Bleeker 1850)
Common name: Banded needlefish
Arabic name: سمكة المخيط المخططه
Etymology: *Strongylura:* Greek, strongylos = round + Greek, oura = tail (Fig. 3.1)

Identification

- Compressed long body.
- Both jaws elongated and equipped with sharp teeth.
- No gillrakers.
- Fins without spines. Shape of anterior part of dorsal and anal fin lobe-shaped. Pectoral fin narrow. No lateral keel on caudal peduncle. Caudal fin emarginate, not deeply forked. Both dorsal and anal fins have scutes on their bases.
- Top of head and back greenish with silver stripe along sides widening posteriorly. White ventral side. Pelvic fins white. Dark spots on pectoral fins with tip of fins yellow. Tips of dorsal and anal fin lobes yellowish. Caudal fin dark with a yellowish colour on the upper lobe (Fischer and Bianchi 1984).

World Distribution The distribution of this needlefish is confined to the Indo-Pacific region. It is found in Somalia, Tanzania, South Africa, and eastward to Pakistan, India, Sri Lanka, and southeast Asia and New Guinea, Australia, and the Philippines. It is also reported from southern China (Collette 1984: 1086; Sommer et al. 1996).

Distribution in the Study Area Fischer and Bianchi (1984) and Randall (1995) reported this species to be present in the entire Arabian-Persian Gulf area and the Iranian side of the Sea of Oman. On the other hand, Froese and Pauly (2016) have suggested that it is found only in the Arabian Sea coasts of Oman. Manilo and Bogorodsky (2003) have reported it from the southern Arabian Peninsula at the coasts of both Oman and Yemen.

Habitat and Ecosystem Role It is a marine species, enters brackish waters, and is sometimes found in association with reefs (Reide 2004).

Biology The larvae of this species is usually found in mangroves (Jeyaseelan 1998). It is an oviparous fish and eggs are found attached to objects in waters by tendrils on the egg's surface (Breder and Rosen 1966). The relation to humans is discussed in a special section below.

L.A. Jawad, *Dangerous Fishes of the Eastern and Southern Arabian Peninsula*,
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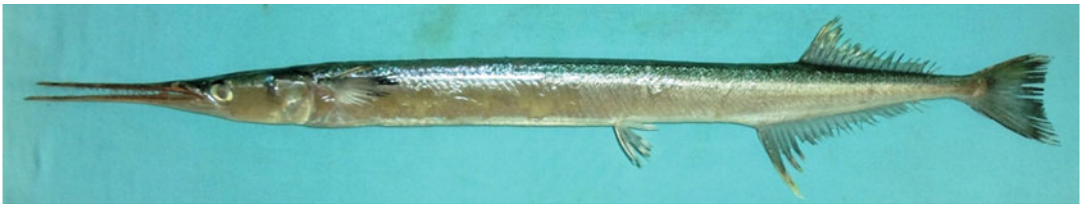

Fig. 3.1 Banded needlefish, *Strongylura leiura* (Bleeker, 1850). Courtesy of Hamid Osmany, Pakistan

Fig. 3.2 Spottail needlefish, *Strongylura strongylura* (van Hasselt, 1823). Courtesy of Ratmuangkhwang, Sahat, Thailand

Economic Value This species is considered an important fish commodity as its meat is considered delicious and most valuable for people taking it along its geographical distribution.

Conservation Status Not evaluated.

Strongylura strongylura (van Hasselt 1823)
Common name: Spottail needlefish
Arabic name: سمكة المخيط منقطة الذنب
Etymology: *Strongylura:* Greek, strongylos = round + Greek, oura = tail (Figs. 3.2 and 3.3)

Identification

- Body elongated.
- No gillrakers.
- No spines in fins. Dorsal and anal fins with lobe-shape anterior sides. Narrow pectoral fins. No lateral keel on caudal peduncle. Caudal fin rounded or truncate and not forked.
- Body greenish above, silvery laterally, and white ventrally. Pectoral, pelvic, and anal fins white. Pigmentation on middle rays of dorsal and anal fins. Round black spot on base of caudal fin. Anterior margin of anal fin orange (Fischer and Bianchi 1984).

World Distribution The distribution of this species is confined to the Indo-Pacific region and is found in Pakistan, India, Sri Lanka, and southern China, the Philippines, and north Australia (Froese and Pauly 2015).

Distribution in the Study Area This species is reported from all the countries of the Arabian-Persian Gulf, the Sea of Oman, and the southern coasts of the Arabian peninsula (Fischer and Bianchi 1984; Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species entering brackish waters and living in depth range 10–13 m (Froese and Pauly 2016).

Biology Individuals of this species are oviparous (Blaber 1980) and eggs are found attached to objects in the water (Breder and Rosen 1966). The human interaction with this species is given in a separate section below.

Economic Value The meat of this fish has high commercial value in countries along its geographical distribution.

Fig. 3.3 Spottail needlefish, *Strongylura strongylura* (van Hasselt, 1823). Courtesy of M.P. Remesan, India

Fig. 3.4 Keel-jawed needle fish, *Tylosurus acus melanotus* (Bleeker, 1850). Courtesy of Hiroyuki Motomura, Japan

Conservation Status Not evaluated.

Tylosurus acus melanotus (Bleeker 1850)
Common name: Keel-jawed needlefish
Arabic name: سمكة المخيط صلبة الأسنان
Etymology: *Tylosurus:* Greek, tylos = callus + Greek, oura = tail (Fig. 3.4)

Identification

- Body elongate.
- Both jaws elongated and equipped with sharp teeth. Lower jaw with an obvious appendage.
- No gillrakers.
- No spines in fins. Dorsal and anal fins with lobe-shaped anterior side. Pectoral and pelvic fins short. Caudal peduncle with small black lateral keel. Caudal fin deeply forked with lower lobe much longer than upper.
- Body dark bluish above, silvery white below (Fischer and Bianchi 1984).

World Distribution In the Indo-Pacific region, it is reported from East Africa to the central, south, and east central Pacific (Collette 1984).

Distribution in the Study Area Fischer and Bianchi (1984) have reported that this species is found on the coasts of the Arabian-Persian Gulf, the Sea of Oman and the southern coasts of the Arabian peninsula. On the other hand, Froese and Pauly (2016) reported it to be found on the southern coasts of the Arabian peninsula at the coasts of Oman and not in the other two seas. Manilo and Bogorodsky (2003) have recorded it from the Arabian Sea coasts of Yemen and Oman.

Habitat and Ecological Role It is a marine species and enters both freshwater and brackish. It is found living in association with reefs. It lives at depth 0–1 m (Reide 2004; Mundy 2005).

Biology Individuals of this species are oviparous and eggs may be found attached to objects in waters by thread-like structures found on the surface of the egg (Breder and Rosen 1966). The human interaction with this species is dealt with in a section given below.

Economic Value The meat of this species as with other needlefish species is delicious with high commercial value in all countries at its geographical distribution.

Conservation Status Not evaluated.

Tylosurus choram (Rüppell 1837)
Common name: Red Sea hound fish
Arabic name: سمكة مخيط البحر الأحمر
Etymology: *Tylosurus:* Greek, tylos = callus + Greek, oura = tail (Fig. 3.5)

Identification
- Body elongated.
- No gill rakers.
- Both jaws long and straight with straight and strong teeth.
- Caudal peduncle with poorly developed keel at posterior end. Emarginate caudal fin with lower lobe longer than upper. Dorsal and anal fins with elevated anterior side.
- Body with green colour on back, silvery on sides and abdomen (Randall 1995).

World Distribution The distribution of this species is confined to the western Indian Ocean. It is also found in the eastern Mediterranean Sea (Froese and Pauly 2016).

Distribution in the Study Area This species is absent from the Arabian-Persian gulf and the sea of Oman. Manilo and Bogorodsky (2003) have reported this species from the southern coasts of the Arabian peninsula in Yemeni waters and

Fig. 3.5 Red Sea hound fish, *Tylosurus choram* (Rüppell, 1837). Courtesy of Robert Patzner, Austria

Randall (1995) and Froese and Pauly (2016) have recorded it from the Omani coasts of the Arabian Sea.

Habitat and Ecosystem Role It is a marine species with pelagic-oceanic habitat (Froese and Pauly 2016).

Biology Females of this species are oviparous and as in other needlefish species, eggs are found attached to objects in the water by thread found on their surface (Breder and Rosen 1966). Human interaction with this species is given in a section below.

Economic Value This species is taken for its delicious meat and considered among the most high-commercial value species in the area where it is distributed.

Conservation Status Not evaluated.

Tylosurus crocodilus (Péron and Lesueur 1821)
Common name: Hound needlefish
Arabic name: سمكة المخيط التمساح
Etymology: *Tylosurus:* Greek, tylos = callus + Greek, oura = tail (Fig. 3.6)

Identification

- Long body with elongated jaws equipped with sharp teeth.
- No gillrakers and no spines in fins.
- Dorsal and anal fins lobe-shaped at anterior sides. Long pectoral and pelvic fins. Caudal peduncle with a small black lateral keel. Deeply forked caudal fin with lower lobe much longer than upper.
- Body dark bluish to green above and silvery below with dark blue stripe along sides. Scales and bones green (Fischer and Bianchi 1984).

World Distribution This species is distributed in several localities in the Indo-West Pacific and western and eastern Atlantic (Randall and Sinoto 1978; Masuda et al. 1984; Collette 1986; Robins and Ray 1986; Collette and Parin 1990; Diouf 1996; Fricke 1999).

Distribution in the Study Area This species is recorded from the Arabian-Persian Gulf in Iranian waters only (Assadi and Dehghani 1997). It is also reported from the Sea of Oman in Omani waters (Randall 1995) and from the southern coasts of the Arabian peninsula in the waters of Yemen and Oman (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species found in reef areas and having an oceanodromous habit. It lives at depth range from the surface down to 13 m (Reide 2004; Mundy 2005).

Biology It lives either in groups or solitary. Females are oviparous and eggs are found attached to objects in waters (Breder and Rosen 1966; Claro 1994; Thollot 1996). The human interaction of this species is given in a section below.

Economic Value The meat of this species has a high commercial value.

Conservation Status Not evaluated.

Fig. 3.6 Hound needlefish, *Tylosurus crocodilus* (Péron & Lesueur, 1821). Courtesy of Hiroyuki Motomura, Japan

3.1.1 Injuries Caused by Needlefishes

Needlefish live near the surface of the water and are able to jump outside the water at speeds of 60 km h^{-1}. In most cases they land on the deck of a shallow boat rather than in the water again. Artificial light during night or when dark evokes needlefish to jump. Usually, the night fishers are their victims and get hit by very fast fish with strong and sharp beaks (Scott 1996).

The description of the following cases from around the world gives an idea about how dangerous the species of the family Belonidae are. The species of this family described above might be involved in such incidents in all the areas at the east and southern Arabian peninsula.

The number of injuries of humans by needlefish is not many, but they affect many parts of the human body with some of them fatal. The injuries can be in the head region (i.e., in the orbit, maxilla, ear, and brain); in the neck; in the thorax (i.e., in the heart); in the abdomen; in the knee; in feet; and in the buttocks. The attack of the needlefish can cause facial analysis and concoction.

Fatal Incidents

Among the fatal cases is the attack on the eye and brain. McCabe et al. (1978) reported on a case where a 10-year-old Hawaiian boy faced a needlefish attack while he was fishing with his father on a boat when a 36–48 cm long fish jumped from the water, hitting the boy in the right eye. On admission to hospital he was found to be comatose, with flaccid paralysis involving the right side of the body. The wound caused by the hit of the fish was about 8 mm long. Later, the patient showed evidence of cerebral infarction and a small left subdural hematoma. After 10 days the boy died as a result of brain damage.

Barss (1982) reported three fatal cases due to the attack of needlefish on people fishing on a boat. In all these cases, the attack happened to the thorax. In one of these cases, the fisher caught the fish, and the fish hit him in the chest. In one of the other two cases, the fisher caught one needlefish and another one pierced his chest. In the third case the fisher died when a needlefish attacked him in the chest.

Deutsche Press (2007) carried news about a 16-year-old Vietnamese boy who died as a result of an attack by a 150 mm long needlefish. The boy was diving for sea cucumber. The boy's diving friends assisted him in pulling the needlefish snout out of the boy's chest. After the stab to his heart the boy died before reaching the hospital.

Nawasiwatte et al. (2014) reported the case of a 41-year-old Maldivian professional diver at one of the hospitals in Sri Lanka. The man was hit by a needlefish while he was diving. The right ear was penetrated deep by the long jaws of the fish. The beak and any other particles of the fish were removed. At the start he showed ear bleeding. The patient developed bilateral visual blurring and sudden onset left face, arm, and leg weakness. The brain showed an acute infarction and the brain stem reflexes were stopped and the brain confirmed dead after 72 h.

Another fatal case happened to a young man swimming at night in the Arabian-Persian Gulf area of Saudi Arabia. The attack was to his neck and as result a severe cut occurred from a strong hit by a needlefish. The man died on his way to the hospital (Sabiq 2015).

Nonfatal Incidents

The case of a Hawaiian man reported by Barss (1982) was a stabbing case in the right eye. As a result the medial canthal ligament was injured, laceration to the lacrimal duct, and decreased vision occurred. After comprehensive examination, it appears that the beak of the fish had penetrated very deep and damaged the optic nerve causing blindness in the right eye. The other case of attack reported by Barss (1982) happened to a man in Hawaii when he was wading in the water driving fish into a net. A big needlefish jumped and pierced his right lower eyelid. He became blind in the right eye with paralysis of the right cranial nerves once he reached the hospital. It seems that the beak passed on into the brain damaging descending motor tracts from the right cerebral cortex. Two months later he was still severely disabled with no sign of recovery from the hemiplegia.

In the thorax–abdomen area, Barss (1982) has reported three cases. In these cases, a 9-year-old girl was stabbed in the stomach while she was wading in the water which resulted in perforating the stomach and the liver; an adult fisher received a peritoneal haemorrhage with prolonged infection; and an adult fisher had an attack on the left side of his abdomen causing a perforation of the large and small intestines.

Bendet et al. (1995) have reported a case of needlefish attack against a man, hitting him in his neck. This incident caused severe injuries to the cervical area.

In the lower limbs, an attack was performed by a needlefish on a knee joint of a man in New Caledonia. The attack caused articular disorder that led to acute arthritis (Labbe et al. 1995).

Among the nonfatal cases, facial paralysis happened to a man diving near the Maldives when a needlefish weighing 30 kg hit his head. Paralysis of the facial nerve resulted 4–5 h after the collision. After examination and surgical operation, part of the fish jaw was removed from the retromandibular fossa. The fish jaw had compressed the facial nerve (Zwisler and Beigel 1997).

Barton and Bond (2007) reported on a case where the patient was nearly killed. A young snorkeler in Florida was attacked by a jumping needlefish that hit her in the heart.

Moreno (2005) reported on a 19-year-old diver stabbed in the stomach by a large needlefish while he was attempting to dive in Kahana Bay, Hawaii. Severe damage to his liver occurred.

An incident happened to a 31-year-old Indian man who was fishing when a large needlefish struck him in his left eye. The examination of the eye revealed bare light perception, fixed and dilated pupil, afferent pupillary defect, absent motility, lid oedema, proptosis, and vitreous haemorrhage. The patient lost vision with his left eye after 2 days (Thakker and Usha 2006).

The maxilla is another place in the head region that becomes a target for the attack of the needlefish. Ebner et al. (2009) have reported on the case of a 29-year-old man with a penetrating facial wound caused by needlefish. This incident happened in the early hours of darkness, when two amateur divers were spearfishing off the shores of Herzliya (10 km north of Tel Aviv, Israel). The strong jaws penetrated the maxilla transversely and obliquely from the left canine-fossae, through the nasal cavity, and to the right maxillary sinus, with its tip reaching the right medial-inferior orbital wall. The needlefish jaws were completely removed using a combined endoscopic and external approach.

In 2012, a German kitesurfer was attacked by needlefish in his foot while he was surfing before taking off (*Kite Magazin* 2012).

The case of Ohtsubo et al. (2013) was about a 27-year-old man who was injured by a fish hitting his right lower eyelid while swimming in Okinawa, a Japanese sea resort. After examination, it appears that there was a small laceration in the right lower eyelid, and a foreign body was detected in the right orbit by computed tomography (CT). Visual function tests indicated diplopia in the right vision and restriction of right eye abduction. Visual acuity of the right eye showed no abnormalities. Computed tomographic findings showed calcifications of 25 mm in the upper part of the superior rectus muscle and 7 mm on the outer side of the lateral rectus muscle in the right orbit. Two elongated bodies that were suspected to be needlefish jaws were found.

There is a high risk of secondary infection after needlefish injury which is most likely to happen as the members of the family Belonidae are carnivorous and their putrid dentition is a source of infection. In this case, intraorbital foreign bodies were removed 10 days after the injury. The bone had begun to undergo decomposition. Reduction of wound infection was achieved by vigorous irrigation and debridement. *Vibrio parahaemolyticus* or *Vibrio vulnificus* are the most suspected *Vibrio* species to be present in such attack. Therefore, antibiotic therapy should be given in such cases.

Mild Nonfatal Incidents

A slight attack by needlefish can be seen in the cases reported by Barss (1982). A man was fishing at night in Hawaii when knocked unconscious into the sea. He was rescued by someone else and survived. A similar case happened to a man hit by needlefish on the side of his head and who fell down in the sea. The man died probably by drowning. Another slight attack happened to a man paddling a canoe at dusk when he felt a strong hit in his buttock. A deep wound resulted from this attack.

3.2 Surgeonfish

Family: Acanthuridae
Acanthurus dussumieri (Valenciennes 1835)
Common name: Eyestripe surgeonfish
Arabic name: سمكة الجراح مخططة العيون
Etymology: *Acanthurus:* Greek, akantha = thorn + Greek, oura = tail (Fig. 3.7)

Identification

- Body high and compressed.
- Small mouth with spatulate teeth.
- Dorsal fin continuous without notch. Emarginate caudal fin to lunate. Clear blade on sides of caudal peduncle which folds into a deep horizontal groove.
- Body light brown in colour with many longitudinal and wavy purple grey lines. Irregular lines on head. Yellow band on anterior end of eye and not reaching posterior end. Cover of caudal fin spine light cream. Dorsal and anal fins with bluish band. Caudal fin deep blue with several small black spots. Pectoral fins light yellowish brown (Fischer and Bianchi 1984).

World Distribution The distribution of this species is confined to the Indo-Pacific region. It is found from east Africa to the Hawaiian Islands and north to southern Japan and south to the Great Barrier Reef and Lord Howe Island (Froese and Pauly 2015).

Distribution in the Study Area This species is absent from the Arabian-Persian Gulf and the Sea of Oman areas (Fischer and Bianchi 1984; Randall 1995; Froese and Pauly 2016), but it has been reported from the southern coasts of the

Fig. 3.7 Eyestripe surgeonfish, *Acanthurus dussumieri* Valenciennes, 1835. Courtesy of Hiroyuki Motomura, Japan

Arabian peninsula at the coasts of Oman (Randall 1995; Manilo and Bogorodsky 2003) and Yemen (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species found living in reef areas at depth range 4–131 m (Lieske and Myers 1996).

Biology Individuals of this species live in schools and adults mainly stay on deep coastal reef slopes (Myers 1991). The juveniles are found in rocky reefs (Kuiter and Tonozuka 2001). They mainly have a diurnal habit (Myers 1991). Sexes are separated in this species as is the case in all members of this family (Reeson 1983). There is no sexual dimorphism in this species, but males usually take on courtship colours (Choat et al. 2012a, b, c). Individuals can live up to 28 years as in the Great Barrier Reef (Choat and Robertson 2002). The human interaction with this species is given in a separate section below.

Economic Value This species is taken for its delicious meat and it is also used in the aquarium trade (Choat et al. 2012a, b, c).

Conservation Status This species is classified as Least Concern in the Red List of the IUCN because it has a wide distribution, habitat range, and occurrence in marine reserves (Choat et al. 2012a, b, c). There are no conservation plans available for this species.

Acanthurus leucosternon (Bennett 1833)
Common name: Powderblue surgeonfish
Arabic name: سمكة الجراح الزرقاء
Etymology: *Acanthurus:* Greek, akantha = thorn + Greek, oura = tail (Fig. 3.8)

Identification

- Body high and compressed.
- Small mouth with spatulate close teeth.
- Dorsal fin continuous with no notch. Emarginate caudal fin. Lancet-like spine on sides of caudal peduncle which fits into groove lying horizontally.
- Body blue in colour with white band across anterior part of thorax from pectoral fin base. Spine of caudal peduncle yellow. Head black with white line connecting chin and dorsal corner of mouth. Dorsal fin yellow and caudal fin black with large white crescentic and posterior marginal area. Pectoral fin clear with yellow rays. Pelvic fins grey (Fischer and Bianchi 1984).

World Distribution It is found in the Indian Ocean area only from east Africa to the Andaman Sea and to Indonesia and Christmas Island.

Fig. 3.8 Powderblue surgeonfish, *Acanthurus leucosternon* Bennett, 1833. Courtesy of D. Terver, France

Distribution in the Study Area This species is absent from the Arabian-Persian Gulf and the Sea of Oman areas (Randall 1995; Froese and Pauly 2015), but it has been reported from the southern coasts of the Arabian peninsula at the coasts of Oman (Randall 1995; Manilo and Bogorodsky 2003) and Yemen (Manilo and Bogorodsky 2003). Fischer and Bianchi (1984) reported it present on the eastern African coast, and in the southern Arabian peninsula.

Habitat and Ecosystem Role It is a marine species found living in reef areas at depth range 0–25 m (Lieske and Myers 1996).

Biology Individuals of this species prefer shallow water areas and are found in schools when feeding (Lieske and Myers 1996). The human interaction for this species is given in a separate section below.

Economic Value This species is taken for its meat and for the aquarium trade along its geographical distribution.

Conservation Status This species is ranked Least Concern in the Red list of the IUCN as it is widely distributed in the Indian Ocean with high abundance in some areas and rare in others and presence of differences in densities were observed in the fished areas (Abesamis et al. 2012a, b).

Acanthurus mata (Cuvier 1829)
Common name: Elongate surgeonfish
Arabic name: سمكة الجراح الطويله
Etymology: *Acanthurus:* Greek, akantha = thorn + Greek, oura = tail (Fig. 3.9)

Identification

- Body is more elongated than in other species of Acanthurus genus.
- Head with sloping profile and short snout.
- Slender caudal peduncle.
- Mouth small with small teeth.
- Lunate caudal fin.
- Body dark brown in colour with blue lines extending lengthwise from head to posterior end of body. Area posterior to eye with yellow colour with two yellow bands extending anteriorly. Upper end of gill opening with black spot. Base of dorsal fin with narrow blue stripe and a black stipe below it getting wider posteriorly (Randall 1995).

World Distribution It is distributed from the Red Sea south to Natal, South Africa and east to the Marquesas and Tuamoto Islands. It is also found in Japanese waters and in the south the Great Barrier Reef and New Caledonia (Froese and Pauly 2016).

Distribution in the Study Area This species is absent from the Arabian-Persian Gulf and the Sea of Oman areas (Randall 1995; Froese and

Fig. 3.9 Elongate surgeonfish, *Acanthurus mata* (Cuvier, 1829). Courtesy of Hiroyuki Motomura, Japan

Pauly 2016), but it has been reported from the southern coasts of the Arabian peninsula at the coasts of Oman (Randall 1995; Manilo and Bogorodsky 2003) and Yemen (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine species found in reef areas at depth range 5–100 m (Al-Sakaff and Esseen 1999).

Biology Adult individuals of this species prefer steep slopes and turbid water (Broad 2003). At spawning time, they aggregate in groups (Domeier and Colin 1997; Kuiter and Tonozuka 2001). Individuals are very mobile with maximum age of 23 years (Choat and Robertson 2002). As in other acanthurid species, the sexes are separated in this species. The human interaction of this species is given in a separate section below.

Economic Value This species is taken for its meat and for the aquarium trade.

Conservation Status This species is ranked as Least Concern in the Red List of the IUCN as it is widespread in the Indo-Pacific and common in its range, fishing is not major threat, and it is found in a number of marine reserves (Abesamis 2012a, b).

Acanthurus sohal (Forsskål 1775)
Common name: Sohal surgeonfish
Arabic name: سمكة جراح سوهال
Etymology: *Acanthurus:* Greek, akantha = thorn + Greek, oura = tail (Fig. 3.10)

Identification

- Body oblong in shape.
- Caudal spine long.
- In adult, caudal fin has strong lunate shape with upper and lower lobes elongated.
- Body light grey. Head with black lines extending down to lower edge of eye. Broader black stripes on body and in pectoral fin region. Single orange blotch near base of pectoral fin. Socket of caudal spine orange in colour. Blue margin on black dorsal, anal, and pelvic fins (Randall 1995).

World Distribution The distribution of this species is confined to the western Indian Ocean (Froese and Pauly 2016).

Distribution in the Study Area This species is recorded from the Arabian-Persian Gulf at the coasts of Iran (Froese and Pauly 2016) at Kuwait (Bishop 2003). It is reported from the Sea of Oman (Randall 1995) and from the south coasts of the Arabian peninsula at the Yemeni and Omani waters.

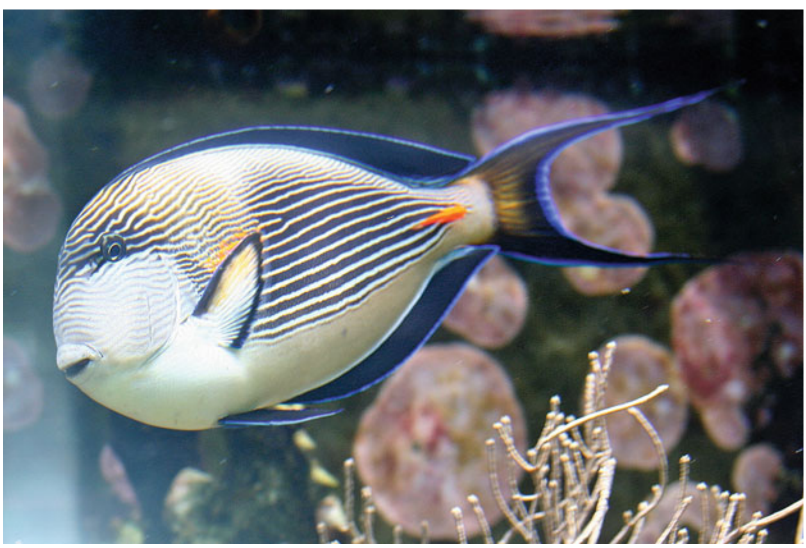

Fig. 3.10 Sohal surgeonfish, *Acanthurus sohal* (Forsskål, 1775). Courtesy of Jan Bukkems, Holland

Habitat and Ecosystem Role This marine species is found living in reef areas (Baensch and Debelius 1997).

Biology This species has an aggressive and territorial behaviour (Lieske and Myers 1996) and swims rapidly towards strangers (Alwany et al. 2005). The maximum age reached by this species is 11 years with a maximum length 323 mm in total. The human interaction with this species is given in a separate section below.

Economic Value This species is taken for its meat and for the aquarium trade.

Conservation Status Least Concern status in the Red List of IUCN is given to this species. This is because the threat that it faces from fishing activities and from collecting live specimens for the aquarium trade do not reach the thresholds for the threatened category. It is also abundant throughout its geographical distribution and found in several marine reserves (Choat et al. 2012a, b, c).

Acanthurus tennentii (Günther 1861)
Common name: Doubleband surgeonfish
Arabic name: سمكة الجراح مزدوجة الخطوط

Etymology: *Acanthurus:* Greek, akantha = thorn + Greek, oura = tail (Fig. 3.11)

Identification

- Body oblong.
- Caudal fin lunate in adult and emarginate in young.
- Body with brownish black colouration. Two broad black bands directed posteriorly from upper corner of gill opening. Caudal spine housed in black socket surrounded with blue margin. Caudal fin bordered posteriorly by white band (Randall 1995).

World Distribution The distribution of this species is confined to the Indian Ocean. It is found from east Africa to Sri Lanka and the Lesser Sunda Islands of southern Indonesia (Froese and Pauly 2016).

Distribution in the Study Area This species has not been recorded from the Arabian-Persian Gulf region or from the Sea of Oman (Randall 1995; Froese and Pauly 2015), but it is present in the coasts of Yemen and Oman in the south Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003).

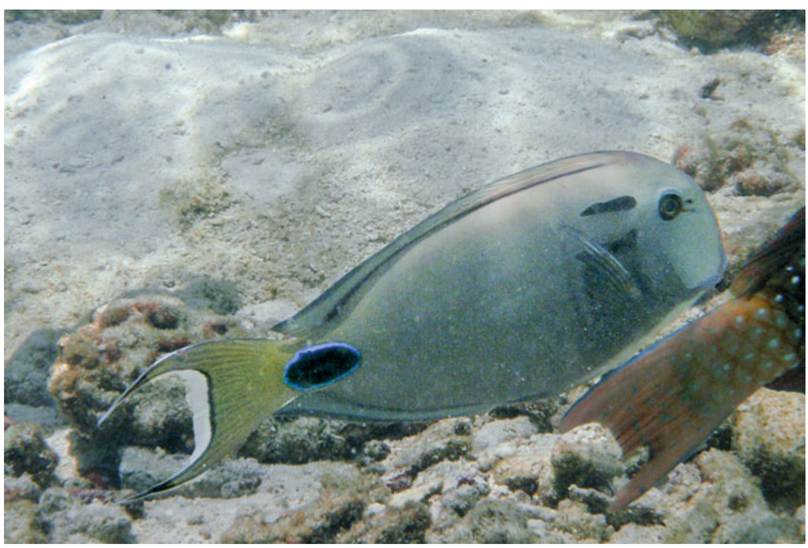

Fig. 3.11 Doubleband surgeonfish, *Acanthurus tennentii* Günther, 1861. Courtesy of Rainer Kretzberg, Bedburg, Germany

Habitat and Ecosystem Role It is a marine species living in the reef area at depth range 1–40 m (Allen and Erdmann 2012).

Biology Individuals of this species are solitary or form groups (Allen and Erdmann 2012). Human interaction of this species is given in a section below.

Economic Value This species is used as food in the countries along its geographical distribution. It is also taken by the aquarium trade.

Conservation Status Least Concern status in the Red List of IUCN was given to this species as it is widely distributed and the fishing and aquarium activities are not at the threatened level. In addition, it is found in marine reserves in parts of its range (Russell et al. 2012a, b).

Ctenochaetus striatus (Quoy and Gaimard 1825)
Common name: Striated surgeonfish
Arabic name: سمكة الجراح المشطبه
Etymology: *Ctenochaetus:* Greek, kteis, ktenos = comb + Greek, chaite = hair (Fig. 3.12)

Identification

- Body high and compressed.
- Small mouth with numerous, movable, and slender teeth.
- Dorsal fin with no notch. Caudal fin lunate.
- Body dark olive in colour with blue-grey lines extending from head to tail. Head and nape with small orange spots. Dorsal and anal fins with five dark blue broad lines extending horizontally. Base of dorsal fin with small black spots in juveniles (Fischer and Bianchi 1984).

World Distribution The distribution of this species is confined to the Indo-Pacific region excluding Hawaii, the Marquesas, and Easter Islands (Randall and Clements 2001).

Distribution in the Study Area There is no record of this species from the Arabian-Persian Gulf and the Sea of Oman (Randall 1995; Froese and Pauly 2016), but it is found in the south Arabian peninsula at the coasts of Yemen and Oman (Randall 1995; Zajonz et al. 2000; Froese and Pauly 2016).

Habitat and Ecosystem Role This marine species lives in association with reefs at depth range 1–35 m (Allen and Erdmann 2012).

Biology Individuals of this species living in the Pacific have a longer lifespan than those living in the Indian Ocean. In the first year of its life, individuals of this species have a rapid growth. The maximum number of annuli reported from this species is 32–35 (Choat and Axe 1996). The

Fig. 3.12 Striated surgeonfish, *Ctenochaetus striatus* (Quoy & Gaimard, 1825). Courtesy of Hiroyuki Motomura, Japan

size at maturity is 1350 mm in total length (Choat and Robertson 2002). The human interaction of this species is given in a section below.

Economic Value This species is taken for its food and for the aquarium trade.

Conservation Status This species has been granted the Least Concern criterion in the Red List of the IUCN for the following reasons: it is a widespread species, common and abundant in reef areas, no evidence of population decline, and it is found in several marine reserves in some regions of its range (Choat et al. 2012a, b, c).

Zebrasoma xanthurum (Blyth 1852)
Common name: Yellowtail tang
Arabic name: سمكة الجراح صفراء الذنب
Etymology: *Zebrasoma:* Derived from Zebra = African horse + Greek, soma = body; referring to the stripes (Fig. 3.13).

Identification

- Body high and compressed.
- Spatulate teeth.
- Patch of small spines anterior to the caudal peduncle spine.
- Long snout.
- Elevated dorsal and anal fins.
- Body with blue colour and dark spots on head, anterior part of body, and on abdomen. Caudal fin and posterior edges of pectoral fin bright yellow (Randall 1995).

World Distribution The distribution of this species is confined to the western Indian Ocean (Randall and Anderson 1993).

Distribution in the Study Area This species is recorded in the waters of all the countries of the Arabian-Persian Gulf and in the Sea of Oman (Randall 1995; Froese and Pauly 2016). It is also reported from the south Arabian peninsula at the coasts of Yemen and Oman (Randall 1995; Manilo and Bogorodsky 2003; Froes and Pauly 2016).

Habitat and Ecosystem Role It is a marine species living in reef areas at depth range from the surface down to 20 m (Lieske and Myers 1996).

Biology Individuals of this species swim and feed during the daytime only. During the night, they hide in their shelter in the reef (Myers et al. 2012). Sexual dimorphism is possible in this species as the cloaca is bigger in females (Bushnell et al. 2010). The human interaction of this species is given in a section below.

Fig. 3.13 Yellowtail tang, *Zebrasoma xanthurum* (Blyth, 1852). Courtesy of Laith Jawad, New Zealand

Economic Value This species is taken for its meat and for the aquarium trade.

Conservation Status This species has been granted the Least Concern criterion in the Red List of the IUCN for the following reasons: this species is distributed around the Arabian peninsula, it is abundant throughout its range, and fishing and aquarium trade activities are minor components (Myers et al. 2012).

3.2.1 Cuts Caused by Surgeonfish

All members of the family Acanthuridae are distinguished in having notable external spines and plates situated laterally on the caudal peduncle. These structures take several shapes. In the members of the subfamily Nasinae, there are one or two immovable bony plates. In the members of the subfamily Prionurinae, there are up to 10 peduncular keels (Smith and Heemstra 1986). Nelson (1976) called them armature for use in inter- and intraspecific interactions (Schober 1984, 1986). The spines are considered poisonous by some authors (Beebe 1926) and cause severe pain when they sting. Actually, the acanthurid spines are not connected to a poisonous gland, but are usually covered with a pigmented epithelium membrane which may have a toxic effect (Randall 1959).

The length of the caudal spine in acanthurid species varies among species. The spine of the species *Ctenochaetus striatus* and *Acanthurus sohal* have the longest and sharpest caudal spine among the acanthurid species (Randall 1959).

As an example of acanthurid species, the anatomy of the caudal spine apparatus, its connection with the vertebral column, and the locking mechanism are given for the species *Acanthurus leucosternon* (Schober and Ditrich 1992).

In this species, the spine is embedded with its basal plate in dermal connective tissue and projects anteriorly (Fig. 3.14). It can be erected nearly to an acute angle as a maximum. The erection happens when the muscles connecting the spine to caudal vertebra no. 21 contract and pull the caudal part of the spine and as result, the spine erects. The support to the erected spine originates from the process of caudal vertebra no. 22. To restore the spine to its resting position, the set of muscles and myosepta present in the region work together to attain this action.

The fish becomes aggressive when an intruder enters its territory. In such behaviour, the surgeonfish erects its spine and begins the attack on the intruder. The attack takes the form of beating the tail of the attacker with the body of the intruder in order to inflict severe injuries and make it leave the territory. A model fish representing an intruder was placed in the territory of a surgeonfish. The latter started its attack by beating its tail with the body of the model intruder fish. Such an attack caused a scratch 20 mm long and depth of up to 2 mm (Schober and Ditrich 1992). The surgeonfish will continue its attack until the intruder leaves its territory. Such an attack could happen to any divers who might find themselves in the territory of a surgeonfish. During this aggressive attack, the caudal peduncle of the surgeonfish stiffens and the fish moves rapidly towards the intruder.

The surgeonfish usually causes its injury when another fish or human swipes its body or part of its body against the surgeonfish. This cut is usually deep or sometimes it is a puncture. The pain occurring is worse than the wound itself if the membrane that covers the spine is inflicted in the wound (Thomas and Scot 1977).

It is very easy for a surgeonfish to slash divers or snorkelers during a feeding session. It is possible to get a surgeonfish cut when you try to remove surgeonfish from a net, spear, or fish hole as anglers usually do.

To prevent the incidence of getting cut by surgeonfish, the following instructions need to be taken into consideration (Thomas and Scot 1977).

1. It is important to throw food away from yourself and others while feeding the surgeonfish underwater.

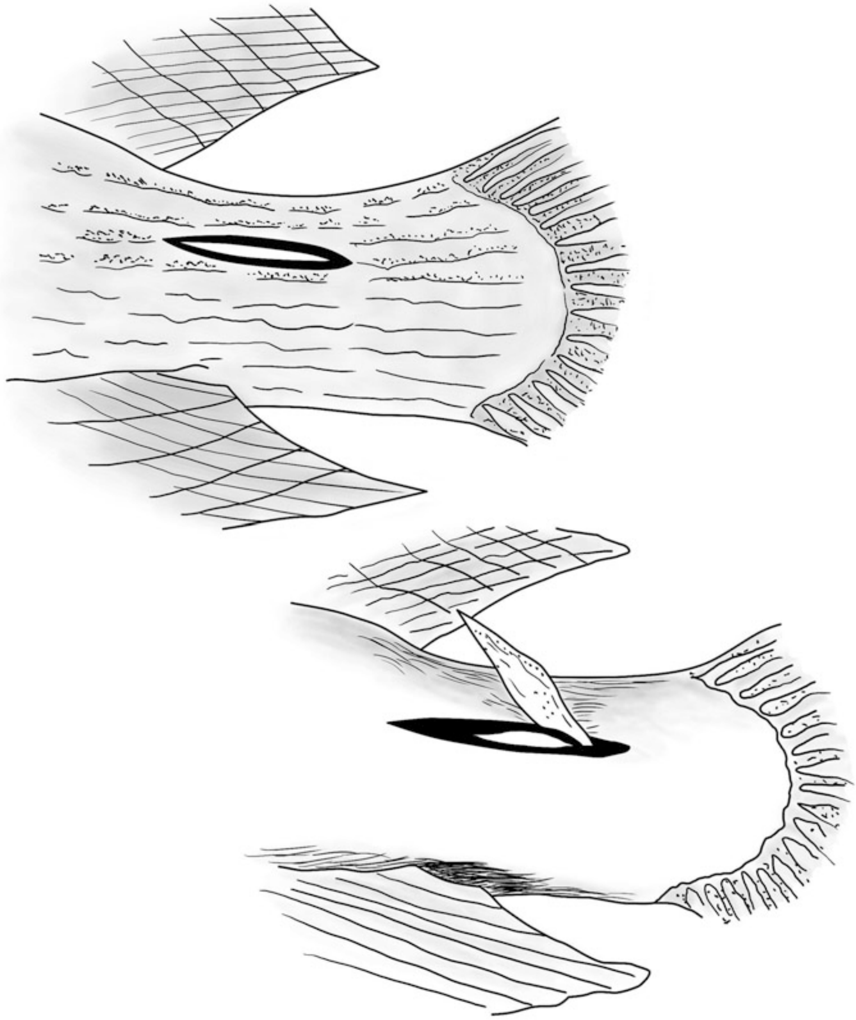

Fig. 3.14 Drawing showing; *above*, the tail of a surgeonfish *Acanthurus* showing the caudal spine in the contracted position; *below*, the tail of *Acanthurus* showing the caudal spine in the extended position. After Halstead (1967)

2. Fishers and anglers should wear thick gloves when handling surgeonfish in nets or on spears.
3. Divers should not chase or corner surgeonfish especially with the territorial species as they are very aggressive.

The cut caused by the surgeonfish is usually short and deep, but bleeds freely. If the membrane covering the spine gets inside the wound, severe pain with burning sensation results. Later, muscle and swelling aches at the cut area will develop. A tendon or nerve damage may cause numbness and inability to move.

The first aid that needs to follow in the case of a surgeonfish cut (Thomas and Scot 1977) is:

1. Gently pull the skin apart and remove any foreign materials and debris left from the incident. This can be done either by rinsing the wound in water or using tweezers.
2. Clean the inside of the wound by scrubbing the cut directly with gauze or a clean cloth soaked in clean fresh water.
3. Press on the wound to stop the bleeding.
4. If bleeding persists or if the edges of the wound are jagged or gaping, the cut needs stitches.

If a toxin is envenomed in the wound as a result of the presence of membrane tissue covering the spine, then localised pain and swelling will result. The spines can break inside the wound and are visible on X-ray or by using ultrasound. Removing the parts of the broken spine will prevent infection and foreign body granulation (Thomas and Scot 1977).

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4 Electric Fishes

4.1 Electric Rays and Their Electric Organ

Among animals, electric organs are only found in fishes. These are specially designed to generate an electric discharge. This electric organ is found in unrelated families of both Chondrichthyes and Osteichthyes living in a wide range of habitats.

In spite of the variety of the families that share the presence of the electric organ, they share a common feature that their electric organs are built up from a large number of disc-like cells called electroplaxes or electroplates arranged in a more or less orderly fashion and facing the same direction. Each of these electroplates is embedded in a jelly-like extracellular material and separated from other electroplates by a layer of connective tissue. A supply of nerves and blood is provided by nerves and blood vessels with nerves distributed on one face of the electroplates, whereas blood vessels form a network of branches. Electroplates are single cells, but with several nuclei located just beneath the two surfaces. The gelatinous masses of the electric organ can easily be distinguished from the surrounding muscle due to their transparent cytoplasm. In torpedoes, the electric organs form two large flat kidney-shaped masses on either side of the mid-line with the horizontal electroplates packed very tightly into hexagonal columns (Keynes 2013).

Turning to the history of the use of the electric rays, Pliny (AD 23–AD 79) has given prescriptions using torpedoes or torpedo parts which may seem strange to us. He followed the steps of the physician Hippocrates (460–c. 370 BC) and suggested for those having problems with their digestive system to include in their diet some of the torpedo's products. For splenic troubles, he suggested applying a live torpedo ray on the area so the electric charges will heal the pain (Finger and Picolino 2011).

During Roman times, gout was the main painful disorder among the aristocrats and royalty as they used to indulge themselves in rich food. Such pain is related to the presence of uric acid of which the meat is rich, in addition to less extraction of this acid through the kidney because of heavy drinking of wine which competes with uric acid for extraction (Finger and Picolino 2011).

It was found by chance that a shock from a live torpedo will numb the pain in the foot. Later the Greek doctor, Scribonius Largus (about AD 47) advised using the torpedo's shock for both foot pain 'gout,' the hot one 'Podagra calda,' characterised by hotness and red swelling, and the cold 'Podagra frigida,' where the pain is not associated with these signs of inflammation (Keynes 2013). It is known that pain sensations can be blocked by peripheral stimuli transmitted by rapidly conducting nerve pathways, which

L.A. Jawad, *Dangerous Fishes of the Eastern and Southern Arabian Peninsula*,
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mainly utilise slowly conducting nerve fibres (Wall and Sweet 1967). It is also known that the release of endogenous opioids in the brain caused by painful stimuli can reduce the sensation of pain. In addition, the electrical shock can reduce the aches and pains caused by chronic diseases including several types of headaches, sometimes for long periods of time (Slavin 2008). Based on these facts originated from modern medicine, we came to know that the Romans made the correct choice in applying live torpedoes to reduce the pain of headaches and chronic gout.

Among the early Islamic physicians who wrote on torpedoes and their usage in medicine is Abu Muhammad Abdullah Ibn al-Bitar (or Ibn al-Bitar) (1197–1248) from Malaga, a part of Muslim Spain. He mentioned in his textbook, *Al-Jami li mufradat al-adwiya wa-l-aghadhiya*, which translates as 'Compendium of Simple Drugs and Foods' about the use of a live torpedo in curing headache if the fish were close to the head of the person who suffered from this pain.

During the second half of the eighteenth century, the electric fishes became an important issue for naturalists, physicists, physicians, and philosophers (Finger and Picolino 2011). At that time, attention was concentrated on the numbness caused by the South American eel, but also some attention was given to the electric ray, the torpedoes.

Bini (1967) has suggested that Europeans have known torpedoes for a long time as a disc-shaped ray with a relatively small tail. Its name originates from the Latin because it could cause 'torpor,'meaning sluggishness or sleepiness.

The torporific fishes transmit their effects to animals and human without direct physical contact. Even when there are media through which the electric discharge can travel such as water, metal rods, and wet nets, such discharges are still strong enough to immobilize, numb, and deter other fishes and even humans. The fishermen are the experienced people in knowing the distance effect of the electric organ, because they use several types of fishing gear to capture fishes (Finger and Picolino 2011).

In the torpedo where the electric organs are large and strong enough to produce a powerful discharge, this discharge is able to stun the prey. On the contrary, in the fish species with weak electric discharge, it is usually used for navigation as these fishes have a nocturnal habit and live in turbid water (Nelson 2011).

The electric field can be detected with the aid of thousands of specialised sense organs that cover the body of the electric fish. Each of these organs is composed of a pit filled with a number of sensory cells. These cells act as small voltimeters and control the voltage across the body surface of the fish. Once a strange object comes closer to the fish, the electric current flow across the skin will change and in turn alter the transdermal voltage monitored by the sense organs. The electric fishes have the ability to analyse the changes in voltage across the surface of their body to recognise the approaching object. They also can recognise electric signals given by other electric fishes found in the environment.

Strong electric fish such as torpedoes usually have thick layers of connective tissue that protect their electric organs from damage by electric charges generated by another electric fish.

The electric shock of a torpedo fish can cause arterial fibrillation. An unusual case of this kind happened to a pipeline inspector working for an oil company in Dubai, United Arab Emirates (Taimur and Hussaini 2008). He was stunned by four electric shocks from a torpedo ray fish. His verbal commands became incomprehensible after the fourth shock. The video footage shows that the diver was shouting, 'Electrical fish.' The diver became unconscious and was rescued by another diver in 8 min. He was confused and restless before being transferred to a nearby hospital. His pulse was irregular and he was referred to a cardiologist. The rhythm was confirmed as slow arterial fibrillation (87 min^{-1}) with BP of 140/80 (Taimur and Hussaini 2008). The investigations revealed an elevated white blood cell count.

An electric shock usually occurs when the human body comes in contact with a source of high voltage that makes it possible for the electric current to flow through the body. Usually, high-tension shocks (>1000 V) cause severe internal burns and cardiac arrest (Forrest et al.

Fig. 4.1 Aden torpedo, *Torpedo adenensis* Carvalho, Stehmann & Manilo, 2002. Courtesy of Simon Weigmann, Germany

1992). Low-tension shocks (<300 V) can cause ventricular fibrillation (Sances et al. 1979). It seems that this diver received a low- voltage shock that caused his arrhythmia (Taimur and Hussaini 2008).

Order: Torpediniformes
Family: Torpedinidae
Torpedo adenensis (Carvalho et al. 2002)
Common name: Aden torpedo
Arabic name: لخمة رعاد عدن
Etymology: *Torpedo:* Latin, torpere = be sluggish; *adenensis:* Named for its type locality, the Gulf of Aden; an adjective (Fig. 4.1).

Identification

- Disc broad and rounded with width larger than length.
- In live specimens, disc slightly overlaps origin of pelvic fin, but in preserved materials and effect of preservation and fixation, a small gap between disc and origin of pelvic fin is present.
- Small eyes, much smaller than spiracles which are large and rounded. Small knob-like papillae at the posterior edge of the spiracle.
- Electric organs are not conspicuous dorsally, but are clear ventrally. Originate very close to disc anterior edge and terminate posteriorly at the posterior end of last gill opening. Length of electric organs is about twice their width.
- Teeth flattened and amber in colour. They are similar in shape with well-developed single cups.
- Pelvic fin long and narrow with convex posterior margin. Cloaca located at the middle of the pelvic fin. Males with clasper having groove extending on its dorsolateral side. Tail short and thick tapering posteriorly. First dorsal fin originates anterior to posterior edge of pelvic fin.
- Preserved specimens with reddish to orange-brown colour. Tip of claspers dark. Dorsal side of disc with small white and unevenly distributed spots. Light creamy at posterior edges of dorsal and caudal fins (de Carvalho et al. 2002).

World Distribution This species is found in the northwestern Indian Ocean.

Distribution in the Study Area The distribution of this electric ray is confined to the Gulf of Aden (de Carvalho et al. 2002).

Habitat and Ecosystem Role This marine and tropical species inhabits a demersal environment at depth range 125–230 m (de Carvalho et al. 2002).

Biology The individuals of this species reach maturity at 280 and 395 mm in total length for

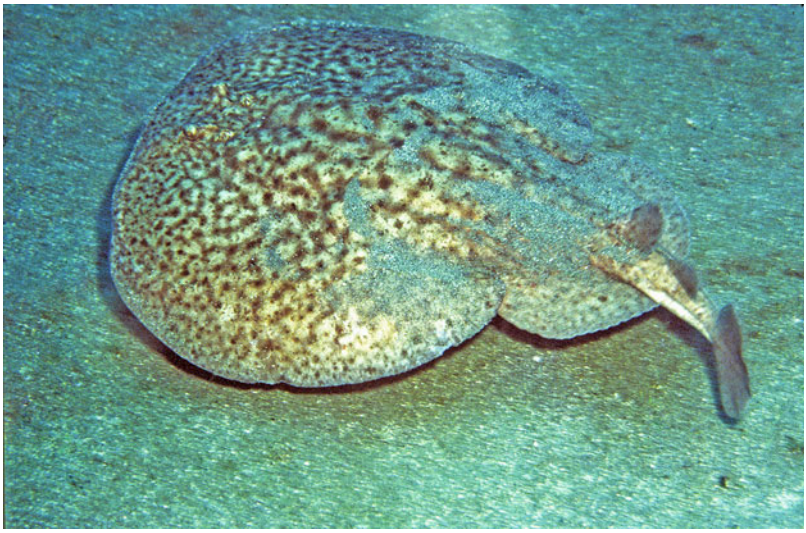

Fig. 4.2 Marbled electric ray, *Torpedo marmorata* Risso, 1810. Courtesy of Robert Patzner, Austria

males and females. The maximum size reached is 410 mm in total length (de Carvalho et al. 2002). This species is considered dangerous to humans because it is equipped with electric organs.

Economic Value No commercial value is known for this species.

Conservation Status This species is given the status of Near Threatened in the IUCN Red List because of its restricted range and continuous catch by the shrimp fisheries in its area. No conservation plan is on record for this species and development and implementation of a national management plan is required for the conservation of this species (de Carvalho and McCord 2006).

Torpedo marmorata (Risso 1810)
Common name: Marbled electric ray
Arabic name: لخمة الرعاد المرقط
Etymology: Torpedo: Latin, torpere = be sluggish (Figs. 4.2–4.4)

Identification

- Disc with rectangular shape.
- First dorsal fin slightly larger than second. Posterior edge of pelvic fins reaching or just passing posterior base of second dorsal fin.
- Presence of two large nuchal pores and several small pores spread irregularly on the dorsal surface.
- Presence of 6–8 tentacles of equal length on margin of spiracles.
- Mottled with brown background above and white ventral side.

World Distribution It has been reported from the eastern Atlantic from north of the United Kingdom and south to the Cape of Good Hope, South Africa and from the Mediterranean Sea (Stehmann and Bürkel 1984). It has also been recorded from the Gulf of Aden by Al Sakaff and Esseen (1999).

Distribution in the Study Area There is no record of this species from either the Arabian-Persian Gulf or the Sea of Oman (Randall 1995), but it has been reported from the Gulf of Aden (Al Sakaff and Esseen 1999).

Habitat and Ecosystem Role This marine species sometimes enters brackish waters and lives in reef areas at depth range 2–370 m (Capapé and Desoutter 1990). This species prefers seagrass beds and a sandy or muddy bottom.

Fig. 4.3 Marbled electric ray, *Torpedo marmorata* Risso, 1810, Mouth and jaws. Courtesy of GICIM Database of the Muséum National d'Histoire Naturelle, Paris, France

Fig. 4.4 Marbled electric ray, *Torpedo marmorata* Risso, 1810, ray in position to discharge electric current. Courtesy of Roberto Pillon, France

Biology The maximum size reached by males is 386 mm in total length and females 395 mm in total length with maturity at size 210–290 mm and 310–390 mm in total length for males and females. Females mature when they reach 12 years of age and can live up to 20 years, and males mature at 12–13 years of age. Females give birth to 5–32 young measuring between 100 and 140 mm in total length (Notarbartolo di Sciara et al. 2009).

The Carnivora website (2016) gives the following information about this ray. The marbled torpedo ray is a solitary and slow-moving species. It can remain motionless for several days due to its low blood oxygen carrying capacity and heart rate. This species is active during the nighttime and remains buried in the sediments for most of the day with eye and spiracles above the bottom of the sea.

This ray is equipped with electric organs and can produce a strong electric shock to defend itself. It has the ability to produce up to 70–80 V and the maximum potential of the electric discharge is estimated to be as high as 200 V. In locating prey, this ray uses the mechanoreceptors present in its lateral line. It follows two types of behaviour in capturing the prey. The first is jumping: in this behaviour, the fish gets very close to the prey and pulls back its head and ups its disc and then produces a high-frequency (230–430 Hz) electric current which causes a break in the vertebral column of the prey. After that, the ray moves over the prey and pushes it towards its mouth. The second type of behaviour is creeping: it is used for slow-moving prey. In this type, the ray moves its disc up and down and its tail to the sides. In doing so, the ray generates a weak current pulling the prey towards the disc. Once the ray reaches the prey, it opens its mouth to suck it. In this type of behaviour short electric bursts are produced.

This species of ray does not fall as prey to sharks and other animals because of the presence of their electronic defence mechanism. If the ray is touched by the disc, it quickly turns towards the attacker while producing electric shocks. If the ray is caught by the tail, it will form itself in a loop and then into a ring with its abdomen facing outward, discharging the highest electric field gradient.

This ray is considered dangerous to humans as they are equipped with strong electric organs. The shock of this ray is quite painful and affected divers might become disoriented underwater.

Economic Value No economic value is assigned for this ray although the ancient Greeks and Romans have suggested using them as live medicine to relieve pain.

Conservation Status This species of ray has been given the rank of Data Deficient due to the lack of information about its abundance, possible threats that it might face, population trends, and impact of fisheries (Notarbartolo di Sciara et al. 2009). No conservation measures are in place and any future measure should include the live release of individuals caught.

Torpedo panthera (Olfers 1831)
Common name: Panther electric ray
Arabic name: لخمة الرعاد النمر
Etymology: Torpedo: Latin, torpere = be sluggish (Fig. 4.5)

Identification

- Eyes small.
- Disc with truncate anterior margin.
- Spiracles with papillae.
- Cutaneous fold on side of tail.
- Dorsal fins are close to each other. Caudal fin with rounded corners.
- Dorsal side with brown background and mottled with white spots. Edge of disc white (Randall 1995).

World Distribution The distribution of this ray is confined to the Western Indian Ocean (Froese and Pauly 2008).

Distribution in the Study Area This species is reported from the Arabian-Persian Gulf in the waters of Saudi Arabia, Kuwait, and Iran (Bishop 2003; de Carvalho and McCord 2006). Engelbert and Kaempfer were the first to report on the presence of this species from the Arabian-Persian Gulf. They wrote their notes on its presence during travel in the area in the period 1684–1688 (Carrubba and Bowers 1982). It is recorded from the Oman Sea at the Omani coasts (Randall 1995; Froese and Pauly 2008) and from the southern coasts of the Arabian peninsula (Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role It is a marine and demersal species living at depths down to 350 m (Khalaf and Zajonz 2007).

Fig. 4.5 Panther electric ray, *Torpedo panthera* Olfers, 1831. Courtesy of Laith Jawad, New Zealand

Biology Individuals of this species reach up to 110 mm in total length. Males reach maturity at 280 mm in total length (de Carvalho and McCord 2006). Females are ovoviparous (aplacental viviparity) and embryos feed on yolk, then absorb the uterine fluid which is rich in mucus, fat, and protein through a specialised structure (Dulvy and Reynolds 1997). This ray is considered dangerous to humans as they have electric organs and give a nasty electric shock.

Economic Value This species has no economic value.

Conservation Status The leopard torpedo has been rated as Data Deficient in the Red List of the IUCN (de Carvalho and McCord 2006) because of the patchiness distribution of its population, little information about its actual distribution, and parts of the area where it is found are under severe fishing pressure. No conservation plans are in place.

Torpedo sinuspersici (Olfers 1831)
Common name: Variable torpedo ray
Arabic name: لخمة الرعاد المتباينه
Etymology: *Torpedo:* Latin, torpere = be sluggish (Fig. 4.6)

Identification

- Disc quadrate in shape with emarginate anterior edge.
- Eye small.
- Spiracles larger than eyes with nine papillae at their edge.
- Two dorsal fins close to each other with origin of first dorsal at posterior or middle pelvic fins. Caudal fin truncate.
- Dark brown with dark bands and spots on the disc (Randall 1995).

World Distribution It is distributed in the Western Indian Ocean area from the Red Sea eastward to India (Compagno and Smale 1986) and southward to Natal and South Africa (Compagno and Niem et al. 1998).

Distribution in the Study Area This species is presumed to be present in the Arabian-Persian Gulf (de Carvalho and McCord 2006). Similar species found in the area are not confirmed as *Torpedo sinuspersici* (Moore et al. 2011). However, Vossoughi and Vossoughi (1999) reported it to be present in Iranian waters of the Arabian-Persian Gulf. Carpenter and Board (1997) have

Fig. 4.6 Variable torpedo ray, *Torpedo sinuspersici* Olfers, 1831. Courtesy of Dawn Goebbels, volunteer with A Rocha Kenya., Kenya

suggested that this species is present on the western coasts of the Arabian-Persian Gulf, but did not give a reference to its presence in any of the Gulf States. It has been recorded by Bishop from Kuwaiti waters and Tourenq et al. (2004) from the United Arab Emirates. This species is reported from both the Sea of Oman and the south Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecosystem Role This marine species lives in the reef areas at depths down to 200 m (Lieske and Myers 1994).

Biology This ray swims very slowly and is active during the night by moving its tail like a shark and not by moving its pectoral fins as other rays do (RQCSR 2007). It has the ability to open its mouth and jaws wide enough to swallow large-size prey (Compagno and Last 1999). It has a solitary life, but it may form groups during mating time. The females are aplacental viviparous with embryos feeding on yolk sacs first, and then on rich uterine fluid. Females produce 9–22 young during summertime at length of about 100 mm in total (Froese and Pauly 2008). Males and females reach maturity when the disc is 390 mm and 450 mm wide, respectively. The ray uses the broad pectoral fins to cover the prey before shocking it with electricity (Heemstra 2004). This ray is considered dangerous to humans as it has the ability to deliver electric shocks.

Economic Value This ray has a commercial value in some areas along its geographical distribution as it is used as a food.

Conservation Status This ray is rated as Data Deficient in the Red List of the IUCN because of the patchiness in its distribution, probable species complex, lack of biological data, and threat from demersal fisheries operating in the area of its distribution (Smale 2006). No conservation plans are in place.

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Part II

Poisonous and Venomous Fishes

5 Poisonous Fishes

The importance of studying and archiving the poisonous and venomous fish species rises from the imperative relationship between human and fish through the thousands of years of human life. Humans have used fish as a source of food, pleasure, chemical and pharmaceutical agents, and industrial and agricultural conventions. Human health might be affected by the ability of the fish to be a vector to deliver toxins or transmitting traumogenous organisms, such as viruses, bacteria, and fungi. They might be harmful enough to transmit electric discharges of various strengths. They might be harmful enough to transmit electric discharges of various strengths, but they continue to play their important role as source of nutrient to both man and animals.

Poisonous and venomous fishes were considered as a hazard to human health, and researches were put forward in this direction, but the role of this group of fishes in the aquatic environment still needs to be unveiled. This group of fishes was shown to set the distribution and density of the organisms in the aquatic environment. On the other hand, the toxins and venoms that they have exerted in the environment of aquatic creatures will affect the health and existence of those organisms. The secretion of toxic substances in the water by the ichthyocrinotoxic fish species will affect directly the distribution of other fish groups living in the same area (Halstead 1965). In fisheries dynamics too, toxic secretions of several aquatic organisms play an important role in the field of biochemical oceanography science that still need to be fully investigated.

The most comprehensive classification system of toxic fishes is that of Halstead (1965), and it is adopted here in this book. Since it has been written down by Halstead about half a century ago, it proved to be convenient and of constant use.

The classification system of toxic fishes put forward by Halstead (1965) is as follows:

I. Poisonous fishes: This group of fishes causes a biotoxication in humans due to a toxic substance present in the fish body. These fishes are not those that have been contaminated by bacterial food pathogens. These fishes are subdivided into
   1. Ichthyosarcotoxic fishes: These fishes contain a poison in their flesh, such as musculature, viscera, skin, or slime, which, when ingested by humans, will produce a toxic effect. The kinds of toxins contained in these fishes include
      Elasmobranch fish poisoning
      Ciguatoxic fishes
      Clupeotoxic fishes
      Gempylotoxic fishes
      Scombrotoxic fishes
      Hallucinogenic fishes
      Tetrodotoxic fishes
   2. Ichthyootoxic fishes: These fishes contain a poison in their gonads—the musculature and other parts are edible.

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3. Ichthyohemotoxic fishes: These fishes contain a poison in their blood.

II. Ichthyocrinotoxic fishes: These fishes contain a poison by means of glandular structures independent of a true venom apparatus.

III. Venomous or acanthotoxic fishes: These fishes contain a poison in their glands that are equipped with a traumagenic device to spread their venom.

5.1 Ichthyosarcotoxic Fishes

5.1.1 Elasmobranch Fish Poisoning

Background

It has been known since the eighteenth century (De Sauvages 1758, 1770) that eating meat of certain shark species might cause intoxication and to stop such an event, shark meat should be boiled and the water should be changed several times (Fabricius 1780). Works on shark poisoning were first published by Coutand (1879) and included observations on cases where the victim ingested shark's liver In New Caledonia intoxication from eating shark meat was reported for the first time for animals such as dogs (Jensen 1914). The meat of several species of sharks was recognised as poisonous by Macht and Spencer (1941). The clinical characteristics of shark poisoning were summarised by Halstead and Lively (1954) and Bouder et al. (1962).

Causative Agent

The poison present in the flesh of the shark appears to be a kind of liposoluble toxin and is found mainly in the liver and usually named carchatoxin-A and -B (Boisier et al. 1995). The shark's poison is different from that of ciguatera. It does not include the pathognomonic paradoxical sensory disturbance (temperature reversal sensation), the characteristic clinical symptoms of ciguatera. Bouder et al. (1962) suggested that shark poisoning resulted from hypervitaminosis A. The variety and severance of the neurological disturbances occurring in shark poisoning do not support hypervitaminosis A (Halstead 1965).

Symptoms

Shark poisoning is generally mild and the symptoms include gastroenteritis and diarrhoea. Eating shark liver could cause more severe intoxication. The symptoms for such ingestion usually develop within 30 min and include vomiting, diarrhoea, abdominal pain, anorexia, headache, prostration, rapid weak pulse, malaise, insomnia, cold sweats, oral paraesthesias, and burning sensation of the tongue, throat, and oesophagous. Complications of the intoxication might develop with time and neurological and other symptoms become clear causing extreme weakness, trismus, muscular cramps, sensation of heaviness of the limbs, blepharospasm, dilatation of pupils, or spasmodic contractions of upper eyelids. In severe cases of intoxication, complications in the health of the victim might lead to death (Halstead 1965).

Treatment and Prevention

There is no specific treatment procedure to follow in cases of shark poisoning. The first step in preventing such intoxication is to avoid eating shark flesh that originates from large tropical shark species. Another preventive measure is to cut the meat of the shark into thin slices and hang them up to dry in the air. The juice containing the toxin will drain leaving the meat free of poison. Later, the meat slices should be sun dried. Poorly dried meat has been shown to be more poisonous than fresh meat.

5.1.1.1 Poisonous to Eat: Sharks and Rays

Order: Hexanchiformes
Family: Hexanchidae
Heptranchias perlo (Bonnaterre 1788)
Common name: Sharpnose sevengill shark
Arabic name: قرش مرصع
Etymology: *Heptranchias:* Greek, heptra = with seven arms + Greek, agchein = throttle (Figs. 5.1, 5.2, and 5.3)

Identification

- Pointed head with big eyes.
- Seven small gill slits.

Fig. 5.1 Sharpnose sevengill shark, *Heptranchias perlo* (Bonnaterre, 1788). Courtesy of Pedro Niny Duarte, Portugal

Fig. 5.2 Sharpnose sevengill shark, *Heptranchias perlo* (Bonnaterre, 1788), head. Courtesy of Pedro Niny Duarte, Portugal

- Mouth narrow. Lower jaw with five rows of combe-shaped teeth.
- Slender to fusiform body.
- Small dorsal fin originating over inner margins of pelvic fins. Small anal fin.
- Body brownish grey on top and paler ventrally. Indistinct dark spots on body. Juveniles have dark-tipped dorsal and caudal fins (Compagno 1984; Bass et al. 1986; Compagno et al. 1989; Last and Stevens 1994; Ebert et al. 2013).

Fig. 5.3 Sharpnose sevengill shark, *Heptranchias perlo* (Bonnaterre, 1788). Courtesy of Joo Park, Korea

World Distribution This species of shark has a circumglobal type of distribution. It is found in all tropical and temperate seas except the northeast Pacific (Compagno and Niem 1998). It is reported from the western and eastern Atlantic. In the Indian Ocean, it is found in southwestern India and westward to South Africa. It is also recorded from Japan to China, Indonesia, Australia, and New Zealand (Froese and Pauly 2016).

Distribution in the Study Area This species is reported from the Gulf of Aden by Ebert et al. (2013) and it is not found in either the Arabian-Persian Gulf or the Arabian Sea.

Habitat and Ecological Role This marine species inhabits bathydemersal environments at depth range 0–1000 m (Hennemann 2001).

Biology Individuals of this species occasionally aggregate near seamounts. It is an active and voracious predator which feeds on pelagic fishes, squid, and crustaceans. It reaches 1400 mm in total length as a maximum size. Males and females mature at 750–850 mm and 900–1050 mm in total length for males and females, respectively. Females are ovoviviparous with 6–20 in a litter. Young are born 250 mm in total length. Individuals can breed year around. The species is aggressive when captured, and even if not retained is likely to be killed (Paul and Fowler 2003).

Economic Value This species has commercial value as food for humans and as fishmeal. In Japan, they are kept in captivity (Paul and Fowler 2003).

Conservation Status This species has been given a Near Threatened status in IUCN Red List because of its wide range distribution, uncommon in the areas it is found, and its centre of abundance lying in the outer shelf, slope, and oceanic seamounts, which make it vulnerable to fishery activities. Because it lives in deep waters, it is included in deep sea fishery activities, which may cause population declines (Paul and Fowler 2003).

Hexanchus griseus (Bonnaterre 1788)
Common name: Bluntnose sixgill shark
Arabic name القرش الأخطم
Etymology: *Hexanchus:* Greek, exa = six + Gree, agcho, narrow; *griseus:* From the Latin 'griseus' meaning gray (Figs. 5.4 and 5.5).

Identification

- Large fusiform body with broad head and presence of six gill slits.
- Eyes small with dark pupil surrounded by white.
- Mouth ventral in position with bladelike, comb-shaped teeth on lower jaw.
- Snout rounded.
- Dorsal fin larger than anal fin.
- Body grey above and white below. Light line along sides. White edge on fins (Compagno 1984; Bass et al. 1986; Cox and Francis 1997; Last and Stevens 1994; Muus and Nielsen 1999; Ebert et al. 2013).

World Distribution This shark has circumglobal distribution in tropical and temperate waters. It is found in both the western and eastern Atlantic and it is also reported from the Mediterranean Sea. In the Indian Sea, it is recorded from South Africa to the northwestern Arabian Sea. The distribution of this species extends eastward to reach Japan, New Zealand, and Hawaii (Compagno and Niem 1998).

Fig. 5.4 Bluntnose sixgill shark, *Hexanchus griseus* (Bonnaterre, 1788). Courtesy of De Sanctis Achille, Italy

Fig. 5.5 Bluntnose sixgill shark, *Hexanchus griseus* (Bonnaterre, 1788), head. Courtesy of De Sanctis Achille, Italy

Distribution in the Study Area It has not been recorded from the Arabian-Persian Gulf or the south coasts of Oman. It is only found in the south of the Gulf of Aden (Ebert et al. 2013).

Habitat and Ecological Role This shark is a marine species living in a bath demersal environment at depth 1–2500 m (Reide 2004; Mundy 2005).

Biology The bluntnose is a recognised predator with a wide spectrum of food items including sharks, rays, skates, and small and large fish species. They appear very sensitive to light, but this information needs to be investigated further as some individuals were photographed underwater using floodlights and no avoidance of lighted areas was noticed (Cook and Compagno 2005). It is ovoviviparous and females bear a large number of litters from 22 to 108 with size at birth ranging 650–740 mm. Males and females mature at 3150 and 4200 mm in total length, respectively. The young prefer shallow water areas and when grown move to deeper waters. Adults show a vertical movement when they rise to the surface at night for feeding (Cook and Compagno 2005).

Economic Value This species has a limited economic value as a food source.

Conservation Status This shark has been granted Near Threatened rank in the IUCN Red List because of its wide range of distribution and incidental catch by deepwater fishery activity (Cook and Compagno 2005).

5.1.2 Ciguatoxic Fishes

Ciguatera is a common ichthyosarcotoxaemia with remarkable clinically important neurological aspects. It presents an acute or chronic intoxication syndrome and constitutes a global health problem. Ciguatera poisoning is little known, but not absent, in temperate countries and is associated with the habit of human ingestion of fish that harbour the bioaccumulated ciguatoxins of the photosynthetic dinoflagellate *Gambierdiscus toxicus*. The large-sized fishes have eaten dinoflagellates and usually harbour the neurotoxin in their viscera. Liver and viscera are the main tissues of the fish body where ciguatoxin is accumulated. The early identification of the neurological features in sentinel patients has the potential to reduce the number of secondary cases in cluster outbreaks (Pearn 2001).

Background

The poisonous characteristics of certain fish species including ciguatera has been known since the time of the ancient Greeks in 800 BC (cited in Savtschenko 1886) and ancient Chinese fishermen have struggled with this type of intoxication since the time of the T'ang Dynasty (AD 618–907) mainly by eating the yellowtail amberjack (quoted by Read 1939). Although ciguatera had such a long history, the first generally accepted reference specifically referring to this fish poisoning was published by Peter Martyr Anghera only in 1457–1526, where the first accounts of fish poisoning in the West Indies were noted.

The Portuguese biologist Don Antonio Parra was the first to use the term ciguatera. It was originally spelled 'Siguatera' because Cuban writers of this period substituted 'S' for the usual 'C' spelling in Spanish words. The name refers to cigua = a person ill with ciguatera, perhaps from the cigua sea snail.

The outbreaks of ciguatera around the world were many, but the best known of these took place on His Majesty's ship Resolution in the eighteenth century during the famous world voyage of Captain James Cook at Port Sandwich, Malekua, New Hebrides, on 23 July, 1774 (Halstead 1965). The fish was *Lutjanis bohar* and the outbreak was cited in Anderson (1776), Forster (1777), Cook (1777), and Sparrman (1944).

The start of the nineteenth century showed an increase in scientific publications about ciguatera poisoning and ciguatoxic fishes (Meyer 1805; Chisholm 1808; Orfila 1817). This period of time saw the publication by Charles Grant in 1801 on the largest ciguatera outbreak in history which took place at Rodrigues Island, east of Mauritius, Indian Ocean, in 1748 (cited by Wheeler 1953). The responsible fish that caused this outbreak of ciguatera was *Serranus lutra* = *Epinephelus fuscoguttatus*. Due to the increased frequency of intoxication resulting from the ingestion of fishes causing ciguatera, this fish intoxication was further studied and reviewed during the second half of the nineteenth century (Meyer-Ahrens 1855; Vinson 1858; De Rochas 1860; D'Arras 1877; Vincent 1883).

With the commencing of the twentieth century, Becke (1901) recognised 30–50% of the fishes in the Ralik Lagoon, Marshland Islands, were poisonous to eat. The studies continue to be done on the poisonous fishes that cause ciguatera and a classification system for fish poisoning was put forward by Engelsen (1922). The poisonous fishes were divided into groups:

1. Ichthyismus choleriformis: A group of toxins distinguished by causing violent gastroenteritis.
2. Ichthyismus exanthematicus: Those types of poisons characterised by a cutaneous eruption with fever and indisposition, but not very dangerous.
3. Ichthyismus neuroticus: Toxins which occur within a few hours after eating the fish, causing burning and dryness in the throat, violent abdominal pain, dizziness and visual disturbances, and death resulting from respiratory paralysis (Halstead 1965).

The toxicological studies were very few during the first half of the twentieth century. Fitch (1952) performed toxicological tests on the musculature and liver of *Tetragomus cuveiri* from Point Conception, California. Later, Halstead and his associates performed extensive studies on the poisonous fishes of the tropical Pacific and Red Sea areas (Halstead and Lively 1954; Halstead and Bunker 1954; Halstead and Schall 1955; Halstead and Schall 1956; Halstead 1958; Halstead and Carscallen 1964). Albert Banner, Philip Helfrich, and their associates conducted thorough investigations on ciguatera in the tropical Pacific towards epidemiology, development of a critical bioassay, and isolation of ciguatoxin (Banner and Boroughs 1958; Martin and Banner 1958; Banner et al. 1960; Helfrich and Banner 1963).

With the advancement of science and technology during the twentieth century and the present time, a large number of scientific publications appeared about ciguatera that the present book cannot accommodate in detail (Calvert et al. 1987; Kodama et al. 1989; Cameron et al. 1991; Benoit et al. 2000; Hamilton et al. 2002a, b; Boydron-Le Garrec et al. 2005; Laurent et al. 2008; Caillaud et al. 2010; Munir et al. 2011; Pearn 2001).

Causative Agent

Ciguatoxin is a product manufactured through the metabolic activities of members of the marine benthic dinoflagellate genus *Gambierdiscus*. Several similar compounds were discovered which are different in their molecular structure (Caillaud et al. 2010). Different forms of this toxin were identified from different geographical locations (e.g., Pacific, Caribbean, and Indian). Several methods were put forward to detect and quantify the ciguatoxins in the fish's tissues as the concentrations of these toxins are very low.

It is known that the toxin reaches higher concentrations through the food chain, a hypothesis which suggests that the transport of toxins along the food web is an elucidation for the movement of ciguatoxic fish species. This hypothesis was first proposed by Mills (1956) and was confirmed when isolation of a toxic marine benthic dinoflagellate, described as *Gambierdiscus toxicus*, was made which indicated the source of ciguatoxin (Yasumoto et al. 1977).

The journey of the ciguatoxin starts with the dinoflagellates then to the herbivorous grazing fish, and then to the carnivorous fish that feed upon grazers (Yasumoto et al. 1979). In the tissue of the fish, this toxin is transformed through the metabolic activities of the fish into different forms of toxins (e.g., Cigutoxin-1B and 51-hydroxy Cigutoxin-3C) from original cigutoxin structures (e.g., Cigutoxin-3C and Cigutoxin-4B) that are ultimately responsible for human intoxication (Caillaud et al. 2010). In such situations, both herbivorous and carnivorous fish from tropical areas can be toxic. More than 400 fish species have been reported to be potentially ciguateric (Halstead 1978). The concentration of the toxin is less in young individuals as they are exposed to the causative dinoflagellates for a shorter period than the adult individuals. Also, those species sitting at a higher level of the food web are riskier than those situated at the lower levels (Oshiro et al. 2009). The ciguatera toxin is found to be concentrated in the liver and viscera of the fish, but is also found in their muscles (Vernoux et al. 1985).

It is important at this stage to give an idea about the biology of the organism that produces ciguatoxin. *Gambierdiscus toxicus* has been considered the main source responsible for the production of cigutoxin. It is a marine dinoflagellate found usually in tropical and subtropical waters as an epiphyte on macroalgae in coral reefs, mangrove systems, and on artificial surfaces or sand (Faust 1995; Villareal et al. 2007). In addition to this species, five more species were described: *G. belizeanus* (Faust 1995), *G. yasumotoi* (Holmes 1998), *G. polynesiensis*, *G. pacificus*, and *G. australis* (Chinain 1999a, b). The factors influencing the occurrence of toxic *Gambierdiscus* blooms remain the aim of researchers in this field (Chinain 1999a, b). Although the exact nature of factors influencing the toxicity and abundance of *Gambierdiscus* spp. remains unclear, light intensity, salinity, water temperature, nutrients, growth stage, and the presence of bacteria have been shown to influence the growth and toxicity of this algal species (Sakami et al. 1999; Lartigue et al. 2009; Llewellyn 2009; Doucette et al. 1998).

The chemical picture of ciguatoxin studied by Caillaud et al. (2010) has shown that it is a lipophilic polyether isolated from fish and *Gambierdiscus* spp. cell extracts (wild samples and cultures). It is also odourless, colourless, devoid of heteroatoms other than oxygen, and bears few conjugated bonds. The different strains of ciguatoxins have different distinct structures (e.g., Pacific, P-CTX, Caribbean, C-CTX, Indian Ocean, I-CTX; Legrand et al. 1992; Murata et al. 1993; Vernoux and Lewis 1997; Hamilton et al. 2002a, b; Pottier et al. 2002a, b; Satake et al. 1993; Murata et al. 1990).

Inside human cells, ciguatoxin targets the membrane excitability resulting in the release of neurotransmitters (Molgó et al. 1990), axonal and Schwann oedema (Benoit et al. 1996; Mattei et al. 1999), increase of intracellular calcium (Molgó et al. 1993), and blockage of voltage potassium channels (Hidalgo et al. 2002). The neurological symptoms the victim usually has are related to the changes in the sodium ion contraction in the cell, and the chronic fatigue syndrome that may last for weeks or months (Racciatti et al. 2001) is related to high nitric oxide (NO) production (Pall 2001).

The records of *Gambierdiscus* in the Indian Ocean are scarce and restricted to the western tropical area, where this genus has been detected in reef lagoons of the Mayotte, Mauritius, and Réunion Islands (Grzebyk et al. 1994; Turquet et al. 2001; Hurbungs et al. 2002; Litaker et al. 2009; Parsons et al. 2012). *Gambierdiscus toxicus* Adachi and Fukuyo was the only species recorded from the Indian Ocean (Litaker et al. 2009). Thus far, five species of *Gambierdiscus* were reported from Pakistani waters, which is close to the east and southern Arabian peninsula (Munir et al. 2011). Recently, species of the genus *Gambierdiscus* were recorded from the Arabian-Persian Gulf in Kuwaiti waters (Saburova et al. 2013).

Symptoms

The main symptoms of ciguatoxin poisoning are gastrointestinal, cardiovascular, neurological, and neuropsychiatric (Friedman et al. 2008). The gastrointestinal symptoms such as vomiting, diarrhoea, abdominal pain, and nausea develop within 6–24 h of eating the flesh of reef fish, and usually resolve spontaneously within 1–4 days. In the early stages, cardiac symptoms may occur;

these include hypotension and bradycardia (Friedman et al. 2008). The neurological symptoms are generally manifested after the gastrointestinal symptoms. Variation in the intensity of the neurological symptoms was shown to present between patients. Victims of this intoxication can show paraesthesias (numbness and tingling) in the extremities (feet and hands) and oral region, generalised pruritus (itching), myalgia (muscle pain), arthralgia (joint pain), and fatigue. However, a unique symptom revealed by many patients is an alteration or ‘reversal’ of hot/cold temperature perception, in which cold surfaces are perceived as hot to the patient, or produce dysaesthesia (unpleasant, abnormal sensation). Such temperature-related dysaesthesia is one of the characteristics of the ciguatoxin. Anxiety (Arena et al. 2004), depression, and subjectively reported memory loss (Quod and Turquet 1996) are among the neuropsychiatric symptoms caused by ciguatoxin. Each strain of ciguatoxin may have different neurological symptoms. For example, hallucinations, giddiness (Bagnis and Legrand 1987), incoordination or ataxia (Quod and Turquet 1996; Bagnis and Legrand 1987), and coma (Bagnis et al. 1979) are specific for ciguatoxin patients in Indian and Pacific Ocean regions. Similarly, the gastrointestinal symptoms have been shown to vary geographically (Lewis 2000). Patients from the Caribbean showed gastrointestinal symptoms and signs predominate in the acute phase (i.e., first 12 h) (Lawrence et al. 1980). For those in the Pacific area, the neurological symptoms and signs predominate (Nicholson and Lewis 2006). In the patients from the Indian Ocean, the symptoms have been associated with neurological and mental status alterations, with reports of hallucinations, giddiness, incoordination, loss of equilibrium, and depression (Quod and Turquet 1996).

Death caused by ciguatoxin poisoning is rare. However, death may occur in severe cases due to severe dehydration, cardiovascular shock during the initial illness period, or respiratory failure resulting from paralysis of the respiratory musculature (Bagnis 1993; Withers 1982), especially in areas where emergency and medical care are unavailable. Eating fish organs or viscera (such as the head, liver, or gonads) is associated with greater symptom severity than eating only the fillet, as ciguatoxin is present in greater concentrations in such organs (Chateau-Degat et al. 2007; Arena et al. 2004).

The chronicity in the symptoms of ciguatoxin poisoning showed some variation. Patients might feel a general weakness lasting a few days to several weeks after the initial illness. Others reveal chronic symptoms lasting weeks to months especially peripheral neurological symptoms such as paraesthesias in the extremities, pruritus, and neuropsychiatric symptoms such as malaise, depression, generalised fatigue, and headaches (Kodama and Hokama 1989; Chan and Kwok 2001; Blythe et al. 1992; Benoit et al. 2000; Chan and Wang 1993).

Patients of ciguatoxin poisoning were reported to have sensitisation to ciguatoxins, that is, individuals who previously suffered from this poisoning have shown a recurrence of ciguatoxication symptoms after eating a potentially ciguateric fish that did not produce symptoms in other individuals (Ruff and Lewis 1994). Still some other patients reported having a recurrence of neurologic ciguatoxication symptoms upon consuming alcohol, any type of fish, and certain other foods, even years after the initial exposure (Glaziou and Martin 1992). Such recurrence does not apply to cardiac or gastrointestinal symptoms. The theory behind the recurrence of neurological symptoms is that in-taken ciguatoxin may be stored in a person’s adipose tissue, and that any activity involving increased lipid metabolism may result in ciguatoxins re-entering the bloodstream, with subsequent re-emergence of ciguatoxin symptoms (Nicholson and Lewis 2006). Other theories refer to the immunologically mediated sensitisation to ciguatoxin after initial exposure (Ting and Brown 2001; Bagnis et al. 1977).

The symptoms of ciguatoxin poisoning share some characteristics with those of the paralytic and neurotoxic shellfish poisonings, scombroid and pufferfish toxicity, botulism, enterovirus 71, and bacteraemia, as well as organophosphate pesticide poisoning, eosinophilic meningitis, multiple sclerosis, and other neurological conditions (Ting and Brown 2001; Baden et al. 1995).

Treatment

Among the methods of treatments is intravenous mannitol infusion, which is the most studied therapy for ciguatoxin poisoning (Schnorf et al. 2002; Bagnis et al. 1992). This injection is administered at 0.5–1.0 g/kg body weight over a 30–45 min period and recommended to be given within 48–72 h of ingestion of toxic fish (Blythe et al. 2001; Palafox et al. 1988), although the effect has been observed even up to several weeks after intoxication (Blythe et al. 2001).

Mannitol infusion can mediated by the osmotic reduction of neural oedema (Pearn 2001) and can get rid of the free radicals that might be generated by ciguatoxin molecules and reduce the action of ciguatoxin on sodium/potassium channels in the cells (Birinyi-Strachan et al. 2005). Support of any depressed vital functions is the other option for treatment. This type of treatment is used with acute cases of ciguatoxin poisoning (Lewis and King 1996), where supportive therapies may be necessary for controlling fluid and electrolyte balance (Lewis 2000) and are necessary for patients in shock.

As to traditional medicine, there are over 60 herbs that were reported as remedies in ciguatoxin poisoning in the Western Pacific (Bourdy et al. 1992) and in New Caledonia, the extract of the leaves of *Argusia argentea* have been reported as medicine to cure ciguatoxin (Benoit et al. 2000).

Patients of ciguatoxin poisoning showed relapse of symptoms with ingestion of alcohol (Lange et al. 1992) or any kind of fish (Ruff and lewis 1994). Drinking coffee (Fleming et al. 1997) and eating nuts (Lewis 2001) and chicken (Gillespie et al. 1986) were also associated with symptom recurrence or augmentation. Such food and drinks need to be avoided for a period of 3–6 months after intoxication.

Prevention

Among the difficulties of preventing ciguatoxication is the flesh of the ciguatoxic fishes is odourless and tasteless, and toxic fish cannot be identified by appearance or behaviour. The ciguatoxication incidences are not attributable to inadequate food handling, storage, preparation, or procurement methods for the contaminated fish. The toxin is heat-stable, and therefore, cooking, boiling, freezing, baking, or frying does not eliminate or destroy the toxin from the fish tissue (Bagnis 1993). It is very rare to have gastrointestinal symptoms transmitted person-to-person, but there are reports of transmission of GI symptoms from an acutely ill mother across the placenta to the fetus/newborn (Fleming et al. 1997) and to a nursing infant (Blythe and de Sylva 1990), and of transient genital paraesthesias in sexual partners of those with acute CFP (Lange et al. 1989).

The first and important step to prevent ciguatoxication is by the individual's avoidance of fish that have a greater likelihood of ciguatoxicity. Local people are aware of certain fish species to be ciguatoxic and therefore they avoid eating them. In addition, they have simple home tests to detect toxic fishes. As the greater illness severity is associated with eating the fish viscera and larger portions (Lewis and King 1996), people are therefore advised to avoid eating the viscera of reef fish. It is also recommended to avoid eating fish in excess of 3 kg (Ting and Brown 2001). To be on the safe side eating small portions (i.e., <50 g) of different fish is better than eating larger portions of any individual fish that might be associated with ciguatoxin (Lewis 2000). In the field, there is no reliable method of detecting ciguatoxicity in fish based on their appearance or behaviour.

5.1.2.1 Possible Ciguatoxic Fish Species

There are about 400 fish species that belong to a large number of families in a wide phylogenetic spectrum. In the east and southern Arabian peninsula, many of these species are present. It is beyond the limit of this book to give details of all these species, but the details of some of the common species are given in different chapters of this book.

Albulidae
Chanidae
Clupeidae
Engraulidae
Aynodontidae
Congridae
Muraenidae
Ophichthidae
Belonidae
Hemiramphidae
Syngnathidae

Holocentridae
Acanthuridae
Apogonidae
Blenniidae
Carangidae
Cirrhitidae
Coryphaenidae
Gempylidae
Istiophoridae
Labridae
Lutjanidae
Mugilidae
Mullidae
Pempheridae
Pomadasyidae
Priacanthidae
Scolophagidae
Scomberidae
Serranidae
Siganidae
Sparidae
Sphyraenidae
Bothidae
Aluteridae
Balistidae
Monocanthidae
Antennaridae
Lophiidae

5.1.3 Clupeotoxic Fishes

Among the types of ichthyosarcotoxism is the clupeotoxin. This kind of toxication is caused by clupeoid fishes such as sardines and herrings (Clupeidae) or anchovies (Engaulidae), Elopidae, the tarpons, and Albulidae, the bonefishes. It is widespread in tropical and subtropical areas of the world but rare. Some fatal cases were reported from different parts of the world because of consuming sardines (Randall 2005). Clupeotoxin is a sporadic and unpredictable public health problem in the tropical Atlantic Ocean, Caribbean Sea, and the tropical Pacific Ocean (Halstead 1967).

Background

The history of clupeotoxication may go back to the second half of the eighteenth century when Desportes (1770) reported on the poisoning caused by eating small sardine species in the Dominican Republic. On the other hand, Oldendorp (1777) suggested that the sprat was the most poisonous fish in the Virgin Islands. Death from eating this type of fish happened within 1 h of consuming the meat. Mariner (1820) reported for the first time on cases of clupeotoxism in the tropical Pacific. He wrote about a fish locally known as 'ooloo caoo' which is similar to sprat and caused intoxication during the month of July. Severe cases of intoxication from eating this fish and several fatalities were reported, but the history of the other aspects of type of intoxication such as toxicology, pharmacology, and chemistry are lacking information.

Causing Agent

The food web of the fish seems to be the origin of clupeotoxin. Melton et al. (1984) suggested that sardines, herrings, and anchovies feed on planktonic organisms, thus the clupeotoxin they produce cannot be of benthic origin. Halstead (1967) reported that D'Arras (1877) was the first to report that sardines become poisonous because they feed on a 'green monad.' These monads cause conjunctivitis, coryza, and erythema in persons coming in contact with them.

Clepeotoxin differs from ciguatoxin in having a nonbenthic origin and occurs during the warm months of the year in contrast to ciguatoxin, which may occur at any season (Randall 2005).

Symptoms

Halstead (1967) gave the following symptoms of clupeotoxism: the first symptoms that the patient feels is the metallic taste that occurs upon ingestion of the fish. Nausea, dryness of the mouth, vomiting, malaise, abdominal pain, and diarrhoea will follow. The further step in symptoms will be gastrointestinal upset accompanied with feeble pulse, tachycardia, chills, cold skin, and a drop in blood pressure, and a variety of neurological disturbances such as dilated pupils, violent headaches, numbness, tingling, hypersalivation, muscular cramps, respiratory distress, progressive muscular paralysis, convulsions, coma, and death. Within 15 min of ingestion of the fish, death could occur. Those victims who survived have shown pruritus and various types of skin eruptions including squamation and ulceration.

Treatment
The treatment is symptomatic and should follow the same regimens as those of ciguatoxin.

Prevention
The main thing to remember is to avoid eating clupeiform fishes during the warm season because the poison of these fishes cannot be detected by their appearance. Clupeotoxin cannot be deactivated by heat, thus cooking procedures, salting, and drying will not prevent intoxication.

5.1.3.1 Clupeotoxic Fish Species

Order: Clupeiformes
Family: Clupeidae
Anodontostoma chacunda (Hamilton 1822)
Common name: Chacunda gizzard shad
Arabic name: صبوره صغيره
Etymology: *Anodontostoma:* Greek, ana = up + Greek, odous = teeth + Greek, stoma = mouth (Fig. 5.6)

Identification
- Body deep and compressed.
- Rounded snout.
- Mouth inferior.
- Posterior edge of scales toothed.
- Body silvery with large black spot behind gill opening. Dorsal side of head golden. Caudal fin yellowish (Randall 1995; Froese and Pauly 2016).

World Distribution The distribution of this species is confined to the Indo-West Pacific region from the Arabian-Persian Gulf to the coasts of India and the Andaman Sea and further eastward to the Gulf of Thailand, Indonesia, and the coasts of south and north Australia and New Caledonia (Froese and Pauly 2016).

Distribution in the Study Area This species is reported from the Arabian-Persian Gulf, Sea of Oman, and the southern coasts of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecological Role This marine species enters fresh and brackish waters and inhabits a pelagic-neritic environment (Reide 2004) at a

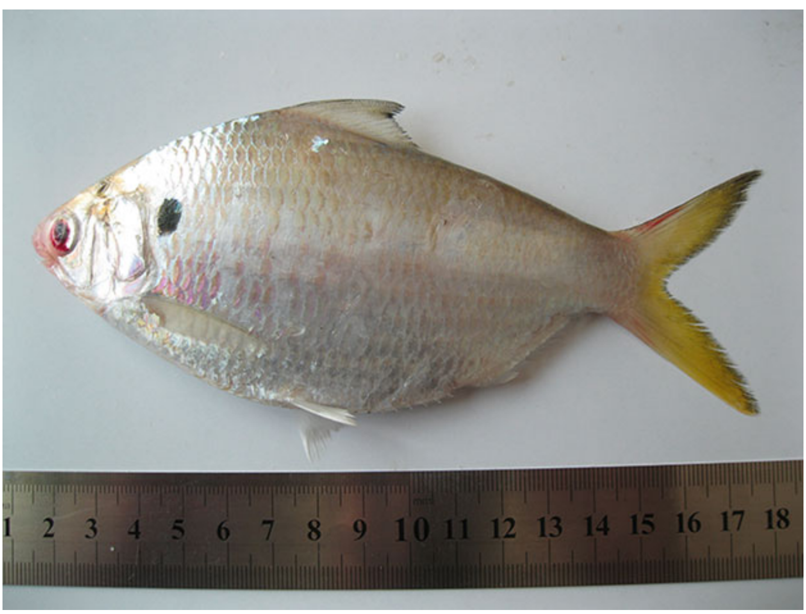

Fig. 5.6 Chacunda gizzard shad, *Anodontostoma chacunda* (Hamilton, 1822). Courtesy of Zahra Sadighzadeh, Iran

depth range from the surface down to 50 m (Whitehead 1985).

Biology This species has a habit of ascending rivers (Rainboth 1996). It feeds on diatoms, mollusks, and crustaceans. November to February is the period for its breeding in Indian waters (Froese and Pauly 2016).

Economic Value It has good market value, and is usually eaten as fresh, frozen, and dried.

Conservation Status Not evaluated.

Nematalosa nasus (Bloch 1795)
Common name: Bloch's gizzard shad
Arabic name: جفوته
Etymology: *Nematalosa*: Greek, nema, -atos = filament + Latin, alausa = a fish cited by Ausonius and Latin, halec = pickle, dealing with the Greek word hals = salt; it is also the old Saxon name for shad = 'alli' (Fig. 5.7)

Identification

- Head slightly pointed.
- Rounded snout.
- Inferior mouth. Lower jaw directed outward.
- Abdomen with 28–32 abdominal scutes.
- Last ray of dorsal fin greatly elongated.
- Scales in the axillary area. Posterior edge of scales toothed.
- Body silvery below and bluish dorsally with dark spot behind gill opening (Whitehead and Wongratana 1986; Randall 1995; Froese and Pauly 2016).

World Distribution It is found in the Indo-West Pacific region from the Gulf of Aden and eastward to the Andaman Sea, South China Sea, and southern tip of Korea.

Distribution in the Study Area It has been reported from the Arabian-Persian Gulf, Sea of Oman, and the southern coasts of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecological Role This marine species has a habit of entering fresh and brackish waters, lives in a pelagic-neritic environment with anadromous migration (Reide 2004). It is found at depth range from the surface down to 30 m (Shao and Lim 1991).

Biology This species is a filter feeder and not much is known about its biology except it ascends rivers and brackish waters.

Economic Value It has good market value as this species is used as food in the areas along its geographical distribution area.

Fig. 5.7 Bloch's gizzard shad, *Nematalosa nasus* (Bloch, 1795). Courtesy of Moazam Khan, Pakistan

Conservation Status This species is granted Least Concern status in the Red List of IUCN (Munroe and Priede 2010).

Family: Dussumieriidae
Dussumieria acuta (Valenciennes 1847)
Common name: Rainbow sardine
Arabic name: سردين قوس قزح
Etymology: *Dussumieria:* In honor of Dussumier, a collaborator of Cuvier, who sent him collections of fishes from the Indian Ocean (Figs. 5.8 and 5.9)

Identification

- Body compressed.
- Line passing through mouth also passes through middle of eye.
- Horizontal striae to posterior end of scales.
- No ventral scutes. Base of pelvic fin surrounded by W-shaped scute.
- Body with iridescent blue at the back and with shiny gold line below. Posterior tip of caudal fin dark.

World Distribution This species of sardine is distributed in the Indo-West Pacific region from the northwest of the Indian Ocean to Pakistan, India, and Malaysia and farther to the east to the Philippines (Froese and Pauly 2016).

Distribution in the Study Area This species is reported from all localities at the Arabian-Persian Gulf, Sea of Oman, and the southern coasts of the Arabian peninsula (Whitehead 1985; Randall 1995; Froese and Pauly 2016).

Habitat and Ecological Role This is a marine species with the habit of entering fresh and brackish waters and preferring to live in pelagic-neritic environments at depth range 10–20 m (Pauly et al. 1996).

Biology Not much information is available on the biology of this species.

Economic Value This species has good market value as it is used a source of food and for oil industries.

Conservation Status Not evaluated.

Family: Engraulidae
Thryssa hamiltonii (Gray 1835)
Common name: Hamilton's thryssa
Arabic name: شيغة هاملتون
Etymology: *Thryssa:* Greek, thrissa, -es = shad (Fig. 5.10)

Identification

- Body slightly deep.
- Tip of snout above dorsal edge of eye.
- Short maxilla.
- Body with shading of grey dorsally and silvery on sides and abdomen. Dark spot behind upper corner of gill opening.

Fig. 5.8 Rainbow sardine, *Dussumieria acuta* Valenciennes, 1847. Courtesy of Milad Khosravi, Iran

Fig. 5.9 Rainbow sardine, *Dussumieria acuta* Valenciennes, 1847. Courtesy of Fereidoon Owfi, Iran

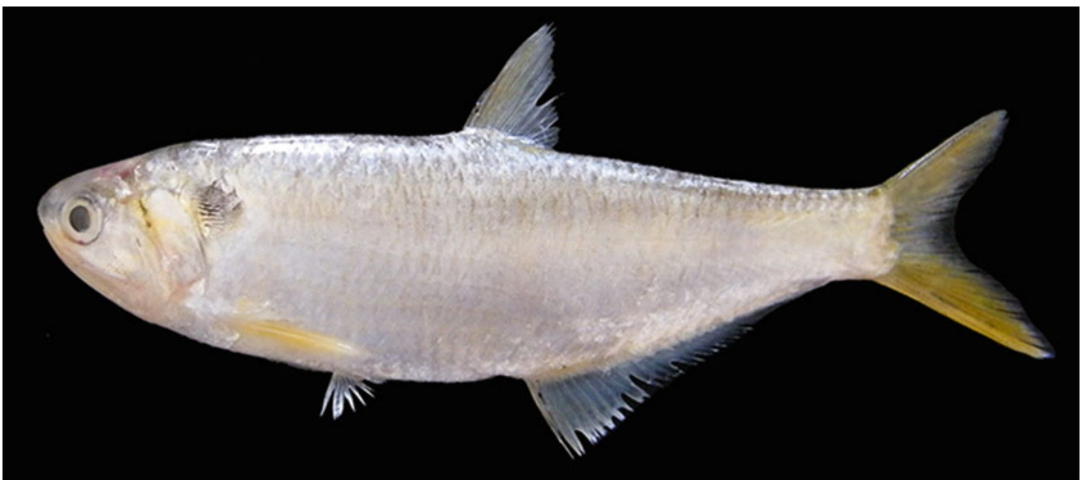

Fig. 5.10 Hamilton's thryssa, *Thryssa hamiltonii* Gray, 1835. Courtesy of Sahat Ratmuangkhwang, Thailand

World Distribution It is distributed in the Indo-West Pacific region from the Arabian-Persian Gulf and eastward to Myanmar, Andaman Sea, and Taiwan, and farther east to the south and north coasts of Australia (Russell and Houston 1989).

Distribution in the Study Area This engraulid species is reported from the whole Arabian-Persian Gulf area, the Sea of Oman, and the southern Arabian peninsula (Hussain et al. 1988; Randall 1995).

Habitat and Ecological Role This marine species has a habit of entering brackish waters, and living in a pelagic-neritic environment (Reide 2004) at depth range 10–13 m (Froese and Pauly 2016).

Biology It prefers to form schools and inhabits inshore areas. Its main food is prawn and copepods. Not much biological data are available.

Economic Value It has good economic value as a source of food and oil.

Conservation Status Not evaluated.

5.1.4 Gempylotoxic Fishes

Gempylotoxication is a case of intoxication occurring when fish species of the family Gempylidae are injected. The case is also known as Keriorrhoea (in Greek: 'flow of wax'), which is a gastrointestinal condition described as an oily orange rectal discharge that occurs after consumption of fish with high content of nonsaponifiable lipids (wax esters), which are nondigestible by humans (Caro et al. 2011; Givney 2002; Ling et al. 2009; Nichols et al. 2001; Yohannes et al. 2002). The condition has been classically associated with the consumption of escolar (*Lepidocybium flavobrunneum*), rudderfish (*Centrolophus niger*), or oil fish (*Ruvettus pretiosus*; Givney 2002; Ling et al. 2009; Yohannes et al. 2002; Shadbolt et al. 2002).

Background

The work of Lowe (1841) is considered the earliest published reference about the purgative effects of castor-oil fish. He wrote, 'The flesh of this very singular species is said to be extremely rich, and the bones, it is affirmed, abound in an oil or marrow, which, when they are sucked incautiously, produces speedy diarrhea.' Poey (1966) also wrote about this fish and mentioned that the bones of the head are soft and spongy filled with oil. An informative review on the history of oilfish was written by Gudger (1925). The review contains information about the medical properties of the oil and the biology of the fish producing this oil. The pharmacology of the oil of the castor-oil fish is discussed by Macht and Barba-Gose (1931a, b). In spite of the purgative effect of the oil of the castor-oil fish, this species is reported to be a favourite food in the Gilbert Islands (Cooper 1964).

Causative Agent

The purgative effect obtained from eating castor-oil fish is due to the presence of wax esters in large concentrations in the body of this fish. Wax esters are esters of long-chain fatty acids with long-chain fatty alcohols. Liquid wax esters are made up of fatty acids and fatty alcohols of between 10 and 30 carbon atoms (Anderson 2010). These esters are present in the skin and muscles of certain deep-sea fish species to help in buoyancy control and to provide a source of stored energy (Ling et al. 2008). Castor-oil fish, *Ruvettus pretiosus*, is a member of the Gempylidae family of fishes. It is commonly found in deep waters of tropical and subtropical seas. It possesses a high level of body lipids, which comprise approximately 20% of their wet weight (Barling and Foong 2015). The known name given to the liquid wax esters in this fish is 'gempylotoxin' because of their laxative and purgative effects (Lum 2012; Maralit et al. 2013). In restaurants and fish markets, different names are given for castor-oil fish such as butterfish, codfish, and even white tuna (BBB 2013; Hwang et al. 2012). The origin of this wax is a deep-living zooplankton (Lee et al. 2006) and the bacteria *Acinetobacter* spp. (Rontani 2010).

The ingested liquid ester wax found in the flesh of the castor-oil fish will cause keriorrhoea within 1–36 h accompanied with a frequent 'call to stool' due to the lubricant effect of the indigestible wax esters and other associated lipids such as potentially undigested triacylglycerols that have accumulated in the rectum. The action of the pancreatic lipases will be very slow leading to passing the liquid ester unmodified into the large intestine, which in turn will lead to keriorrhoea and other gastrointestinal (GI) symptoms (Ling et al. 2009).

The mechanism of the digestion of triacylglycerols in the human body starts in the oral cavity, where the lingual lipase starts its effect, in the stomach, the gastric lipase, and is completed by pancreatic lipase in the jejunum. Pancreatic colipase and bile salts are needed to activate the pancreatic lipase. The resulting compounds are partial hydrolysis of triacylglycerols, free fatty acids, and glycerol (Barling and Foong 2015).

Symptoms

The symptoms of intoxication by gempylotoxin are an involuntary anal discharge of orange or brownish green liquid associated with gastrointestinal symptoms including nausea, vomiting, and stomach cramps.

Treatment and Prevention
No treatment is required and gempylotoxism is not a serious matter; people should be aware of the laxative effect of the castor-oil fish.

5.1.4.1 Fishes of Gempylotoxic

Order: Perciformes
Family: Gempylidae
Ruvettus pretiosus (Cocco 1833)
Common name: Castor-oil fish
Arabic name: سمك الدهن (Figs. 5.11 and 5.12)

Identification
- Spinous bony tubercles are found between scales.
- Skin very hard and rough.
- Mid-ventral keel on ventral side of body.
- Body brown with black tips of pectoral and pelvic fins. Second dorsal and anal fins with white margins in young.

World Distribution This species has a circumtropical distribution in the temperate seas.

Distribution in the Study Area There are no records of this species from the Arabian-Persian Gulf and from the Sea of Oman. It is reported from the southern coasts of the Arabian peninsula (Manilo and Bogorodsky 2003).

Habitat and Ecological Role This marine species inhabits a benthopelagic environment, living at depth range 100–800 m (Nakamura 1995).

Biology Members of this species are usually solitary or in pairs. They feed on crustaceans and squid (Nakamura and Parin 1993). Not much is available on the biology and behaviour of this species.

Economic Value It used as a food source and marketed fresh and as fish cakes in Japan (Nakamura 1995), and also processed into fishmeal (Cervigón et al. 1992).

Conservation Status Not evaluated.

5.1.5 Scomberotoxic Fishes

The fish species of the family Scomberidae can bear a toxin known as scomerotoxine. This substance can cause a case of poisoning called

Fig. 5.11 Castor-oil fish, *Ruvettus pretiosus Cocco, 1833, adult. Courtesy of* Bañón Díaz, Rafael, Spain

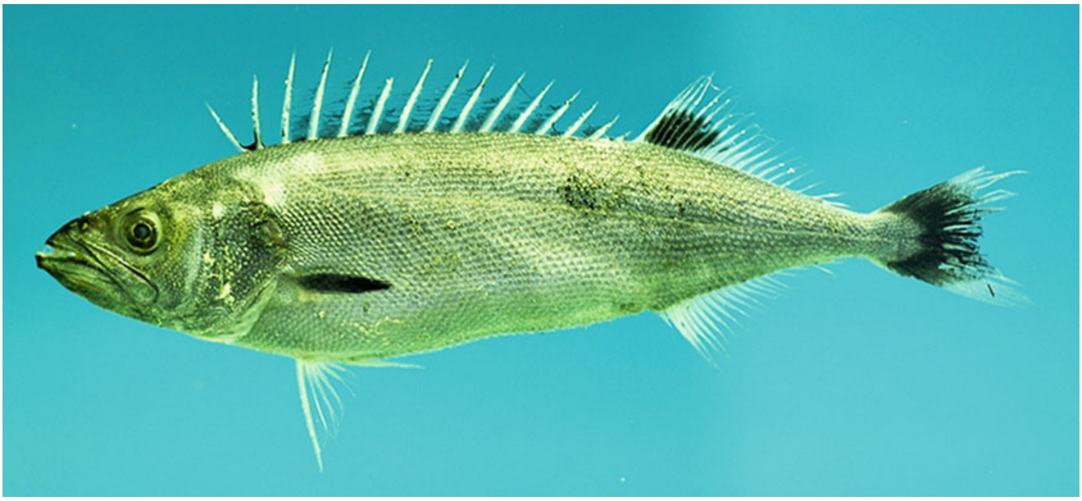

Fig. 5.12 Castor-oil fish, *Ruvettus pretiosus Cocco, 1833, juvenile. Courtesy of* Noble, Brandi, USA

'scombroid poisoning.' It is also known as histamine fish poisoning. It is a type of food poisoning with symptoms and treatment similar to those associated with seafood allergies (Hungerford 2010). Mishandled fish samples will cause scombroid poisoning as a result of their consumption. Histamine [2-(1H-imidazol-4-yl) ethanamine] and other decomposition products are generated in time-temperature ill-treated raw fish by bacterial, enzymatic conversion of free histidine (Rawles et al. 1996). The scombroid fish species share in common high levels of free histidine in their muscle tissues (Suyama and Yoshizawa 1973; Perez-Martin et al. 1988; Ruiz-Capillas and Moral 2004). It has been found that non-scombroid fish species belonging to a wide range of fish groups are also involved in causing scombrotoxism (Taylor 1986; Hwang et al. 1997) as their flesh is rich in histidine (Lukton and Olcott 1958; Taylor 1986).

Background

The earliest writing about the scombroid fishes causing poisoning is that of Thomas (1799). With the publication of the work by Burrows (1815), there were a large number of reports and publications about outbreaks of scombroid poisoning in Europe and the West Indies. Maracacci (1891) was the first to apply toxic analysis using the blood of certain scombroids. He concluded that the blood of tuna can cause convulsion and paralysis in dogs when given either intravenously or intraperitoneally. Markov (1943) described the process of forming the poison in the muscles of the scombroid fishes. He stated that certain fermentation processes by bacteria on harmless chemicals changed them into toxic compounds. Igarashi (1939) suggested that histidine in large amounts will form if the meat of Scomber japonicus is left at temperatures of 24–25 °C as a result of autolysis. Probably Geiger (1944) was the first to suggest a method for determination of the freshness of fish using the measurement of histamine level in the muscles.

Over time, there was a disagreement about the exact nature of scomberotoxin. It started when Pergola (1937) proposed that the poison was produced by a special toxigenic bacterium called 'ichthyovenim.' Others believed that the toxic substance was histamine which appeared in the decayed scombroid fishes (Legroux et al. 1947; Pergola 1956). The presence of histamine by itself will have no poisonous effect (Kawataba 1962), but there are related toxic substances present that enhance the effect of histamine (Kawataba et al. 1955).

Causative Agent

Biogenic amines are formed mainly through the decarboxylation of specific free amino acids by exogenous decarboxylase bacteria released by the microbial populations associated with seafood

(Rawles et al. 1996). *Morganella* (*Proteus*) *morganii*, *Klebsiella pneumoniae*, and *Hafnia alvei* have been known to be related to scombroid poisoning (Taylor and Speckard 1983).

In the human body, histamine plays the role of a messenger molecule and therefore it is not a natural toxin. It is abundant in its distribution and released from mast cells, enterochromaffin-like cells, and neurons. It has many essential functions ranging from control of gastric acid secretion to neurotransmission in the central nervous system (Katzung 2007; Maintz and Novak 2007). Other important roles of histamine include haematopoiesis, wound healing, and day–night rhythm (Kusche et al. 1980; Raithel et al. 1998). The response to histamine involves the immune system and, more specifically, allergic responses, which for some people are most familiar and dramatic (White 1990). Such roles will help understand the nature, mechanism, and treatment of scombroid poisoning (Hungerford 2010).

In the case of ingesting a large amount of histamine through eating fish meat with a high concentration of this substance, a potentiation of histamine toxicity by other compounds present in toxic fish will occur. This compound reaction has been suggested by a number of investigators (Bjeldanes et al. 1978; Paik and Bjeldanes 1979; Taylor and Lieber 1979; Lyons et al. 1983; Taylor 1986; Stratton and Taylor 1991) and requires the presence of dietary histamine. The protective binding of histamine to intestinal mucin is disrupted by potentiators.

Symptoms

Following the consumption of the poisoned scombroid fish, the symptoms start from 10 min to 1 h (Ansdell 2015). There are variations in the symptoms and can include peppery or metallic taste, oral numbness, headache, dizziness, palpitations, rapid and weak pulse (low blood pressure), difficulty in swallowing, and thirst (Arnold and Brown 1978; Kim 1979; Gilbert et al. 1980; Taylor 1986). Other symptoms are allergy-like symptoms such as hives, rash, flushing, and facial swelling (Kim 1979; Taylor et al. 1989). Some symptoms related to the central nervous system such as anxiety are less frequently observed (Russell and Maretić 1986; Sabroe and Kobza Black 1998; Specht 1998). There are some general symptoms that the victim experienced such as nausea, vomiting, abdominal cramps, and diarrhoea (Gilbert et al. 1980). Recovery is usually complete within 24 h, but could last for days (Taylor 1986). Serious cardiac and respiratory complications observed seldom occur (Russell and Maretić 1986; Taylor et al. 1989; Ascione et al. 1997; Kounis 2013; Anastasius and Yiannikas 2015). Dermatological effects might occur as a result of severe poisoning (Tanew 2009).

Treatment

Treatment for anaphylactic shock has been required in some cases (Sanchez Guerrero et al. 1997; Otani et al. 2004). People may show variations towards the sensitivity to scombroid poisoning (Motil and Scrimshaw 1979). The attack rate is considered the key aspect and in some cases the early diagnosis of histamine poisoning versus seafood allergy. Usually, individuals eating poisoned scombroid fish respond to the toxin, but only a small percentage of illnesses are expected if the observed symptoms are caused by an allergy (Taylor et al. 1989). The administration of antihistamines is the only treatment of scombroid poisoning (Lerke et al. 1978; Blakesley 1983; Guss 1998).

Prevention

Because scombrotoxin is a result of improper handling/storage of fish and there are effective testing methods to identify toxic fish, prevention and control of outbreaks are possible. Contamination with histidine-decarboxylating bacteria can occur immediately after the fish are caught on the fishing vessel, in the processing plant, in the distribution of the fish, and also with the consumer, such as at home or in a restaurant (Taylor 1986). The main step to the prevention of the spread of scombrotyoxin is proper cooling of the fish immediately after they have been caught (Lehane and Olley 2000; Ritchie and Mackie 1979). Many countries have introduced limits for the maximum-permitted levels of histamine in fish. The amount of histamine produced is a function of the fish type, the part of the fish sampled, temperature, and the types of bacteria found on the fish (Rawles et al. 1996).

Normal fish have less than 100 ppm of histamine (1 mg/100 g of flesh) (Stommel 2007). Although the toxic dose and symptoms of HFP are variable (Taylor 1986; Taylor et al. 1989; Motil and Scrimshaw 1979), illness usually occurs at levels of 1000 ppm (100 mg/100 g of flesh), but lower levels (20 mg/100 g of flesh) can also cause illness in some individuals (Morrow et al. 1991).

5.1.5.1 Scombrotoxic Fishes

Order: Perciformes
Family: Scombridae
Auxis thazard (Lacepède 1800)
Common name: Frigate tuna
Arabic name: تونه فرقاطه
Etymology: *Auxis:* Greek, auxis = a variety of tunna (Fig. 5.13)

Identification

- Large, rounded, elongated body.
- Small conical teeth fall in single series.
- Short pectoral fins. Large pointed flap between pelvic fins.
- No scales on body except in corselet.
- Strong central keel on each side of base of caudal fin.
- Body bluish colour on back and deep purple to black on head. Fifteen oblique to horizontal dark lateral line. White ventral side. Pectoral and pelvic fins purple with black inner side (Froese and Pauly 2016).

World Distribution It has a worldwide distribution in the Atlantic, Indian, and Pacific Oceans (Froese and Pauly 2016).

Distribution in the Study Area It is found in the east and southern Arabian peninsula.

Habitat and Ecological Role This marine species inhabits a pelagic-neritic environment with oceanodromous habit (Reide 2004). Adults are coastal or found near coastal areas (Collette et al. 2011a)

Biology Individuals of this species of tuna feed on small fish, squid, planktonic crustaceans (megalops), and stomatopod larvae. It lives up to 4 years. Individuals reach 2290, 3040, 3670, and 4040 mm at their first, second, third, and fourth year of their lives, respectively (Grudtsev and Korolevich 1986). Fecundity ranges from 78,000 to 1.37 million eggs in 3150–4420 mm females. In some areas the spawning season extends throughout the year (Collette et al. 2011a).

Economic Value This species of tuna has high commercial value along its geographical distribution line.

Conservation Status This species has been granted Least Concern criteria in the Red List of IUCN for the following reasons as Collette et al. (2011a) stated: ‘This species is widespread

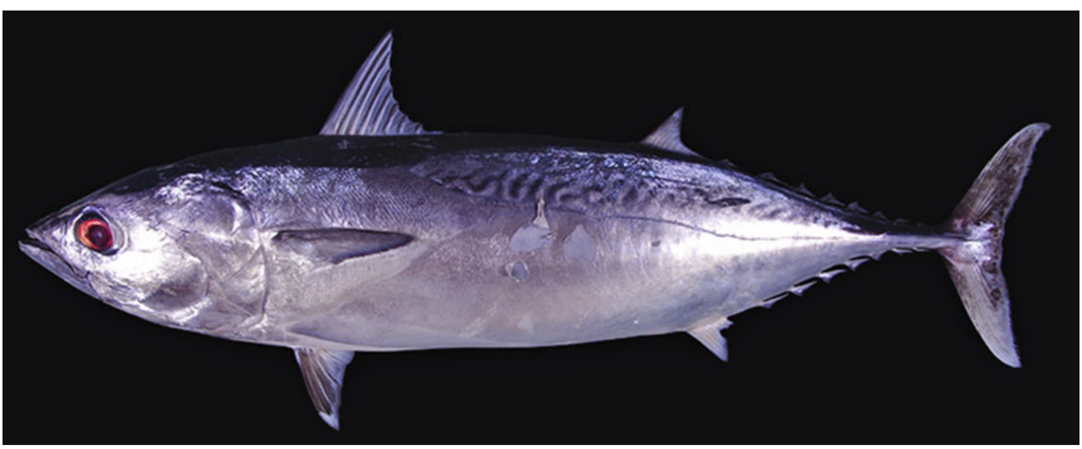

Fig. 5.13 Frigate tuna, *Auxis thazard* (Lacepède, 1800). Courtesy of Hiroyuki Motomura, Japan

and is abundant in many parts of its range. It is important in artisanal fisheries and is caught as bycatch in commercial fisheries, but landings are often mixed with *Auxis rochei*.'

Euthynnus affinis (Cantor 1849)
Common name: Kawakawa
Arabic name: تونه
Etymology: *Euthynnus*: Greek, eu = good + Greek, thynnos = tunna (Fig. 5.14)

Identification

- First dorsal fin with long anterior spine higher than those in middle.
- Small and divided interpelvic process.
- No scales on body except in corselet area and lateral line.
- Broken oblique bands on posterior portion of back (Froese and Pauly 2016).

World Distribution This species is distributed in the Indo-West Pacific region.

Distribution in the Study Area It is found in the east and southern Arabian peninsula.

Habitat and Ecological Role This marine species inhabits a pelagic-neritic environment with oceanodromous habit (Reide 2004). It is found at depth ranges from the surface down to 200 m (FAO-FIGIS 2005). Young may enter bays and harbours (Collette et al. 2011c).

Biology Individuals of this species tend to form multispecies schools by size with other scombroid species. They are predators feeding on small fishes (Griffiths et al. 2009). Squid and crustaceans are also included in its food menu (Collette 2001). Maximum size reached is 1000 mm in fork length and weight 13.6 kg (Collette et al. 2011c).

Economic Value It has high economic value.

Conservation Status This species has been given the status of Least Concern in the red List of IUCN for the following reasons as stated by Collette et al. (2011c):

> This species is widespread and abundant in the Indian and Western Pacific Ocean. It is caught in commercial fisheries, primarily as bycatch. It is marketed in a variety of products, and reported worldwide landings are increasing. Currently, there is no information on population trends. More information is needed on this species population and the impact of fisheries, especially as it seems that many catches are not being reported.

Rastrelliger kanagurta (Cuvier 1816)
Common name: Indian mackerel

Fig. 5.14 Kawakawa, *Euthynnus affinis* (Cantor, 1849). Courtesy of Hiroyuki Motomura, Japan

Fig. 5.15 Indian mackerel, *Rastrelliger kanagurta* (Cuvier, 1816). Courtesy of Hiroyuki Motomura, Japan

Arabic name: المكريل الهندي ضلعه
Etymology: *Rastrelliger*: Latin, rastra = rake + Latin, gero = to carry (Fig. 5.15)

Identification

- Head long and longer than body depth.
- Maxilla not fully exposed, covered with lachrymal bone extending to posterior edge of eye.
- Small and undivided interpelvic process.
- Small anal spine.
- Lower margin of pectoral fin with black spot.

World Distribution It is distributed in the Indo-West Pacific region from the Red Sea southward to east Africa and then eastward to Indonesia, north of the Ryukyu Islands, and China. It is also found on the coasts of Australia, Melanesia, and Samoa (Froese and Pauly 2016).

Distribution in the Study Area It is found in the east and southern Arabian peninsula.

Habitat and Ecological Role This marine species inhabits a pelagic-neritic environment with oceanodromous habit (Reide 2004). It is found at depth range 20–90 m (Pauly et al. 1996).

Biology It is often found in pelagic schools. It feeds on phytoplankton (diatoms) and small zooplankton (Cladocerans, ostracods, larval polychaetes). Adults feed on macroplankton such as larval shrimp and fish (Collette et al. 2011d). It reaches 170–200 mm in total length at maturity (Tampubolon and Merta 1987; Sivadas et al. 2006)

Economic Value It has high commercial value.

Conservation Status This scombroid species has been given Data Deficient criteria in the Red List of the IUCN for the following reasons stated by Collette et al. (2011d).

> This species is widespread in southeastern Asia. There is no information on population or general abundance. This species is targeted in commercial and artisanal fisheries throughout its range, but landings are primarily reported in combination with mixed *Rastrelliger* spp. Reported worldwide landings for *Rastrelliger* species have steadily increased since 1950 to over 800,000 tonnes, but no effort information is available. Given that effort is assumed to be increasing, and that there some evidence of localised declines, it is not known how this species population is affected by current and historical fishing pressure. Given the absence of an international management body, further monitoring of this species is needed on the national level, in addition to species-specific data on landings, effort and population status.

Thunnus albacares (Bonnaterre 1788)
Common name: Yellowfin tuna
Arabic name: تونه ذات ذنب الأصفر
Etymology: *Thunnus*: Greek, thynnos = tuna (Fig. 5.16)

Fig. 5.16 Yellowfin tuna, *Thunnus albacares* (Bonnaterre, 1788). Courtesy of Hiroyuki Motomura, Japan

Identification

- Second dorsal and anal fins very long. Pectoral fin moderately long passing origin of second dorsal fin.
- Body metallic dark blue. Abdomen yellow to silvery. Vertical broken lines on abdomen. Bright yellow dorsal and anal finlets (Froese and Pauly 2016).

World Distribution This species has a worldwide distribution in the tropical and subtropical seas. No record is present in the Mediterranean Sea (Froese and Pauly 2016).

Distribution in the Study Area There is no record of this species from the Arabian-Persian Gulf (Randall 1995). It is reported from the Sea of Oman and southern Arabian peninsula (Manilo and Bogorodsky 2003).

Habitat and Ecological Role This marine species sometimes enters brackish water but prefers a pelagic-oceanic environment and has an oceanodromous habit (Reide 2004). It is found at depth range 1–250 m (Kailola et al. 1993).

Biology Individuals of this species can school in size either monospecific or multispecific with large individual schools with porpoises. Fishes, crustaceans, and squid are its main food items. It cannot stand low oxygen concentration (Collette et al. 2011b). Its maximum age is between 4.8 and 6.5 years (Lehodey and Leroy 1999) and maximum size is 2000 mm fork length (Collette et al. 2011b).

Economic Value It has a high commercial value.

Conservation Status This species of tuna has been given Near Threatened criteria in the Red List of IUCN for the reasons stated by Collette et al. (2011b):

> This species is fast-growing, widely distributed and highly productive. It is important in commercial fisheries around the world. It is being effectively managed throughout the majority of its range. All stocks are being fished below current maximum sustainable yield. Based on weighted declines of biomass or spawning stock biomass across all stocks, there has been an estimated 33% decline globally over the past 10 years (1998–2008), or three generation lengths. This species is listed as Near Threatened, primarily as population declines would be much greater if it were not for the catch quotas that have been implemented. Although model projections are variable, concerns however remain about possible overfishing in recent years in the Indian Ocean. This species should be reassessed in the next coming years, primarily because catches in the Indian Ocean region have declined substantially in 2009 (and possibly also in 2010) partly due to Somali-based piracy, which has shifted fishing effort to the Atlantic Ocean.

Thunnus tonggol (Bleeker 1851)
Common name: Longtail tuna
Arabic name: تونه طويلة الذنب
Etymology: *Thunnus*: Greek, thynnos = tunna (Fig. 5.17)

Fig. 5.17 Longtail tuna, *Thunnus tonggol* (Bleeker, 1851). Courtesy of Hiroyuki Motomura, Japan

Identification

- Body small.
- Deepest point of body at middle of first dorsal fin. Second dorsal fin higher than first. Short pectoral fin.
- Body lower; sides and abdomen silvery white with colourless elongated spots, arranged horizontally. Dorsal, pectoral, and pelvic fins blackish. Tip of second dorsal and anal fins yellowish. Anal fin silvery. Dorsal and anal finlets yellow with greyish margins. Black caudal fin (Froese and Pauly 2016).

World Distribution It is distributed in the Indo-West Pacific region from the Red Sea southward to east Africa and eastward to New Guinea, north to Japan, and south to Australia and New Zealand (Murray et al. 1984).

Distribution in the Study Area It is not reported from the Arabian-Persian Gulf (Randall 1995). It is found in the Sea of Oman and the southern coasts of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecological Role This marine species inhabits a pelagic-neritic environment with oceanodromous habit (Reide 2004). It avoids very turbid waters and areas with reduced salinity (Collette et al. 2011e).

Biology It is a probable school-forming species of varying sizes and feeds on fishes, cephalopods, and crustaceans. It can attain 1300 mm fork length and can live up to 5 years. This species may live as long as 18 years in the central Indo-Pacific (Griffiths et al. 2009) and is a multispawner per year (Collette et al. 2011e).

Economic Value It has high commercial value.

Conservation Status This species was given Data Deficient criterion in the Red List of the IUCN for the following reasons set by Collette et al. (2011e).

> This species grows more slowly and lives longer than other tuna species of similar size. Coupled with their restricted neritic distribution, longtail Tuna may be vulnerable to overexploitation by fisheries. Worldwide landings have been rapidly increasing, but there is no effort information or stock assessments. More information is needed on the status of this species population, including better catch data and effort information. Management of this species also needs to be included under a fisheries management organisation.

5.1.6 Hallucinogenic Fishes

Hallucinogenic or ichthyoallyeinotoxism is a less common form of Ichthyosarcotoxism, and is characterised by development of central nervous system disturbances, especially hallucinations and nightmares. Ichthyoallyeinotoxism has been reported in many locations around the world (Halstead 1988; Château-Degat 2003). The biotoxication is a result of eating either the head or the flesh of the fish.

Background

The first report on the ichthyoallyeinotoxism was that of Jordan et al. (1927). They reported on a case of intoxication that happened to the mayor of Honolulu as a result of eating the head of a fish. References to the ichthyoallyeinotoxic fishes were published over the years by Tinker (1944), Nichols and Bartsch (1945), Titcomb and Pukui (1952), Fish and Cobb (1954), and Randall (1958). In most of these reports, the causative fish was *Kyphosus vaigiensis*. On the other hand, Smith (1961) suggested that eating the brain of members of the family Mullidae can cause convulsions. Helfrich and Banner (1960) were the first to give the entity the name ichthyoallyeinotoxism and also gave it the term 'hallucinogenic fish poisoning' or 'ichthyosarcephialtilepsis.' A clinical summary of the biotoxications was given by Bouder et al. (1962).

Causative Agent

The causative agents for ichthyoallyeinotoxism are still unknown, but some authors have incriminated the toxic macroalgae (Caulerpaceae family) that are ingested and contaminate the flesh of fish (Helfrich and Banner 1960; Chevaldonne 1990). Because case reports have been described after ingestion of fried, boiled, steamed, or raw fish, these toxins are probably heat stable (Helfrich and Banner 1960; Raikhlin-Eisenkraft and Bentur 2002). Some cases of intentional consumption of 'dreamfish' have been reported (Helfrich 1963; Roughly and Roberts 1960; Cooper 1964). During Roman times in the Mediterranean region, consumption of *Sarpa salpa* was reported for recreational purposes (de Haro et al. 1993), and for ceremonial purposes particularly in Polynesian populations (Helfrich 1963; Roughly and Roberts 1960; Cooper 1964). The toxic effect can be detected from the traditional names given to hallucinogenic species. *Sarpa salpa* is called 'the fish that makes dreams' in Arabic; *Siganus spinus* is called 'the fish that inebriates' in Mascareignes (southwest coast of Reunion Island; Lebeau 1979; Quod and Turquet 1996); and *Mulloidichthys samoensis* is called 'the chief of ghosts' in the Hawaiian Islands of Molokai, Kauai, and Oahu (Helfrich 1963; Jordan et al. 1927; Banner 1973). It should be noted that there are differences in clinical expression between ichthyoallyeinotoxism and ciguatera. The former is characterised by central nervous system involvement, whereas the latter features peripheral nervous system involvement. The two diseases are also different with regard to potential severity and duration. Most patients with ichthyoallyeinotoxism recover within 36 h (1–3), whereas many patients with ciguatera die or present prolonged symptomatology for several months (de Haro et al. 2003).

Symptoms

Symptoms may develop within 2 h after eating fresh fish. These start with nausea and vomiting, which develop quickly. Later symptoms persist and may be accompanied by marked muscle weakness, blurring of vision, and hallucinations such as aggressive and screaming animals (de Haro and Pommier 2006). The general symptoms include dizziness, loss of equilibrium, lack of motor coordination, hallucinations, and mental depression.

Treatment

Stomach evacuation should be immediately applied to the victim. The remaining treatments are symptomatic.

Prevention

Care should be taken when a decision is made to eat reef fish species that are considered as causative agents for ichthyoallyeinotoxism. It is advisable not to eat the head of tropical reef fish. Hallucinogenic fish cannot be detected by their appearance.

5.1.6.1 Hallucinogenic Fish Species

Order: Perciformes
Family: Mullidae
Mulloidichthys flavolineatus (Lacepède 1801)
Common name: Yellowstripe goatfish
Arabic name: سمكة المعزصفراء الخطوط
Etymology: *Mulloidichthys:* Latin, mullus = soft + Greek, ichthys = fish (Fig. 5.18)

Identification

- This species can be characterised by its colouration. Body back grey to olive. Sides and abdomen white. Longitudinal yellow lines on body. Dark spot below first dorsal fin (Ben-Tuvia 1986). Yellow band from eye to tail (Kuiter and Tonozuka 2001).

World Distribution This species is distributed in the Indo-West Pacific region from the Red Sea southward to east African coasts and eastward to Hawaii, Marquesas, and north to Ryukyu Islands and south to Lord Howe Islands (Froese and Pauly 2016).

Distribution in the Study Area It is found in the eastern and southern Arabian peninsula.

Habitat and Ecological Role It is a marine species living in association with reefs at depth range 1–76 m (Allen and Erdmann 2012).

Biology Individuals of this species form schools occasionally (Lieske and Myers 1994). Adults prefer solitary life. They feed on crustaceans, mollusks, worms, sea urchins, and foraminifera (Froese and Pauly 2016).

Economic Value It has good commercial value and is taken as a food source.

Conservation Status Not evaluated.

Order: Perciformes
Family: Kyphosidae
Kyphosus vaigiensis (Quoy and Gaimard 1825)
Common name: Brassy chub
Arabic name: سمكة باس مخطط
Etymology: *Kyphosus:* Greek, kyphos = ben (Fig. 5.19)

Identification

- Body elongated and oval shape.
- Incisor-shaped teeth.
- Rows of scales arranged horizontally.
- Emarginate caudal fin. Dorsal and anal fins not high. Body metallic blue dorsally with white abdomen. Rows of scales golden and bluish (Knudsen and Clements 2013).

World Distribution It is distributed in the Indo-West Pacific region from the Red Sea southward to the east African coasts and South Africa

Fig. 5.18 Yellowstripe goatfish, *Mulloidichthys flavolineatus* (Lacepède, 1801). Courtesy of Hiroyuki Motomura, Japan

Fig. 5.19 Brassy chub, *Kyphosus vaigiensis* (Quoy & Gaimard, 1825). Courtesy of Hiroyuki Motomura, Japan

(Smith 1986). It continues its distribution eastward to Hawaii, Tuamoto, and Rapa Islands (Froese and Pauly 2016).

Distribution in the Study Area It is found in the Sea of Oman (Randall 1995) and the southern Arabian Peninsula, but its presence in the Arabian-Persian Gulf needs confirmation.

Habitat and Ecological Role This marine species lives in association with coral reefs and as oceanodromous habit (Reide 2004). It is found at depths from the surface down to 40 m (Bacchet et al. 2006).

Biology Individuals of this species have a habit of aggregating over hard and algal-coated lagoons. It feeds on crustaceans (Masuda et al. 1984).

Economic Value It has good commercial value within its geographical distribution.

Conservation Status Not evaluated.

Order: Mugiliformes
Family: Mugilidae
Mugil cephalus (Linnaeus 1758)
Common name: Flathead grey mullet
Arabic name: بياح الرمادي مسطح الرأس
Etymology: *Mugil:* Latin, mugil, -ilis = grey mullet; *cephalus: cephalus* meaning head (Figs. 5.20 and 5.21)

Identification

- Strong body, compressed and cylindrical in cross-section.
- Broad flat head.
- Adipose eyelid well-developed.
- Absence of papillae from upper lip.
- First dorsal fin origin nearer to snout tip than to caudal-fin base.
- Dense coverage of scales at base of second dorsal and anal fins (Albaret 2003; Keith and Allardi 2001).

World Distribution This species of mullet has a cosmopolitan type of distribution.

Distribution in the Study Area It has been reported from the eastern and southern coasts of the Arabian peninsula.

Habitat and Ecological Role This marine species sometimes enters fresh and brackish waters but prefers benthopelagic habitats and has a catadromous habit (Reide 2004). It is found at depth range from the surface down to 120 m (Harrison 1995).

Biology Adults of this species are often found in schools over a mud or sand bottom (Eschmeyer et al. 1983). They are diurnal, feeding on detritus, microalgae, and benthic organisms (Blaber 1976; Tung 1981; Cardona 2000). They mature at 3–4 years (Tung 1981). Their maximum length is

Fig. 5.20 Flathead grey mullet, *Mugil cephalus* Linnaeus, 1758. Courtesy of Hiroyuki Motomura, Japan

Fig. 5.21 Flathead grey mullet, *Mugil cephalus* Linnaeus, 1758. Courtesy of Joo Park, Korea

reported as 1200 mm in standard length (Thomson 1990) and maximum weight is reported as 12 kg (Fadeev 2005).

Economic Value It is marketed fresh, dried, salted, and frozen; roe are sold fresh or smoked (Harrison 1995); it is also used in Chinese medicine (Tang 1987).

Conservation Status This species has been given Least Concern criterion in the Red List of IUCN because of its widespread distribution with no known major threats (Kottelat and Freyhof 2012).

Order: Perciformes
Family: Siganidae
Siganus argenteus (Quoy and Gaimard 1825)
Common name: Streamlined spinefoot
Arabic name: سمكة الصافي الأنسيابيه
Etymology: *Siganus:* Latin, siganus = a fish, rabbit fish; by the similarity of the nose (Figs. 5.22 and 5.23)

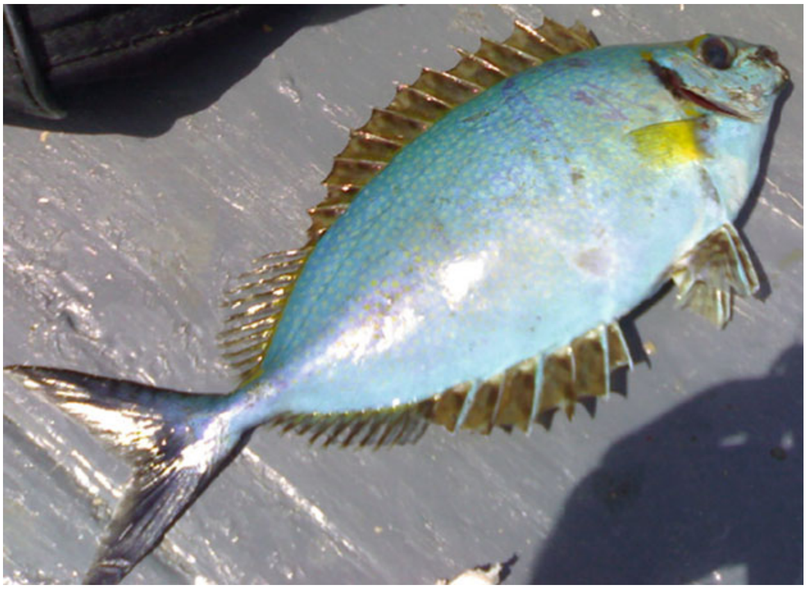

Fig. 5.22 Streamlined spinefoot, *Siganus argenteus* (Quoy & Gaimard, 1825). Courtesy of Ehshan Nuckchady, France

Fig. 5.23 Streamlined spinefoot, *Siganus argenteus* (Quoy & Gaimard, 1825). Courtesy of Rainer Kretzberg, Germany

Identification

- Elongated body, with pointed head.
- Spines slender and venomous.
- Cheek with fine scales.
- Caudal fin forked.
- Body blue above, silvery below; variations in markings (spots, curved lines) occur. Silvery-yellow iris. When frightened or asleep, entire fish becomes mottled with very light and dark browns, with dark ones predominating in seven diagonal zones across the sides; fins become mottled (Myers 1991).

World Distribution This species is distributed in the Indo-Pacific region from the Red Sea north to coasts of East Africa, and south to Pitcairn and Rapa Islands in the Pacific Ocean (Froese and Pauly 2016).

Distribution in the Study Area It reported from the southern coasts of the Arabian peninsula only (Randall 1995).

Habitat and Ecological Role This marine species lives in association with coral reefs at depth range from the surface down to 40 m (Woodland 1997), but usually lives at depth range 1–30 m (Baensch and Debelius 1997).

Biology Individuals of this species prefer large schools that swim very fast and dive down to the bottom for feeding (Kuiter and Tonozuka 2001). Juveniles favour small schools around corals.

Economic Value It has good commercial value as a source of food. Prejuveniles are eaten fresh, pickled in brine, or made into fish paste (Woodland 1997). It is consumed as food although it is known to be occasionally poisonous (Robins et al. 1991). It is used in Chinese medicine (Tang 1987).

Conservation Status Not evaluated.

Siganus canaliculatus (Park 1797)
Common name: White-spotted spinefoot
Arabic name: سمكة الصافي ذات البقع البيضاء
Etymology: *Siganus*: Latin, siganus = a fish, rabbit fish; by the similarity of the nose (Figs. 5.24 and 5.25)

Identification

- Naked preopercular area.
- Mid-thorax scaleless.
- Anterior nostril with margin encircled by low flange and flap extended posteriorly.
- Body silvery grey colour dorsally and silvery at abdomen. Nape with touch of olive green colour. Creamy pale spots below lateral line (Froese and Pauly 2016).

World Distribution It is distributed in the Indo-West Pacific region from the Arabian-Persian Gulf and eastward to Pakistan, India, Thailand, Indonesia, and China. It is also found in Western Australia (Froese and Pauly 2016).

Distribution in the Study Area It has been reported from the Arabian-Persian Gulf (Hussain et al. 1988), the Sea of Oman, and southern coasts of the Arabian peninsula (Randall 1995).

Habitat and Ecological Role This marine species enters brackish waters and sometimes lives in association with coral reefs and with oceanodromous habit (Reide 2004). It is found at depths of 3–50 m (Woodland 1997).

Biology Adults prefer deeper water several kilometres offshore. Juveniles form large schools in coral reef flats. It feeds on benthic algae and to some extent on seagrass.

Economic Value There is a good commercial market.

Conservation Status Not evaluated.

Siganus jarvus (Linnaeus 1766)
Common name: Streaked spinefoot
Arabic name: سمكة الصافي المخطط

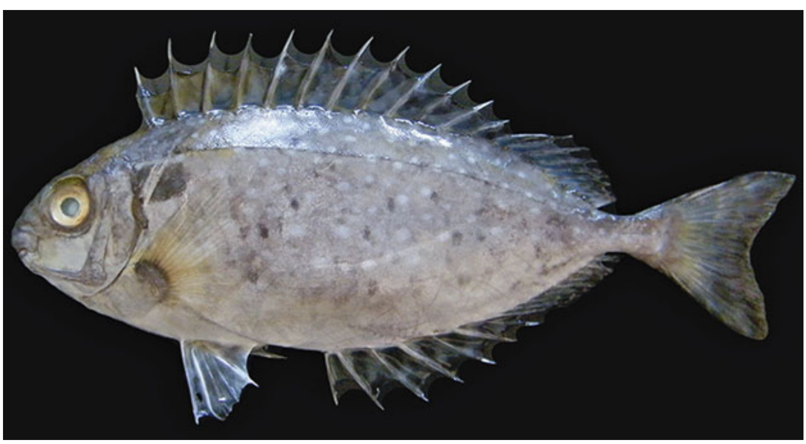

Fig. 5.24 White-spotted spinefoot, *Siganus canaliculatus* (Park, 1797). Courtesy of Sahat Ratmuangkhwang, Thailand

Fig. 5.25 White-spotted spinefoot, *Siganus canaliculatus* (Park, 1797), fish market. Courtesy of Trevor Meyer, Australia

Fig. 5.26 Streaked spinefoot, *Siganus javus* (Linnaeus, 1766). Courtesy of Hamid Osmany, Pakistan

Etymology: *Siganus:* Latin, siganus = a fish, rabbit fish; by the similarity of the nose (Fig. 5.26)

Identification

- Deep body.
- Caudal fin emarginate. Spines of dorsal fin slender.
- Hard scales on cheeks.
- Body bronze above, white on belly and thorax; iris light brown; pectoral fins hyaline, pelvic fins white (Froese and Pauly 2016).

World Distribution This species is distributed in several localities in the Indo-Pacific region. It is reported from Pakistan, India, Sri Lanka, Burma, Andaman Islands, Thailand, Viet Nam, southern China, Malaysia, Indonesia, Philippines, Australia, New Guinea, Vanuatu, and New Caledonia. Records for the Ryukyu and Ogasawara Islands could be based on strays (Woodland 1997).

Distribution in the Study Area It is reported from different localities of the Arabian-Persian Gulf and the Sea of Oman (Randall 1995).

Habitat and Ecological Role This marine species enters brackish water, and lives in association with coral reefs at depth range from the surface down to 15 m (Reide 2004; Allen and Erdmann 2012).

Biology Individuals of this species prefer living in small schools. They feed on algae attached to the substrate and on floating algal fragments. They are found resting in midwater at depths of 2–6 m when not feeding (Froese and Pauly 2016).

Economic Value This species has high commercial value in spite of the presence of poisonous spines. It is marketed fresh (Woodland 1997).

Conservation Status Not evaluated.

Siganus luridus (Rüppell 1829)
Common name: Dusky spinefoot
Arabic name: سمكة الصافي بطاطا
Etymology: *Siganus:* Latin, siganus = a fish, rabbit fish; by the similarity of the nose (Fig. 5.27)

Identification

- Body elongated.
- Caudal fin truncate. Anterior spines of median fins slender and pungent, posterior spines stout, all venomous including that on nape.
- Long, broad flap on anterior nostril.
- Two diurnal colour forms, one greyish yellow, with small, irregular pale blue spots on body, the other dark greyish yellow on dorsal side of body, with narrow white stripes from nostril (Randall 1995).

World Distribution It is distributed in the Western Indian Ocean region from the Red Sea at the north to the coasts of east South Africa at the south. It also penetrates the Mediterranean Sea as an immigrant fish (Froese and Pauly 2016).

Distribution in the Study Area It is reported from several localities in the Arabian-Persian Gulf area, the Sea of Oman, and the southern coasts of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecological Role This marine species lives in association with reefs at depth range 2–40 m (Göthel 1992).

Biology Individuals of this species prefer living in small schools and in shallow water. They feed on a wide range of benthic algae.

Economic Value They are good commercial fish.

Conservation Status Not evaluated.

5.1.7 Tetrodotoxic Fishes

Tetrodotoxin is a toxin produced by pufferfish and named after the fish's order name Tetraodontiformes and is a powerful neurotoxin. It is of low

Fig. 5.27 Dusky spinefoot, *Siganus luridus* (Rüppell, 1829). Courtesy of Hamid Osmany, Pakistan

molecular weight, with a unique structure, only relatively recently determined in 1964 (Tsuda et al. 1964; Woodwardm 1964; Goto et al. 1965). This toxin is considered among the powerful marine toxins and has the ability to block the sodium channel in the nerves and muscles (Catterall 1995; Kao 1986). The inhibition of sodium entry through the ion channel renders these tissues nonfunctional. It is found not only in pufferfish but also in some gastropods. Tetrodotoxin is about 10,000 times more lethal than cyanide by weight with a lethal dose of about 1–2 mg for adults (Hwang and Noguchi 2007; Noguchi and Ebesu 2001).

Tetrodotoxin poisoning is well encountered in Japan, Taiwan, and Southeast Asia including Hong Kong, where fugu or pufferfish are used as a food. During the 5 years from 2002 to 2006, 116 incidents of pufferfish poisoning occurred in Japan, involving 223 patients and 13 deaths (Arakawa et al. 2010). From 1993 to 2006, 10 incidents of pufferfish poisoning were reported in Hong Kong (Mak and Ho 2006) which involved 23 persons with 1 fatality.

Several genetically unrelated marine animal groups are able to cause tetrodotoxin poisoning. This wide variation occurs along with the regional and seasonal variability in toxin concentration making the origin of tetrodotoxin one of the most debated topics. Further research revealed that cultured puffer fish were nontoxic but easily became toxic upon ingesting toxic livers of wild puffers (Matsui et al. 1981). Accordingly, a presumption that all tetrodotoxin-bearing animals were infected by tetrodotoxin-producing microorganisms living symbiotically within their bodies was established (Matsui et al. 1985; Mosher and Fuhrman 1984) which was later confirmed by the isolation of tetrodotoxin-producing bacteria from different tetrodotoxin-bearing animals.

Background

Since ancient times, puffer poisoning, one of the best known types of ichthyosarcotoxism, has been recognised by humans due to its violent nature. It was possibly an Egyptian who was first to mention the toxicity of the pufferfish as seen from writings on their tombs (Gaillard 1923). In other parts of the world, China and Japan, the toxicity of pufferfish has been known since the time of the T'ang dynasty (AD 618–907; Halstead 1967).

The first account of puffer poisoning in California was published by Clavijero (1852). He cited the incident of four soldiers who were poisoned by eating the liver of a pufferfish. One of them died in 30 min, the other died a short time later, the third, who only chewed the liver without swallowing it, lost consciousness until the following day, and the fourth, who had barely touched it, was sick for several days. The flesh of pufferfish was used by natives in Baja California for poisoning stray dogs (Phisalix 1922). Puffer poisoning terminated the famous Captain Cook's voyage (Forster 1777).

The toxicology of the puffer poison was extensively studied by Rémy (1883). He used dogs in his experiments. He fed them puffer's gonads and also injected crude extracts of puffers into their bodies in order to make observations. With the start of year 1885, the Japanese literature about puffer poisoning mounted rapidly (Suehiro 1947). Among the outstanding Japanese chemical research were those of Tahara (1894, 1896, 1897, 1910). He was the first to isolate the puffer poison. The term 'tetrodotoxin' or 'fugutoxin' was introduced to refer to the toxic principle which was found to be identical to what was previously known as tetrodonic acid. The Brazilians started their work on the toxicology of puffer poisoning in 1903, when Furtado began his investigations in this field (Halstead 1967). The articles and research about puffer poisoning have increased drastically with the turn of the nineteenth century led by Japanese researchers (Ishihara 1917; Yano 1938; Suehiro 1947; Fukuda 1951). Advances in research about the pharmacology of tetrodotoxin were achieved by Hamada (1960), Ogura (1963), Mosher et al. (1964), Halstead (1964), and Russell (1965).

Causative Agent

Several species of marine bacteria are able to produce tetrodotoxin: *Pseudomonas* sp., *Vibrio* *alginolyticus*, *Alteromonas tetraodonis*, *Shewanella alga*, *S. putrefaciens*, *Microbacterium arabinogalactanolyticum*, and *Serratia marcescens* (Yasumoto et al. 1986; Yotsu et al. 1987; Noguchi et al. 1986). It is bioconcentrated via the food chain, symbiosis, and/or parasitism in many marine organisms including several puffer species, many invertebrates (e.g., blue-ringed octopus, starfish, xanthid crab, gastropods), as well as some vertebrates (e.g., at elopid frogs, gobies, newts; Noguchi and Arakawa 2008; Hwang and Noguchi 2007; Fuchi et al. 1991). Tetrodotoxin and its derivatives have a heterocyclic guanidine structure (Chulanetra et al. 2011). They are relatively stable to cooking temperature (Arakawa et al. 2010). It has been known for many years that toxicity of the ovaries of pufferfish is more potent than that of other organs, but whether the anatomical variation of toxicity is due to the different distribution of tetrodotoxin-producing bacteria is not known (Wu et al. 2005).

The mechanism of action of tetrodotoxin involves mainly selective blockade of voltage-gated neuronal channels in the cell by binding extracellularly at certain receptors. This results in the inhibition of the generation and propagation of nerve and muscle action potentials (Bentur et al. 2008). The blockade of neuromuscular transmission occurs on motor nerve axons and muscle fibre membranes and not on motor end plates. Axonal blockade probably also occurs at sensory nerves (Halstead 1988; Isbister and Kiernan 2005; Kiernan et al. 2005). Blockade of sympathetic vasomotor nerves, direct effects on arterial smooth muscles, and medullary cardiovascular effects are thought to be the main mechanisms for vasodilation and hypotension (Kao 1972; Bousquet et al. 1980; Cottrell et al. 1984; Chang et al. 1996).

Symptoms

Fukuda and Tani (1941) introduced a grading system for the symptoms of tetrodontoxin poisoning. In the first step, perioral numbness and paraesthesia will occur with or without gastrointestinal symptoms such as nausea. In the second stage, lingual, facial numbness will appear on the victim followed by early motor paralysis and incoordination. The victim will suffer from slurred speech. The third stage will include generalised flaccid paralysis, respiratory failure, aphonia, and fixed or dilated pupils. The patient becomes conscious and in the fourth stage, severe respiratory failure, hypoxia, hypotension, bradycardia, and cardiac dysrhythmias will follow. In the fourth stage the patient will suffer from severe respiratory failure and hypoxia, hypotension, bradycardia, and cardiac dysrhythmias. The patient may enter an unconscious period. There are three factors contributing to the degree of intoxication: the amount of tetrodotoxin ingested, time lag after ingestion until admission to hospital, and pre-existing diseases (Leung et al. 2011). The first two stages are relatively mild, whereas the third and fourth stages are characterised by severe disturbances.

Treatment

There is no antidote for tetrodontoxin poisoning; treatment is mainly by supportive therapy and may involve mechanical ventilation for oxygen supply, normal saline infusion for distending the intravascular volume, and gastric emptying procedures (Leung et al. 2011). To lower the rate of mortality due to tetrodontoxin poisoning, early diagnosis and prompt clinical management are essential.

To assist in the process of diagnosis of tetrodontoxin poisoning, analysing the poison in leftover food is an alternative way to make the diagnosis. On the other hand, the detection of the toxin in the patient's urine or blood is essential to confirm the diagnosis of poisoning (Leung et al. 2011). Death is mainly due to respiratory muscle paralysis and less frequently, profound hypotension (Halstead 1988; Yang et al. 1996; Yang and Deng 1996). Death usually occurs within 6–24 h of consumption, and as soon as 17 min (Halstead 1988; Yang and Deng 1996).

Prevention

In general and if you want to avoid intoxication with tetrodontoxin, the best idea is to avoid scaleless fishes. In Japan, people should seek firstclass restaurants to eat fugu. It is important how the individuals prepare the fish for food. They should have knowledge of where in the fish body the toxin is found and avoid these parts. The tetrodontoxin is heat resistible and therefore frying, stewing, baking, boiling, and so on do not inactivate the poison. The only way to inactivate the toxin is by boiling the meat in a strong solution of sodium bicarbonate, ‘baking soda,’ for a prolonged period of time, but the fish will be rendered tasteless and not useful for consumption. Immunity against the toxin cannot be acquired after a repetition of injections. Individuals may become poisoned several times and die after another incident of poisoning (Halstead 1967).

5.1.7.1 Species of Tetrodontoxic Fishes

Order: Tetraodontiformes
Family: Tetraodontidae
Arothron hispidus (Linnaeus 1758)
Common name: White-spotted puffer
Arabic name: فقه بيضاء النقطه (Fig. 5.28)

Identification

- Small spines on body except around snout and caudal peduncle.
- Two fleshy solid tentacles at each nostril.
- Lateral with single bent.
- Body greenish colour. Abdomen greenish with white bands.

World Distribution The distribution of this species is confined to the Indo-West Pacific region. It is distributed from the Red Sea southward to east African coasts (Smith and Heemstra 1986) and eastward to Japan and Hawaii and south to the Lord Howe Islands. It is reported from the East Pacific at Baja California and the Gulf of California to Panama (Allen and Robertson 1994; Bussing 1995).

Distribution in the Study Area There is no record of this species from the Arabian-Persian Gulf, but it is reported from the Sea of Oman and the southern coasts of the Arabian peninsula (Randall 1995).

Habitat and Ecological Role This marine species sometimes enters brackish water and lives in association with reefs at depth range 1–50 m (Allen and Erdmann 2012). It inhabits outer reef slopes (Smith and Heemstra 1986).

Fig. 5.28 White-spotted puffer, *Arothron hispidus* (Linnaeus, 1758). Courtesy of Albert Cook, Amsterdam, Holland, via Wikimedia commons CC BY-SA 3.0

Fig. 5.29 Stellate puffer, *Arothron stellatus* (Anonymous, 1798). Courtesy of Hiroyuki Motomura, Japan

Biology Juveniles prefer areas with weeds (Smith and Heemstra 1986). Individuals are usually solitary and feed on algae, detritus, mollusks, sponges, crabs, worms, and echinoderms (Myers 1991).

Economic Value They have no economic value, but are taken as a food in some East Asian countries

Conservation Status Not evaluated.

Arothron stellatus (Anonymous 1798)
Common name: Stellate puffer
Arabic name: فقه مرقطه (Figs. 5.29 and 5.30)

Identification

- Body covered with small spines except top of snout, base of fins and sides of caudal peduncle.
- Rounded caudal fin.
- Body mainly white with black spots on head.

World Distribution It is distributed in the Indo-Pacific region from the Red Sea southward to the East African coasts (Smith and Heemstra 1986) and eastward to Japan and south to the Lord Howe Islands (Froese and Pauly 2016). It is also reported from the south coast of South Africa (Smith and Heemstra 1986).

Distribution in the Study Area It is reported from the eastern and southern coasts of the Arabian peninsula (Manilo and Bogorodsky 2003).

Fig. 5.30 Stellate puffer, *Arothron stellatus* (Anonymous, 1798). Courtesy of Juuyoh Tanaka, Japan

Habitat and Ecological Role This marine species lives in association with coral reefs at depth range 3–58 m (Myers 1991).

Biology Juveniles prefer sandy and weedy inner reefs, whereas adults are found in clear lagoons and seaweed reefs (Lieske and Myers 1994). It is considered among the large size puffers if the length is in excess of a metre (Froese and Pauly 2016).

Economic Value No economic value.

Conservation Status Not evaluated.

Canthigaster rivulata (Temminck and Schlegel 1850)
Common name: Brown-lined puffer
Arabic name: فقه بنية الخطوط (Fig. 5.31)

Identification

- Two dark bands stretching along body joined anterior to gill slit. Lower band with faint colour. Abdomen with small and dark spots. Dark stripes on caudal fin and dark spots at its base (Smith and Heemstra 1986).

World Distribution It is distributed in the Indo-West Pacific region along the east coasts of Africa (Smith and Heemstra 1986) and eastward to Hawaii, Japan, and northwestern coasts of Australia (Allen and Swainston 1988).

Distribution in the Study Area There is no record of this species from the Arabian-Persian Gulf (Randall 1995), but it has been reported from the southern coasts of the Arabian peninsula (Manilo and Bogorodsky 2003).

Habitat and Ecological Role This marine species lives in association with coral reefs at depths ranging from the surface down to 350 m (Randall 1995).

Biology Not much has been published about the biology and behaviour of this species.

Conservation Status Not evaluated.

Chelonodon patoca (Hamilton 1822)
Common name: Milkspotted puffer
Arabic name: فقه بيضاء النقاط (Fig. 5.32)

Identification

- Body with patches of spicules extending from back of interorbital space to dorsal fin.
- Other patches on throat and abdomen.
- Anal fin originates below midbase of dorsal fin.
- Body mainly brownish with large white spots (Randall 1995).

World Distribution It is distributed in the Indo-Pacific region from east African coasts to China and Australia. (Froese and Pauly 2016).

Distribution in the Study Area It has been recorded from the Arabian-Persian Gulf, but not from the southern coasts of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecological Role This marine species enters fresh and brackish waters and lives in association with reefs (Reide 2004). It is found at depth range 4–60 m (Fricke et al. 2011).

Biology Not much has been published on the biology and behaviour of this species.

Fig. 5.31 Brown-lined puffer, *Canthigaster rivulata* (Temminck & Schlegel, 1850). Courtesy of Hiroyuki Motomura, Japan

Fig. 5.32 Milkspotted puffer, *Chelonodon patoca* (Hamilton, 1822). Courtesy of Hiroyuki Motomura, Japan

Fig. 5.33 Lunartail puffer, *Lagocephalus lunaris* (Bloch & Schneider, 1801). *Side view*. Courtesy of Jeremy Yip, Singapore

Conservation Status Not evaluated.

Lagocephalus lunaris (Bloch and Schneider 1801)
Common name: Lunartail puffer
Arabic name: فقه ذات الذنب القمي
Etymology: *Lagocephalus*: Greek, lagos = hare + Greek, kephale = head (Figs. 5.33 and 5.34)

Identification

- Two lateral lines.
- Spicules on dorsal side of head and another batch below eye.
- Tapered caudal peduncle.
- Pectoral fin opposite gill slit. Pointed dorsal and anal fins.
- Body grey with dark marking on dorsal side. Yellowish caudal fin with lower half bluish in colour (Randall 1995).

World Distribution It is distributed in the Indo-West Pacific region from the Red Sea to the Arabian-Persian Gulf. It is distributed southward to the east coasts of Africa and eastward to Japan and Australia (Randall 1995).

Fig. 5.34 Lunartail puffer, *Lagocephalus lunaris* (Bloch & Schneider, 1801). *Anterior view*. Courtesy of Jeremy Yip, Singapore

Fig. 5.35 Silver-cheeked toadfish, *Lagocephalus sceleratus* (Gmelin, 1789). Courtesy of Robert Patzner, Austria

Distribution in the Study Area It is recorded from the eastern and southern coasts of the Arabian peninsula.

Habitat and Ecological Role This marine species enters brackish water and sometimes prefers demersal habitat (Reide 2004).

Biology There is not much information about the biology and behaviour of this species.

Conservation Status Not evaluated.

Lagocephalus sceleratus (Gmelin 1789)
Common name: Silver-cheeked toadfish
Arabic name: فقه فضية الخدود
Etymology: *Lagocephalus*: Greek, lagos = hare + Greek, kephale = head (Figs. 5.35 and 5.36)

Identification

- Elongated body.
- Long and tapering caudal peduncle.
- Base of dorsal and anal fins narrow.
- Presence of two lateral lines.
- Presence of small spinules on head and on body near caudal fin.
- Body greenish with small dark spots on dorsal side. Abdomen silvery white. Bright silvery band on side (Randall 1995).

Fig. 5.36 Silver-cheeked toadfish, *Lagocephalus sceleratus* (Gmelin, 1789). Courtesy of Hamid Osmany, Pakistan

World Distribution It is distributed in the Indo-West Pacific region (Smith and Heemstra 1986) and Lessepsian migrant to the Mediterranean Sea (Akyol et al. 2005).

Distribution in the Study Area This species of puffer has been reported from the Arabian-Persian Gulf and the Sea of Oman (Randall 1995), but not found in the southern coasts of the Arabian peninsula (Manilo and Bogorodsky 2003).

Habitat and Ecological Role This is a marine species living in association with reefs at depth range 18–100 m (Randall 1995).

Biology There is not much information about the biology and behaviour of this species.

Economic Value No commercial value is present due to the presence of toxin.

Conservation Status Not evaluated.

Family: Diodontidae
Chilomycterus reticulatus (Linnaeus 1758)
Common name: Spotfin burrfish
Arabic name: فقهه منقطه
Etymology: *Chilomycterus:* Greek, cheilos = lip + Greek, mykter, -eros = nose (Figs. 5.37 and 5.38)

Identification

- Body colouration represents the characteristic features of this species. Adults grey to brown with black gular band and small black spots on upper surfaces and fins; pelagic juveniles blue with dark spots above; spots descending to belly (Leis 1986).

World Distribution This species has a circumtropical type of distribution.

Distribution in the Study Area It has been reported from the Arabian Sea coasts of Oman only (Manilo and Bogorodsky 2003).

Habitat and Ecological Role This marine species lives in association with reefs at depth range 20–100 m (Leis 1986).

Biology There is no biological information available about this species. At night, individuals have been shown to attach themselves against substrate to sleep (Fitch and Lavenberg 1975). They are active during the day. The solitary juvenile living a pelagic life in the oceanic surface water (Sommer et al. 1996). It feeds on invertebrates with hard shells.

Economic Value No commercial value.

Fig. 5.37 Spotfin burrfish, *Chilomycterus reticulatus* (Linnaeus, 1758). Courtesy of Open Cage, Japan via Wikimedia commons CC By SA-2.5

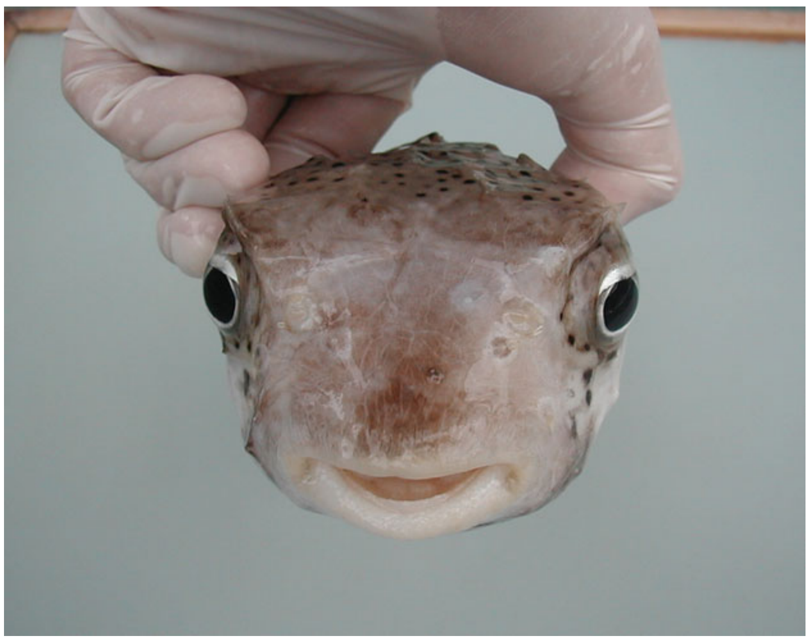

Fig. 5.38 Spotfin burrfish, *Chilomycterus reticulatus* (Linnaeus, 1758). Courtesy of Pedro Niny Duarte, Portugal

Conservation Status Not evaluated.

Cyclichthys orbicularis (Bloch 1785)
Common name: Birdbeak burrfish
Arabic name: فقهة منقار الطير
Etymology: *Cyclichthys*: Greek, kyklos = round + Greek, ichthys = fish (Fig. 5.39)

Identification

- Body with rooted immovable short spines. Absence of spines form caudal peduncle.
- Absence of fleshy tentacles.
- Rounded dorsal, anal, and caudal fins.
- Body brownish grey dorsally and white ventrally. Band of black spots anterior to dorsal fin. Few black spots behind eye.

Fig. 5.39 Birdbeak burrfish, *Cyclichthys orbicularis* (Bloch, 1785). Courtesy of Karen Honeycutt, Manhattan, USA

World Distribution It is distributed in the Indo-West Pacific region from the Red Sea and southward to the east African coasts and eastward to the Philippines, Japan, Australia, and New Caledonia (Leis 2001). It is also reported from the south coasts of South Africa (Leis 1986).

Distribution in the Study Area It is reported from the eastern and southern coasts of the Arabian Peninsula.

Habitat and Ecological Role It is a marine species living in association with reefs at depth 9–170 m (Sommer et al. 1996).

Biology There is not much information about the biology and behaviour of this species.

Economic Value No commercial value except for limited sales of the inflated skin of this fish for tourists.

Conservation Status Not evaluated.

Cyclichthys spilostylus (Leis and Randall 1982)
Common name: Spotbase burrfish
Arabic name: فقهه منقطه

Etymology: *Chilomycterus*: Greek, cheilos = lip + Greek, mykter, -eros = nose (Fig. 5.40)

Identification

- Body with short spines.
- No spines on caudal peduncle.
- Adults with black spots on sides and belly, the spots associated with spine bases.
  (Randall 1995).

World Distribution It is distributed in the Indo-West Pacific region from the Red Sea at the north to South Africa in the south and eastward to southern Japan, the Philippines, Australia, and New Caledonia (Leis 1986).

Distribution in the Study Area This species is reported from the Sea of Oman (Randall 1995). Manilo and Bogorodsky (2003) recorded it from the Arabian Sea coasts of Oman.

Habitat and Ecological Role This marine species lives in association with reefs at depth range 3–90 m (Sommer et al. 1996).

Biology No biological information available.

Economic Value No commercial value.

Fig. 5.40 Spotbase burrfish, *Cyclichthys spilostylus* (Leis & Randall, 1982). Courtesy of Jon Hanson London, via Wikimedia commons CC By SA-2.0

Fig. 5.41 Longspined porcupinefish, *Diodon holocanthus* Linnaeus, 1758. Courtesy of Robert Patzner, Austria

Conservation Status Not evaluated.

Diodon holocanthus (Linnaeus 1758)
Common name: Longspined porcupinefish
Arabic name: فقه طويلة الشوكه
Etymology: *Diodon:* Greek, di = two + Greek, odous = teeth (Figs. 5.41 and 5.42)

Identification

- Mixed types of spines, rooted and erectile. Spines form a row in front of snout. Absence of spines from caudal peduncle.
- Pair of short tentacles on chin.
- Body with olive colour turning to light brown dorsally. Numerous small dark spots on back.

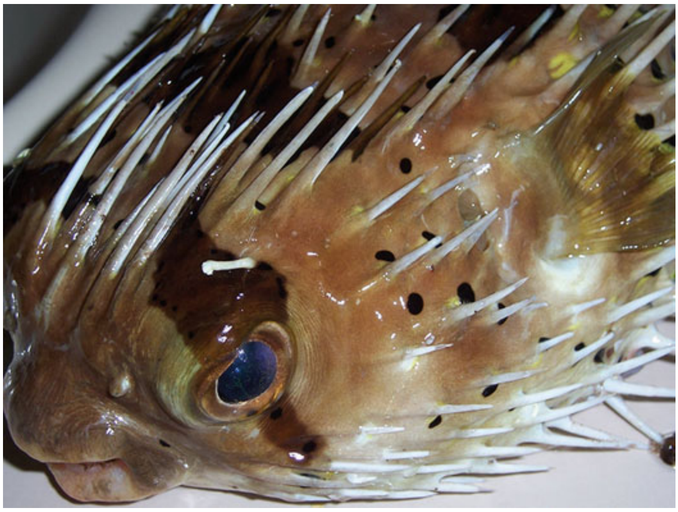

Fig. 5.42 Longspined porcupinefish, *Diodon holocanthus* Linnaeus, 1758, Spines. Courtesy of Bing Ramous, Philippine

Abdomen white. Large oval dark spot above pectoral fin.

World Distribution This species of puffer has a circumtropical type of distribution. It is found in western and eastern Atlantic and western Indian Oceans. It is also reported from the Pacific Ocean. (For references on distribution see Froese and Pauly 2016.)

Distribution in the Study Area It is reported from the eastern and southern coasts of the Arabian Peninsula (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecological Role This marine species lives in association with coral reefs and is found at depths 2–200 m (Scott and Scott 1988).

Biology Individuals of this species are sometimes found in groups (Kuiter and Tonozuka 2001). They feed on mollusks, sea urchins, and hermit crabs (Leis 2001).

Economic Value They are used to manufacture some Chinese medicines (Tang 1987).

Conservation Status Not evaluated.

Diodon hystrix (Linnaeus 1758)
Common name: Spot-fin porcupinefish
Arabic name: السمكه القنفذيه مقطة الزعنفه
Etymology: *Diodon:* Greek, di = two + Greek, odous = teeth Spot-fin porcupinefish (Figs. 5.43 and 5.44)

Identification
- Body strong.
- Teeth united in each jaw without central division.
- Long and sharp spines covering body. Caudal and abdomen areas spiny.
- Body greyish tan colour, with small black spots. Abdomen white (Jiménez Prado and Béarez 2004; Smith 1997).

World Distribution This species has a circumtropical type of distribution (Froese and Pauly 2016).

Distribution in the Study Area It has been reported from the southern coasts of the Arabian Peninsula only (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecological Role It is a marine species living in association with reefs at depth range 2–50 m (Leis 2001), but usually at 3–20 m (Gasparini and Floeter 2001).

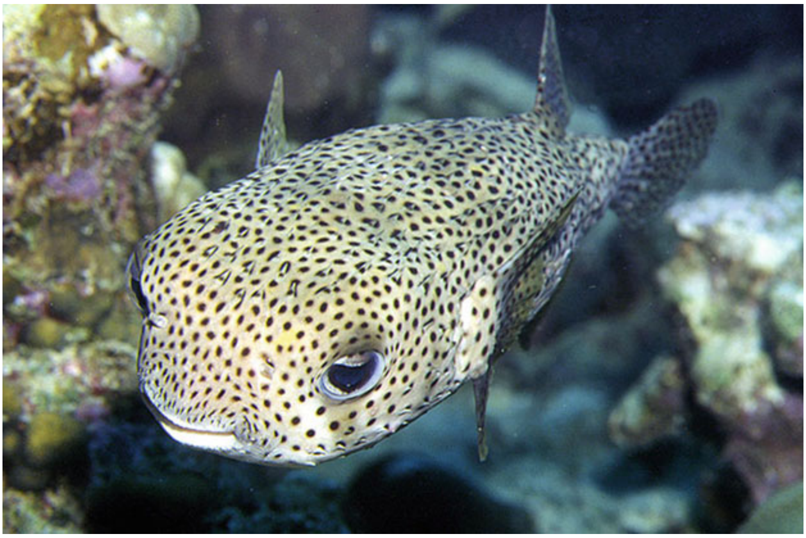

Fig. 5.43 Spot-fin porcupinefish, *Diodon hystrix* Linnaeus, 1758. Courtesy of Robert Patzner, Austria

Fig. 5.44 Spot-fin porcupinefish, *Diodon hystrix* Linnaeus, 1758. Courtesy of Hamid Osmany, Pakistan

Biology Individuals of this species prefer visiting caves and holes in shallow reefs (Smith 1997; Kuiter and Tonozuka 2001). They are solitary and feed at night on hard-shelled invertebrates such as sea urchins, gastropods, and hermit crabs (Leis 2001).

Economic Value No commercial value.

Conservation Status Not evaluated.

Diodon liturosus (Shaw 1804)
Common name: Black-blotched porcupinefish
Arabic name: فقه هذات بقع سوداء
Etymology: *Diodon:* Greek, di = two + Greek, odous = teeth (Fig. 5.45)

Identification

- Body colouration is a characteristic feature. Several yellow-edged dark blotches on body (Masuda et al. 1984).

World Distribution It is distributed in the Indo-Pacific region from the coasts of east Africa and eastward to the Society Islands, north and south of Japan and New South Wales (Froese and Pauly 2016).

Fig. 5.45 Black-blotched porcupinefish, *Diodon liturosus* Shaw, 1804. Courtesy of Nick Hobgood, Australia via Wilimedia commons CC BY SA-3.0

Distribution in the Study Area It is reported from the southern coasts of the Arabian Peninsula (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecological Role This marine species lives in association with reefs at depth range 1–90 m (Myers 1999), but usually 15–30 m (Leis 2001).

Biology Individuals of this species prefer to hide during the day and feed during the night. They are solitary and feed on crustaceans and mollusks (Leis 2001; Kuiter and Tonozuka 2001).

Economic Value No commercial value.

Conservation Status Not evaluated.

Lophodiodon calori (Bianconi 1854)
Common name: Four-bar porcupinefish
Arabic name: فقهه ذات الأربع خطوط
Etymology: *Lophodiodon*: Greek, lophos = crest + Greek, odous = teeth (Fig. 5.46)

Identification

- Body colouration characterises this species. Body covered with small white spots. Mouth black; black bar below eye. Big blotch anterior to base of pectoral fin. Fin with no spots (Randall 1995).

World Distribution It is distributed in the Indo-Pacific region.

Distribution in the Study Area It has been reported from both the Sea of Oman (Files, in Froese and Pauly 2016) and from Arabian Sea coasts of Oman (Randall 1995).

Biology No biological information is available.

Economic Value No commercial value.

Conservation Status Not evaluated.

Family: Molidae
Masturus lanceolatus (Liénard 1840)
Common name: Sharptail mola
Arabic name: سمكة الشمس حادة الذنب
Etymology: *Masturus:* Greek, mastax, -agos = bite + Greek, oura = tail (Fig. 5.47)

Identification

- Oval and laterally compressed body.
- Mouth small.

Fig. 5.46 Four-bar porcupinefish, *Lophodiodon calori* (Bianconi, 1854). Courtesy of Bajoelmar, Spain via Wkimedia common BY-SA 3.0

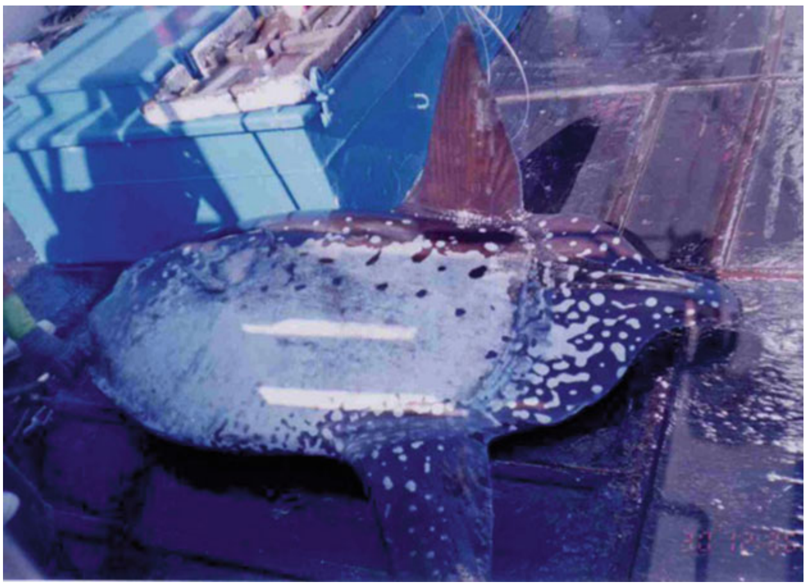

Fig. 5.47 Sharptail mola, *Masturus lanceolatus* (Liénard, 1840). Courtesy of Santiago Montealegre Quijano, Brazil

- Oval gill openings, situated slightly above and forward of pectoral fin origin.
- Upper middle rays of caudal fin elongate. Coarse granular scales on head and body extending to bases of dorsal, anal, and caudal fins.
- Band of scaleless skin divides body scales from smaller granular scales of fins.
- Body blue-grey above, silvery laterally, and white ventrally. Vertical fins blue-black (Paulin et al. 1982).

World Distribution This species has a circumglobal type of distribution in tropical to subtropical waters (Parenti 2003; Froese and Pauly 2016). It has a broad distribution in the western Atlantic, occurring from Nova Scotia to southeastern Brazil (Klein-MacPhee 2002; Menezes 2003).

Distribution in the Study Area This species has been reported from the Sea of Oman (Jawad et al. 2012).

Habitat and Ecological Role This marine species enters brackish water but prefers a bathypelagic environment at depths ranging from the surface down to 670 m (Figueiredo and Menezes 2000).

Biology Due to the large depth that this species lives in, it is nearly impossible to study their biology and behaviour.

Economic Value The skin of this species might be useful for leather industries. It is taken as a food in some parts of its range extension.

Conservation Status Not evaluated.

Mola mola (Linnaeus 1758)
Common name: Ocean sunfish
Arabic name: سمكة الشمس المحيطيه
Etymology: *Mola:* Latin, mola, -ae = stone mill; because of the shape of this fish (Figs. 5.48, 5.49, and 5.50)

Identification

- Body naked and extremely thick and elastic.
- Rudder-like structure known as 'clavus' replaces caudal fin. Long dorsal and anal fins. Small and round pectoral fin.
- Small mouth with teeth fused together forming a structure similar to parrot beak.
- Gill opening reduced to small hole at base of pectoral fin (Hart 1973).

World Distribution It is distributed in the warm and temperate areas of the world oceans. (For distribution references see Froese and Pauly 2016.)

Distribution in the Study Area This species has been recorded from the Arabian-Persian Gulf (Al-Baz et al. 1999) but not from the southern coasts of the Arabian peninsula. Recently it has been recorded from the Sea of Oman (Jawad 2013).

Habitat and Ecological Role This marine species prefers a pelagic-oceanic environment with an oceanodromous habit (Reide 2004). It is found at depth range 30–480 m (Fricke et al. 2011).

Biology Individuals of this species are usually shy, but may become familiar with divers (Kuiter and Tonozuka 2001). They often drift at the surface while lying on their sides. Females are larger than males (Pope et al. 2010). This species feeds on fishes, mollusks, zooplankton, jellyfish, crustaceans, and brittle stars. The sunfish is registered as the heaviest bony fish and as the

Fig. 5.48 Ocean sunfish, *Mola mola* (Linnaeus, 1758). Courtesy of Joo Park, Korea

Fig. 5.49 Ocean sunfish, *Mola mola* (Linnaeus, 1758), fish market. Courtesy of Joo Park, Korea

Fig. 5.50 Ocean sunfish, *Mola mola* (Linnaeus, 1758), skeleton. Courtesy of Sandstein, Germany

one with the most eggs in the *Guinness Book of World Records* (Foot 2000).

Economic Value The meat of the sunfish can be eaten fresh or broiled (Frimodt 1995). It also used in Chinese medicine (Tang 1987).

Conservation Status Not evaluated.

Mola ramsayi (Giglioli 1883)
Common name: Southern sunfish
Arabic name: سمكة الشمس الجنوبية
Etymology: *Mola:* Latin, mola, -ae = stone mill; because of the shape of this fish (Fig. 5.51)

Identification

- Body scaleless, but covered by one layer of mucus.
- Caudal fin replaced by a rudder-like structure called a clavus. Dorsal and anal fins similar in shape, positioned far back on body with short base.
- Pectorals small and directed upward.
- Mouth very small; teeth fused to form parrot-like beak.
- Gill openings reduced to small hole at base of pectoral fins.

Fig. 5.51 Southern sunfish, *Mola ramsayi* (Giglioli, 1883). Courtesy of Molly Varghere, India

- Clavus supported by 16 rays, 12 of which bear ossicles; ossicles much broader than spaces between them, forming the margin of the clavus; those situated on paraxial rays separate much smaller than others.
- No band of reduced denticles between dorsal and anal fins.
- Body grey silver or coffee dark, with darker spots; white belly with dark spots.

Fraser-Brunner (1951) suggested that *Mola ramsayi* differs from *M. mola* in the following set of characters: (1) skin smooth with no denticles and no band of reduced denticles between dorsal and anal fins; (2) ossicles close together, much broader than spaces between them; and (3) clavus supported by about 16 fin rays, of which 12 bear ossicles.

World Distribution The known distribution of *M. ramsayi* is in the southern oceans, southwest Pacific, Australia and New Zealand, southeast Pacific, Chile and southeast Atlantic, and South Africa.

Distribution in the Study Area Al-Ghais (1994) recorded this species from the eastern coasts of the United Arab Emirates at the northern part of the Sea of Oman. Yasemi and Bejgan (2014) recorded this species from the northern part of the Sea of Oman (Iranian side) and Jawad et al. (2012) reported *M. ramsayi* from the Omani side of the Sea of Oman.

Habitat and Ecological Role This marine species prefers a pelagic-oceanic habitat and lives at depths ranging from the surface to 300 m (Fricke et al. 2011).

Biology Due to the large depth that this species lives in, it is nearly impossible to study their biology and behaviour.

Economic Value No commercial value is present for this species.

Conservation Status Not evaluated.

Ranzania laevis (Pennant 1776)
Common name: Slender sunfish
Arabic name: سمكة الشمس المستطيل
Etymology: *Ranzania*: Because of Camillo Ranzani, 1775–1841, Catholic priest and naturalist (Fig. 5.52)

Identification

- Postlarval stage has caudal fin, but resorbed during metamorphosis and replaced by clavus (Heemstra 1986).
- Elongated body and mouth in a form of vertical slit (Muus and Nielsen 1999).

World Distribution This species of sunfish has a cosmopolitan distribution. (See Froese and Pauly (2016) for reference on distribution.)

Distribution in the Study Area It has been recorded from the Sea of Oman (Jawad et al. 2010) and from the Arabian-Persian Gulf (Jawad et al. 2011), but no record from the southern coasts of the Arabian peninsula.

Fig. 5.52 Slender sunfish, *Ranzania laevis* (Pennant, 1776). Courtesy of Hiroyuki Motomura, Japan

Habitat and Ecological Role This marine species prefers a pelagic-oceanic environment and is found at depth 1–140 m (Mundy 2005).

Biology Not much information is available about the biology and behaviour of this species.

Economic Value No commercial value.

Conservation Status Not evaluated.

5.2 Ichthyootoxic Fishes

This type of intoxication is less known compared with the other well-known poisonings such as ciguatera and tetrodontoxism. In fish species causing ichthyootoxication, the poison is restricted to the gonads, where there is a certain relationship between gonad activity and toxin production. Freshwater species are mainly the source of this poisoning, but there are some other anadromous, brackish water or marine species that fall under this category.

Background

Although ichthyootoxism is a lesser-known poisoning, it is one of the oldest known intoxications. Since 1491 it has been reported in Europe that the ingestion of the roe of the cyprinid fish *Barbus barbus* will cause a case of poisoning (Halstead 1967). Francii (1683) reported on a case of a pregnant woman who became very ill after eating a large amount of gravid barbel. Cases of poisoning after eating roe of American gar were reported by Brooks (1850), Coker (1929), and Taft (1945). Because the poisoning occurs during the breeding season of the barbels, this fish is prohibited from sale during the reproductive cycle (Meyer-Ahrens 1855). Toxic substances were extracted from the milt of some fish species such as salmon and called 'salmin,' from *Acipenser sturio*, 'sturin,' and from *Cyprinus carpio*, 'cyprinin' (Knox 1888). A trial on the effect of pike and barbel roe was done on dogs and rabbits by Kossel (1896) and showed sensory disturbances, respiratory and muscular paralysis, and finally death. In 1921, McGrudden wrote on the chemistry and toxicity of roe poisons and he believed at that time it was 'sapotoxins.' Among the marine species whose roe was found to be toxic is a species of groupers found at the coast of Ecuador (Halstead and Schall 1955). Outbreaks of poisoning due to eating marine fishes at Mori, Japan during 1952–1953 were reported by Takayanagi et al. (1953; cited by Asano and itoh 1962). Ichthyootoxin was found to harbor a lipoprotein called 'dinogrunellin' as a result of investigations done by Asano and Itoh (1962).

Causative Agent

Polysaturated fatty acids found in aquatic organisms originate mainly from the food chain, which in turn come from plankton-type organisms (Mancini et al. 2011). The polyunsaturated fatty acids are used by aquatic organisms to adapt themselves in cold environments by increasing membrane fluidity and preventing any tendency to crystallise (Jütter 2001). In species of the genus *Barbus* (Family: Cyprinidae), there are high concentrations of polyunsaturated fatty acids (u3 and u6) originating from the food chain (Aras et al. 2009). Regardless of their beneficial contribution to human health, high concentrations of free unsaturated fatty acids have been reported to induce toxic effects in higher invertebrates and humans as some of them cause haemolysis, which could be responsible for icthyotoxicity by accumulating in fish (Fu et al. 2004). It was found that the toxicity of unsaturated fatty acids was up to eightfold higher than that of saturated ones, the most toxic being linolenic acid (C18:3 u3), AA (20:4 u6), and EPA (C20:5. u3). Arachidonic acid, which is abundant in the extract of roe of the barbel has haemolytic and cytotoxic activities (Mancini et al. 2011).

Symptoms
There is a set of symptoms given by Halstead (1967) that the patient showed after eating the roe of the causative fish species, including: abdominal pain, nausea, vomiting, diarrhoea, dizziness, headache, fever, bitter taste, dryness of the mouth, intense thirst, sensation of constriction of the chest, cold sweats, rapid irregular weak pulse, low blood pressure, cyanosis, pupillary dilatation, dysphagia, and tinnitus. In severe cases and before death occurs, muscular cramps, paralysis, convulsions, and coma are usually experienced by victims.

Treatment
The main treatment step to be taken is to evacuate the stomach of the patient. The remaining treatment steps are symptomatic. The treatment of ichthyootoxin is different from ciguatoxin or tetrodontoxin.

5.2.1 Ichthyootoxic Fish Species

The fish species responsible for the ichthyootoxism are mainly freshwater. In the east and southern coasts of the Arabian peninsula, those species are not native, but they are found in river drainages to the Arabian-Persian Gulf. Because these species have high food value, frozen or even fresh specimens are usually sold in the fishmarkets and supermarkets of the cities in the coastal areas of the Arabian-Persian Gulf and in Yemen. Therefore, to become intoxicated by eating these fishes is highly possible.

Order: Cypriniformes
Family: Cyprinidae
Carasobarbus luteus (Heckel 1843)
Common name: Yellow barb
Arabic name: حمري
Etymology: *Carasobarbus:* Latinisation of, karass, karausche, European crucian carp + Latin, barbus = barbel (Fig. 5.53)

Identification
- Deep body with arched dorsal side.
- Snout blunt.
- Posterior barbels present.
- Last dorsal ray spinified in its lower side (Ekmekçi and Banarescu 1998).

World Distribution The distribution of this species is confined to Asian freshwater systems. It is found in Tigris, and rivers in Iran and Syria (Froese and Pauly 2016).

Fig. 5.53 Yellow barb, *Carasobarbus luteus* (Heckel, 1843). Courtesy of Borkenhagen K. and Krupp, F., via Wikimedia commons CC By 3.0

Distribution in the Study Area This species is a freshwater inhabitant, and fresh specimens are usually sold in fishmarkets and supermarkets of the coastal cities in Iran, Arabian-Persian Gulf countries, and in Yemen.

Habitat and Ecological Role It is a freshwater species preferring a benthopelagic habitat in temperate regions (Froese and Pauly 2016).

Biology The largest specimen obtained was 380 mm in total length and 500 g in weight (Najafpour and Coad 2002). In Iraq, the spawning of this species occurs from April to July (Epler et al. 1996).

Economic Value It has a high commercial value and is used as a food source in the areas of its distribution.

Conservation Status This species has been assigned the Least Concern criterion in the Red List of the IUCN for the reasons stated by (Freyhof 2014): 'This species is very widespread and often abundant even in heavily impacted water bodies.'

Cyprinus carpio (Linnaeus 1758)
Common name: Common carp
Arabic name: الكارب الأعتيادي
Etymology: *Cyprinus*: Latin, cyprinus = carp; *carpio: carpio* is the Latinised form of carp (Ref. 1998). *Cyprinus* is the old world name for the carp (Fig. 5.54)

Identification

- Two pairs of barbels.
- Deeply emarginated caudal fin.
- Robust molar-like pharyngeal teeth.
- Large scales on body.
- Large variation in shape, squamation, and colour.
- Last simple anal ray bony and serrated posteriorly (Kottelat and Freyhof 2007; Spillman 1961; Kottelat 2001).

World Distribution This species is distributed in the river systems of both Europe and Asia. It is also introduced throughout the world (Froese and Pauly 2016).

Distribution in the Study Area Although this species is a freshwater inhabitant, fresh specimens are usually sold in fishmarkets and supermarkets of the coastal cities in Iran, Arabian-Persian Gulf countries, and Yemen.

Habitat and Ecological Role This freshwater species sometimes enters brackish water but prefers a benthopelagic environment living at depth range 10–15 m (Reide 2004).

Biology Adults prefer deep and slow-flowing waters (Kottelat and Freyhof 2007). They tolerate a wide variety of environmental conditions and can stand turbid water (Scott and Crossman 1973). Individuals are active at both dusk and dawn and feed on a variety of benthic organisms

Fig. 5.54 Common carp, *Cyprinus carpio* Linnaeus, 1758. Courtesy of Mustafa Al-Mukhtar, Iraq

and plant materials. Adults migrate for long distances for spawning (Kottelat and Freyhof 2007).

Economic Value It has a high commercial value as it is considered a source of food. It is utilised fresh and frozen (Frimodt 1995). It is widely used in aquarium industries.

Conservation Status This species is given a Vulnerable criterion in the Red List of IUCN for the reasons stated by Freyhof and Kottelat (2008):

> The native populations (Black, Caspian and Aral Sea basins) are slowly but continuously declining due to river regulation. Also hybridisation with domesticated introduced stocks, East Asian congeners and their hybrids, is a serious long-term threat for the species. However, superficially pure carp (currently it is impossible to identify pure carp by genetic analysis) are still abundant in the lower parts of rivers within its native range. Most likely, only very few stocks remain 'genetically unpolluted' as a result of this long-lasting process. The average age of the spawners is estimated to be between 20 and 25 years, as they are a long-lived species (up to 50 years). Although no population data exist, it is suspected that in the past 60–75 years within the species' native range, river regulation (due to channelisation and dams), which impacts the species as they need flooded areas at very specific times to successfully spawn, and hybridisation with introduced stock, has caused a population decline of over 30%.

Order: Siluriformes
Family: Siluridae
Silurus glanis (Linnaeus 1758)
Common name: Wels catfish
Arabic name: جري
Etymology: *Silurus:* Greek, silouros = a cat fish + Greek, odous = teeth (Fig. 5.55)

Identification

- Elongated and laterally compressed body.
- Snout rounded, flattened with widely spaced nostrils anterior to olfactory cavities (Mihálik 1995).
- Head broad, triangular-shaped (Černý 1988) with small eyes.
- Mouth large, with two very long, slender, flexible cartilaginous barbs on upper jaw (Mukhamediyeva and Sal'nikov 1980) and four short, flexible barbs below lower jaw (Davies et al. 2004).
- Body naked and covered with mucus that contains sensory cells and participates in exchange of gasses during respiration (Mihálik 1955; Davies et al. 2004).

Fig. 5.55 Wels catfish, *Silurus glanis* Linnaeus, 1758. Courtesy of Brian Coad, Canada

- Pectoral fin strong situated behind gill cover. Very small pelvic fins located near anal opening (Mukhamediyeva and Sal'nikov 1980). Moderate size caudal fin, with rounded shape and cut off at end. Absence of adipose fin. Dorsal fin very small equipped with hard first ray (Maitland and Campbell 1992; Greenhalgh 1999; Davies et al. 2004; Copp et al. 2009).
- Body pigmentation varies to match habitat. In general, body dark colour, marbled sides, and greyish white abdomen.

World Distribution It is distributed in both Europe and Asia. It has been introduced in several countries around the world (Froese and Pauly 2016).

Distribution in the Study Area This species is found in the freshwater system of Iran and sold frozen in supermarkets of the coastal cities in Iran for foreigners as this fish is not eaten by Shiat Muslims, the majority in Iran.

Habitat and Ecological Role This freshwater species sometimes enters brackish water but prefers benthopelagic habitat and lives at depth range from surface down to 30 m (Frimodt 1995).

Biology The dimensions and position of fins indicate that the species lives predominantly on the bottom (Mihálik 1995). This species hibernates during winter in deep holes and crevices in the bed of the river (Lelek 1987). The species does not have high oxygen requirements (Lelek 1987). It is able to withstand prolonged periods of hypoxia depending on water temperature (Massabuau and Forgue 1995). It can use small amounts of oxygen efficiently due to low haemoglobin concentration (Mihálik 1995), which also makes it relatively tolerant of pollution (Lelek 1987). It is capable of surviving under different climates and water temperature regimes, indicating a tolerance of relatively low temperatures (Hilge 1985). It is more active during nighttime than daytime (Pohlmann et al. 2001; Carol et al. 2007a, b).

Economic Value This species has a high commercial value as it is used as a source of food.

Conservation Status This species has been given the Least Concern criterion in the IUCN Red List for the reasons as suggested by Freyhof and Kottelat (2008): a widespread species with no known major widespread threats. However, the species is locally threatened due to river regulation destruction of shallow spawning sites.

5.3 Ichthyogallotoxic Fishes

The ichthyogallotoxin is a type of ichthysarcotoxin, where the poison is confined to the bile of the gallbladder of the fish. This toxin is found in certain freshwater fish species of the family Cyprinidae. People are exposed to ichthyogallotoxin through their traditional medicine practices, where they believe that the bile of these fish species can cure several diseases.

Background

The habit of eating fish gallbladder is practiced in India and other East Asian countries including China (Pandey et al. 2014). In India and East Asian countries except China, the history of this practice is not well documented. People of the Assam region, India usually consume the roe and gallbladder of the cyprinid fish Rohu (*Labeo rohita*) believing that it is good for health, improves vision, and cures rheumatism (Bhattacharyya et al. 2009; Pandey et al. 2014) and some young people especially in Barak valley ingest the gallbladder for fun and for challenge (Das et al. 2015). Rohu (*Labeo Rohita*) is a cyprinid species (carp family) living in fresh water in South Asia. It is treated as a delicacy in India, Bangladesh, and Nepal. In the northeastern part of India it is a common observation that people take fish gallbladder as remedies for fever and as a food supplement to improve strength (Jamil et al. 2013).

The history of ingestion in China of fish gallbladder in particular and of other animals including humans in general was reviewed in detail by Wang and Carey (2014). They wrote: 'It is possible to trace the history of using animal bile as a drug to the beginning of the Qin dynasty (c. 221 BCE).' In the winter of 1973, medical writings were unearthed from an ancient tomb at Mawangdui in Hunan Province. In this excavation most of the medical inscriptions were written on silk fragments, and a minority on bamboo cuttings (Shi 1992; Hu 1986; Zhong and Li 1975). The texts of the manuscripts contained no titles, but the transcribing paleographers (RGCMMB 1975) accorded them the following names: (1) Moxa manual of the 11 tracts on the upper and lower limbs; (2) Moxa manual of the 11 tracts according to the Yin and Yang; (3) Method of taking the pulse; (4) Fatal prognoses determined by the Yin and Yang; and (5) Prescriptions for 52 types of diseases (*Wu Shi Er Bing Fang*). The latter probably represented the earliest extant writings of Chinese medical prescriptions (c. 475–221 BCE) and included 291 prescriptions for the treatment of the 52 categories of disease. The earliest recorded monograph on materia medica in China, Shen Nong's *Herbal Classic*, which appeared in the years c. 475–206 BCE, recorded the use of common carp bile as a drug in addition to dog and ox biles. Therefore, these paleo-archaeological discoveries provide irrefutable evidence that animal biles have been employed therapeutically for more than 2500 years in China, with dog and ox biles being the first to be used, followed closely by common carp bile. In general in the East Asian countries and especially in traditional Chinese medicine, top-grade bear bile has been valued 'more than gold' principally for its preventative as well as therapeutic efficacy, because can be utilised widely in treating patients from several diseases (Wang and Carey 2014).

Wang and Carey (2014) wrote about the bile of three carp species that the Chinese used to cure diseases. The black carp bile was used to treat acute conjunctivitis and ophthalmalgia. Pills of fish biles were compounded with biles of black carp and common carp (Li 1957; JNMC 1977; Meng 1934). The pills were swallowed with tea to treat various kinds of ophthalmopathies such as optic atrophy, cataract, nebulae, and glaucoma. Black carp bile was believed to be effective in treating herpetic ulcers (cold sores), malignant boils ('rodent ulcers'), tonsillitis, pharyngitis, as well as fish bones struck in the throat (Wang and Carey 2014). The grass carp bile was used in treating diseases of the pharynx, especially acute pharyngitis. This bile was used in cases of emergency after mixing with wine and gargled by patients with a fishbone or other foreign body stuck in the throat or esophagus (Li 1957). The crucian carp bile was utilised externally to treat chancres, vulval erosions, and pruritus vulvae. Because bile of the crucian carp could also expel intestinal worms, it was effective in the treatment of abdominal pain caused by intestinal parasites, especially in children (Li 1957). This bile was used to soften fish bones and pieces of wood including bamboo stuck in the throat or esophagus, thereby allowing them to slide into the stomach. Wang and Carey (2014) gave the following other usage of crucian carp bile: it is used in treating carbuncles of the head in malnourished infants. Together with pumice stone (volcanic rocks composed of 65–75% silicon dioxide and 9–20% aluminium oxide), ground gecko or red-spotted house lizard (*Gekko gecko*), and cicada slough (*Cicadidae*), crucian carp bile was employed to treat diabetes mellitus at least as inferred by the combined complaints of polydipsia, polyphagia, and polyuria. Furthermore, in the treatment of deafness, crucian carp bile was placed in the cavity of a scallion (large green onion) together with black donkey fat (*Equus asinus*) and sesame oil (*Sesamum indicum*) for 7 days, and then used as ear drops.

Traditional Chinese medicine including the use of the fish bile entered Japan during the Qin (221–206 BCE) and the Han (206 BCE to 25 CE) dynasties (Nakayama 1931; BCTCM 1978; Otruka et al. 1988). With the turn of the twentieth century, modern medical research on animal biles entered a new era. In 1900–1901, Danish and Swedish explorers led by Amdrup and Kolthoff, respectively, set out to explore Greenland (Vahl et al. 1928). Gallbladders from polar bears (*Thalarctos maritimus*) were obtained and brought back to Hammarsten's laboratory in Uppsala, Sweden. Hammarsten isolated an unknown bile acid from polar bear bile, and named it ursocholeinic acid (Ursocholeinsäure; Hammarsten 1901, 1902).

Collecting, Preserving, and Quality of Gallbladder Biles of Animals

It is interesting to know how the Chinese used to extract bile from the gallbladder of wild animals without killing them. A description of the process of extracting bile from the gallbladder of selected wild and domestic animals are given in this section as stated by Wang and Carey (2014):

> In the southern part of China, the python was often raised mainly for collecting gallbladder bile, and usually bile was collected from the python in the early summer. An adult python was restrained in a wooden 'sandwich' cage and its abdomen was exposed. During a mini-laparotomy, liver and gallbladder were carefully examined. If the python's gallbladder was as large as a duck's head in size, a careful surgical cholecystectomy was accomplished. After the liver was returned to the abdominal cavity, the abdominal incision was closed with silk sutures. Post operation, the python continued to be raised because its muscle meat, subcutaneous fat, and skin could be used to treat other diseases. The fresh gallbladder bile was often dried in a shadowy place away from direct sunlight. If the gallbladder contained dark green coloured bile with a very thin wall and possessed a pleasant sweet and bitter taste, it was categorised as high grade.

In winter, the collection of gallbladder biles from fish such as common carp, grass carp, black carp, murrel, crucian carp, and shark was often carried out (Li 1957; JNMC 1977). These fresh gallbladder biles were dried in a cool place, and stored for later medicinal use.

It is interesting to know how ancient Chinese medical works differentiate authentic bear bile (treasured above all others) from other animal biles (Li 1957). High-quality bear biles spread on the surface quickly, whereas low-quality bile spread slowly when a gallbladder bile sample was dropped upon the surface of water. An additional characteristic for high-quality bear's bile is that it draws a yellow tail when sunk to the bottom of a vessel containing pure water. The bear gallbladder bile is highly valued in traditional Chinese medicine due to its content which is primarily bile acid (Hagey et al. 1993). Bile is collected constantly from bears with chronic biliary fistulae. Such bears were kept individually in iron cages or were kept free-living on bear farms (now illegal in China). After a successful cholecystostomy or choledocotomy under anaesthesia, a bear was placed in a specific, custom-fabricated 'iron-cage' filled with a sterile drainage tube, one end of which was sutured into the common bile duct and the other leading to a glass receptacle firmly holstered externally to the abdominal wall. Usually with the aid of a stopcock, 20–100 mL of bear bile (approximately one third of the daily bile secretion) was collected daily, and dried at 65 °C for 3–4 days. By this means up to more than 36 kg of dilute fistula bile or 1.5 kg of dried bear bile could be obtained each year from one 'free-living' bear (Wang and Li 1991).

Tao Hong-Jing (c. 452–536 CE) in his *Records of Famous Physicians* (c. 510 CE) wrote a description of the pathobiology of ox gallstones (i.e., principally calcium bilirubinate): 'Ox gallstones are mainly obtained from oxen raised in the central regions of China, and are one of the most valued of drugs. An ox suffering from gallstones roars constantly and its body is "luminous" at frightening noise will cause the animal to vomit the gallstones into the basin. These gallstones are called *Sheng Huang* and are the most costly.' Based on stone size and texture, ox gallstones were divided into three kinds. The *San Huang* was composed of small granules like green beans. The *Man Huang* was described as being soft 'like the yolk of a hen's egg,' and was always found in the intrahepatic bile ducts. The *Tuan Huang* was an agglomeration of small stones that varied in size. According to the methods of collecting stones, gallstones were divided into four kinds. The *Sheng Huang* has been described above. The *Zhong Huang* was obtained in slaughterhouses. The *Xin Huang* was obtained at necropsy after a sick ox had died. This stone which was as soft as an egg yolk at first, became hard once it was placed in water. The stones obtained from the intrahepatic bile ducts were called *Gan Huang*. Li Shi-Zhen (1518–1593 CE) in his *Compendium of Materia Medica* (1596 CE) wrote: 'For the ox to form gallstones, it must be diseased'. Only a sick ox suffers from the formation of gallstones and dies easily of their complications. In the present time, artificial ox gallstones or the prepared synthetic calcium bilirubinate salt have been used to treat many thousands of patients with high fever, pneumonia, pyogenic tonsillitis, and bronchitis in China (Chen 1987).

Causative Agent

The bile of the gallbladder of the grass carp, *Ctenopharyngodon idella* contains salt and alcohol composition: taurochenodeoxycholate, taurocholate, taurodeoxycholate, and 5a-cyprinol-26 SO4 (Hagey 1992). The pigments include bilirubin monoglucuronide, biliverdin, phycobilin, and unconjugated bilirubin (Cornelius 1986; Colleran and O'Carra 1977). The bile of crucian carp, *Carassius auratus*, contains salt and alcohol composition: a-cyprinol-26 SO4 (Hagey 1992). Pigment composition includes bilirubin monoglucuronide, biliverdin, phycobilin, and unconjugated bilirubin. For the black carp *Mylopharyngodon piceus*, the bile contains salt and alcohol of 5a-cyprinol-26 SO4 (Hagey 1992) and the pigment composition is bilirubin monoglucuronide, biliverdin, phycobilin, and unconjugated bilirubin (Cornelius 1986; Colleran and O'Carra 1977). The toxin believed to be behind all this nephrotoxicity and hepatotoxicity is cyprinol sulphate or cyprinol, a C27 bile acid (Hwang et al. 2001). It was reported that the toxic effect of 5α-cyprinol sulphate on the kidney functions was more harmful than that of 5-α-cyprinol (Asakawa and Noguchi 2014). On the other hand, there are highly virulent bile toxins in the grass carp bile, which cannot be damaged easily by ethanol or heat. One of the main toxic components is water-soluble sodiumcyprinol sulphate, which can lead to multiple organ dysfunctions (Singh et al. 2004). Poison of the fish bile will affect mainly the kidney and cause renal failure and is the most commonly reported effect of fish bile poisoning (Goldstein et al. 1995). The damage will target the renal tubules, where damage occurs to epithelial cells in the proximal tubule and focal destruction of epithelial cells (Deng et al. 2002). The toxin in fish gallbladder might damage or break lysosomes, meanwhile inhibiting cytochrome oxidase and blocking cellular energy metabolism, thus necrosis of the proximal tubular epithelial cells will result (Pandey et al. 2014). Gallbladder bile of fish can also damage the heart, liver, and gastrointestinal tract and lead to multiple organ dysfunction syndrome (MODS; Deng et al. 2002).

Symptoms

The patient shows initial symptoms such as nausea, vomiting, abdominal cramps, and watery diarrhoea. Oliguria or anuria will appear within 24 h. Another prominent feature of this intoxication is seizure activity, which may result in no permanent neurological deficits. Following the ingestion of the fish gallbladder, a depletion of the extracellular fluid volume is likely to occur due to vomiting and diarrhoea.

Treatment

Patients usually take tablets of sodium bicarbonate three times a day to promote fish bile toxins from the urethra and oral lactulose is given thrice a day to remove fish bile toxins from the intestinal tract. Traditional Chinese medicine (Niaoduqing) may be given to protect renal function. Haemodialysis may be performed several times and dextrose and sodium chloride injections could be given for adequate rehydration. To maintain rehydration and electrolytes, intravenous 10% potassium chloride 15 mL and oral salt capsules are to be administrated.

Prevention

To make a plan to prevent intoxication with gallbladder toxin, an understanding of the factors that lead to this intoxication is necessary. Luyckx (2012) suggested a few factors that contribute to nephrotoxicity. In many cases, incorrect use of traditional medicine may reflect loss of traditional knowledge passed down in villages as a consequence of urbanisation. Coexisting illness is another factor that could easily affect the patient. Alternative remedies are often sought when people feel unwell. Many medications are sought for gastrointestinal or urinary disorders, therefore, significant volume depletion as a result of pre-existing vomiting or diarrhoea, or as a desired effect or side effect of an alternative medicine, may enhance nephrotoxicity. Pharmacokinetics and potential interactions of alternative medicines with many conventional 'western' medications are being increasingly recognised, although limited knowledge of the composition of many remedies makes interactions difficult to predict (De Smet 2002; Chao et al. 2006).

5.3.1 Ichthyogallotoxic Fish Species

The species belonging to this group of poisonous fishes, which are available for consumption by humans in the cities located on the east and southern coasts of the Arabian peninsula are all freshwater. These are: common carp, *Cyprinus carpio*, grass carp *Ctenopharyngodon idella*, silver carp (Silver bighead) *Hypophthalmichthys molitrix*, striped bighead *Hypophthalmichthys nobilis*, and the Indian carp *Labeo rohita*. No species account is given here for the common carp as it has already been given in the previous sections of this book. The Indian carp, *L. rohita*, is not a native species in the freshwater systems adjacent to the Arabian peninsula, but frozen and fresh specimens are usually imported from the Indian subcontinent and sold in supermarkets of the coastal cities in the Arabian-Persian Gulf and the southern part of the Arabian peninsula. The author studied cases of scale abnormalities in specimens of this species bought from a supermarket in Muscat, Sultanate of Oman (Jawad and Al-Mamry 2011). The grass, silver, and striped bighead carp are basically species of the aquaculture industry, but they are found in nature in freshwater systems adjacent to the studied area.

Family Cyprinidae

Ctenopharyngodon idella (Valenciennes 1844)
Common name: Grass carp
Arabic name: الكارب العشبي
Etymology: *Ctenopharyngodon*: Greek, kteis, ktenos = comb + Greek, pharyngx = pharynx + greek, odous = teeth, *idella: Cteno* = comb; *pharynx* = throat; *odon* = tooth (in reference to its comb like pharyngeal teeth); and *idella*: presumably derived from the Greek idios, distinctive or peculiar (Fig. 5.56)

Identification

- Slender, slightly compressed body.
- Head wide with no scales.
- Mouth terminal or subterminal with thin lips.

Fig. 5.56 Grass carp, *Ctenopharyngodon idella* (Valenciennes, 1844). Courtesy of Mustafa Al-Mukhtar, Iraq

- Absence of barbels.
- Snout short and jaw slightly protracted (Page and Burr 1991; Eccles 1992; Opuszynski and Shireman 1995).
- Curved lateral line extending along middle of depth of tail (Shireman and Smith 1983; Page and Burr 1991; Opuszynski and Shireman 1995).
- Dorsal fin originates above, or just in front of, pelvic fin origin (Page and Burr 1991; Keith and Allardi 2001).
- No spines in dorsal and anal fins (Shireman and Smith 1983).
- Medium size cycloid scales on body with dark edges.
- Adults dark grey on dorsal surface with lighter sides (white to yellow) that have slightly golden shine. Fins clear to grey-brown (Page and Burr 1991; Opuszynski and Shireman 1995).

World Distribution The native locality of this species is China to the Amur River, Siberia. It is widely distributed around the world through introduction and aquaculture practices (Skeleton 1993).

Distribution in the Study Area Although this species is a freshwater inhabitant, fresh specimens are usually sold in fishmarkets and supermarkets of the coastal cities in Iran, Arabian-Persian Gulf countries, and in Yemen.

Habitat and Ecological Role This is a freshwater species living in a demersal habitat (Reide 2004) at depths from the surface down to 30 m (Shao and Lim 1991).

Biology Adults prefer large, slow-flowing or standing water bodies with vegetation. Individuals can tolerate a wide range of temperatures from 0 to 38 °C, and salinities to as much as 10 ppt and oxygen levels down to 0.5 ppm. They feed on higher aquatic plants and submerged grasses and also detritus, insects, and other invertebrates (Froese and Pauly 2016). This species is used for weed control in rivers, fish ponds, and reservoirs (Frimodt 1995). It can be a pest in some countries due to the damage to submerged vegetation (Kottelat 2001).

Economic Value It has high commercial value as it is a source of food.

Conservation Status Not evaluated.

Hypophthalmichthys molitrix (Valenciennes 1844)
Common name: Silver carp
Arabic name: كارب الفضي
Etymology: *Hypophthalmichthys*: Greek, hypo = under + Greek, ophthalmos = eye + Greek, ichthys = fish, *molitrix: molitrix*, approximately grinder (referring to the pharyngeal grinding apparatus) (Fig. 5.57).

Fig. 5.57 Silver carp, *Hypophthalmichthys molitrix* (Valenciennes, 1844). Courtesy of Mustafa Al-Mukhtar, Iraq

Identification

- Body deep, spindle-shaped, and laterally compressed.
- Abdomen with well-developed keel extending from throat to anus.
- Scales present on anterior part of keel only. Body with small cycloid scales.
- Pectoral fin with anteriorly thick and finally serrated ray. All fins with spines.
- Upper jaw with notch dorsally.
- Body grey in colour and dark dorsally. Fins dark (Kolar et al. 2005).

World Distribution This species is found in major Pacific drainages of east Asia to Xi Jiang, China (Kottelat and Freyhof 2007). It has been introduced around the world for aquaculture purposes.

Distribution in the Study Area Although this species is a freshwater inhabitant, fresh specimens are usually sold in fish markets and supermarkets of the coastal cities in Iran, Arabian-Persian Gulf countries, and Yemen.

Biology Individuals of this species feed in shallow and warm backwaters, lakes, and flooded areas with slow current on phytoplankton and zooplankton (Billard 1997; Etnier and Starnes 1993). They breed in rivers or tributaries over shallow rapids with gravel or sand bottom providing that high current, turbid water, temperatures above 15 °C, and high oxygen concentrations are available (Kottelat and Freyhof 2007). During spawning season, adults and juveniles form large schools. Mature adults can undertake long-distance upriver migration at the start of a rapid flood and are able to leap over obstacles up to 1 m.

Economic Value It used fresh for human consumption and it is used to clean reservoirs and other waters of clogging algae (Frimodt 1995).

Conservation Status This species is under the Near Threatened criterion in the Red List of the IUCN for the reasons given by Zhao (2011):

> In its natural range, the species has been impacted by dams, pollution, and overfishing. Dams have greatly impacted the species' reproductive success. The Amur populations are thought not to have yet been impacted, however, populations in China have declined greatly as a result of the widespread development of dams. Population declines in the natural population have been significant in the Chinese parts of its range. It is assessed as Near Threatened due [to] the scale of wild population decline in China, as it is suspected to be close to meeting a threatened category under population decline (category A2). Monitoring of population trends and reproductive success in the wild is needed.

Hypophthalmichthys nobilis (Richardson 1845)
Common name: Bighead carp
Arabic name: كارب ذوالرأس الكبير
Etymology: *Hypophthalmichthys*: Greek, hypo = under + Greek, ophthalmos = eye + Greek, ichthys = fish, *nobilis: nobilis*, meaning noble (Fig. 5.58)

Identification

- Body deep, moderately compressed.
- Head very large relative to body. Bony lips formed from protruded premaxilla and maxilla. Mouth not expandable. Eyes ventrally positioned on head.
- Fins without spines.
- Small, cycloid scales.
- Smooth keel between base of caudal fin and pelvic fins.
- Body dark grey dorsally and off-white on abdomen. Dark gray to black irregularly shaped and positioned blotches over entire body (Jennings 1988).

World Distribution The native country of this species is China, but now it has a global distribution due to introduction practices around the world (Froese and Pauly 2016).

Distribution in the Study Area Although this species is a freshwater inhabitant, fresh specimens are usually sold in fishmarkets and supermarkets of the coastal cities in Iran, Arabian-Persian Gulf countries, and Yemen.

Fig. 5.58 Bighead carp, *Hypophthalmichthys nobilis* (Richardson, 1845). Courtesy of Khoo, Wee Lee, Singapore

Habitat and Ecological Role This freshwater species prefers a benthopelagic habitat (Reide 2004).

Biology The species feeds in shallow water and breeds in very deep, very turbid, and warm water above 18 °C, with high current and high oxygen concentrations (Kottelat and Freyhof 2007). Zooplankton and algae are its main food items and it is also a bottom-feeding fish (Ukkatawewat 1999). It migrates for a long distance upriver at the start of flood season in the locality in which it is found. The eggs are placed in the upper water layer or even at the surface during floods. It stops spawning if conditions change and resumes again when the water level increases. Adults leave the spawning area and migrate for foraging habitats, and larvae drift downstream and settle in water bodies with little or no current. Adults and juveniles migrate to deep water areas seeking warmth during cold months (Kottelat and Freyhof 2007). They can live up to 20 years and mature at 5–6 years old with 550–700 mm standard length. Variation in the maturity time varies according to the locality (Huckstorf 2012). They are often crossed with *H. molitrix* (Kottelat and Freyhof 2007).

Economic Value This species has high commercial value and is used as a food source.

Conservation Status This species was given a Data Deficient criterion in the Red List of the IUCN for the reasons stated by Huckstorf (2012): 'The species is only native to central and southern China where it has been declining due to dams, overfishing and loss of habitat. The species may be threatened and is therefore assessed as Data Deficient due to the lack of knowledge regarding species population size and current population trends and threats in its natural distribution range.'

Labeo rohita (Hamilton 1822)
Common name: Roho
Arabic name: روهو
Etymology: *Labeo:* Latin, labeo = one who has large lips (Fig. 5.59)

Identification

- Body elongated.
- Eye located in anterior half of head.
- Mouth wide, inferior, transverse, and protractile. Thick lips covering jaws, continuous at angle of mouth, papillate or smooth. Lower lip with inner transverse fold. Soft and

Fig. 5.59 Roho labeo, *Labeo rohita* (Hamilton, 1822). Courtesy of Subodha Kumar, India

movable horny covering with sharp margin on inner side of one or both lips.
- Snout broad and rounded to obtusely pointed, projecting beyond mouth.
- Barbels when present, four or two; if only one pair, they are on the maxilla, second being the rostral, or they may be absent.
- Dorsal fin originates before pelvic fins.
- Small to moderate scales.
- Lateral line running along middle of tail.
- Body bluish dorsally becoming silvery on sides and abdomen. Fins greyish or black. Eyes reddish (Khan and Jhingran 1975).

World Distribution The distribution of this species is confined to Asia. It is reported from Pakistan, India, Bangladesh, Myanmar, and Nepal (Froese and Pauly 2016).

Distribution in the Study Area Although this species is a freshwater inhabitant and not native to the freshwater systems around the Arabian Peninsula, fresh specimens are usually sold in fishmarkets and supermarkets of the coastal cities located on the Arabian-Persian Gulf countries.

Biology Individuals of this species are diurnal and solitary. They feed on plants and their spawning season coincides with the southwest monsoon season. It has been widely introduced outside its native range for stocking reservoirs and aquaculture (Froese and Pauly 2016).

Economic Value The species has high economic value as a source of food in its geographical range.

Conservation Status This species is given a Least Concern criterion in the Red List of the IUCN for the reasons stated by Dahanukar (2010): '*Labeo rohita* is a widespread species with no known major widespread threats. It is also cultured in captivity throughout India and adjacent countries.'

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6 Ichthyohemotoxic Fishes

Several fish groups with different phylogenetic relationships were shown to have toxic serum. The members of the order Anguilliformes, which includes morays, congers, and anguillids have been the centre of research on the poisonous blood in fishes. The toxins in eel serum are commonly known as 'ichthyohemotoxin' or 'fish serum toxin' and drinking the fresh blood of eels will cause severe poisoning and probably lead to death (Yoshida et al. 2008).

6.1 Background

Autenrieth (1833) wrote on the toxic eels that cause skin eruptions, fever, paraesthesias, paralysis, and gastrointestinal disturbances, but the work of Mosso (1889) is considered the starting point for the study of ichthyohemotoxins. He mainly dealt with several aspects of the serum poison of the eel including toxicology and called the toxin 'ichyotoxicum.' Later, Sprinfield (1889) injected the extract from the blood of *Anguilla anguilla* into rabbits to confirm the symptoms. Tuna blood was investigated and Marcacci (1891) declared that a fraction of toxin is present in tuna blood similar to that of eel serum. Several other scientists studied the blood serum of other fish species or aquatic animals such as marine turtles and others confirmed the symptoms resulted from the eel blood poison (Kobert 1893; Linstow 1894; Blyth 1895). Phisalix (1896) began studies related to the immunological chemistry of fish blood. Camus and Gley (1898) concluded that a small amount of eel serum on rabbits and guinea pigs caused neurological symptoms and death and also degeneration of renal tubules. Liefmann and Andrew (1911) showed that the haemolytic part of the eel serum is composed of two fractions: one fraction is responsible of causing lysis to the blood cells and the other works as a sensitiser. The effect of eel serum on the eye was studied by Steindorff (1914) and the complication of conjunctivitis was discussed by Pöllot and Rahlson (1911). The severity of moray eel serum poison was tested by Kopaczewski (1917) who found that this serum is very violent if taken intraperitoneally. Several other studies on different aspects of the eel serum continued to appear (Ralls and Halstead 1955; Halstead 1964).

6.2 Causative Agent

Ichthyohaemotoxin is the toxin found in eel serum; it is also known as fish serum toxin. The chemical content is mainly proteinaceous (Rocca and Ghiretti 1964). The greenish pigments are lipoprotein having biliverdin as chromophore (Kochiyama et al. 1966). The eel serum poison is a monomeric simple protein with a molecular mass of 100 kDa and an isoelectric point of 6.1

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(Yoshida et al. 2008). The toxicity might be related to the blue-green colour pigments (Kochiyama et al. 1966).

6.3 Symptoms

Halstead (1967) suggested that there are the following types of fish serum intoxication.

1. Systemic, with intoxication resulting from drinking fresh, uncooked, fish blood. In this case, the symptoms comprise diarrhoea, bloody stools, nausea, vomiting, frothing at the mouth, skin eruptions, cyanosis, apathy, irregular pulse, weakness, paraesthesia, paralysis, respiratory distress, and possibly death.
2. Local, with intoxication producing several inflammatory responses when raw eel serum is placed in the eye or on the tongue. Symptoms shown when the serum is put on the tongue include burning, redness of the mucosa, and hypersalivation. On the other hand, when put on the eye, severe burning and redness of the conjunctivae follow, which develop within a few minutes. People who frequently cook eel often suffer from local inflammations during dissection of live eels. Therefore, cases of eel serum intoxication can be excluded from the viewpoint of public hygiene (Yoshida et al. 2008).

6.4 Treatment and Prevention

There is no specific vaccine against eel serum toxin, but repeated subcutaneous injections of eel serum have been shown to produce an immunity in laboratory animals. When you have to handle fresh eel, you should take great care and it is better to wear thick gloves so fresh blood does not come in contact with your body, mainly the eyes and mouth. Never attempt to drink fresh eel blood serum. This toxin might be destroyed by cooking (Halstead 1967).

6.5 Ichthyohemotoxic Fish Species

Different eel species belonging to different families were described elsewhere in this book. Therefore, no species account is given in this chapter.

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7 Venomous Fishes

7.1 Ithyocrinotoxic Fishes

This group of poisonous fishes has poisonous glands, but lacks the venomous apparatus such as spines and teeth to convey the toxin to the body of the victim. With no venomous apparatus, the poisonous fishes secrete their toxins into the water. These fishes belong to different phylogenetic groups and form a wide spectrum of species diversity. They use their toxins as a defence mechanism and as a repellent (Halstead 1967).

The poisonous fishes are important in the ecosystem because of the toxins that they secrete to their environment. Such toxins are involved in the succession process that takes place in the ecosystem and affects the presence or absence of other organisms, a process called the 'exclusion effect.' Toxins are metabolic products of poisonous fishes and these compounds interfere with the vertical migration of animals in relation to the concentration of plants (Hardy 1956). Variation in the input of organic materials in the environment has a direct effect on chemical, physical, and biological factors, which in turn have an effect on the fauna present (Pearson and Rosenberg 1978). The diversity of the organisms in any such environment and through time will face inevitable changes in the abundance and species richness. Results of the role of toxins secreted in the inspected water showed that the toxins of one group might affect the number and distribution of associated plants and animals (Halstead 1967).

Background

Most of the information about poisonous fishes are related to toxins found in the skin of these fishes. In the late nineteenth century, Cavazzani (1892), Kobert (1894, 1902), and Coutière (1899) were the first to write about this poison in the skin of marine fishes. Later in the early twentieth century, investigators have followed the same principles of the earlier writers in this field (Englesen 1922; Fredericq 1924; Maass 1937). Clarke (1918) was the first to write on the poisonous nature of the jelly secretions of the labial glands of boxfishes. The toxicology of the Japanese puffers was the centre of investigations by Tani (1945). Other researchers became interested in the toxic skin secretions such as Hashimoto (1950), Macober (1956), and Flaschentrager and Abdallah (1957) who disovered that the poison found in the internal organs of the fish is similar to that present in their skin, but the toxin of the skin is more dangerous (Larson et al. 1960). Researchers such as Collette (1966) and Nigrelli (1958, 1962) have written about the pectoral fin glands and its poison in some fish species. Later, studies were published on different aspects of the poisonous glands and the ichthycrinotoxic fish

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species by Halstead (1988), Church and Hodgson (2002), and Haddad et al. (2003a, b).

Poison Organs

The glandular organs that contain toxin have the same basic structure with some variation in the different species. Boxfish is among the fish species that has poisonous glands in both the skin and mouth. Here the short description of the histology of these two structures is dealt with based on the original investigations done by Thomson (1963, cited in Halstead 1967).

Unlike other teleost fishes, the skin of boxfish has hard and soft parts. The hard bony carapace covers almost the whole body, whereas the soft part is restricted to the lips, base of the fins, and the caudal peduncle. When the fish is disturbed, a foamy material is secreted at the base of the soft skin (i.e., the lips, base of the fins, and caudal peduncle areas). Pocket structures that designed to contain foamy toxic material are found in the soft areas of the skin.

The skin is composed of three layers: the outer epidermis, the dermis, and subcutaneous tissue. The epidermis is the important part of the skin, where the glandular secretion occurs. This layer consists of stratified squamous epithelium separated from the dermis by a layer of melanophores. Among the distinct cells in this layer are the undifferentiated basal cells, mucous cells, and club cells. The undifferentiated cells have large nuclei and form the matrix of the epidermis. They change their shape according to their position in the epidermis. The mucous cells are smaller than the undifferentiated cells with nuclei of different shape and they are numerous at the epithelium surface. The third type of cells is the club cells, which are large and with variable shapes. These cells have the ability to discharge their content while they are in the middle part of the epidermis and thus have no need to come to the surface. Both mucous and club cells contain mucins, but of different type in each of them.

Poisonous glands are present in several locations in the mouth region of the boxfish. They are found in the lips, in the epithelial lining of the buccal cavity, and the oesophagus. The labial villi are a noticeable structure in the buccal cavity. These villi are extensions of the mucous membrane and also known as ‘labial glands’ that extend deep in the epidermis and form a duct to empty outside the buccal cavity. The villi are contained in pockets located above the dorsal row and below the ventral row of the teeth. In addition, there is a separate pocket opposite each tooth. The three types of cells found in the skin are also found in the epidermis of the lips and with similar structure. These cells are able to secrete toxin and are considered poison glands, but with ichthyocrinotoxic structure, as the venomous apparatus is absent.

In the pufferfish, *Arthron hispidus*, the whole body is covered with numerous cartilaginous spines and concentrated on the ventral side of the body. The histological description is based on the investigation made by Rosen (1913a, b) and Eger (1963) and given by Halstead (1967). The skin in this species is composed of three layers, epidermis, dermis, and the subcutaneous. The poisonous secretions are located in the epidermis layer only. The spines or prickles have no direct connection with the epidermis or the poisonous glands. These spines are covered with an epidermal layer that has contact with a poisonous gland deep in the epidermis. When the fish is disturbed, the stomach expands by taking in air or water. The ventral body wall of the fish inflates and the prickles extend. This results in stretching of the glandular tissue mass covering the prickles and the poison becomes ready to be expelled outside the body. The basic content of the epidermis layer is similar to that of the boxfish with a slight variation. Here the toxin is produced in the club cells of the epidermis and flows around the prickles. In no way can the prickles be a venomous apparatus as their structure is very simple and differs greatly from the spines of catfishes, scorpionfishes, and weevers, but it is an ichthyocrinotoxic structure.

In toadfish, there are two types of poisonous glands, a pectoral and axillary. The description given below is based on the study by Collette (1966) and stated by Halstead (1967). The glands of the pectoral fin are found on the surface of the upper ray of this fin, and the axillary glands are found in a pouch located in the pectoral axilla. In the case of excitement, the pectoral fin expands and the foramen of the gland opens wide so the poisonous content is ready to be excreted outside in the water.

7.1.1 Catfishes

Not all species of catfishes have naked skin; bony plates covering all or parts of the body have been seen in others (Sire 1993). There have been a large number of studies related to the structure of the skin of catfishes. (For review, see Arratia 2003.) The skin of catfishes is recognised as a paraneuron because of the presence of a large number of receptosecretary cells previously believed to be endocrine and sensory cells (Fujita 1994). The number of different cells found in the epidermis varies with the body region of the individual (Arratia 2003).

The environment that the fish lives in is full of microbes of different types. To avoid the harmful action of these microbes, the fish developed a distinctive physical barrier comprised of skin and skin mucus, which act as a first line of defence against these microorganisms. There are several immune constituents found in this defence mechanism of the skin such as lysozyme, immunoglobulin, carbonic anhydrase, lectins, crinotoxins, calmodulin, C-reactive protein, proteolytic enzymes, and peptides, which have the ability to kill bacteria (Alexander and Ingram 1992; Whyte 2007; Ramos et al. 2012). Fish skin mucus lectins exhibit variation in their structural make-up and can be separated into five distinct compounds: galectin (Tasumi et al. 2004; Muramoto and Kamiya 1992; Muramoto et al. 1999), C-type (Tsutsui et al. 2003, 2007), B-type (Tsutsui et al. 2003; Evangelista et al. 2009), rhamnose-binding lectin (RBL; Okamoto et al. 2005), and pentraxin (Tasumi et al. 2004). Because fish have a long evolutionary history and thus display huge species diversity, it may not be surprising to find other types of lectins in their skin secretions.

7.1.2 Boxfishes

The boxfishes belong to the family Ostracidae. They are distributed in shallow waters through the tropical and subtropical seas of the world and are restricted in their distribution to the Indo-Pacific and Atlantic oceans (Khora 1986). They are characterised by a rigid dermal carapace encasing the body and are often confused with their close relatives, the pufferfishes (Thomson 1963), but the poisonous nature of puffers is well known (Mosher et al. 1964). Experiments showed that introduction of newly captured, highly excited trunkfish into an aquarium with other fishes resulted in the death of all other fish inhabitants within minutes. Such rapid mortality is due to the poisonous substance produced by distressed trunkfish. The viscera and muscles of freshly killed boxfish were nontoxic. Ostracitoxin was detected only in the epidermal mucous secretions. This is different from tetrodotoxin, which is found in the skin and viscera of many species of pufferfish and only recently found in large amounts in the skin secretions of a few puffers (Thomson 1964). The ostracitoxin is activated during the process of secretion. The boxfish is vulnerable to its own toxin and results showed that intramuscular injections of fresh mucous secretions caused instant loss of balance, and death occurred within a few minutes (Thomson 1963). Unlike boxfishes, puffers are immune to tetrodotoxin. Ostracitoxin closely resembles certain red tide, sea cucumber, and starfish toxins (Abbott and Ballantine 1957). The many similarities between ostracitoxin and holothurin *A*, and the clearly saponin-like properties (Shilo and Rosenberger 1960) of crude ostracitoxin, indicated that the boxfish toxin might be a steroid saponin (Thomson 1963). However, later research showed that the pure ostracitoxin is not a saponin (Abbott and Ballantine 1957).

7.1.3 Species of Eels

The epithelial surface of the skin of eels secretes a large amount of mucus (0.5–1.0% of body weight) compared with other teleosts (Uthayakumar et al. 2012). The mucus protects the skin from pathogens and suspended particles with a potential of antimicrobial and noxious properties (Knouft et al. 2003). The characteristics of the mucus depend on its capacity to form a gel on the epithelial surface (Bragadeeswaran and Thangaraj 2011). This mucus is composed mainly of water and gel forming macromolecules such as mucins and other glycoproteins (Martinez-Antón et al. 2006). The mucus layer is continuously replaced which possibly prevents stable colonisation by parasites, bacteria, and fungi. Skin secretions contain a wide variety of polypeptides with antimicrobial properties. In addition, fish mucus also contains a variety of biologically active substances such as lysozyme, lectins, flavoenzymes, immunoglobulins, C-reactive protein, apolipoprotein *A-I*, and antimicrobial peptides, which gives protection to the fish from potential pathogens (Villarroel et al. 2007).

The mucus secretion of the most eels has proteinaceous substances which show potent bioactivity (haemolytic) when mixed with blood cells. Mucus extracts such as *A* and *D* exhibit a high level of haemolytic activity when the concentration increases. Some antimicrobial agents present in the mucus of bony fishes bind with microbes and destroy the blood cells (haemolysis) (Hellio et al. 2000).

7.1.4 Flatfishes

The poisonous flatfish and especially members of the genus *Pardachirus* (Family: Soleidae) can be distinguished from all other pleuronectiform flatfishes by the presence of a series of pores at the bases of the dorsal, anal, and pelvic fin rays on both the eyed (right) and blind (left) sides. In 1796, Commerson (1796) cited in Lacépède 1802; Klunzinger 1871) stated that putting pressure on the area around these little orifices causes a milky mucus to come out. Ckhiai (1957) suggested that the milky liquid is a toxin. Clark and Chao (1973) demonstrated that this milky secretion was toxic and lethal to small teleosts (*Mugil*, *Dascyllus*, *Bathygobius*), but on boiling or standing at room temperature for several days the poison lost its toxic properties. Secretion from *Pardachirus marmoratus* on human erythrocytes was both ichthyotoxic and haemolytic and it is about seven times greater than that of the lyophilised secretion and becomes gradually reduced when stored cold or frozen (Primor and Zlotkin 1975).

The ampullae-like poison glands usually occur in pairs (right and left) near the base of almost every dorsal and anal fin ray and occur unpaired on the outer surface of the pelvic fins. Fin glands and their pores probably develop after metamorphosis, as no glands are present in small individuals (Matsubara and Ochiai 1963). The distribution of the poisonous glands on both sides is asymmetric. There are more poisonous glands on the eyed side of the fish than the blind side (Clark and George 1976) and no poison glands on the medial (inner) sides of the pelvic fins. The glands are large and long near mid-body and taper off towards the beginning and end of each fin (Pal et al. 1981). Each poisonous gland opens externally by a slit-like pore located on the fins between two rays. When pressure is applied to the glands, the secretion flows out onto the fin in the grooves between the rays (Pal et al. 1981).

The toxin of *Pardachirus* is unusual among poisonous fish secretions (Cameron and Endean 1973) in being associated with hundreds of multicellular poison glands. The metameric arrangement of the glands suggests a primitive condition even though the Pleuronectiformes (flatfishes) are a specialised branch of advanced teleosts. No other genus of flatfishes is known to contain toxic species. The fish species of the genus *Pardachirus* can use the skin toxins in two ways. The toxic secretion from the glands on the right (upper) side appears to mix with the mucus and defend the body against predators by its distasteful and repellent effect (Clark 1974), whereas the toxin from the glands on the blind side is used to paralyse or kill its prey (Pal et al. 1981).

Pardaxin has an icthyolytic-haemolytic function: it is an acidic protein of molecular weight

17,000 and composed of 162 amino acids (Primor et al. 1978; Primor et al. 1980). It is rich in hydrophobic amino acids (Primor et al. 1978).

7.1.5 Pufferfish

In most marine puffers, high concentrations of tetrodotoxin *TTX* are found in livers and ovaries/eggs, especially during spawning, but significant amounts are also detected in digestive tissue, muscles, and skin (Arakawa et al. 2010; Noguchi and Arakawa 2008; Hwang and Noguchi 2007; Fuchi et al. 1991). Not all species of pufferfish are toxic, and some are only mildly toxic. The toxicity also varies with sex, season, and geographical variation. The ovaries of the female fish are more toxic than the male testes, and the toxicological pattern varies between temperate and tropical zones (Yasumoto et al. 1986; Noguchi et al. 1986, 1987; Simidu et al. 1987).

Pufferfishes are equipped with *TTX*-bearing glands or secretory cells (succiform cells) in their skin (Tanu et al. 2002; Tsuruda et al. 2002; Mahmud et al. 2003a, b), and secrete *TTX* by external stimuli (Kodama et al. 1985; Saito et al. 1985a; Tsuruda et al. 2002). Such structures denote that pufferfishes use *TTX* as a biological defence agent to protect themselves or their eggs from predators. When tetrodotoxin is intramuscularly administered to nontoxic cultured pufferfish it rapidly transferred to other body tissues, and the toxin content of the liver and skin exceeded that of muscle within as little as 1 h after administration (Arakawa et al. 2010). There are two forms of *TTX*, the *PTTX*—purified tetrodotoxin and *CTTX*—crude tetrodotoxin. The former is retained in the skin, and the latter is confined to the liver (Matsui et al. 1981). Brackish water pufferfishes have *TTX* (Mahmud et al. 1999a, b), but in the freshwater species, saxitoxins (STXs) are present, toxins that belong to the paralytic shellfish poison (PSP) family (Deeds et al. 2008).

Mechanism of Intoxication

Very little is known about the mechanism of intoxication by ichthyocrinotoxic fishes, but the mechanism differs according to the species of fish. The skin and slime of the different eel species are poisonous if they are ingested and they may cause inflammation in the mucus membranes. Dermatitis may result if human skin comes in contact with the fish slime. Intoxication by fish species other than eels can occur through eating the poisonous glands in the skin of a flatfish or pufferfish.

Symptoms, Treatment, and Prevention

The general symptoms of intoxication by ichthyocrinotoxic fishes include nausea, vomiting, dysenteric diarrhoea, abdominal pain, and general weakness. Ingestion of trunkfish could lead to instability similar to drunkenness and the effect could be dangerous (Brown 1945). The treatment is similar to that of puffer intoxication mentioned above. The skin of ichthyocrinotoxic fishes should not come in contact with that of humans. Irritation and a burning sensation could result.

7.1.6 Ichthyocrinotoxic Fish Species

Order: Batrachoidiformes
Family: Batrachoididae
Colletteichthys dussumieri (Valenciennes 1837)
Common name: Flat toadfish
Arabic name: سمكةالضفدعه المسطحه
Etymology: *Colletteichthys*: This genus is named in honour of Bruce B. Collette who has contributed greatly to toadfish systematics over the years (Fig. 7.1).

Identification

- Body compressed.
- Head depressed.
- Two lateral lines.
- Three spines on opercle.
- Jaws with three irregular rows of teeth anteriorly.
- Chin with short tentacles.
- Foramen in upper part of pectoral axil.
- Body light brown becoming white ventrally. Four broad, irregular, brown bands on side of body. Dark blotches on head (Randall 1995; Greenfield 2006).

Fig. 7.1 Flat toadfish, *Colletteichthys dussumieri* (Valenciennes, 1837). Courtesy of Bineesh, India

World Distribution The distribution of this species is the northwest Indian Ocean.

Distribution in the Study Area This species is reported from the Arabian-Persian Gulf (Randall 1995).

Habitat and Ecological Role This is a marine species living in tropical demersal areas (Froese and Pauly 2016).

Biology There is not much information available about the biology of this species.

Economic Value This species has low commercial value in the Arabian-Persian Gulf.

Conservation Status Not evaluated.

Order: Pleuronectiformes
Family: Soleidae
Pardachirus marmoratus (Lacepède 1802)
Common name: Finless sole
Arabic name: مزلك بدون ذنب
Etymology: *Pardachirus*: Greek, pardias, -ou = a fish similar to grey mullet + Greek, cheir = hand (Fig. 7.2)

Identification

- Body covered with cycloid scales.
- Eyes small with upper anterior to lower.
- Dorsal fin originates anterior to interorbital space.
- Absence of caudal peduncle, with both dorsal and anal fins not connected to caudal fin. Rounded caudal fin.
- Body light brown colouration with scattered irregular dark brown spots (Randall 1995).

World Distribution It is found from the Red Sea north to Durban south and to Sri Lanka in the east (Sommer et al. 1996).

Distribution in the Study Area It has been reported from several localities in the study area.

Habitat and Ecological Role This marine species lives in association with coral reefs at depth ranges 1–15 m (Heemstra and Gon 1986).

Biology This species prefers shallow waters and lives on sandy and muddy bottoms (Sommer et al. 1996).

Economic Value It has good commercial value in spite of the presence of poisonous glands. Its toxic secretion is used as shark repellent (Robins et al. 1991).

Conservation Status Not evaluated.

Fig. 7.2 Finless sole, *Pardachirus marmoratus* (Lacepède, 1802). Courtesy of Mike Nembard, Barbados

7.2 Acanthotoxic (Venomous) Fishes

The oceans of the world are rich with creatures which are venomous or poisonous to humans. There are about 2000 aquatic organisms which can be classified under these two categories (Fitzgerald 2000). Most of the serious envenomation occurs in the temperate or tropical waters of the Indo-Pacific region, with a smaller number of venomous fishes living in North American and European waters (Auerbach 1991; Russell 1958).

Envenomation in the marine environment can be either surface stings (erythema, vesicles, and urticaria) or puncture wounds (bites, stings; Atkinson et al. 2006).

Four orders of teleost fishes are venomous (Church and Hodgson 2002; Haddad et al. 2003a, b; Halstead 1988; Smith-Vaniz et al. 2001; Vetrano et al. 2002). They live in diverse habitats ranging from mountain streams to coral reefs and oceanic midwaters (Nelson 1994). Several types of symptoms result from cases of envenomation ranging from blisters to intense pain, fever, and death (Haddad et al. 2003a, b; Halstead 1970, 1988; Vetrano et al. 2002).

It is possible to pinpoint the venomous fish groups from around the world. They are currently distributed among the catfishes (Siluriformes) and six groups of 'acanthomorphs' or spiny-rayed fishes (Church and Hodgson 2002; Halstead 1970, 1988; Nelson 1994; Smith-Vaniz et al. 2001): toadfishes (Batrachoidiformes); scorpionfishes (Scorpaeniformes: Scorpaenoidei); surgeonfishes, scats, and rabbitfishes (Perciformes: Acanthuroidei); saber-toothed blennies (Perciformes: Blennioidei); jacks (Perciformes: Percoidei); and stargazers and weeverfishes (Perciformes: Trachinoidei).

Venomous organisms are capable of producing venom in specialised tissues or glands that are connected with application structures (e.g., stings), unlike poisonous creatures that usually produce poisons in nonspecialised tissues or accumulate them after ingestion of prey or algae and may be dangerous to people who consume them (Spanier 1987; Russell 1996). Antivenom is not available for all types of envenomations, but antivenom for the treatment of stonefish and box stings is available. In addition, traditional medications are used in some countries including vinegar, fig juice, boiled cactus, heated stones, hot urine, hot water, and ice (Auerbach 1991; Russell 1958).

7.2.1 Venomous Stingrays

The famous stingray groups are Gymnurid (butterfly rays), Urolophid (round stingray), Myliobatid (bat or eagle rays), and Dasyatid (proper stingrays;

Daly and Scharf 2012; Trickett et al. 2009). These fishes are usually found and confronted in the waters off coastal regions. They utilise camouflage by partially submerging themselves in the sand (Daly and Scharf 2012; Auerbach 1991).

One famous stingray attack was that of the Australian wildlife expert Stephen Robert 'Steve' Irwin, 'The Crocodile Hunter.' The envenomation incident which happened to Steve is a typical stingray attack against humans and should be remembered. In this section of the book, I give a highlight about the death of this great man, and quote the death story of Steve Irwin as given by Wikipedia (2016):

> On 4 September 2006, Irwin was on location at Batt Reef, near Port Douglas, Queensland, taking part in the production of the documentary series *Ocean's Deadliest*. During a lull in filming caused by inclement weather, Irwin decided to snorkel in shallow waters while being filmed in an effort to provide footage for his daughter's television programme.
>
> While swimming in chest-deep water, Irwin approached a stingray with an approximate span of two metres (6.5 ft) from the rear, in order to film it swimming away.
>
> According to the incident's only witness, 'All of a sudden [the stingray] propped on its front and started stabbing wildly with its tail. Hundreds of strikes in a few seconds.' Irwin initially believed he only had a punctured lung; the stingray's barb pierced his heart, causing him to bleed to death (Selby 2014; Bond 2014). The stingray's behaviour appeared to have been a defensive response to being boxed in. Crewmembers aboard Irwin's boat administered CPR and rushed him to shore. Medical staff pronounced him dead at the scene (*The Age* 2006; *Sydney Morning Herald* 2006; Callinan 2006). Irwin's death is believed to be the only fatality from a stingray ever captured on video (CNN, Reuter 2006).
>
> Queensland state police as part their mandatory investigations viewed footage of the incident. All copies of the footage were then destroyed at the request of Irwin's family (Gerard and Koch 2006). Production was completed on *Ocean's Deadliest*, which was broadcast in the US on the Discovery Channel on 21 January 2007. The documentary was completed with footage shot in the weeks following the accident, but without including any mention of Irwin's accidental death (*The Daily Telegraph* 2006; *International Business Times* 2007).

Background

Humans' awareness of stingrays and their venomous spines goes back to the time of Aristotle (324–322 BC), when he mentioned it in his book, *Historia Animalium* (Halstead 1970). During medieval times not much information was available about the poison of the stingray. All the writing at that time was a replication of that information given by Aristotle, Nicander, Dioscorides, and others (Halstead 1970). The probable earliest illustration of a stingray was of the European common stingray, *Dasyatis pastinaca*, in Pierre Belon's *De Aquatilibus Libri Duo* published in Paris in 1553 (Schwartz 2005). Halstead (1970) wrote about the first fatal incident by stingray reported by Lycophoran (285–247 BC). It is about the death of Ulysses by a spear believed to have been tipped by a stingray sting. Other early European papers by Grevin (1568) and Eupharasen (1790) treated *D. pastinaca* and *Aetobatis narinari*, respectively.

Structure of the Venom Apparatus

In the stingray, the venomous apparatus consists of: (1) caudal appendages, (2) the spine enveloped in an integumentary sheath, (3) a venomous gland, and (4) the cuneiform area below the spine. The venomous structures of different species of stingrays have different shapes. Such variations affect the ability of the fish to sting. Halstead and Bunker (1953) recognised four types of venomous structure. It is possible to find more than one type within a single family of stingrays. The differences in shape of the four types of venomous apparatus are related to the shape of the caudal fin and the thickness of its base (Fig. 7.3).

Halstead (1967) described the general gross anatomy of the venomous apparatus as follows (Fig. 7.4).

> The spine in the venomous structure is bilaterally retroserrate and covered with an integumentary sheath and composed of two layers, an inner vasodentine and thinner outer layer of enamel. There are number of shallow longitudinal furrows

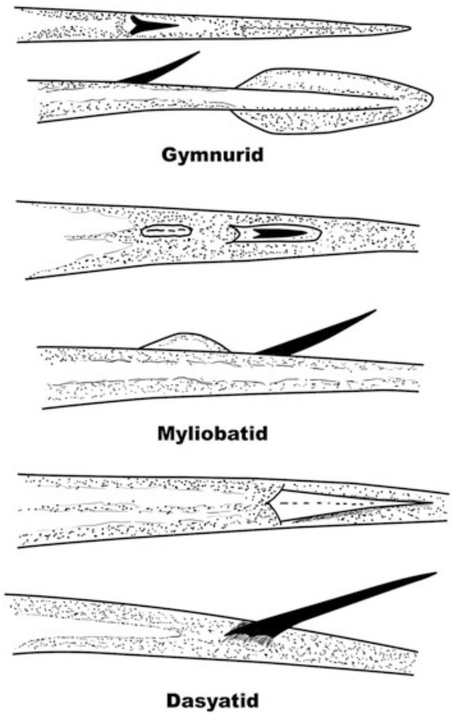

Fig. 7.3 Drawing showing the various types of stingray caudal appendages. After Halstead (1967)

> on the surface of the spine, where they are more clearly seen at its base. The dentations at the two margins of the spine are with medial grooves known as 'ventrolateral glandular groove,' which [is] covered with thin gray tissue supplied with blood vessels and connected with the integumentary sheath in the dermis. The epidermis will rapture under a pressure, when the spine enters the body of the victim and resulted in damage to the stingray epidermis, further traumatization of the recipient's wound and secretion and envenomation of poison inside the wound. The integument of the cover lies underneath the spine secretes venom. Therefore, the spine is fully covered with poison once it enters the body of the victim.

Schwartz (2005) found that the total number of serrations on the spine could indicate the environment of the stingray. For example, total serrations above 100 indicate an open water ocean species (*Dasyatis centroura, Pteroplatytrygon violacea, Aetobatis narinari*); 70+ a midwater species *(Dasyatis pastinaca, Pteromylaeus bovinus, Himantura uarnak*, and *Taeniura meyeni*); 50+ near-substrate inhabitant (*Gymnura altavela, Myliobatis aquila*, *Dasyatis margarita*); 25–50 substrate species (*Taeniura grabata, Urogymnus ukpam*); and below 25 a freshwater species.

Causative Agent

Several authors agree about the mechanism by which the stingray inflicts its spines into the body of the victim. The main points in this mechanism are that the stingray has no habit of attacking humans, but when the ray is disturbed, it reflexively swings a barbed tail upwards, which can inflict deep puncture wounds (Gray et al. 1988). The spines have retroserrated teeth making removal extremely difficult, which can lead to retained tail in the wound (Escoubas et al. 2000). The serrated spines are covered by an epithelial layer that has venom secretory cells located in the epithelium or in close contact with it (Fletcher et al. 1996; Saminathan et al. 2006) (Fig. 7.5). Serrated spines of rays may cause mechanical damage too (Wright 2009).

Injury results in a subcutaneous mass of granulomatous dermatitis and panniculitis with large zones of necrobiosis (Tartar et al. 2013). As a complicating factor, the sting might break and provoke the retention of dentine fragments in the wound. Bacterial infections especially that caused by *Pseudomonas* sp. and *Staphylococcus* sp. are also commonly associated with these injuries (Haddad et al. 2004; Haris and Chapman 1995).

Studies on toxicology and envenoming caused by elasmobranches report mostly cases associated with stingrays of suborder Myliobatoidei (Haddad et al. 2004), as they are the most clinically important inasmuch as their venom may result in increasing local pain which may spread to involve the entire limb swelling and a characteristic bluish-white appearance of the wound.

Aquatic animals produce an enormous number of metabolic complex molecules, such as alkaloids, steroids, peptides, and proteins with chemical and pharmacological properties, different from those presented by the poisons of

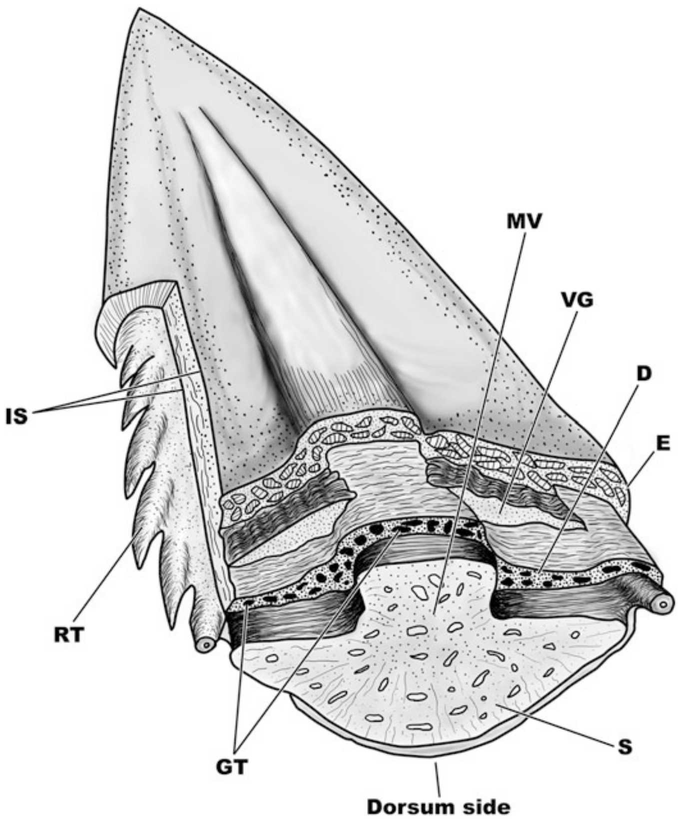

Fig. 7.4 Drawing showing the gross anatomy of a typical stingray sting. *IS* integumentary sheath; *TR* retrorse teeth; *GT* glandular triangle; *E* epidermis; *VG* venom gland; *D* dermis; *MV* median ventral ridge; *S* spine. After Halstead (1967)

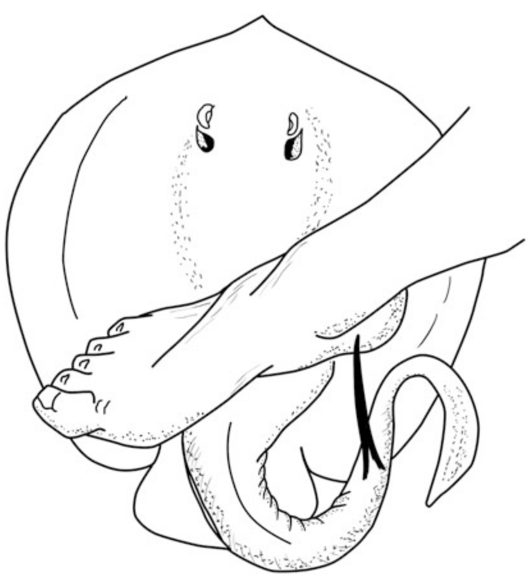

Fig. 7.5 Drawing showing the method by which a stingray usually inflicts its sting. After Halstead (1967)

terrestrial animals (Ravi 2006). There appear to be several different chemicals in the venom. There are some neurotoxicity (Ravi 2006), cardiotoxicity, and circulatory disturbances (Ravi 2006). Some studies demonstrated that the venom of rays contains serotonin, 5′-nucleotidase and phosphodiesterases (Fenner et al. 1989).

Symptoms

The spines and the venom gland may be damaged during the attack and the spine may remain in the wound, which may be large and serrated; the patient then experiences severe pain from the injected venom. Injuries made by a ray's stings can be accompanied by intense local pain and can cause moderate to severe complications such as nausea, vomiting, salivation, sweating, respiratory depression, muscle fasciculations, convulsions, oedema, and ischemic necrosis

Fig. 7.6 Bleeker's whipray, *Himantura bleekeri*. Courtesy of Hamid Osmany, Pakistan

(Ravi 2007; Haris and Chapman 1995; Dehghani et al. 2009; Forrester 2005).

Treatment

Anticoagulants play a vital role as agents for the prevention and treatment of thromboembolic disorder (Auerbach and Norris 2012). For more than five decades, anticoagulant drugs consisting of heparins, vitamin K-antagonists, and their derivatives have been the main medicines in a clinical setting. Although their efficacy remains undoubted, the harmful life-threatening side effects of these drugs have also been documented (Tartar et al. 2013).

Prevention

The natural position that the stingray takes is to bury its whole body in the sand or mud at the bottom of the area in which it is found. Therefore, it forms a threat to those who wade with bare feet in water occupied by them. To avoid stingray attacks, waders should shuffle the water along the bottom before stepping in.

Species of Stingrays

Order: Myliobatiformes
Family: Dasyatidae
Himantura bleekeri (Blyth 1860)
Common name: Bleeker's whipray
Arabic name: لخمة بليكر
Etymology: *Himantura*: Greek, iman, imantos = thong, strap + Greek, oura = tail (Fig. 7.6)

Identification

- Disc squarish in shape.
- Pointed anterior end.
- Brown metallic colour on dorsal side and white ventral side. Tail banded with light and dark bands.

World Distribution It is distributed in the Indo-Pacific region from the Arabian-Persian Gulf and eastward to the Malay peninsula.

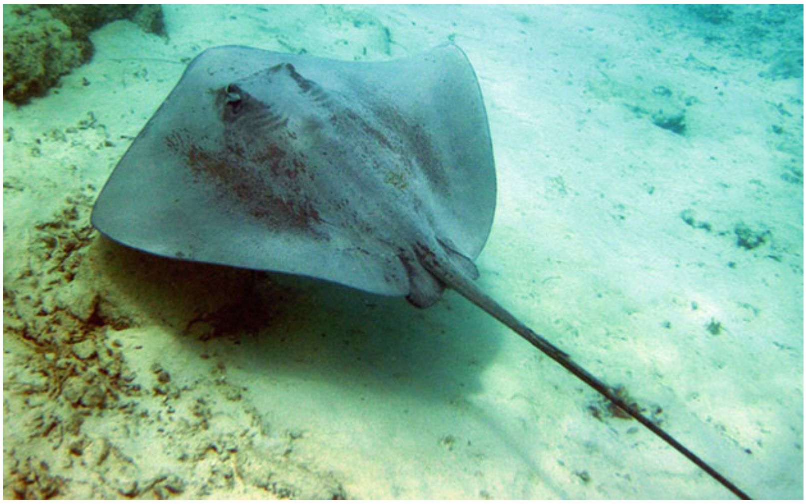

Fig. 7.7 Pink whipray, *Himantura fai* Jordan & Seale, 1906. Courtesy of Coco et Jo – Moorea – Raie, Italy via Wikimedia commons BY SA-2.0

Distribution in the Study Area It has been reported from several localities in the Arabian-Persian Gulf only (Carpenter et al. 1997).

Habitat and Ecological Role This marine species enters brackish water but prefers a benthopelagic habitat and living at depths ranging from the surface down to 30 m (Riede 2004).

Biology Females of this species are ovoviviparous (Dulvy and Reynolds 1997). They feed on invertebrates (Carpenter et al. 1997).

Economic Value They are used as a source of food and the skin is used in leather industries (Last and Compagno 1999).

Conservation Status Not evaluated.

Himantura fai (Jordan and Seale 1906)

Common name: Pink whipray
Arabic name: اللخمه الورديه
Etymology: *Himantura*: Greek, iman, imantos = thong, strap + Greek, oura = tail (Fig. 7.7)

Identification

- Disc quadrangular with short broad snout.
- Rounded tail base. Tail very long and free of skin folds.
- Poisonous spines at anterior side of tail.
- Midline and tail free from enlarged thorny denticles (Al-Mojil et al. 2015).
- Uniformity of brownish pink color of dorsal side of body. Dark colouration beyond sting.

World Distribution It is distributed in the Indo-Pacific region from South Africa to Micronesia (Last and Compagno 1999).

Distribution in the Study Area It has been reported from the United Arab Emirates, Arabian-Persian Gulf (Al-Mojil et al. 2015), and from Oman (Henderson and Reeve 2011).

Habitat and Ecological Role This marine species lives in association with reefs at depths ranging from the surface down to 200 m (Fricke et al. 2011).

Biology Individuals of this species sometimes aggregate in groups of up to 25 individuals (Vaudo and Heithaus 2009). Tracking data indicate that such aggregations are likely seasonal, with more frequent aggregations known during warmer months (Vaudo and Heithaus 2012). The species has also been observed ‘catching a ride’ on other large-bodied ray species (Manjaji Matsumoto et al. 2016a, b, c).

Fig. 7.8 Sharpnose stingray, *Himantura gerrardi* (Gray, 1851). Courtesy of Alan Reeve, USA

Economic Value This species is usually captured as bycatch throughout its range, but retained for its meat, highly valued skin, and cartilage in parts of Southeast Asia (Last and Compagno 1999; Last and Stevens 2009; Last et al. 2010a, b).

Conservation Status The pink whip ray has been evaluated as Vulnerable in the Red List of the IUCN for the following reasons given by Manjaji Matsumoto et al. (2016a, b, c).

> The Pink Whipray (*Himantura fai*) has a wide, but poorly defined range throughout the Indo-West Pacific. It is frequently misidentified as *H. jenkinsii*, which can complicate species-specific catch data. It is taken as an utilised bycatch of tangle/gillnet, trawl net, and dropline fisheries throughout Southeast Asia and parts of the Indian Ocean. Inshore fishing pressure is intense throughout this species' range in Southeast Asia and in parts of the Indian Ocean. It is caught in particularly high numbers in the target fishery for rhynchobatids operating in the Arafura Sea. Although no species-specific data are available, overall catches of sharks and rays are reported to be declining, with fishermen having to travel further to sustain catch levels. Given the continuation of high levels of exploitation throughout its range in Southeast Asia where the species is commonly caught in multiple types of fisheries, along with evidence for declines in catches of rays, the level of decline (>30% over the last three generations) and exploitation can be inferred from overall declines in fish catches in the region, as well as from habitat loss.

Himantura gerrardi (Gray 1851)
Common name: Sharpnose stingray
Arabic name: لخمه حادة الخطم
Etymology: *Himantura*: Greek, iman, imantos = thong, strap + Greek, oura = tail (Fig. 7.8)

Identification

- Disc with rhomboidal shape with rounded lateral corners.
- Snout pointed.
- Papillae present on floor of mouth behind teeth.
- Slender tail.
- Band of tubercles on dorsal side of body.
- Body yellowish brown on dorsal side. Tail has alternating black and white rings (Randall 1995).

World Distribution This species is found in the Indo-Pacific region from India to New Guinea, and north to Japan. It is also found in the Red Sea and east African coast (Froese and Pauly 2016).

Distribution in the Study Area It is reported from the Arabian Gulf (Carpenter et al. 1997).

Habitat and Ecological Role It is a marine species which sometimes enters brackish waters and prefers demersal habitat at depth down to 50 m (Compagno et al. 1989).

Biology This stingray is found over sand and mud bottoms (Sommer et al. 1996). It feeds on bottom crustaceans including shrimp, crabs, and small lobsters (Compagno et al. 1989). Females are ovoviviparous, with embryos feeding on yolk in the early stage of their life, and then receiving additional nourishment from the mother by indirect absorption of uterine fluid enriched with mucus, fat, or protein through specialised structures (Dulvy and Reynolds 1997). Females give birth to litters of 1–4 pups usually born at 18–21 cm Disc Width.

Economic Value It is considered an important food fish, and the skin and flesh are used in the leather industry (Last and Compagno 1999), but there is no commercial value in the study area.

Conservation Status The sharpnose stingray has been given a Vulnerable status in the Red List of IUCN for the following reasons. Large numbers of *Himantura gerrardi* are caught regularly by tangle/gillnet, trawl net, and drop-line fisheries operating in Southeast Asia. This species is caught in particularly high numbers in the target fishery for rhynchobatids that operates extensively in some areas in this region. Throughout its range, juveniles about 20–40 cm disc width (DW) are extensively caught and landed daily. Larger individuals are highly sought after because of their high-quality skin, which used in the manufacturing of items such as wallets, watchbands, belts, handbags, and the like, which fetch high prices and commonly are exported. Exploitation of this species is very intense, particularly in the Java Sea. Although no species-specific data are available, overall catches of stingrays are reported to be declining, with anglers having to travel farther and farther to sustain catch levels. Little specific information on catches is available in other parts of the species' range, but population declines elsewhere are inferred from Indonesia. Given continuing high levels of exploitation throughout much of this species' range and evidence for declines in catches of stingrays off Southeast Asia, this species is assessed as Vulnerable (Manjaji Matsumoto et al. 2016d).

Himantura imbricata (Bloch and Schneider 1801)
Common name: Scaly whipray
Arabic name: لخمه قشريه
Etymology: *Himantura*: Greek, iman, imantos = thong, strap + Greek, oura = tail (Fig. 7.9)

Identification

- Hemispherical disc.
- Pointed snout.
- Eyes equal in size to spiracles.
- Two papillae on floor of mouth.
- Tail short. Large tubercles on dorsal side of tail.
- Two poisonous spines.
- Body dark grey on dorsal side and white ventrally (Randall 1995).

World Distribution It is found from the Red Sea north to East Africa south and to Japan, Micronesia, tropical Australia, and Lord Howe Island east. It is recorded from the Cocos and the Galapagos Islands (Grove and Lavenberg 1997; Froese and Pauly 2016).

Distribution in the Study Area It is reported from several localities in the Arabian-Persian Gulf and from the Sea of Oman (Carpenter et al. 1997; Randall 1995).

Habitat and Ecological Role This marine species lives in association with reefs at depths of

Fig. 7.9 Scaly whipray, *Himantura imbricata* (Bloch & Schneider, 1801). Courtesy of George Grinsted, USA via Wikimedia commons CC BY SA-2.0

1–500 m (Myers 1999), but it is usually found at 20–60 m (Sommer et al. 1996).

Biology This species feeds on bottom fishes, bivalves, crabs, and shrimp (Compagno et al. 1989). Females are oviviparous (Dulvy and Reynolds 1997).

Economic Value It usually taken for its meat and cartilage

Conservation Status Kyne and White (2015) assessed this species for the IUCN red List and found it to be Vulnerable for the following reasons. *Taeniurops meyeni* is a large (up to 180 cm DW), widely distributed, Indo-West Pacific stingray associated with coral reefs and sandy habitats. It is found inshore to a depth of 439 m. Little is known of its biology, although litter size is known to be small (up to seven young). There is little specific information on threats and catches in fisheries throughout much of the species' range, but given the intense and unregulated fishing pressure known to exist on large batoid species across much of its range, particularly in Southeast Asia, the particular sensitivity of this species to various fishing methods, its limiting life history characteristics, and the general declining health of coral reef ecosystems (its main habitat) throughout its Indo-West Pacific distribution, the species is inferred to have undergone a decline in population size of at least 30% over the past three generations (65 years), and is therefore assessed globally as Vulnerable. In Australia, this species is considered Least Concern because of protection afforded in marine parks and the effective use of turtle exclusion devices in northern Australian prawn trawl fisheries, which should limit the catch of the species there. Similarly, it is assessed as Least Concern in the Maldives where it has a high ecotourism value and is thus afforded protection through the prohibition of the export of rays and ray products.

Himantura jenkinsii (Annandale 1909)
Common name: Jenkins whipray
Arabic name: لخمة جنكنز
Etymology: *Himantura*: Greek, iman, imantos = thong, strap + Greek, oura = tail (Fig. 7.10)

Identification
- Rhomboidal disc, with straight anterior margin. Disc with broadly rounded corners.
- Tip pointed.
- Four papillae on floor of mouth.

Fig. 7.10 Jenkins whipray, *Himantura jenkinsii* (Annandale, 1909). Courtesy of Tassapon Krajangdara, Thailand

- Tail longer than disc, cylindrical, and tapering posteriorly. Large, heart-shaped denticles on dorsal side of tail.
- Body olive brown colour dorsally, white ventral side, and disc edges (Randall 1995).

World Distribution It is distributed in the Indo-Pacific region, and known from South Africa and east to Australia and Papua New Guinea (Froese and Pauly 2016).

Distribution in the Study Area The only report from the study area is that of the Sea of Oman (Randall 1995).

Habitat and Ecological Role This marine species enters brackish water, prefers demersal habitat, and lives at depth range 33–50 m (Last and Compagno 1999).

Biology Females of this species are ovoviviparous (Dulvy and Reynolds 1997). Embryos feed on yolk and then receive additional nourishment from the mother by indirect absorption of uterine fluid enriched with mucus, fat, or protein through specialised structures (Dulvy and Reynolds 1997).

Economic Value It is taken for its meat as a food and its skin and cartilage for other industries.

Conservation Status This species was evaluated for the IUCN Red List as Least Concern for the following reasons stated by Manjaji Matsumoto et al. (2016a, b, c).

> Jenkins' Whipray (*Himantura jenkinsii*) [is] distributed in inshore waters (to 90 m depth) in the Indian and Western Central Pacific Oceans. It taken as an utilised bycatch of tangle net, gillnet, trawl net, and dropline fisheries throughout Southeast Asia and parts of the Indian Ocean where inshore fishing pressure is intense. It [is] caught in particularly high numbers in the target fishery for rhynchobatids operating in the Arafura Sea. Levels of exploitation are very high throughout its range in Southeast Asia and in many parts of the Indian Ocean; hence it is under a severe level of threat within most of this range. Although no species-specific data are available, overall catches of stingrays are reported to be declining in areas of Southeast Asia for which information is available, with anglers having to travel [farther] and [farther] to sustain catch levels. The species is highly sought after in Southeast Asia for the high value of its skin. Little [is] known of the subpopulation off southeastern Africa, although the species [is] probably taken as [a] bycatch of shrimp trawlers there. Fisheries in northern Australia are generally well managed and the introduction of

Fig. 7.11 Arabian banded whipray, *Himantura randalli* Last, Manjaji-Matsumoto & Moore, 2012. Courtesy of Hamid Osmany, Pakistan

turtle exclusion devices (TEDs) has significantly reduced the bycatch of large stingrays. In Australia, Jenkins' Whipray is considered at minimal threat throughout its wide range, as there is no information to suggest that this species has declined in this area. This large species may have limiting life history characteristics that make it biologically susceptible to depletion in fisheries and therefore, efforts should be made to assess and monitor mortality in fisheries and population trends throughout its range. Given the continuation of high levels of exploitation throughout its range in Southeast Asia where the species is caught in multiple types of fisheries along with evidence for declines in catches of rays[,] the level of decline (>30% over the last three generations)[,] and exploitation can be inferred from overall declines in fish catches in the region and from habitat loss.

Himantura randalli (Last, Manjaji-Matsumoto and Moore 2012)
Common name: Arabian banded whipray
Aabic name: اللخمه العربيه مخططة الذنب
Etymology: *Himantura*: Greek, iman, imantos = thong, strap + Greek, oura = tail; *randalli*: Named for J. E. Randall, Bishop Museum, whose work on the taxonomy of Indo-Pacific fishes is legendary, and who was amongst the first authors to publish a photographic image of this species (as *H. gerrardi*) in his guide to the fishes of Oman (Randall 1995) (Fig. 7.11).

Identification

- Medium-sized body.
- Disc weakly rhomboidal.
- Snout moderately elongate with weak apical lobe.
- Pectoral fins, with rounded apices.
- Mouth broad.
- Broadly heart-shaped to seed-shaped suprascapular denticles on dorsal side of body.
- Dorsal surface mainly uniformly dark coloured, with disc margin sometimes paler dorsally. Ventral disc uniformly whitish, not black edged. Dorsal surface of tail sharply demarcated from paler ventral surface (Last et al. 2012).

World Distribution This species is distributed in the Western Indian Ocean region.

Distribution in the Study Area The species has been reported from several localities in the Arabian-Persian Gulf (Last et al. 2012). It

Fig. 7.12 Honeycomb stingray, *Himantura uarnak* (Gmelin, 1789). Courtesy of CIRO, Australia via Wikimedia commons BY 3.0

might be endemic to the Arabian-Persian Gulf (Al-Mojil et al. 2015).

Habitat and Ecological Role This marine species prefers demersal habitat and lives at depth range 1–40 m (Last et al. 2012).

Biology No biological information is available about this species.

Economic Value No commercial value.

Conservation Status Not evaluated.

Himantura uarnak (Gmelin 1789)
Common name: Honeycomb stingray
Arabic name: اللخمه ذات تلوين خلية النحل
Etymology: *Himantura*: Greek, iman, imantos = thong, strap + Greek, oura = tail (Fig. 7.12)

Identification

- Pointed snout.
- Poisonous spine very large.
- Rounded corners of disc. No thorns on disc.
- Long slender tail, with no caudal finfolds.
- Conspicuous dark spots on light brown background on dorsal side of disc. Spots well-spaced in young but crowded to form reticulated pattern in adult. Ventral side white. Tail marked with bands of black and white (Compagno et al. 1989).

World Distribution It is distributed in the Indo-Pacific region from the Red Sea north to South Africa in the south and to Australia in the east (Froese and Pauly 2016).

Distribution in the Study Area This species has been reported from several localities around the Arabian peninsula.

Habitat and Ecological Role This marine species enters brackish water and lives in association with reefs at depth range 20–50 m (Al Sakaff and Esseen 1999; Riede 2004).

Biology Females of this species are viviparous, with histotrophy. This species reaches 160 cm DW (Last and Stevens 2009; up to 450 cm total length in Compagno and Last

1998). Males mature at 82–84 cm DW and size at birth is 21–28 cm DW (Manjaji 2004; White et al. 2006; White and Dharmadi 2007). It is believed that this species lives for 20 years (Jacobsen and Bennett 2011).

Economic Value The flesh of this ray is used fresh or salted and dried for human consumption (Last et al. 2010a, b). In some areas, vertebrae are dried and exported, and the skin is dried and used for wallets, belts, shoes, handbags (high value), and so on, most of which are exported (White et al. 2006).

Conservation Status This species has been evaluated as Vulnerable on the basis of the following reasons given by Manjaji Matsumoto et al. (2016a, b, c).

> The Reticulate Whipray is a large-bodied stingray (to 160 cm DW) that has a wide distribution in the Indian and Western Pacific Oceans. This species has also entered the Mediterranean Sea from the Red Sea through the Suez Canal. It is taken as a utilised bycatch of tangle/gill net, trawl net, and dropline fisheries throughout Southeast Asia and parts of the Indian Ocean where inshore fishing pressure is intense. The Reticulate Whipray faces many of the same threats as other *Himantura* species within its range, however, its large size at maturity and maximum size, low fecundity and preference for shallow waters (which are being heavily utilised and degraded in many parts of its range), suggest that it may be more vulnerable than some of its congeners. It is caught in particularly high numbers in the target fishery for rhynchobatids operating in the Arafura Sea.
>
> Although no species-specific data are available, overall catches of stingrays are reported to be declining, with fishermen having to travel further and further to sustain catch levels. This species' preference for inshore coastal waters means it is also threatened by extensive habitat degradation and destructive fishing practices throughout a large part of its range. Given the species' high levels of exploitation, extensive habitat degradation and its large size, significant population declines are inferred to have occurred and are likely to be ongoing in Southeast Asia and more widely in the Indian Ocean. Conversely, this species has refuge from fishing pressure in northern Australia, where fishing pressure is light, bycatch mitigation measures are in place and it is not commercially utilised and consequently is considered at low risk.

Pastinachus atrus (Macleay 1883)
Common name: Ater sting rays
Arabic name: لخمة أتر الاسعه
Etymology: *Pastinachus*: Latin, pastinaca = a sting ray (Fig. 7.13)

Identification

- Body rhomboidal and quadrangular.
- Short rounded snout.
- Blackish and deep finfold on tail. Tail with broad and depressed base. Poisonous spine at posterior side of tail.
- Uniformly greyish in colour (Al-Mojil et al. 2015).

World Distribution It is distributed in the Indo-West Pacific region from Madagascar and eastward to Western Australia, the Philippines, Indonesia, and Malaysia (Last et al. 2010a, b). It has been reported from Papua New Guinea (Eschmeyer 2014).

Distribution in the Study Area It has been recorded from the Arabian-Persian Gulf (Al-Mojil et al. 2015).

Habitat and Ecological Role This marine species lives in association with reefs.

Biology No biological information is available.

Economic Value No commercial value is present for this species.

Conservation Status Not evaluated.

Pastinachus sephen (Forsskål 1775)
Common name: Cowtail stingray
Arabic name: لخمة ذنب البقره
Etymology: *Pastinachus*: Latin, pastinaca = a sting ray (Fig. 7.14)

Identification

- Body large, with angular snout and pectoral disc.
- Long tail, with broad base and no caudal finfold. No large thorns.
- Teeth hexagonal, with high crowns.

Fig. 7.13 Ater sting rays, *Pastinachus atrus* (Macleay, 1883). Courtesy of Tassapon Krajangdara, Thailand

Fig. 7.14 Cowtail stingray, *Pastinachus sephen* (Forsskål, 1775). Courtesy of Hamid Osmany, Pakistan

- Body dark brown or black dorsally without conspicuous markings, white ventrally. Tail black (Compagno 1986; Compagno et al. 1989).

World Distribution This ray is distributed in the Indo-Pacific region from the Red Sea north to South Africa in the south and eastward to Micronesia and north of Japan (Russell and Houston 1989).

Distribution in the Study Area This species has been recorded from several localities around the Arabian peninsula (Hussain et al. 1988; Randall 1995; Randall 1997; Carpenter et al. 1997).

Habitat and Ecological Role This marine species enters fresh and brackish waters and lives in association with reefs at depths ranging from surface down to 60 m (Riede 2004; Last and Stevens 1994).

Biology There are two distinct forms of *P. sephen* present in Southeast Asia: a thick-fold tail and a thin-fold tail form. The thick-fold tail form reaches about 325 cm total length (TL; Fahmi pers. obs.; ~300 cm TL in the literature (Sommer et al. 1996), and 149 cm DW (White and Dharmadi 2007). Females mature at >100 cm DW and males at 98–100 cm DW (White and Dharmadi 2007). Size at birth is approximately 18 cm DW (Last and Stevens 1994; White et al. 2006). Fecundity is low, with one pup per litter (Fahmi pers. obs. 2007).

Economic Value This species is targeted for its skin, which is used as 'shagreen' in fashion accessories, from wallets to fancy pens; as a result, the species is in danger of disappearance (Sommer et al. 1996).

Conservation Status The conservation status of this species has been evaluated as Data Deficient in the Red List of IUCN for the reasons stated by Fahmi et al. (2009):

> It is reported throughout a wide range from the western Indian Ocean to the western Pacific, but may be a complex of species. It is captured in demersal tangle net, bottom trawl, longline, Danish seine and beach seine fisheries in Southeast Asia and parts of the Indian Ocean. Inshore fishing pressure is intense throughout large areas of the species' range in Southeast Asia and in parts of the Indian Ocean. It is caught in particularly high numbers in the target fishery for rhynchobatids operating in the Arafura Sea. Although no species-specific data are available, overall catches of stingrays are reported to be declining, with fishermen having to travel further and further to sustain catch levels. Given continuing high levels of exploitation throughout its range in Southeast Asia and evidence for declines in catches of stingrays, it is regionally assessed as Vulnerable there. The species is considered at minimal threat throughout its wide range of northern Australia, where it is assessed as Least Concern. Globally, investigation is vital to resolve the taxonomic issues associated with this species complex and it is not possible to assess it beyond Data Deficient at present. Further work is required to identify the species involved and make full assessments of their status.

Taeniura lymma (Forsskål 1775)
Common name: Ribbontail stingray
Arabic name: لخمه ذات الذنب الشريطي
Etymology: *Taeniura*: Latin, taenia = stripe + Greek, oura = tail (Fig. 7.15)

Identification
- Rounded and angular snout.
- Disc with broadly rounded outer corners and no large thorns but small, flat denticles along midback (in adults).
- Tail thick, tapering, less than twice body length, with broad lower caudal finfold reaching tail tip.
- Body with large bright blue spots on oval, elongated disc and blue side-stripes along tail. Grey-brown to yellow, olive-green or reddish brown dorsally, white ventrally (Compagno et al. 1989).

World Distribution It is distributed in the Indo-Pacific region from the Red Sea at the north to

Fig. 7.15 Ribbontail stingray, *Taeniura lymma* (Forsskål, 1775). Courtesy of Stephan Moldzio, Marine Biology Workshops

South Africa at the south and eastward to Solomon Islands, and northern to southern Japan (Lieske and Myers 1994).

Distribution in the Study Area This species is reported from many localities around the Arabian peninsula.

Habitat and Ecological Role This marine species lives in association with reefs at depth range 1–20 m (Last and Compagno 1999).

Biology Individuals of this species feed on mollusks, worms, shrimp, and crabs; they disperse on falling tides to seek shelter in caves and under ledges (Last and Stevens 1994). They are rarely found buried under the sand (Michael 1993). Females are ovoviviparous (Dulvy and Reynolds 1997), with embryos feeding initially on yolk, then receiving additional nourishment from the mother by indirect absorption of uterine fluid enriched with mucus, fat, or protein through specialised structures (Dulvy and Reynolds 1997). They bear up to 7 young (Compagno et al. 1989). Their maximum length is about 70 cm TL (Sommer et al. 1996).

Economic Value Small specimens are popular among marine aquarists (Compagno et al. 1989). They are utilised widely for their meat (Froese and Pauly 2016).

Conservation Status This species of ray has been rated as Near Threatened in the Red List of IUCN based on the reasons given by Fowler et al. (2005) and given by Compagno (2005). Although very wide ranging and common, the Ribbontailed Stingray (*Taeniura lymma*) is subject to human-induced problems because of heavy inshore fisheries in most places where it occurs, its attractiveness for the marine aquarium fish trade (small size and brilliant colour pattern), and especially by widespread destruction of its reef habitat.

Taeniurops meyeni (Müller and Henle 1841)
Common name: Round ribbontail ray
Arabic name: لخمه شريطية الذنب (Fig. 7.16)

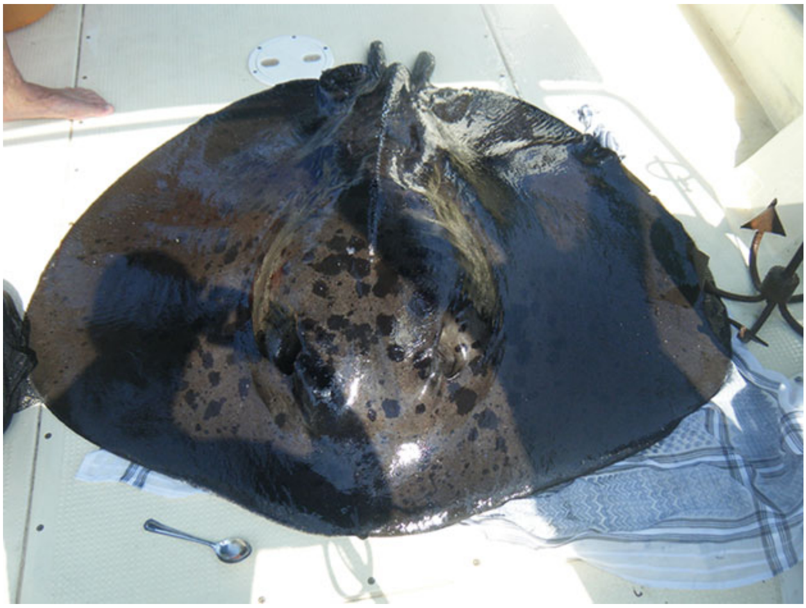

Fig. 7.16 Round ribbontail ray, *Taeniurops meyeni* (Müller & Henle, 1841). Courtesy of Alan Reeve, USA

Identification

- Large circular disc.
- No tubercles on back.
- Ventral skin fold that extends to tail tip (Last and Stevens 1994).
- Dorsal surface with black and white mottled upper.

World Distribution It is distributed in the Indo-West Pacific region, Red Sea, and East Africa to southern Japan, Micronesia, tropical Australia, and Lord Howe Island. It is found in the eastern Pacific and known only from oceanic islands (Cocos and the Galapagos; Grove and Lavenberg 1997).

Distribution in the Study Area It is reported from the Arabian Gulf (Carpenter et al. 1997).

Habitat and Ecological Role This marine species lives in association with reefs and is found at depth range 1–500 m (Myers 1999).

Biology Individuals of this species feed on bottom fish, bivalves, crabs, and shrimp (Compagno et al. 1989). Females are ovoviviparous (Dulvy and Reynolds 1997). The smallest free-swimming specimen recorded was 33 cm WD. It was taken for its meat and cartilage. This species may form schools, but usually swims with jacks and cobia (Michael 1993).

Economic Value No commercial value in the study area.

Conservation Status Kyne and White (2015) assessed the conservation status of this species and considered it as Vulnerable because (1) it was found inshore to a depth of 439 m; (2) little is known of its biology, although litter size known to be small (up to seven young); (3) there is little specific information on threats and catches in fisheries throughout much of the species' range; (4) its limiting life history characteristics; and (5) the general declining health of coral reef ecosystems (its main habitat) throughout its Indo-West Pacific distribution. This species is inferred to have undergone a decline in population size of at least 30% over the past three generations (65 years).

Family: Gymnuridae
Gymnura poecilura (Shaw 1804)
Common name: Long-tailed butterfly ray

Fig. 7.17 Long-tailed butterfly ray, *Gymnura poecilura* (Shaw, 1804). Courtesy of Alan Reeve, USA

Arabic name: لخمة الفراشه طويلة الذنب

Etymology: *Gymnura*: Greek, gymnos = naked + Greek, oura = tail (Fig. 7.17)

Identification

- Disc very wide. Corners of disc rounded.
- Curved snout.
- Spiracles larger than eye.
- Short tail about half-length of body. Venomous spine small at base of tail.
- Body light brown, with white spots dorsally and white ventrally. Tail has black and white bands (Randall 1995).

World Distribution It is distributed in the Indo-Pacific region from the Red Sea to French Polynesia, north of Japan (Carpenter et al. 1997).

Distribution in the Study Area It has been reported from several localities in the study area (Al-Mojil et al. 2015).

Habitat and Ecological Role This marine species prefers a demersal habitat.

Biology Individuals of this species prefer living in shallow waters (Sommer et al. 1996). Females are ovoviviparous. Embryos feed on yolk and then receive additional nourishment from the mother by indirect absorption of uterine fluid enriched with mucus, fat, or protein through specialised structures (Dulvy and Reynolds 1997).

Economic Value It usually taken for its meat.

Conservation Status It was assessed for the IUCN Red List as nearly threatened by Bizzarro and White (2006) for the following reasons.

> *Gymnura poecilura* has a widespread but apparently disjunct distribution in the Indo-West Pacific. The species has long been targeted in India, Thailand, Indonesia and likely elsewhere by artisanal and commercial fisheries for human consumption. Very little is known about most aspects of its biology and no recent quantitative information is available to determine population structure or fluctuations and potential fishery impacts. It is restricted to the inner continental and coastal shelves with a narrow depth range (to ~30 m), which is heavily exploited throughout much of its range. Furthermore, exploitation in these regions is only likely to increase into the future. Fecundity appears to be low, being reported up to seven pups/litter, and females are known to commonly abort embryos upon capture. With a lack of data to quanti[t]y declines, which may confirm this species is in fact threatened, at least in some regions, *Gymnura poecilura* is assessed as Near Threatened globally due to the high level of exploitation through much of its range, its restricted habitat and declines in closely related sympatric species, such as the zone tail butterfly ray *Aetoplatea zonura*. The longtail butterfly ray is highly susceptible to a variety of gear types and its restricted life history limits its ability to recover from population

Fig. 7.18 Longheaded eagle ray, *Aetobatus flagellum* (Bloch & Schneider, 1801). Courtesy of Hamid Osmany, Pakistan

depletion. Monitoring of catches of this species throughout its range is required immediately.

Family: Aetobatidae
Aetobatus flagellum (Bloch and Schneider 1801)
Common name: Longheaded eagle ray
Arabic name: لخمه طويلة الرأس (Figs. 7.18 and 7.19)

Identification

- Body rhomboidal.
- Snout fleshy and long.
- Nasal with a very deep notch.
- In both jaws, teeth fall in a single row.
- Pointed edges of pectoral fins. Pectoral fins join head at level of eye. Poisonous spine found behind dorsal fin.
- Body uniform brownish colour (Al-Mojil et al. 2015).

World Distribution This species is distributed in the Indo-Pacific region.

Distribution in the Study Area Al-Mojil et al. (2015) have reported this species from the Arabian-Persian Gulf. There is no record of this species from other localities around the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003; Henderson et al. 2007; Froese and Pauly 2016).

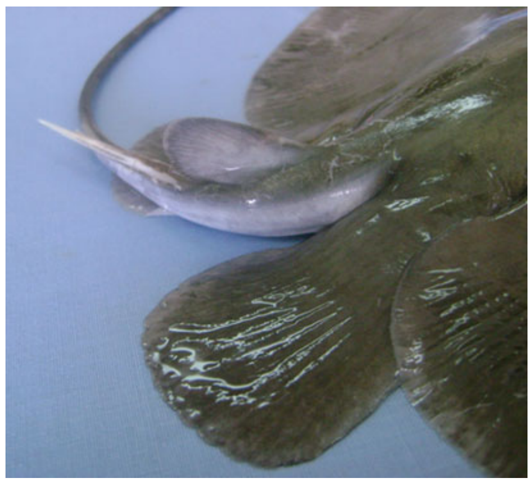

Fig. 7.19 Longheaded eagle ray, *Aetobatus flagellum* (Bloch & Schneider, 1801), poisonous spine. Courtesy of Hamid Osmany, Pakistan

Habitat and Ecological Role This marine species enters brackish water and prefers a benthopelagic habitat (Riede 2004).

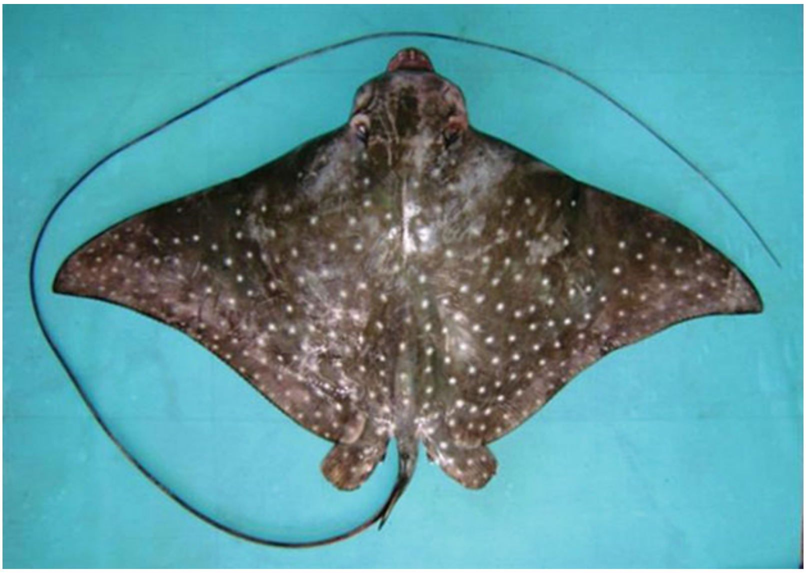

Fig. 7.20 Spotted eagle ray, *Aetobatus narinari* (Euphrasen, 1790). Courtesy of Hamid Osmany, Pakistan

Biology Females of this species are ovoviviparous (aplacental viviparity), with embryos feeding initially on yolk, then receiving additional nourishment from the mother by indirect absorption of uterine fluid enriched with mucus, fat, or protein through specialised structures (Dulvy and Reynolds 1997).

Economic Value They are caught occasionally by bottom trawling and inshore demersal gillnet fisheries off Jakarta. They are utilised for their meat, but are of limited value due to their rarity and small size (Froese and Pauly 2016).

Conservation Status The longheaded eagle ray is considered an endangered species for reasons given by White (2006):

> *Aetobatus flagellum* is a small (to 47 cm DW), uncommon, inshore Indo-West Pacific eagle ray which is highly susceptible to a variety of fishing methods in regions where the level of exploitation of marine resources is extremely high. This species has a disjunct distribution off Pakistan, India, Indonesia (Java), and southern China, occurring primarily on the inner continental shelf. It is suspected to have limiting life history parameters similar to other myliobatid rays (including low fecundity). Very few specimens are landed from any fisheries, but all of its known range is very heavily exploited. This species is has been given this criterion due to the very high (and increasing) level of fishing pressure in inshore regions where it occurs, which is of great concern given that it is a naturally very uncommon species with limiting life history characteristics.

Aetobatus narinari (Eupharasen 1790)
Common name: Spotted eagle ray
Arabic name: لخمه منقطه
Etymology: *Aetobatus*: Greek, aetos = eagle + Greek, batis, batidos = a ray (Figs. 7.20 and 7.21)

Identification

- Body rhomboidal shape.
- Long broad snout.
- Single row of teeth on both jaws. Teeth flat and chevron-shaped (Compagno et al. 1989).
- Disc with sharp pectoral angles.
- No caudal fin.
- Poisonous spine behind dorsal fin.
- Body with numerous white spots on black background. White ventral side.

World Distribution This species of ray is distributed in the western and eastern Atlantic Ocean (Smith 1997; McEachran and Séret 1990). In the Indo-Pacific region, it is found in the Red Sea at the north and South Africa in the

Fig. 7.21 Spotted eagle ray, *Aetobatus narinari* (Euphrasen, 1790), Poisonous spine. Courtesy of Hamid Osmany, Pakistan

south. It is also distributed to the east to South Australia (Compagno 1997).

Distribution in the Study Area It has been reported from several localities around the Arabian peninsula (Carpenter et al. 1997; Henderson et al. 2007).

Habitat and Ecological Role This marine species enters brackish water and lives in association with reefs at depth range 1–80 m (Lieske and Myers 1994).

Biology Individuals of this species have been shown to swim close to the surface, occasionally leaping out of the water, or close to the bottom (Stehmann 1981). They tend to form large schools during the nonbreeding season (Robins and Ray 1986). They feed mainly on bivalves but also eat shrimp, crabs, octopus, worms, whelks, and small fishes. Females are ovoviviparous (aplacental viviparity), with embryos feeding initially on yolk, then receiving additional nourishment from the mother by indirect absorption of uterine fluid enriched with mucus, fat, or protein through specialised structures (Dulvy and Reynolds 1997). Females bear up to four young (Compagno et al. 1989; Stehmann 1981; Myers 1999). Their width at birth is 17–35 cm (Myers 1999). According to Uchida et al. (1990) 'the male chases the female in mid water, then nibbles on her dorsal surface. The female stops swimming to begin copulation. The male bites the female on a pectoral fin and bends one clasper forward, then attempts abdomen to abdomen copulation with either clasper, usually mid-water.' Copulation lasts for 20 s to 1 min (Pratt and Carrier 2001).

Economic Value It is taken for its meat and cartilage (Ref. 58048) and the tail is used as a decorative item (Mohsin and Ambak 1996).

Conservation Status This species has been evaluated for the Red List of IUCN as Near Threatened for the reasons stated by Kyne et al. (2006):

> It is widely distributed across the Indo-Pacific and eastern and western Atlantic in tropical and warm-temperate waters. Recorded over the continental shelf from the surface to 60 m depth in coastal and open ocean environments. Sometimes enters lagoons and estuaries and is often associated with coral-reef ecosystems.
>
> Females bear a maximum of four pups/litter after a gestation period of probably a year. These limited biological parameters, the species' inshore habitat and hence availability to a wide variety of inshore fishing gear (beach seine, gillnet, purse seine, benthic longline, trawl etc.), its marketability and the generally intense and unregulated nature of inshore fisheries across large parts of the species' range warrant a global listing of Near Threatened, and a Vulnerable listing in Southeast Asia where fishing pressure is particularly intense and the species is a common component of landings.

Aetobatus ocellatus (Kuhl 1823)
Common name: Ocellated eagle ray
Arabic name: لخمة النسر المبقعة
Etymology: *Aetobatus*: Greek, aetos = eagle + Greek, batis, batidos = a ray (Figs. 7.22 and 7.23)

Identification

- Large size fish.
- Tail and poisonous spines long.
- Teeth in single row.

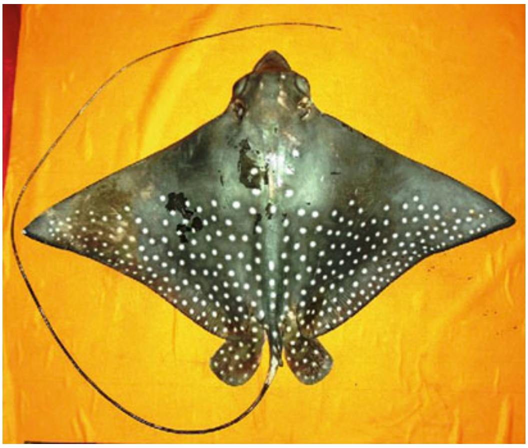

Fig. 7.22 Ocellated eagle ray, *Aetobatus ocellatus* (Kuhl, 1823). Courtesy of Hamid Osmany, Pakistan

- Radial-shaped pectoral fin.
- Body dorsal side dark greenish colour, with white ocellated spots (White et al. 2010).

World Distribution It is reported from several localities in the Indo-Pacific region (Froese and Pauly 2016).

Distribution in the Study Area It is reported from the Arabian-Persian Gulf (Al-Mojil et al. 2015).

Habitat and Ecological Role This marine species prefers a benthopelagic habitat and living at depth range 1–100 m (Randall and Cea 2011).

Biology Females ovoviviparous (Dulvy and Reynolds 1997). Not much biological information is available about this species.

Economic Value No commercial value presents for this species.

Conservation Status Not evaluated.

Aetomylaeus maculatus (Gray 1834)
Common name: Mottled eagle ray
Arabic name: لخمه مرقطه

Etymology: *Aetomylaeus*: Greek, aetos = eagle + Greek, mylio = mill, grinder (Fig. 7.24)

Identification

- Body rhomboidal with acute pectoral corners.
- Snout long, rounded anteriorly.
- Eye big.
- Tail very long.
- Distinctive coloration on dorsal side of body (Myers 1999).

World Distribution It is distributed in the Indo-West Pacific.

Distribution in the Study Area It has been reported form several localities in the Arabian-Persian Gulf (Carpenter et al. 1997) and from Iran (IFC and IFRO 2000). There is no record of this species from the Sea of Oman and southern coasts of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003; Henderson et al. 2007).

Habitat and Ecological Role This marine species enters brackish water and lives in association with reefs at depth range 1–18 m (Myers 1999).

Biology This species is an active swimmer and able to travel long distances. Individuals feed on crustaceans and molluscs (Carpenter et al. 1997). Females are ovoviviparous (aplacental viviparity), with embryos feeding initially on yolk, then receiving additional nourishment from the mother by indirect absorption of uterine fluid enriched with mucus, fat, or protein through specialised structures (Dulvy and Reynolds 1997).

Economic Value It is taken for its meat (Dulvy and Reynolds 1997).

Conservation Status The mottled eagle ray is considered an endangered species for the reasons given by White (2006):

Fig. 7.23 Ocellated eagle ray, *Aetobatus ocellatus* (Kuhl, 1823), fish market. Courtesy of BEDO, Thailand, via Wikimedia commons CC BY-SA 4.0

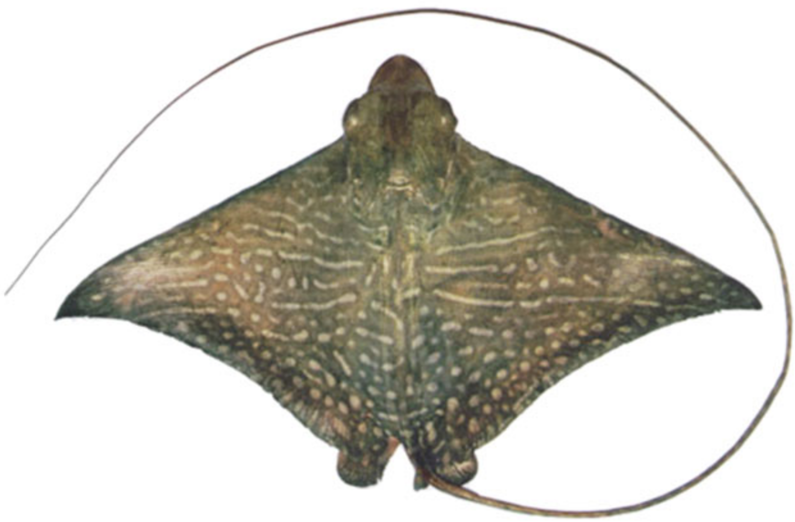

Fig. 7.24 Mottled eagle ray, *Aetomylaeus maculatus* (Gray, 1834). Courtesy of S. Rezvani, Iran

[M]edium-sized (to 78 cm DW), inshore Indo-West Pacific eagle ray which is highly susceptible to a variety of fishing methods in regions where the level of exploitation of marine resources is extremely high (e.g., India, Thailand, Taiwan and Indonesia). It is caught regularly by demersal gill-net and trawl net fisheries that operate throughout its range. It is suspected to have limiting life history parameters similar to other myliobatid rays (including low fecundity). This species is assessed as endangered due to the very high (and increasing) level of fishing pressure in inshore regions where it occurs, which is of great concern for any inshore species with limiting life history characteristics that is highly susceptible to fishing activities, and evidence of extirpation from some areas (this species no longer occurs in the Gulf of Thailand where eagle rays were historically common).

Fig. 7.25 Oman cownose ray, *Rhinoptera jayakari* Boulenger, 1895. *Dorsal view*. Courtesy of Hamid Osmany, Pakistan

Fig. 7.26 Oman cownose ray, *Rhinoptera jayakari* Boulenger, 1895. *Front view*. Courtesy of Hamid Osmany, Pakistan

Rhinoptera jayakari (Boulenger 1895)
Common name: Oman cownose ray
Arabic name: لخمة أنف البقره العمانيه
Etymology: *Rhinoptera*: Greek, rhinos = nose + Greek, pteron = fin, wing (Figs. 7.25 and 7.26)

Identification

- Body rhomboidal in shape.
- Pointed pectoral fin edges. Pectoral fins with straight and slightly curved edges, respectively. Origin of dorsal fin nearly at level of insertion of pectoral fins.
- Snout with bi-lobed upper part separated from lower projected and bi-lobed lower part.
- Teeth plate-like (Randall 1995; Al-Mojil et al. 2015).
- Tail short.
- Poisonous spine located behind dorsal fin.

World Distribution It is distributed in the western Indian Ocean.

Distribution in the Study Area Randall (1995) stated that the distribution of this species is confined to the Sea of Oman, but Henderson et al. (2007) have reported it from the Arabian Sea coasts of Oman and Al-Mojil et al. (2015) have recorded it from the Arabian-Persian Gulf.

Habitat and Ecological Role This marine species prefers a pelagic habitat.

Biology This is a poorly known species with not much information available.

Economic Value No commercial value.

Conservation Status Not evaluated.

7.2.2 Venomous Catfishes

There are 34 valid families in the group of catfishes (Order Siluriformes) and over 400 genera with over 3000 known species (Ferraris 2007). However, there is a lack of the actual number of species of catfishes in spite of the available estimate about the number of species of this group. The venom glands in catfish are located on the dorsal spine and on the spines of the two pectoral fins. They have axillary venom glands, and one dorsal, and two pectoral fin barbels to inflict envenomation (Singletary et al. 2005). The fins are composed of sharp retrose teeth that can lacerate the skin, increasing exposure and absorption of the venom (Baker 1997; Blomkalns and Otten 1999). Soft tissue infections secondary to catfish envenomation are relatively uncommon pathologic conditions presenting to emergency departments at hospitals. Complications related to catfish envenomation involve infection. The severity of the infection varies with the species of the catfish (Roth and Geller 2010).

Background

The ability of catfishes to cause painful stings has been well known for a long time, but it is not very well documented. Autenrieth (1833) mentioned that Richter (1764) cited in Autenrieth (1833) wrote about a fatal incident that happened to a Spanish angler after a strike by a sea catfish. Günther (1864) was the first to gather all the information about the attack of catfish and stated that there is a lack of scientific knowledge regarding the venom organs of these fishes. Later, Bottard (1899) described for the first time the venom apparatus of the oriental catfish *Plotosus lineatus*. In the early twentieth century, the works of Reed (1900a, b, 1906, 1907) and Reed and Lloyd (1916) mark the beginning of a comprehensive description of the venom organs of a catfish. The toxicological and immunological properties of catfish venom were dealt with by Toyoshima (1918). Mansueti (1951) reported on the stinging ability of a catfish. Several studies on the venom structure of the catfish have continued to appear since then (Halstead et al. 1953; Halstead 1959; Halstead and Mitchell 1963).

Structure of the Venom Apparatus

The morphology of the venom apparatus of several catfish species has been described, but that of *Plotosus lineatus* is considered in this book as this species is common in the study area. The following description is based on the writings of Pawlowsky (1913), Bhimachar (1944), and Tang (1954). Here a summary of this description is given according to Halstead (1967; Fig. 7.27).

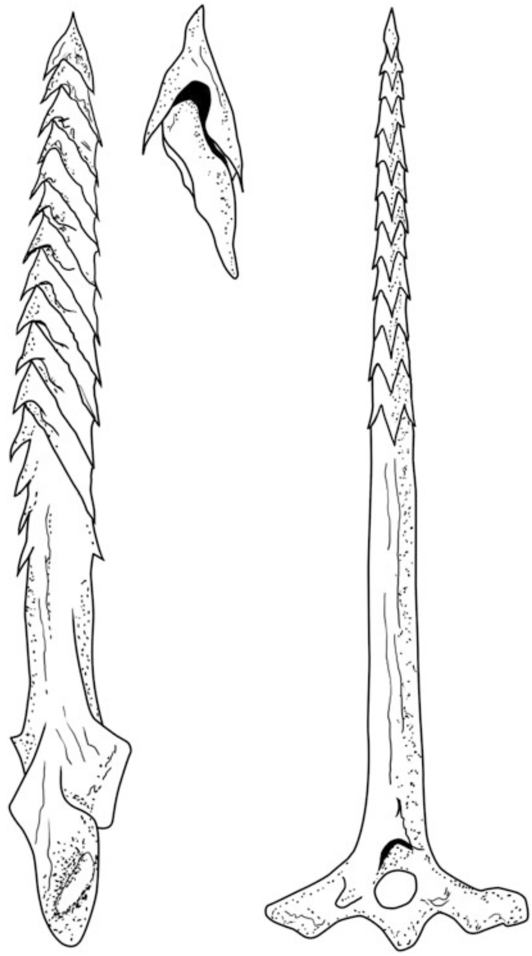

Fig. 7.27 Dorsal spine of *Plotosus lineatus*. *Left*, lateral view of dorsal spine showing the retrorse dentations. *Right*, posterior view of the dorsal spine showing the proximal opening and the median foramen at the base of the spine. After Halstead (1967)

The venom apparatus of *P. lineatus* is composed of the dorsal and pectoral spines and an axillary gland. The dorsal spine is hard, strong, elongated, compressed, tapered, and bears a series of retrorose dentations along the anterior and posterior surfaces and ending in acute sagittae tip. There are more serrations and they are more conspicuous on the anterior side than the posterior. These serrations extend from the basal third of the spine to the tip. The spine is covered with thin skin, which is continuous with that of the fin, with an absence of an external venomous gland. The central shaft of the spine is a hollow canal running along the length of the spine and there is no indication of its connection with the poison gland that runs along the spine on each side. This gland covers the whole width of the spine.

The pectoral spine is similar in structure to that of the dorsal spine. It also contains the integumentary sheath and central canal. The venomous gland is similar to that of the dorsal spine poisonous gland. The axillary gland has a chestnut shape, and is located at the base of the pectoral spine. This gland opens on the surface of the pectoral spine by a small orifice.

The microscopic structure of both the dorsal and pectoral stings is the same. The cross- section of the spine shows that each spine is composed of three zones: a peripheral integumentary sheath, an intermediate osseous portion, and a central canal. Rich glandular elements are found in the integumentary sheath. The poisonous gland is broad at the middle of the spine and tapered towards the proximal and distal ends of the spine. The cross-section shows that the axillary gland is surrounded on the outside by a thick capsule of connective tissue, which penetrates into the gland and divides the glandular parenchyma into several sections or pockets.

Vanscoy et al. (2015) have suggested that the shape of the pectoral fin spines of some species they studied is a good taxonomic criterion. At the same time, the shape of the pectoral spine supports hypotheses of monophyly for subgenera *Malacobagrus*, and suggests a close relationship between some species.

Fig. 7.28 Drawing showing a catfish in the act of stinging. After Halstead (1967)

Causative Agent

The general sting mechanism of catfishes is shown in Fig. 7.28. When a spine enters a potential predator, the integument surrounding the venom gland cells is destroyed, releasing venom into the wound. Catfish venom is shown to display neurotoxic and haemolytic properties and can produce a variety of additional effects such as severe pain, ischemia, muscle spasm, and respiratory distress, although any single species' venom may not display all of these properties (Halstead 1978). The neurotoxic and haemolytic properties could be due to a 15-kDa protein, termed toxin-PC (Auddy and Gomes 1996). In some catfish species, the venom contains from two to eight toxic proteins with approximate molecular weights of 10 kDa (Calton and Burnett 1975). Both the mechanism by which these toxins act and their physiological targets are very poorly understood. It is thought that cytolytic activity caused by pore formation in cell membranes is a likely explanation, as this activity is present in other 'pain-producing' venoms, such as those produced by bees (Pawlak et al. 1991) and platypus (Kourie 1999), and reactions consistent with this mechanism have been observed in response to piscine venoms (Church and Hodgson 2002).

Symptoms

Catfish envenomation manifests as local intense pain, oedema, erythema, and paleness, and occasionally as cutaneous necrosis (Baker 1997; Blomkalns and Otten 1999; Haddad 2000, 2003a, b; Haddad and Lastoria 2005). Systemic manifestations, such as cardiac arrhythmias, dyspnoea, or neurological symptoms, do not occur during the acute envenomation phase (Haddad

Fig. 7.29 Spotted catfish, *Arius maculatus* (Thunberg, 1792). Courtesy of Thomas Gloerfelt-Tarp, Australia

2000; Haddad and Lastoria 2005). The punctures caused by catfish are always painful, but when the fish have venomous stings, the pain is intense and persists longer. The pain can spread. There is local inflammation, but symptoms subside after about 6 h, without other complications. Complications occur when stings break in the wound, acting as foreign bodies and encouraging secondary bacterial and fungal infections, which are a major problem.

Treatment

The treatment of catfish envenomation is similar to that of stingray stings.

Prevention

Envenomation by catfish can be prevented by avoiding direct contact with dorsal and pectoral spines of the fish. To handle the catfish, one should grasp the fish firmly behind the dorsal and pectoral fins.

Venomous Catfish Species

There are several catfish species in the study area whose description is beyond the scope of this book. The account of the very common catfish species is given below.

Order: Siluriformes
Family: Ariidae
Arius maculatus (Thunberg 1792)

Fig. 7.30 Spotted catfish, *Arius maculatus* (Thunberg, 1792), head. Courtesy of Hamid Osmany, Pakistan

Common name: Spotted catfish
Arabic name: سمكة القط المنقطه
Etymology: *Arius*: Greek, arios, areios = dealing with Mars, warlike, bellicose (Figs. 7.29 and 7.30)

Identification

- Body stout, deeper at anterior side.
- Head shield covered with coarse granules.
- First dorsal ray usually prolonged as a filament. Short median dorsal groove.
- Maxillary barbels not reaching base of pectoral fin.

Fig. 7.31 Bronze catfish, *Netuma bilineata* (Valenciennes, 1840). Courtesy of Gloerfelt-Tarp, Thomas, Australia

- Body grey to brown dorsally, silvery shading on sides. White abdomen. Adipose fin with black blotch (Randall 1995).

World Distribution This species is distributed in the Indo-West Pacific region (Russell and Houston 1989).

Distribution in the Study Area This species is reported from the Sea of Oman and southern coasts of the Arabian peninsula (Randall 1995; Manilo and Bogorodsky 2003).

Habitat and Ecological Role This marine species enters fresh and brackish waters and prefers a demersal habitat (Riede 2004). It lives at depth range 50–100 m (Al Sakaff and Esseen 1999).

Biology Individuals of this species occasionally form schools. They feed on invertebrates and small fishes. Males incubate eggs in the mouth (Breder and Rosen 1966). During incubation, males starve which sometimes make them resort to swallowing one or two eggs probably to maintain basal metabolism (Jeyaseelan 1998). Early hatching embryos commence feeding on inhaled particles by the female when still in possession of large yolk.

Economic Value It is taken for its flesh and marketed fresh. Air bladders are exported as isinglass used by the wine industry (Jeyaseelan 1998).

Conservation Status Not evaluated.

Netuma bilineata (Valenciennes 1840)
Common name: Bronze catfish
Arabic name: سمك القط البرونزي
Etymology: *Netuma*: A Tamil word that means 'dance' (Fig. 7.31)

Identification

- Body thick and stout with triangular cross-section.
- Short rounded snout.
- Coarse granules on head shield.
- Body dark grey colour, with silvery to bronze sides (Randall 1995).

World Distribution It is found in the Indo-Pacific region from the northwest Indian Ocean to the Indo-Malayan region, northern Australia, Queensland, and north to southern Japan (Froese and Pauly 2016).

Distribution in the Study Area It is reported from several localities in the study area.

Fig. 7.32 Giant catfish, *Netuma thalassina* (Rüppell, 1837). Coutresy of Hamid Osmany, Pakistan

Habitat and Ecological Role This marine species enters brackish water and prefers a demersal habitat.

Biology Not much information is available about this species.

Economic Value This species is taken for its meat, and has good commercial value.

Conservation Status Not evaluated.

Netuma thalassina (Rüppell 1837)
Common name: Giant catfish
Arabic name: سمكةالقط الكبيره
Etymology: *Netuma*: A Tamil word that means 'dance' (Fig. 7.32)

Identification

- Body strong and thick with nearly triangular cross-section.
- Snout blunt.
- Head shield with fine granules.
- Predorsal plate small and with a V-shape.
- Body blue-black with white abdomen.

World Distribution It is distributed in the Indo-Pacific region, Red Sea, and northwestern Indian Ocean (Froese and Pauly 2016). It is recorded from Australia, Polynesia, and Japan (Rainboth 1996).

Distribution in the Study Area It is reported from several localities in the Arabian Gulf area (Froese and Pauly 2016).

Habitat and Ecological Role The giant catfish is a marine species that enters freshwater and brackish, prefers a demersal habitat, and has an amphidromous habit (Riede 2004). It lives at depth range 10–195 m (Pauly et al. 1996).

Biology Individuals of this species feed on crabs, prawns, mantis shrimp, mollusks, and fishes.

Economic Value It is considered as an important food item.

Conservation Status Not evaluated.

Plicofollis dussumieri (Valenciennes 1840)
Common name: Blacktip sea catfish
Arabic name: سمكة القط سوداء الزعنفه (Figs. 7.33 and 7.34)

Identification

- Body stout and deep under pectoral fin area.
- Anterior profile of fish pointed.
- Body dark brown, lower surfaces completely covered with fine brown pigment specks (Taylor 1986).

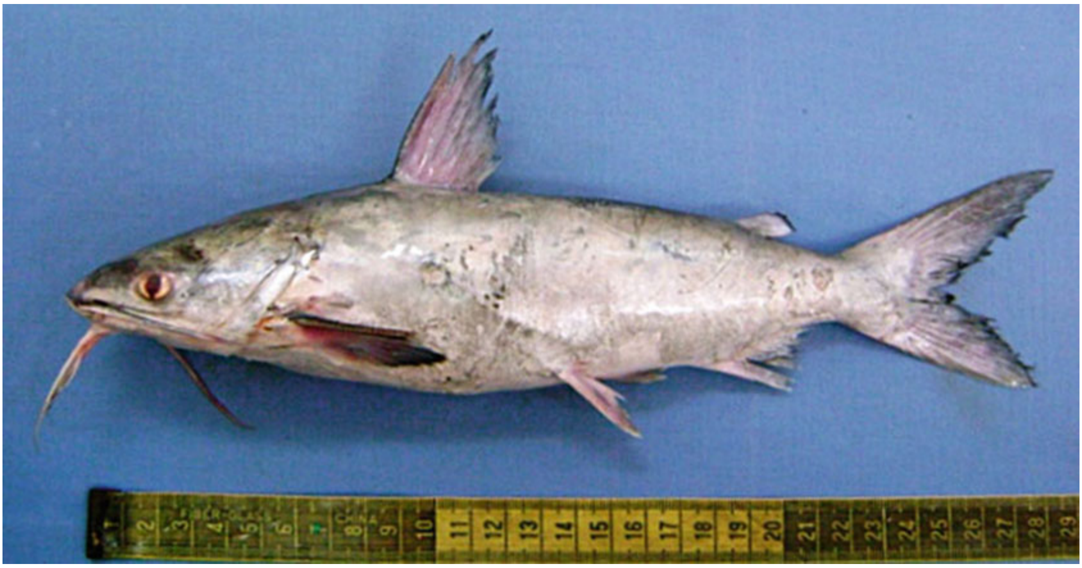

Fig. 7.33 Blacktip sea catfish, *Plicofollis dussumieri* (Valenciennes, 1840). *Lateral view*. Courtesy of Hamid Osmany, Pakistan

Fig. 7.34 Blacktip sea catfish, *Plicofollis dussumieri* (Valenciennes, 1840). *Dorsal view* of head. Courtesy of Hamid Osmany, Pakistan

World Distribution It is distributed in the Indo-West Pacific region from east African coasts to Sri Lanka (Ng and Sparks 2003).

Distribution in the Study Area It has been reported from the southern coasts of the Arabian peninsula (Al Sakaff and Esseen 1999).

Habitat and Ecological Role This marine species enters fresh and brackish waters, prefers a demersal habitat, and lives at depth range 20–50 m (Al Sakaff and Esseen 1999).

Biology Not much information is available about the biology of this species. Individuals feed on invertebrates and small fishes.

Economic Value It is taken for its meat and marketed fresh and dried-salted. The air bladder is utilised for isinglass (Jayaram 1984).

Conservation Status This species has been evaluated as Least Concern in the Red List of IUCN for the reasons given by Devi and Boguskaya (2009): 'Very large distribution and the lack of any known major widespread threats. Though it is utilized, there is no evidence at present that this poses a major threat to the species, however, further research into harvest levels would be beneficial in confirming this.'

Plicofollis tenuispinis (Day 1877)
Common name: Thinspine sea catfish
Arabic name: سمكة القط ذات الشوكة النحيفة (Fig. 7.35)

Identification

- Head has gentle slope.
- Three pairs of barbels, with maxillary pair extending to pectoral fin base.
- Thin granules on head shield.
- Strong spines on pectoral and first dorsal fins.

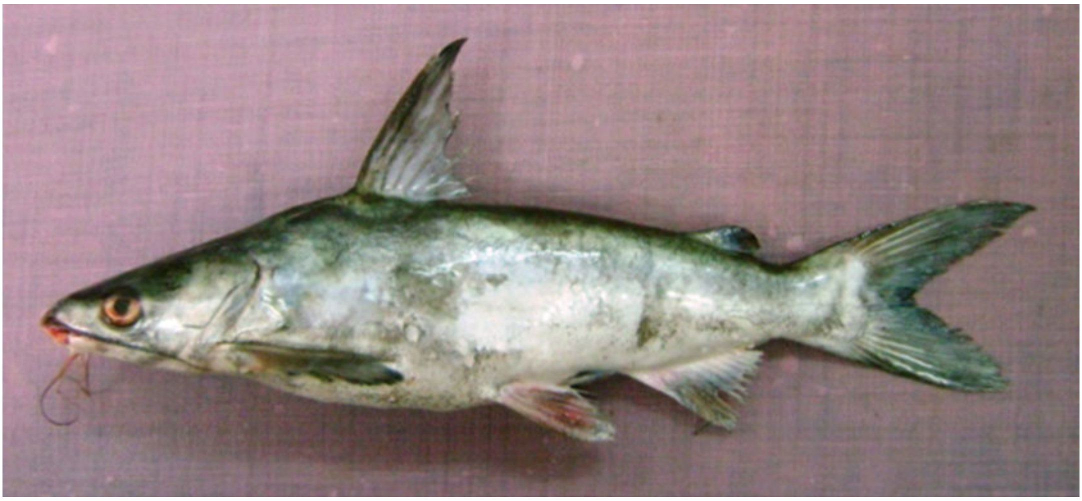

Fig. 7.35 Thinspine sea catfish, *Plicofollis tenuispinis* (Day, 1877). Courtesy of Hamid Osmany, Pakistan

- Upper side of head and upper half of body cement-grey, merging to silvery grey on belly. Tips of dorsal, pectoral, and caudal fins dark.

World Distribution It is distributed in the western Indian Ocean from Mozambique to Sri Lanka (Froese and Pauly 2016).

Distribution in the Study Area It has been reported from several localities around the Arabian peninsula (Wright 1988; Carpenter et al. 1997).

Habitat and Ecological Role This marine species enters brackish water, prefers a demersal habitat, and lives at depth range 20–50 m (Al Sakaff and Esseen 1999).

Biology It feeds mainly on invertebrates and small fishes (Froese and Pauly 2016).

Economic Value It is taken for its meat.

Conservation Status Not evaluated.

Family: Plotosidae
Plotosus lineatus (Thunberg 1787)
Common name: Striped eel catfish
Arabic name: سمكة القط المخططه
Etymology: *Plotosus*: Greek, plotos = swimming (Figs. 7.36 and 7.37)

Identification
- Short nasal barbels. Four pairs of mouth barbels.
- Continuous dorsal and anal fins with caudal fin.
- Single highly venomous serrate spine at the beginning of first dorsal and each pectoral fin (Myers 1991).

World Distribution It is distributed in the Indo-Pacific region from the Red Sea north and south to east Africa and to the east to Samoa, Japan, Korea, south of Australia, and Lord Howe Island (Myers 1991).

Distribution in the Study Area It is reported from several localities in the study area.

Habitat and Ecological Role It is a marine species that enters brackish water and is found in association with coral reefs (Riede 2004).

Biology It lives in depth range 1–60 m (Myers 1999). It is the only catfish that lives in

Fig. 7.36 Striped eel catfish, *Plotosus lineatus* (Thunberg, 1787). Courtesy of Sahat Ratmuangkhwang, Thailand

Fig. 7.37 Striped eel catfish, *Plotosus lineatus* (Thunberg, 1787). Courtesy of Robert Patzner, Austria

association with coral reefs. Adults prefer solitary life, but juveniles form an aggregation of more than 100 fish in the shape of a ball (Cornic 1987; Rainboth 1996; Myers 1991, 1999; Kuiter and Tonozuka 2001). Individuals of this species feed on crustaceans, mollusks, worms, and fish (Fischer et al. 1990). Females are oviparous, with demersal eggs and planktonic larvae (Breder and Rosen 1966).

Economic Value No commercial value.

Conservation Status Not evaluated.

7.2.3 Venomous Scorpaenid Fishes

Among the most dangerous venomous fishes are the members of the family Scorpaenidae. They are slow-moving animals and widely distributed in tropical and temperate shallow waters. These fishes prefer hiding near rocks, in reefs, or under plants, which are enhancing factors to human accidents (Russell 1965; Haddad 2000). Human activities such as careless fish handling or the fish being stepped on will lead to the release of the venom from the poisonous glands into the wound (Russell 1965). Pain and oedema are the most distinct symptoms of such poisoning.

Background

The writing of Aristotle (384–322 BC; Coutière 1899) about the sea hog (*Scorpaena porcus*) could be considered the first publication in the history of scorpaenid fish poisoning. No known writings were published about the venom of the scorpion fish since the time of Aristotle until the middle of the sixteenth century when Rondelet (1507–1557), Salviani (1514–1572), and Belon (1517–1564; cited by Halstead 1970) published their work on scorpionfishes and their venom. Autenrieth (1833) wrote on the stings of several scorpionfish species. Bottard (1899, cited in Coutière 1899) described for the first time the morphology of the venom organs of scorpionfishes in his *Les Poisons Venimeux*. In the early twentieth century, the nearly complete anatomical description on the venom organs of scorpaenids was that of Pawlowsky (1906, 1913, 1929), where he investigated a large number of species of this group. As to the toxicological studies, the works of Duhig (1929) and Duhig and Jones (1928a, b) are considered pioneering in this field. Since then, an increased interest in the study of the incidents of scorpionfish stings and venom were noticed and appeared in several publications (Tang 1953, 1954; Halstead et al. 1956; Endean 1961; Kizer et al. 1985; Patel and Wells 1993; Haddad et al. 2003a, b).

Morphology of the Venom Apparatus of Scorpaenid Fishes

There are three types of venom organs in scorpionfishes which differ in their structure, and are found in the three genera *Pterois*, *Scorpaena*, and *Synanceja* (Fig. 7.38). In general, the venom organs of scorpionfishes are more complicated than other poisonous fishes. Below is a summary of the description of venom organs

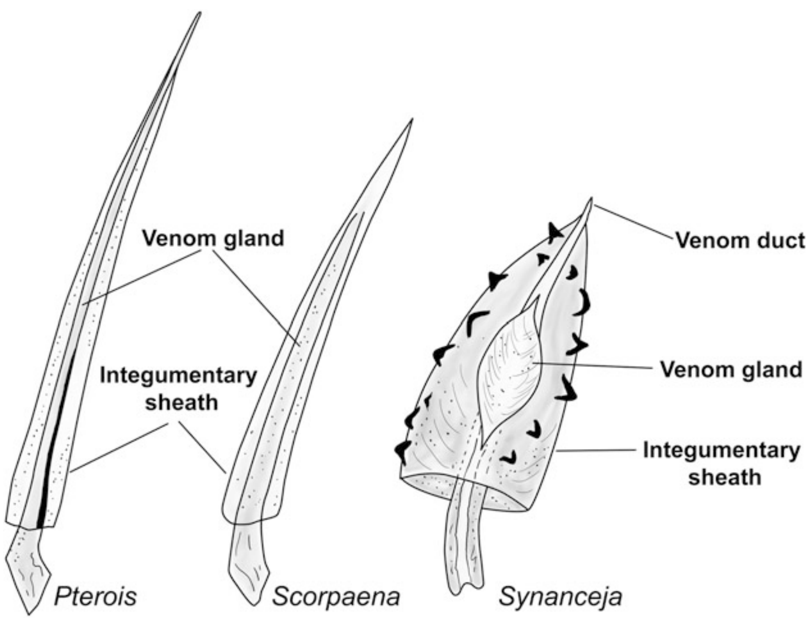

Fig. 7.38 Drawing showing morphological differences in the stings of *Pterois*, *Scorpaena* and *Synanceja*. After Halstead (1967)

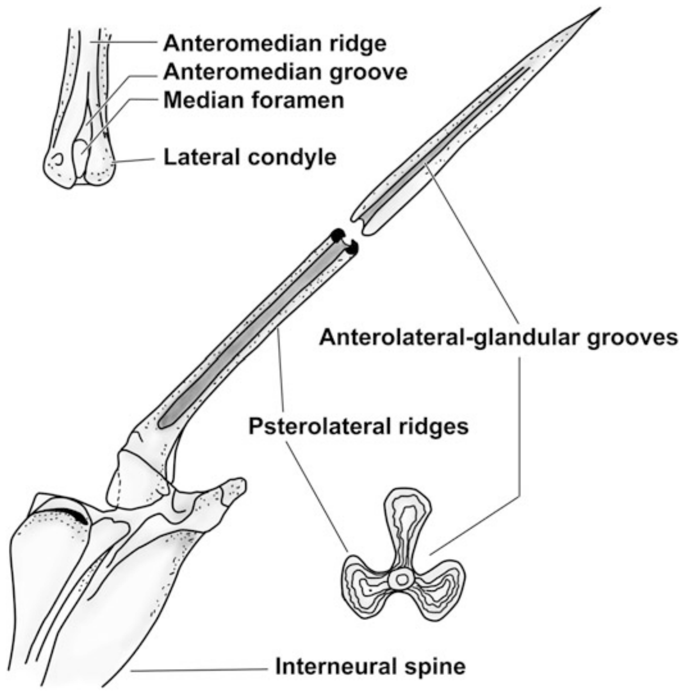

Fig. 7.39 Drawing of a typical dorsal spine of *Pterois volitans*. After Halstead (1967)

of *Pterois*, *Scorpaena*, and *Synanceja* based on Halstead (1970).

Venomous Organs of the Members of the Genus *Pterois* (Fig. 7.39)

There are 13 dorsal spines, three anal spines, and two pelvic spines included in the venom organs of this group of scorpionfishes. All these spines are connected with appropriate poisonous glands and covered by integumentary sheaths. The integumentary sheath is part of the poisonous structure, where venom is produced within its inner surface. The spine of the dorsal fin is elongated and straight except for its terminal end, where it is slightly curved. The outline of the tip of the spine is triangular in cross-section. A groove known as the 'anterolateral-glandular groove' runs along the dorsal side of the spine and is connected with the lateral condyle at the base of the spine, with a deep channel running along its length. The anal spines are short, firm, and slightly curved at the tip, which is triangular in shape. The anterolateral–glandular groove is similar in shape to that found in the dorsal spine, but shallow. There some differences in the structure of the spine among the anal fin spines as some of the spines lack the anterolateral–glandular groove. The spines of the ventral fin are different from those of dorsal and anal fins. In these spines, the anterolateral–glandular groove is absent, and instead there are superior and inferior grooves originating from condyles near each of them.

Venomous Organs of the Members of the Genus *Scorpaena* (Fig. 7.40)

There are 12, 3 and 2 dorsal, anal and pelvic spines respectively in the venom organ of the member of the genus *Scorpaena*. Similar to those spines of the genus *Pterois*, they are covered with a glandular integumentary sheath. The spine itself is slender with fusiform shape. The spines of the dorsal fin are elongated, straight, and slightly curved at the tip, which is trigonal in outline. The anterolateral–glandular groove originates in the middle third of the spine. It is shallow along the length of the spine and gets deeper near the tip. The anal spines are similar in shape to those of the dorsal spines. The grooves are narrow and shallow in the basal part of the

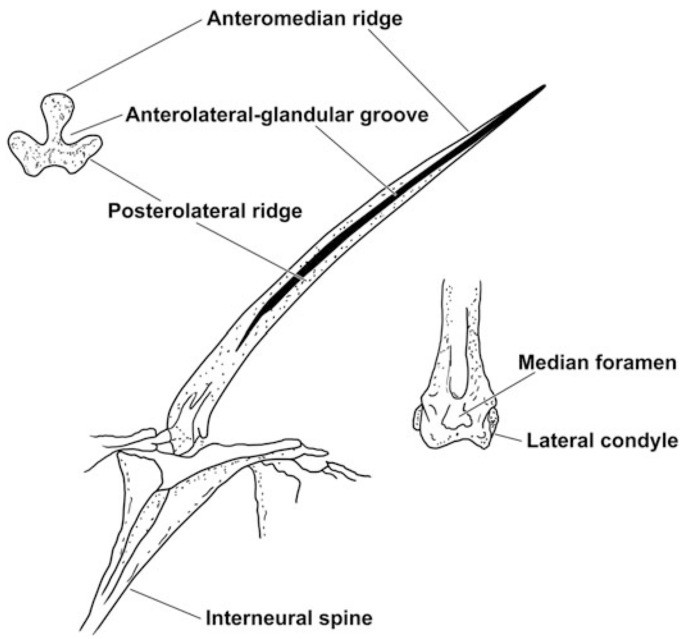

Fig. 7.40 Drawing of a typical dorsal spine of *Scorpaena guttatua*. After Halstead (1967)

spine and become wider and deeper towards the tip of the spine. The pelvic spines are also similar to those of the dorsal and anal spines in shape and structure.

The microscopic structure of the venom organs of all scorpionfishes is the same. The spine is composed of a dentine structure and is invested in the layer of the skin. The peripheral sides of the spines are composed of viterodentine. Inside the shaft of the spine, the cross-section shows the presence of a broad groove of variable dimensions that gets smaller in size towards the tip of the spine. The integumentary sheath that covers the spine is a thin layer of dense fibrous connective tissue. In this epithelial tissue, there are numerous large mucous cells, with a clear cytoplasmic area. The epidermis and dermis of the sheath are separated by a thick pigmented layer adjoining the basement membrane of the epidermis. Within the anterolateral–glandular groove, there is a cluster of large polygonal glandular cells filled with granular cytoplasm. In the longitudinal section of the spine, the dentine-like substance is shown to be thick near the base and narrow cavities appear in the structure of the spine towards the tip.

Causative Agent

Two types of envenomation mechanisms are employed by the different species of scorpionfishes. The victim either gets a stab from the spines by mishandling of a fish through removing them from a net or a hook, or by unwary stepping on the dorsal stings of a stonefish. In both cases, the venom will be injected into the body of the victim with aid of the spines. In the process of envenomation and due to the pressure resulting from the penetration of the spines into the body of the victim, the glandular sheath covering the spines ruptures and venom is injected in the wound by the anterolateral–glandular groove.

The scorpaenid venom is an unstable protein, with a molecular weight 150,000. It can be denatured by heat, a characteristic used in its treatment. Saunders and Taylor (1959) and Choromanski et al. (1984) suggested that the tissue from the lionfish spine contains one or more soluble lethal toxins. As with other soluble venom preparations from Scorpaenidae, the toxic component in soluble extracts is not stable under conventional storage conditions. The scorpaenid venom is composed of several biologically active factors: (1) hyaluronidase fraction, (2) capillary-permeability factor, (3) a toxic or lethal fraction (Wiener 1959), and (4) a pain- producing factor (Austin et al. 1965).

Symptoms

Halstead (1970) gave the following general symptoms when the venom of a scorpaenid fish species enters the body of a victim. The venom can cause sharp throbbing pain, which can continue for several hours. The skin around the wound may become swollen, red, and hot. Gangrene will follow subsequently as a result of secondary bacterial infection. Systemic failure includes cardiac failure, delirium, convulsions, and nervous disturbances. Victims may have a primary shock accompanied with faintness, weakness, nausea, loss of consciousness, rapid weak pulse, low blood pressure, and respiratory distress. There are some variations in the symptoms caused by introducing the venom of different species of scorpaenid fishes.

Scorpaenid venom contains high concentrations of acetylcholine that affects the physiology of isolated heart and skeletal muscle preparations. The role of acetylcholine in spine tissue might enhance the action of the toxic component, perhaps by inducing local vasodilation at the injection site or by producing pain by direct or indirect action on sensory neurons (Saunders and Taylor 1959; Choromanski et al. 1984). The toxin induces a period of muscle fibrillation followed by neuromuscular blockade, which could account for the toxic symptoms, that is, respiratory distress, uncoordinated movement, muscular weakness and paralysis, followed by death (perhaps as a result of respiratory arrest; Cohen and Olek 1989).

The capillary permeability factor of the venom leads to huge oedema after envenomation (Poh et al. 1991) and may account for haemorrhagic pulmonary oedema. The stonustoxin is the lethal part of the toxin and may cause significant hypotension, which is the main cause of death (Low et al. 1994).

Treatment

The following treatment steps were summarised from Halstead (1970). Alleviation of the pain, preventing the effect of the venom, and stopping secondary infection are the main targets in scorpaenid fish poisoning. The wound should be thoroughly cleaned in order to remove the venom as much as possible. In the scorpionfish stings, bleeding is encouraged and a bandage should be applied above the wound and released every few minutes. Hot water as much as the victim can tolerate should be applied to the wound as soon as possible and the process of cleaning the wound should last for more than an hour. No surgical closure of the wound is recommended and antitetanus agents should be applied. Envenomation of the stonefish is more severe and dangerous than scorpionfishes and requires immediate intensive care. For such cases, antivenin is used, which consists of refined and concentrated hyperimmune horse serum, which neutralises the stonefish venom.

Species of Scorpionfishes

Parapterois macrura (Alcock 1896)

Common name: Wide side scorpionfish

Arabic name: السمكه العقربيه عريضة الزعنفه

Etymology: *Parapterois*: Greek, para = the side of + Greek, pterois, derived from pteron = wing, fin (Fig. 7.41)

Identification

- Elongated compressed body.
- Short high head.
- Ctenoid scales covering sides of snout, interorbital space, suborbital and postorbital areas, occiput, preopercle and opercle; absent on interopercle, maxilla, both lips, and mandible.
- Ctenoid scales on lateral side of body.
- Snout with deep dorsal profile.
- Eye high, located laterally on head. Posterior margin of maxilla reaching to vertical

Fig. 7.41 Wide side scorpionfish, *Parapterois macrura* (Alcock, 1896). Courtesy of Hamid Osmany, Pakistan

through middle of eye. Interorbital space relatively deep.

- Posterior tip of pectoral fin extending well beyond anal-fin origin, but not reaching to caudal-fin base. Origin of pelvic-fin spine just below origin of pectoral fin; behind pectoral fin in lateral view.
- Head and body brownish-cream. Several indistinct narrow vertical bars on body; broad brown vertical bands behind eye, from posterior ventral margin of orbit to posterior upper corner of maxilla. Numerous small black spots on soft-rayed portions of dorsal fin and upper half of caudal fin; middle portion of pectoral fin blackish, ca. four uppermost rays with several black bands; pelvic fin blackish(Matsunuma et al. 2013).

World Distribution They are found in the Indian Ocean and the west coast of India.

Distribution in the Study Area It is reported from the southern coasts of the Arabian peninsula only (Matsunuma et al. 2013).

Habitat and Ecological Role This marine species lives at depth range 64–430 m (Matsunuma et al. 2013).

Biology No biological information is available about this species.

Economic Value No commercial value is present.

Conservation Status Not evaluated.

Pterois miles (Bennett 1828)
Common name: Devil firefish
Arabic name: السمكه العقربيه الشيطان
Etymology: *Pterois*: Greek, pteron = wing, fin (Fig. 7.42)

Identification

- Body covered with cycloid scales.
- Body reddish to tan or grey in color, with numerous thin dark bars on body and head. Faintly banded tentacle above eye (Eschmeyer 1986). Adults have band of small spines along cheek and small spots in median fins.

World Distribution It is distributed in the Indian Ocean from the Red Sea north to South Africa in the south and eastward to Sumatra and Indonesia (Fricke 1999). It is reported from the Atlantic Ocean and also from the Mediterranean Sea (Golani and Sonin 1992).

Distribution in the Study Area It has been recorded from several localities around the Arabian peninsula (Carpenter et al. 1997).

Habitat and Ecological Role It is a marine species living in association with reefs at depth range 25–85 m (Turan et al. 2014).

Biology No biological information is available.

Fig. 7.42 Devil firefish, *Pterois miles* (Bennett, 1828). Courtesy of Robert Patzner, Austria

Fig. 7.43 Radial firefish, *Pterois radiata* Cuvier, 1829. Courtesy of Chih-Wei, Taiwan

Economic Value No commercial value present.

Conservation Status Not evaluated.

Pterois radiata (Cuvier 1829)
Common name: Radial firefish
Arabic name: سمكة الديك الشعائيه
Etymology: *Pterois*: Greek, pteron = wing, fin (Fig. 7.43)

Identification

- Ctenoid scales on body.
- Long supraorbital tentacle and not colored.
- Rays of pectoral fin long reaching almost to base of caudal fin.
- Body has dark broad reddish bands. Reddish thin stripes on sides of caudal peduncle. Head with dark reddish brown bar from nape across operculum. Fin spines and rays red (Randall 1995).

World Distribution The distribution of this species is restricted to the Indo-Pacific region from the Red Sea north to Sodwana Bay in the

Fig. 7.44 Plaintail turkeyfish, *Pterois russelii* Bennett, 1831, Courtesy of Lorraine Brennan, Indonesia

south and eastward to the Society Islands. Northward, it is distributed in the Ryukyu Islands and south to New Caledonia (Fricke 1999).

Distribution in the Study Area It has been reported from the Sea of Oman only (Randall 1995).

Habitat and Ecological Role This marine species lives in association with reefs at depth range 1–30 m (Sommer et al. 1996).

Biology It feeds solely on small crabs and shrimp. It is capable of inflicting a painful sting (Froese and Pauly 2016).

Economic Value No commercial value is present for this species.

Conservation Status Not evaluated.

Pterois russelii (Bennett 1831)
Common name: Plaintail turkeyfish
Arabic name: السمكه العقربيه مستوية الذنب
Etymology: *Pterois*: Greek, pteron = wing, fin (Fig. 7.44)

Identification

- Compressed body.
- Feeble spines on head in young, well developed in adult.
- Dorsal fin membrane strongly incised. Pectoral with long rays, the longest reaching to or beyond end of segmented part of dorsal fin. Rounded caudal fin.
- Cycloid scales on body.
- Reddish-brown with four dark crossbars on head. Segmented part of dorsal, anal, and caudal fins plain, without spots; pectoral fin membrane usually covered with dark spots; pelvic fins mostly dusky, with light round spots, mainly on proximal half (Fischer and Bianchi 1984).

World Distribution It is distributed in the Indo-Pacific region from the Arabian-Persian Gulf and eastward to Western Australia (Froese and Pauly 2016).

Distribution in the Study Area This scorpionfish has been reported from several localities around the Arabian peninsula (Randall 1995; Carpenter et al. 1997).

Fig. 7.45 Cheekspot scorpionfish, *Scorpaenodes evides* (Jordan & Thompson, 1914). Courtesy of Feriedoon Owfi, Iran

Habitat and Ecological Role This marine species enters brackish water and lives in association with reefs at depth range 15–60 m (Allen and Erdmann 2012).

Biology No biological information is available.

Economic Value No commercial value.

Conservation Status Not evaluated.

Scorpaenodes evides (Jordan and Thompson 1914)
Common name: Cheekspot scorpionfish
Arabic name: سمكة العقرب المبقعه
Etymology: *Scorpaenodes*: Latin, scorpaena = a kind of fish, 1706 + Greek oides = similar to (Fig. 7.45)

Identification

- Scales on body ctenoid fall in 45 longitudinal series.
- Interorbital area with two spines. Posteriorly directed spines on suborbital ridges. Three spines on preopercle.
- Body red to dark brown, mottled with dark brown spots. Large dark brown spots on subopercle. Caudal peduncle with two reddish brown bands (Randall 1995).

World Distribution The species is common in the Indo-Pacific region.

Distribution in the Study Area This species is reported from the Arabian coasts of Oman (Randall 1995).

Habitat and Ecological Role This marine species prefers a demersal habitat and lives at depth range 1–40 m (Allen and Erdmann 2012).

Biology Not much information is available about this species.

Economic Value No commercial value is present for this species.

Conservation Status Not evaluated.

Scorpaenopsis lactomaculata (Herre 1945)
Common name: Whiteblotched scorpionfish
Arabic name: السمكه العقربيه ذات البقعه البضاء
Etymology: *Scorpaenopsis*: Latin, scorpaena = a kind of fish, 1706 + Greek, opsis = appearance (Fig. 7.46)

Identification

- Body covered with ctenoid scales falling in 60–67 longitudinal lines.

Fig. 7.46 Whiteblotched scorpionfish, *Scorpaenopsis lactomaculata* (Herre, 1945). Curtesy of Hamid Osmany, Pakistan

Fig. 7.47 Raggy scorpionfish, *Scorpaenopsis venosa* (Cuvier, 1829). Curtesy of R. Saravanan, India

- Four spines on suborbital ridge. One spine on upper edge of eye.
- Deeply concave interorbital space.
- Body reddish brown with white markings. White spot below eye (Randall 1995).

World Distribution This species is distributed in the western Indian Ocean region.

Distribution in the Study Area It is has been recorded from several areas around the Arabian peninsula.

Habitat and Ecological Role This marine species prefers to live in a demersal habitat.

Biology Not much information is available on this species.

Economic Value No commercial value is present.

Conservation Status Not evaluated.

Scorpaenopsis venosa (Cuvier 1829)
Common name: Raggy scorpionfish
Arabic name: السمكه العقربيه ذاالت التلوين السجادي
Etymology: *Scorpaenopsis*: Latin, scorpaena = a kind of fish, 1706 + Greek, opsis = appearance (Fig. 7.47)

Fig. 7.48 Günther's wasp fish, *Snyderina guentheri* (Boulenger, 1889). Courtesy of Bineesh, India

Identification

- Coloration is the best characteristic. Tiny light-blue ocelli scattered over body, and dark triangle below eye. Small juveniles have three distinctive white spots along back (Kuiter and Tonozuka 2001).
- Body covered with ctenoid scales.

World Distribution It is distributed in the Indo-West Pacific region from East Africa to Papua New Guinea, north of Taiwan (Randall 1995) and the Philippines and the Great Barrier Reef (Fricke 1999).

Distribution in the Study Area This scorpionfish has been reported from several localities around the Arabian peninsula (Randall 1995; Carpenter et al. 1997).

Habitat and Ecological Role This marine species lives in association with reefs at depth range 2–95 m (Motomura 2004).

Biology Not much information is available about this species.

Economic Value No commercial value is present for this species.

Conservation Status Not evaluated.

Family: Tetrarogidae
Snyderina guentheri (Boulenger 1889)
Common name: Günther's wasp fish
Arabic name: سمكة كنثر العقربيه الاسعه (Fig. 7.48)

Identification

- Body covered with small embedded scales.
- No scales on head.
- One short and one long spine on lacrymal bone.
- Dorsal fin extends anteriorly to middle of eye.
- Long and rounded caudal peduncle.
- Body dark reddish brown with small pale spots. Three dark bars radiating down from eye (Randall 1995).

World Distribution It is distributed in the western Indian Ocean to south India (Randall 1995).

Distribution in the Study Area It is recorded from the southern coasts of the Arabian peninsula (Randall 1995).

Habitat and Ecological Role This marine species prefers a demersal habitat and lives at depth 24–300 m (Randall 1995).

Biology No biological observation is available on this species.

Economic Value No commercial value.

Conservation Status Not evaluated.

7.2.4 Venomous Stonefishes

The members of this group of fishes prefer calm shallow waters such as coral islands, sheltered bays, and estuaries as well as weed-covered rocks and muddy sea beds (Endean 1961). The scorpionfish take positions in depressions in the seabed using their pectoral fins (Gwee et al. 1994). When an appropriate fish passes by, the stonefish attacks it with its large mouth, then settles back into its original position (Sutherland 1983). They are inactive and will not attack a human being unless the dorsal spines are trampled upon. The fish can survive out of water for a few hours (Endean 1961). The dorsal spines usually support the venom glands and the latter are arranged along the dorsal aspect of the body (Gwee et al. 1994). A white excretion is conveyed from the skin once the fish is disturbed.

Venomous Organs of the Members of the Genus *Synanceja* (Fig. 7.49)
There are 13 dorsal spines, 3 anal spines, and 2 pelvic spines in the venom organ of the members of the genus *Synanceja*, where all are connected to the poison gland. As in the spines of other scorpionfishes, these spines are covered with a glandular–integumentary sheath. The tips of the spines of the dorsal fin can be seen protruding through the sheath, whereas those of the anal and pelvic fins are embedded within the thick sheath covering them. The first three dorsal spines take an upright position when erect, and the remaining spines of the dorsal fin stay in an inclined plane. Fusiform poison glands are found on each side of the base of the spine. The position of these poisonous glands is different in different dorsal spines. In the first three spines, the glands are located about the middle of the spine,

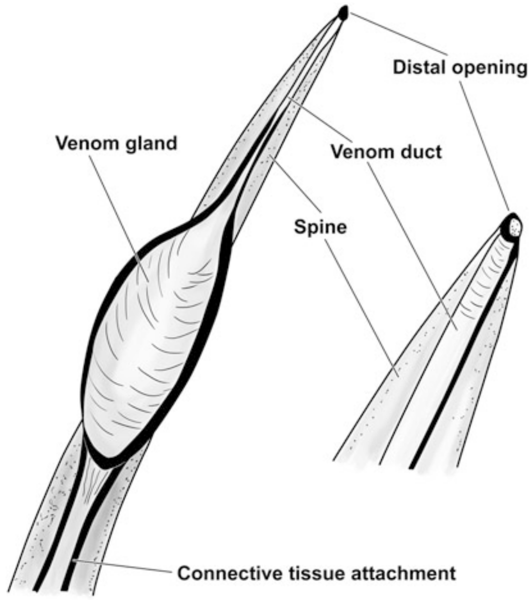

Fig. 7.49 Drawing of a typical dorsal spine of *Synanceja horrida*. After Halstead (1967)

whereas in the remaining spines they are situated farther up the spine near the tip. The anal spines are similar in shape and structure to those of the dorsal fin except for their poison glands which are smaller in size. Similarly, the pelvic spines are the same in structure and shape to those of the dorsal and anal spines, but their poison glands are very small and minute in comparison to those found attached to the dorsal and anal spines. The structure of the poison glands in the spines of all fins is the same. The body of the gland is attached to a tough strand of connective tissue. The proximal end is buried at the base of the spine, and the distal end reaches the tip of the spine.

The microscopic anatomy of the sting organs of stonefishes is nearly the same except for a minor variation between species. The following description is based on that given by Halstead (1970). In general, the dorsal spine is goblet-shaped and with a T-shape at the tip. The edges of the spine are composed of a thin layer of viterodentine. The groove is found only in the longitudinal centre of the spine. Tan bodies, which are dense granular and oval-shaped cells are enclosed in a thin connective tissue around part of the spine and the whole body of the spine. These bodies are the areas where the venom is produced. Together with the tan bodies, there are patches of yellowish, homogeneous, amorphous secretion.

The microscopic structure of the anal spines is similar to those of the dorsal spines. These spines are designed to convey venom to the wound of the victim. Therefore, they are goblet-shaped rather than T-shaped in outline. In addition, the groove areas are reduced in comparison with those of the dorsal spines. As to the spines of the pelvic fin, they show similar anatomy to those of the anal fin.

Causative Agent

There are no specific bioactive venomous properties of stonefish toxin, but scientists are searching for such compounds (Tay et al. 2016). Several species of stonefish showed different degrees of lethal venom effect. Within the stonefish family, stonustoxin is the lethal protein from *Synanceja horrida*, trachynilysin from *Synanceja trachynis*, and verrucotoxin from *Synanceja verrucosa* (Khoo 2002). The enzymes hyaluronidase, stonustoxin, and trachynilysin play vital roles as bioactive agents. Tay et al. (2016) suggested that hyaluronidase has strength many times higher than the enzyme from snake venom (Poh et al. 1991) and is able to destroy connective tissue, which leads to a significant necrosis associated with stonefish envenomation (Poh et al. 1991) and is responsible for the rapid spread. Stonustoxin acts as a haemolytic and vasorelaxant and causes extensive oedema after envenomation. It acts as a hypotensive agent, which has myotoxic and neurotoxic activity as well. The trachynilysin is a neurotoxin and causes hyperstimulatory neuroblockade. They also concluded that their findings are still at the experimental stage and need further investigation before definite conclusions can be reached. The chemical nature of the toxin was examined by Tay et al. (2016) and showed that the venom is an unstable protein, with a pH of 6.0 and a molecular weight of 150,000. Heat, acid and alkalis, potassium permanganate, and Congo red might denature this venom (Edmonds et al. 1992).

There are two theories that can explain the mechanism of the effect of hot water on the activity of the venom. The enzymes contained in the venom of marine organisms can be denatured by heat at temperature above 50 °C. Marine venoms consist of multiple proteins and enzymes, and there is evidence that these become deactivated when heated to temperatures above 50 °C (Carrette et al. 2002), which lead in turn to the deactivation of the venom. They show that venom loses its lethality more rapidly at temperatures over 43 °C. On the other hand, the high temperature might cause burns and necrosis to the patient (Muirhead 2002). The other theory is that hot water immersion can cause relief to the pain receptors in the nervous system leading to a reduction in pain. Established pain hypotheses and the diffuse noxious inhibitory control theories have been suggested as possible mechanisms of the action of hot water (Kizer et al. 1985).

Symptoms

The pain starts as soon as the spines penetrate the body of the victim and gradually becomes more severe during the next few hours. The pain is described as throbbing and the wound area becomes inflamed and tender. Swelling generates and might extend to the ankle, and even to the lower leg in severe cases. The pain and inflammation may affect the regional lymph nodes. The local signs and symptoms will become stabilised after 12–24 h. There may also be systemic signs and symptoms including respiratory difficulty due to pulmonary oedema, hypotension and bradycardia, arrhythmia, cardiovascular collapse, fever, muscle weakness, and paralysis. In severe cases delirium, generalised paralysis convulsions, and death may occur (Gwee et al. 1994).

Several researchers back the idea of using antivenom injections as a treatment in stonefish envenomation and most studies support the use of injected antivenom (Lau 2000; Lehmann and Hardy 1993). Antivenom injections should be taken when systemic symptoms, severe pain, paralysis, or multiple punctures are present.

Fig. 7.50 Orangebanded stingfish, *Choridactylus multibarbus* Richardson, 1848. Courtesy of Hamid Osmany, Pakistan

Although the intramuscular (IM) route is well established, intravenous administration remains controversial.

Fish Species of Stonefishes
Choridactylus multibarbus (Richardson 1848)
Common name: Orangebanded stingfish
Arabic name: السمكه البرتقالية التخطيط
Etymology: *Choridactylus*: Greek, choris = separately + Greek, daktylos = finger (Fig. 7.50)

Identification

- Body naked.
- Fins blackish brown, with an oblique pale band between fourth and sixth dorsal spines; margins of pectoral fins orange; caudal fin with black band at base and another in distal third of fin, pale terminally; distal two thirds of anal fin dark brown or black; inner surface of pectoral fins black with several oblong orange bands; pelvic fins black or dark brown with numerous white spots (Fischer and Bianchi 1984).

World Distribution It is distributed in the Indo-Pacific region from the Red Sea at the north and to the east to Pakistan and India (Froese and Pauly 2016).

Distribution in the Study Area It has been reported from several localities around the Arabian peninsula.

Habitat and Ecological Role This marine species prefers a demersal habitat.

Biology No biological information is available.

Economic Value It is considered as a food in very restricted areas along its geographical distribution.

Conservation Status Not evaluated.

Minous dempsterae (Eschmeyer, Hallacher and Rama-Rao 1979)
Common name: Obliquebanded stingfish
Arabic name: السمكه الصخريه مائلة التخطيط (Fig. 7.51)

Identification

- Black pectoral fin, posterior part of dorsal fin. Six white bands extending from dorsal edge of dorsal fin not reaching base of anal fin.

World Distribution It is distributed in the Western Indian Ocean from the Sea of Oman to Pakistan and northwestern India (Froese and Pauly 2016).

Fig. 7.51 Obliquebanded stingfish, *Minous dempsterae* Eschmeyer, Hallacher & Rama-Rao, 1979. Courtesy of Hamid Osmany, Pakistan

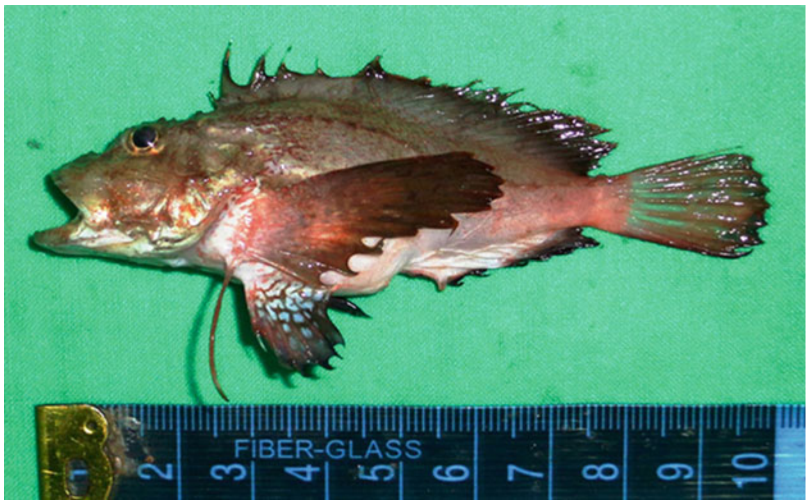

Fig. 7.52 Alcock's scorpionfish, *Minous inermis* Alcock, 1889. Courtesy of Hamid Osmany, Pakistan

Distribution in the Study Area It has been reported from the Sea of Oman (Randall 1995) and from the Arabian-Persian Gulf (Assadi and Deghani 1997).

Habitat and Ecological Role This marine species prefers a demersal habitat and lives at depth range 5–117 m (Randall 1995).

Biology No biological information available.

Economic Value No commercial value.

Conservation Status This species has been evaluated as Least Concern in the Red List of the IUCN for the reasons given by Poss (2010): 'This species has not been impacted by any major threat processes and is found within a habitat that is rarely disturbed by anthropogenic activities.'

Minous inermis (Alcock 1889)
Common name: Alcock's scorpionfish
Arabic name: سمكة الكوك الصخريه (Fig. 7.52)

Identification

- Long pectoral fin reaching to last anal ray.
- Snout pronounced.
- Pectoral fin and edges of anal, caudal fins and soft part of dorsal fin colouration.

World Distribution It is distributed in the Indian Ocean from Somalia and eastward to India, Myanmar, and west to Thailand (Smith and Smith 1963).

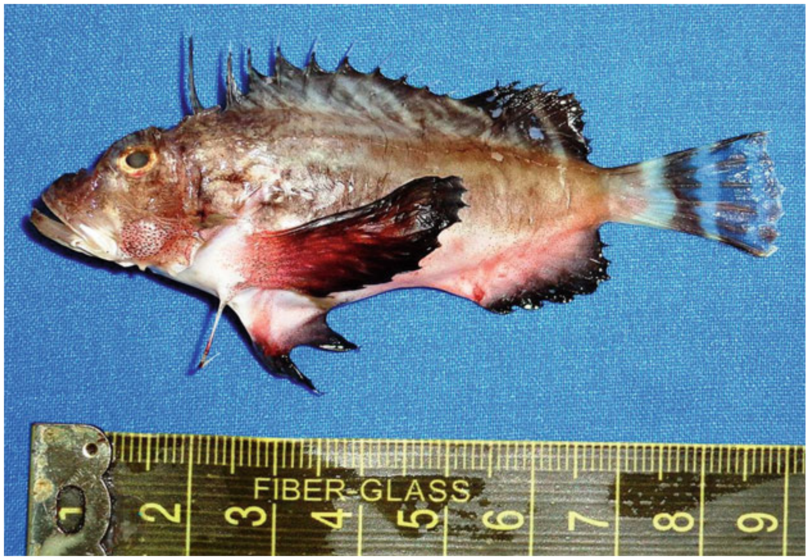

Fig. 7.53 Grey stingfish, *Minous monodactylus* (Bloch & Schneider, 1801). Courtesy of Hamid Osmany, Pakistan

Habitat and Ecological Role This marine species prefers a demersal habitat and lives at depth range 18–420 m (Randall 1995).

Biology No biological information available.

Economic Value No commercial value.

Conservation Status Not evaluated.

Family Synanceiidae
Minous monodactylus (Bloch and Schneider 1801)
Common name: Grey stingfish
Arabic name: السمكه العقربيه الرماديه (Fig. 7.53)

Identification
- Body naked.
- Two spines on lachrymal bone.
- Long pectoral extending to middle of anal fin.
- Body basic colour pale grey with large black spot on posterior side of dorsal fin. Anal and pelvic fins have dark brown edges. Caudal fin has two dark bands (Randall 1995).

World Distribution This species is distributed in the Indo-West Pacific region from the Red Sea at the north to East South African coast at the south and eastward to Indonesia and southern Japan (Froese and Pauly 2016).

Distribution in the Study Area This species is reported from several localities in the Arabian-Persian Gulf (Poss and Rama Rao 1984). It is also reported from the Sea of Oman and southern coasts of the Arabian peninsula (Randall 1995).

Habitat and Ecological Role This marine species prefers a demersal habitat and lives at depth range 10–55 m (Allen and Erdmann 2012).

Biology Not much information on the biology of this species is available.

Economic Value This species has commercial value at some localities in its geographical range.

Conservation Status Not evaluated.

Pseudosynanceia melanostigma (Day 1875)
Common name: Blackfin stonefish
Arabic name: السمكه العقربيه سوداء الذنب
Etymology: *Pseudosynanceia*: Greek, pseudes = false + Synanceia. (Figs. 7.54 and 7.55)

Identification
- Body naked.
- No wart-like protuberances present.
- Eye small, located on dorsal side of head.
- Superior mouth.

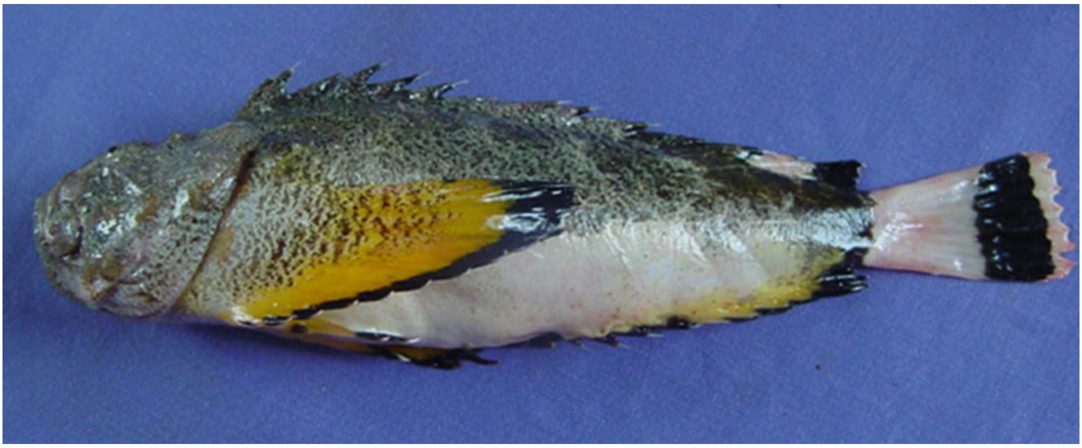

Fig. 7.54 Blackfin stonefish, *Pseudosynanceia melanostigma* Day, 1875. Curtesy of Moazam Khan, Pakistan

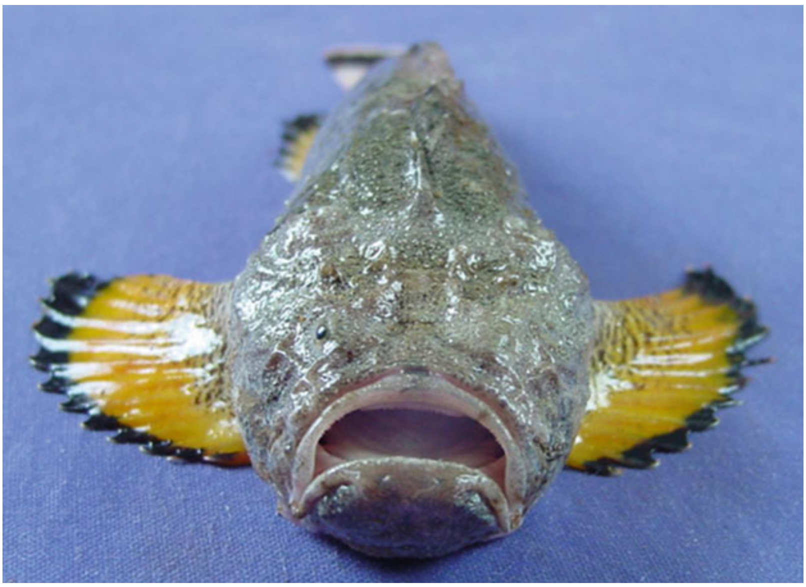

Fig. 7.55 Blackfin stonefish, *Pseudosynanceia melanostigma* Day, 1875, Head and pectoral fins. Curtesy of Moazam Khan, Pakistan

- Long pectoral fins extending to long spine of anal fin.
- Body greyish with pale ventral side. Tips of all fins black. White caudal fin with broad band.

World Distribution This species is distributed in the western Indian Ocean region.

Distribution in the Study Area It is recorded from several localities around the Arabian peninsula.

Habitat and Ecological Role This marine species sometime enters brackish water.

Biology Not much information on the biology of this species is available.

Fig. 7.56 Reef stonefish, *Synanceia verrucosa* Bloch & Schneider, 1801. Courtesy of Sean Mack, Wikipedia via Wikimedia commons CC BY 2.5

Economic Value This species has no commercial value.

Conservation Status Not evaluated.

Synanceia verrucosa (Bloch and Schneider 1801)
Common name: Reef stonefish
Arabic name: السمكه الصخريه
Etymology: *Synanceia*: Greek, syn = as a whole + Greek, aggeion = vein (Fig. 7.56)

Identification

- Body naked.
- Large, broad, dorsally flattened head.
- Eyes upward directed and very well separated.
- Two depressions in front of and behind eyes.
- Upward mouth equipped with cirri.
- Thick skin, with warts. Dorsal spines covered with thick skin.
- Large pectoral fin.
- Body colour highly variable, matching surroundings.

World Distribution It is distributed in the Indo-Pacific region from the Red Sea north to East Africa in the south and to the east to French Polynesia and Ogasawara Islands, south to Queensland, Australia (Froese and Pauly 2016).

Distribution in the Study Area This species is reported from several localities around the Arabian peninsula.

Habitat and Ecological Role This marine species lives in association with reefs at depth range 0–30 m (Myers 1999).

Biology This species lives on sandy or rubble areas of reef flats and shallow lagoons and in small pools. During low tide it is well camouflaged among the substrate and sometimes even covered with algae (Cohen and Olek 1989; Fischer et al. 1990). This solitary species (Myers 1999) feeds on fishes and crustaceans.

Economic Value No commercial value is present.

Conservation Status Not evaluated.

7.2.5 Venomous Toadfishes

Greenfield et al. (2008) wrote about the toadfishes: they belong to the family Batrachoididae, which is the only family in the order Batrachoidiformes. They are small to

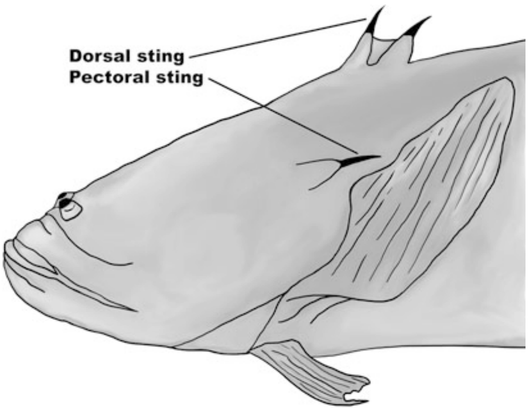

Fig. 7.57 The head of the toadfish *Thalassophryna dowi* showing the location of the opercular and dorsal stings. After Halstead (1967)

medium-sized fishes (to 57 cm) easily recognised by their characteristic shape, with a large, broad, flattened head, often with barbels and/or fleshy flaps around their large mouths. Spines are present on the opercle and often the subopercle. There are separate dorsal fins, the first with two or three spines, and the second long with up to 40 soft rays. The anal fin is somewhat shorter than the second dorsal with up to 39 rays. Glandular tissue may be present in the opercular region and pectoral-fin axil or between the pectoral-fin rays (Fig. 7.57). Toadfishes usually are rather dull coloured, often brownish with darker saddles, bars, or spots; however, some species in the Atlantic genus *Sanopus* are brightly colored as is *Bifax lacinia* from the Gulf of Oman. The maximum size of the species ranges from 56 mm to at least 570 mm standard length. The toadfishes, called frogfishes in Australia, are found worldwide and along continents in marine and brackish waters, occasionally entering rivers, with several freshwater species in South America. They are found from the shoreline down to a depth of at least 366 m, often burrowing in the sand or under rocks or coral heads where they function as ambush predators feeding on crabs, shrimp, mollusks, sea urchins, and fishes.

Background

Information about the toxicity of toadfishes goes back to the mid-nineteenth century when Cantor (1839) wrote about the attitude of the locals in Penang, Malaya towards the toadfishes, even refusing to use them as a manure (Halstead 1970). The research of Günther (1864, 1869, 1880) and Wallace (1893) mark the start of studies on the venom organs of toadfishes although they were incomplete and limited to a brief discussion of the gross anatomy of the stings. Discussion on the venom organs of toadfishes were written by Pellegrin (1889), Faust (1924), Gill (1907), Pawlowsky (1927), and others. (See Halstead 1970 for references.) Froes (1932, 1933) was the first to report on the effect of batrachoid venom on guinea pigs, chickens, and humans. Information on the venomous toadfishes was also given by Halstead (1956, 1959) and Halstead and Mitchell (1963). Later, the search on the nature and the envenomation of toadfishes was expanded and covered many species with and without specialised venom apparatus (Collette 1966; Lane 1967; Collette and Russo 1981; Walker and Rosenblatt 1988; Lopes-Ferreira et al. 2014; Pareja-Santos et al. 2009).

Morphology of the Venom Apparatus of Toadfishes (Figs. 7.58 and 7.59)

In general the venom apparatus of a toadfish consists of dorsal and opercular spines, venom glands, and the glandular sheath enclosing the spines. The following gross anatomy of the venom apparatus of the toadfishes is summarised from Halstead (1967). The opercular spine has a distinctive tip and is covered with a mass of glistening, whitish, pyriform gel-like fluid. This mass is located at the base of the spine and tapers towards its tip. The mass is enclosed in a special compartment separated from the muscles of the opercle. The microscopic structure of the mass showed that it is the opercular venom gland of the fish and has no duct to convey the venom. However, the hollow spine serves this function. The bone structure of the opercle enables the gill cover to act as a defensive organ. The opercular spine is controlled by two muscles, the abduction and the adduction responsible for moving the gill cover, and the venom spine is attached close and away from the fish body.

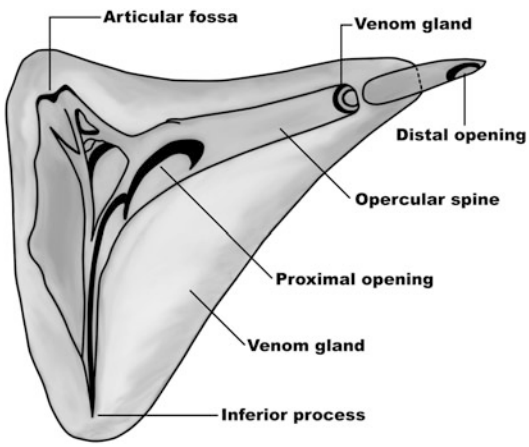

Fig. 7.58 Drawing showing the left opercular sting of *Thalassophryna* dowi. After Halstead (1967)

If there are two dorsal spines, then they will be enclosed in a single integumentary sheath, but separated from each other by a thin sheet of connective tissue. Each spine is enclosed by another connective tissue sheath that separates them from each other and contains the venom gland that has a similar shape to that of the opercular venom gland. The venomous spine of the dorsal fin is long, hollow, and slightly curved at the tip, which is very acute. At the anterior side of the tip there is an ovoid opening. Another opening, the proximal opening is situated on the anterior side of the base of the spine. The thickness of the spine is reduced towards the tip, and broadens at the base, forming triangular-shaped basal articulations. The media notch is found at the base of the proximal opening and articulates with the interneural spine. From the condyles present at the base of the spine, several processes flare out in different directions. If there are two dorsal spines, they work together as a single unit because of their connection to a single connective tissue sheath.

The microscopic anatomy of the toadfish *Thalassophyne dowi* showed that the opercular sting is comprised of four principle zones: a peripheral integumentary sheath, a glandular zone, a dentinal portion, and a central canal. The cross-section of the spine was shown be an ovoid ring of a dentine-like substance with a clear series of concentric rings. In some toadfish species, the opercular and dorsal spines are solid and do not show the ability to convey venom. In other toadfish species, the integumentary sheath is shown to have no dorsal and opercular spines.

Causative Agent

A thorough study of the venoms in toadfishes has been limited to the venoms of fish of the Batrachoididae family. Proteomic and transcriptomic approaches on the toadfish venom revealed the identity of the major toxins as a family of new proteins displaying kininogenase activity, the natterins (Lopes-Ferreira et al. 2004; Magalhães et al. 2006), and a galactose-specific lectin belonging to the family of C-type lectins named nattectin, which showed a Ca2þ-independent haemagglutinating activity and induced persistent neutrophil mobilisation in mice (Lopes-Ferreira et al. 2011).

Symptoms

Envenoming symptoms by toadfish venom are readily evident, including local oedema, erythema, and severe pain followed by intense necrosis and a markedly inefficient healing response. This problem of inefficient healing is very important for the evolution and treatment of the accident, which is devoid of specific drug treatment (Lopes-Ferreira et al. 2000; Haddad et al. 2003a, b). Healing of the injuries caused by toadfish is slow (Sosa-Rosales et al. 2005) in comparison with other injuries caused by venomous fish such as stingrays and catfish. Both venoms are described to induce a large increase in the number of rolling and adherent leucocytes in the endothelium of the cremaster muscle of mice (Magalhães et al. 2006; Junqueira et al. 2007).

Treatment and Prevention

The treatment of toadfish envenomation is similar to that of scorpionfishes. The venom poisoning can be neutralised the toxins and inducing polymorphonuclear recruitment in the lesion. A vital role for neutrophil in injury and the regenerative process was recently described by Teixeira et al. (2003). It has been shown that mice treated with antisera containing neutrophils and monocytes, displays a deficient regenerative

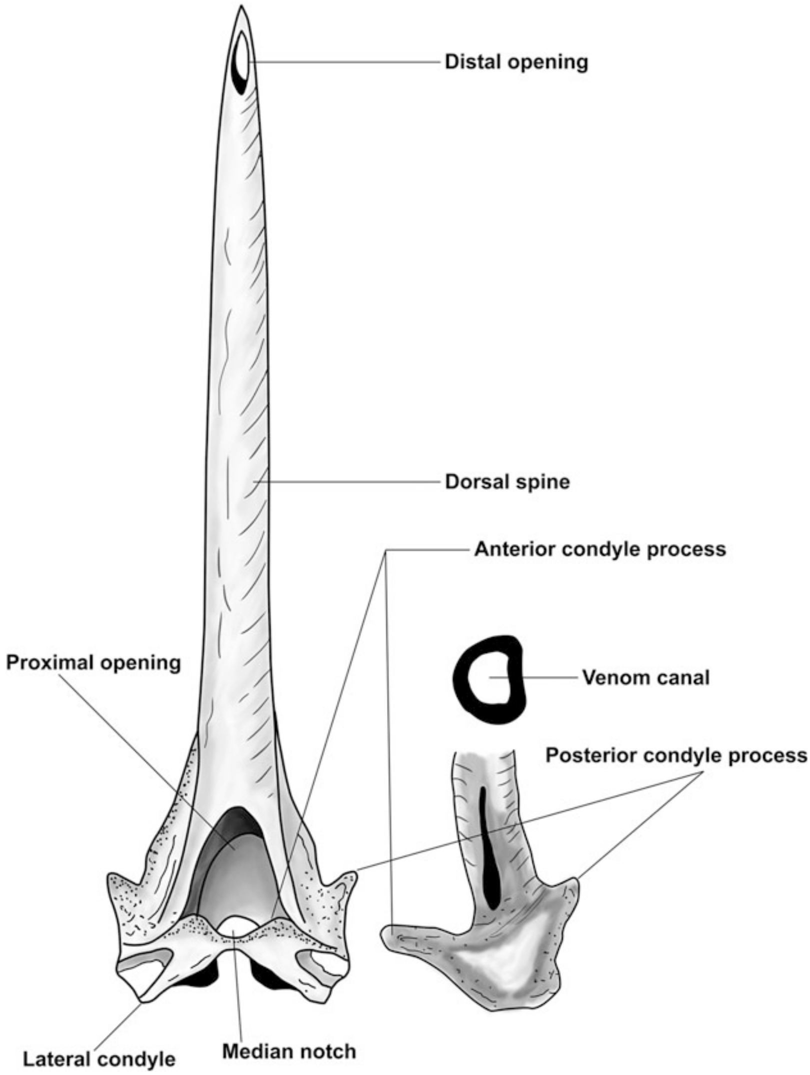

Fig. 7.59 Drawing showing the dorsal spine left of *Thalassophryna* dowi. After Halstead (1967)

response suggesting the importance of neutrophils for normal muscle repair.

Species of Toadfishes

Please refer to the Ichthyocrinotoxic fishes for species accounts of toadfish species.

7.2.6 Venomous Spadefishes or Scats

Members of the family Scatophagidae are distributed in the brackish water and in marine habitats of the Indo-Pacific, South and SouthEast Asia, the Malay Archipelago, the Philippines, and Australia (Barry and Castanos 1988; Bardach et al. 1972). The quality and taste of the fish ranks it as an edible fish and the beautifully spotted rhombic body ranks it as a fascinating aquarium fish. It has a wide distribution, large catch, and close proximity to humans, who are unaware that the scats are venomous fishes. Fishermen are the people most wounded while handling these fishes. The puncture is painful and aches for many hours (Barry and

Fig. 7.60 Spotted scat, *Scatophagus argus* (Linnaeus, 1766). Curtesy of Sahat Ratmuangkhwang, Thailand

Castanos 1988). Of the family Scatophagidae, *Scatophagus argus* is able to inflict more painful wounds than allied species (Marshall 1964).

The Venom Apparatus of Scat Fishes
The venom organ of scat fishes is not complicated and basically looks similar to that of scorpionfishes or toadfishes. In *S. argus*, the venom apparatus consists of an elongated poisonous gland located in grooves in the anterior portion of the dorsal spine. In this species, there are 11 dorsal spines, each of them bearing a poisonous gland. The venom gland is also found in the two pelvic and four anal fin spines (Cameron and Endean 1977). In the case of the fish facing danger, the spines are erect and the mechanical pressure on the spine tears or pushes down the integumentary sheath over the spine as venom passes into the wound.

Causative Agent
The venom of the green scat has a proteinous nature and is composed of 12 separate proteins or peptides in the range of 7–250 kDa (Ghafari et al. 2013, 2015). It shows a haemolytic activity on washed erythrocytes.

Symptoms
The symptoms of green scat envenomation appear within 5–10 min as unbearable and persistent local pain disproportionate to the size of the injury, redness, swelling, and a throbbing sensation that extends to the limbs, followed by dizziness. The venom induces a complex pattern of muscle damage characterised by a direct myotoxic effect (Sivan et al. 2010). Depending on the size of the fish and the quantity of poison injected, the symptoms show much variation.

Scatfish Species
Family: Scatophagidae
Scatophagus argus (Linnaeus 1766)
Common name: Spotted scat
Arabic name: بنت النوخذه
Etymology: *Scatophagus*: Greek, skatophagos = feeding upon dung (Fig. 7.60)

Identification
- Body quadrangular shape, strongly compressed.
- Large eyes.
- Rounded snout.
- Small horizontal mouth. Villiform teeth falling in seven rows on jaws.

- Body greenish colour, with large dark spots on dorsal side (Froese and Pauly 2016).

World Distribution This species is distributed in the Indo-Pacific region from the northwest Indian Ocean and to the east to Fiji, north and south of Japan, and south New Caledonia (Froese and Pauly 2016). It is also reported from Samoa (Lieske and Myers 1994), Tonga (Randall et al. 2003), and the Society Islands (Allen 1991).

Distribution in the Study Area It is reported from several localities in the Arabian-Persian Gulf area. There is no record of this species from the Sea of Oman or the southern coasts of the Arabian peninsula.

Habitat and Ecological Role This marine species enters brackish water and lives in association with coral reefs at depth range from surface down to 5 m (Riede 2004; Allen and Erdmann 2012).

Biology This species with an omnivorous feeding habit has been reported by most researchers (Das et al. 2014), but others suggested an herbivorous feeding habit (Barry and Fast 1992). It has a preference for low salinity (Barry and Castanos 1988; Barry and Fast 1992; Chang et al. 2005), but for breeding requirements, it prefers high salinity water (Hering 2000; Cai et al. 2010). This fish species has a slow growth rate that is a drawback explaining the lack of progress in its culture (Gupta 2016). Females and males attain sexual maturity at 14 cm and 11.5 cm of standard length, respectively (Barry and Fast 1992). The reported size of this species is 12–12.9 cm and 14–14.9 cm in total length at first maturity for males and females, respectively. Females dominate the population of this species (Gandhi 1998). The breeding season coincides with the onset of the southwest monsoon rain (Barry and Fast 1992).

Economic Value This fish is taken as a food source and also as a commodity in the aquarium industry (Gupta 2016).

Conservation Status This species is given a Least Concern status in the IUCN Red List for the reasons given by Collen et al. (2010): 'This species has a very large distribution, extending from the Arabian-Persian Gulf to the east coast of Australia. Although harvested for food, medicine, and the aquarium trade, it is of little commercial importance. This species is also able to utilise a number of habitat types that undergo large scale environmental fluctuations, indicating resilience and adaptability.'

7.2.7 Venomous Stargazers

The stargazers belong to the family Uranoscopidae. They are benthic-living fishes distributed worldwide in tropical and temperate oceans, with a few species occasionally entering brackish water or even freshwater habitats. They bury themselves in sand or mud, leaving only the eyes and anterior part of the head exposed. Members of the group are characterised by having dorsally or dorsolaterally directed eyes placed on or near the top of a large, flattened, cuboid head. They have an oblique to vertical mouth, with lips usually lined with cutaneous cirri, and an elongate, subcompressed body (Pietsch 1989: 253). In the family, 8 genera and 51 valid species are known (Eschmeyer and Fong 2012).

Background

Bottard (1899) was the first to describe in full the anatomy of the weever *Uranoscopus*. Port on the venom apparatus of the weeverfishes. Not much information is available on the venom apparatus of this group of poisonous fishes. Halstead and Dalgeish (1967) described the venom apparatus of *Uranoscopus scaber*.

Morphology of the Venom Apparatus of the Weeverfishes

The following gross and microanatomy is based on the work of Halstead and Dalgeish (1967; Fig. 7.61). The venom apparatus in the weeverfishes consists of two shoulder spines, which are located on both sides of the fish, associated venom glands, and the integumentary sheath that envelops them. The spine has a sharp conical shape and the ability to protrude in and

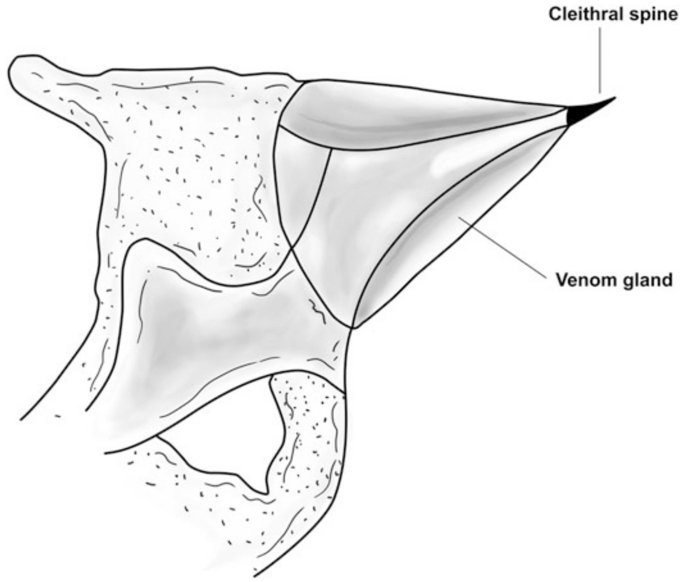

Fig. 7.61 Drawing showing the left cleithral spine of *Uranoscopus scaber* and its anatomical relationship to the venom gland. After Halstead (1967)

out of the enclosing integumentary sheath. When it protrudes, the spine appears on the upper corner of the opercle just above the dorsal edge of the pectoral fin. Dissecting the integumentary sheath will expose a dense mass of gelatinous material accumulated around the spine and packed between the spine and the body of the fish. This mass is the poisonous gland, where the venom is secreted. Unlike the spine of stingrays, weevers, and catfishes, the spines of stargazers are rigid and inflexible. The spine in stargazers is considered the continuation of the cleithrum bone (Fig. 7.62). This bony extension is long and straight ending in a sharp and pointed tip. On the inferior margin of the spine, a shallow groove runs along the length of the spine and disappears near the mid-part of the spine. The outer surface of the spine has an irregularly shaped rough groove.

The microscopic anatomy of the venom apparatus shows that the spine is composed of cement-like material, with concentric growth layers. The distal part of the spine is smooth and rounded, and the proximal part is broad. The grooves deepen to form canals. These canals are continuous with a spacious area in the cleithrum bone. The sheath enveloping the spine is composed of stratified cuboidal tissue and unicellular mucous glands. The venom in the poisonous gland is believed to be breakdown products of cells by holocrine secretion or denaturation of the connective tissue fibres themselves.

There is nothing on record about the chemical aspect of the stargazer venom although the mechanism is believed similar to that of the scorpionfishes.

Family: Uranoscopidae
Uranoscopus crassiceps (Alcock 1890)
Common name: Star watcher
Arabic name: السمكه المراقبه للنجوم
Etymology: *Uranoscopus*: Greek, ouranos = sky + Greek skopein = to watch (Fig. 7.63)

Identification

- Head large.
- Anterior part of body broad, depressed; body tapering and becoming slightly compressed posteriorly.
- Head, nape between lateral lines; breast and belly naked.
- Tubiform scales embedded along lateral line. Lateral line positioned dorsally, bending down on caudal peduncle to continue in extension of central two caudal-fin rays, extending along basal one-third of those rays.
- Spines 1–4 in first dorsal fin well developed, connected by membranes; rudimentary fifth

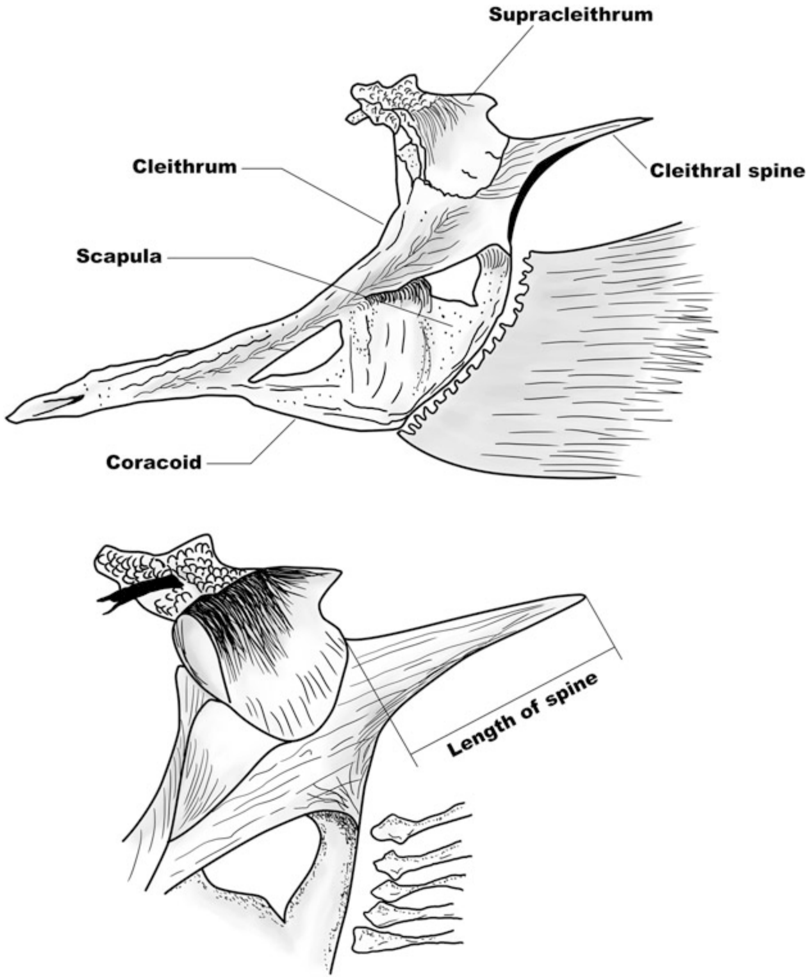

Fig. 7.62 Drawing showing; *above*, the left pectoral girdle of *Uranoscopus scaber* and the cleithral spine; *below*, the position of the cleithral spine. After Halstead (1967)

Fig. 7.63 Star watcher, *Uranoscopus crassiceps* Alcock, 1890. Courtesy of Laith Jawad, New Zealand

element covered by skin. First element of second dorsal fin segmented and unbranched. Membranes of anal and paired fins fleshy and thickened. Pectoral fin broad, dorsoposterior margin truncate, remainder of distal margin convex. Soft dorsal and anal-fin bases long. Caudal fin distally convex.

- Pelvic spine feeble, closely connected to first soft-ray by tendon.
- External apparent bones of head slightly concave along mid-dorsal line. Joints of head bone elements marked by deep channels.
- Eye large, positioned dorsally, slightly telescopic, without membranous tentacle.

- Teeth in jaws small, conical, in two series: one series of widely separated caniniform teeth on premaxillary and dentary.
- Dorsal parts of head and body dark brown, back has irregular large whitish blotches. Sides of head and body brownish violet. Belly, thorax, and pectoral-fin base white. Eye dorsally dark brown, laterally yellowish green. First dorsal fin black, base of first and second spines reddish brown, fourth membrane white. Rays of second dorsal and anal fins greenish brown, membranes translucent. Caudal fin rays dark brown, membranes in lower half greenish yellow, membranes in dorsal half dusky. Upper half pectoral fin greyish brown, lower half greenish yellow. Pelvic fin whitish rose, first to third rays distally mottled with dark brown; fifth ray greenish yellow (Fricke et al. 2013).

World Distribution This species is distributed in the Indian Ocean and known from the type locality, off the Madras coast, India.

Distribution in the Study Area It is reported from the southern coasts of the Arabian peninsula (Fricke et al. 2013).

Habitat and Ecological Role This marine species prefers a demersal habitat and lives at depth range from the surface down to 187 m (Bogutskaya 2007).

Biology Not much information is available about this species except that it is a poisonous fish and is a threat to people wading on the seashore.

Economic Value No commercial value.

Conservation Status Not evaluated.

7.2.8 Venomous Rabbit Fishes

Members of the family Siganidae are popularly called rabbit fish, fox face, or spine foot. They are much-valued food items by people in several areas along its geographical distribution such as the Indo-Pacific and eastern Mediterranean (Lam 1974). There are over 33 valid species distributed worldwide in reefs among sea grasses, mangroves, and estuaries and also in shallow lagoons of tropical and subtropical coastal environments (Bariche 2005; Lam 1974; Randall et al. 1990; Woodland 1983; Woodland 1990).

Rabbit fishes feed on filamentous algae and sea grasses. They exhibit consistency in their body characters (i.e., numbers of fin spines and rays, tooth shape, tooth count, spines), on which the systematising of fishes usually relies. The majority of the rabbit fishes have bright and unique colour patterns, which have been exploited for defining species boundaries, but higher-level classification basically depends on gross body proportions, shape of tail, and length of snout (Woodland 1990).

The members of the family Siganidae are economically important fishes (Woodland 1983) and have attracted the attention of fish culturists mainly in the Indo-Pacific region because of their herbivorous food habits, rapid growth, and commercial value (Lam 1974; Randall et al. 1990).

Background

Bottard (1899) was the first to report on the venom apparatus of the rabbit fishes and subsequent authors based their studies on his work. The work of Amemyia (1921) was not available to scientists until it was published in English in 1950. In this work, the venom apparatus of *Siganus fuscescens* was described in detail and supplemented with good drawings. Tange (1955) redescribed the venom apparatus of the same species.

Morphology of the Venom Apparatus of Rabbit Fishes

The following description of the gross and microscopic anatomy of the venom apparatus of the family Siganidae is based on the description of Tange (1955), given by Halstead (1967) and summarised here. In the members of the family Siganidae, the venom apparatus consists of 13 spines of the dorsal fin, 4 spines of the pelvic fins, and 7 spines of the anal fin. The dorsal spines are curved and pointed anteriorly. The proximal end is broad and has two condyles, large left and small right. The distal end is pointed and forms the tip of the spine. The two basal condyles are separated by a foramen and articulated with the underlying supporting interneural spine. The anterior aspect of the spine has a pronounced median line, at both sides of which two deep grooves are present that extend almost the entire length of the spine. A similar groove is present on the posterior side of the spine, but no poison glands are attached to it. The venom gland is thick, elongated, prismatic in form, and tapering at both ends.

In the microscopic anatomy, the cross-section of the dorsal spine shows an irregular T-shaped dentinal structure. This dentinal part differs from that found in scorpionfishes. It is enveloped completely by an integumentary sheath that consists of a very thin layer of moderately dense fibrous connective tissue. The poison gland is located on both sides of the median ridge, and is composed of two clusters of large polygonal glandular cells. In the mature cells of the poison gland, it is possible to see yellowish droplets of venom inside the cells. The structure of the pelvic spine in the cross-section is similar to that of the dorsal spine, but the poison gland is smaller.

Causative Agent

The venom of rabbit fishes consists of different amounts of essential amino acids among which are lysine, leucine, and aspartic acid, the major amino acids. In addition, proline tryptophan was found but low in basic amino acids. This suggests that the enzymic activities of spine venom differ based on amino acid composition (Prithiviraj and Annadurai 2014). Nitro compounds, sulphates, phosphates, and methylene are also present in the venom. In addition it contains methyl ether, isothiocyanate, and aldehyde.

The venom of rabbit fish has haemolytic activity on the blood of several animals and humans (Prithiviraj and Annadurai 2014), similar to that activity found in the venom of other poisonous fish species (Garnier and Goudey 1995). The source of the haemolytic activity is by forming hydrophilic pores in the cell membrane, which results in cell lysis (Chen et al. 1997).

Symptoms

Once the rabbit fish venom enters the body of the victim, the following symptoms develop: intense pain locally, with no swelling or redness; pain and complications from a secondary infection is the main concern. No systemic toxicity is reported (HKPCN 2007).

Treatment

The treatment of rabbit fish venom includes: hot water immersion of injured parts, cleaning foreign bodies, tetanus injection, and prophylactic antibiotics may be considered, especially with coverage of vibrio species.

Species of Venomous Rabbit Fishes

The rabbit fish's species account was dealt with in the Hallucinogenic Fishes section of this book.

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