

Mangrove Fauna of Asia

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Abstract Mangrove is a plant community of salt tolerant plant species which grow within transitional or inter-tidal zones of coastal, estuary and riverine areas of tropical and subtropical regions where rivers drain into the sea. They are highly productive habitat for a variety of fauna such as birds, fishes, reptiles, amphibians, mammals and aquatic as well as terrestrial invertebrates. The occurrence of higher diversity of fauna could be due to richness of food resources and diversity of vegetation, i.e. they provide ideal foraging and breeding sites and also shelter for these wide array of animals. Mangrove fauna are an important component of the food web and play a significant role in the mangrove ecosystem. Unfortunately, despite such a richness in animal communities, mangrove areas are still declining at an alarming rate day by day due to human activities. The habitat loss has seriously caused threats to different mangrove dependent animals such as birds, mammals, reptiles and amphibians, i.e., extinct

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and critically endangered species. The current information on the various fauna such as reptiles, mammals, invertebrates and fishes in Asia's mangrove ecosystem is not sufficient. In the future, more research is required to determine the various aspects of fauna such as species richness, diversity, distribution and the association of fauna with water quality, food resources and habitats to explore the ways and means to conserve the fauna in and around mangrove areas.

1 Introduction

Mangrove is a plant community of salt tolerant species such as trees, shrubs, palms, and ferns which grow within transitional or inter-tidal zones of coastal, estuary and riverine areas of tropical and subtropical regions where rivers drain into the sea (Macintosh and Ashton 2002; FAO 2007; Rajkumar et al. 2009; Naidoo 2009; Wan Juliana et al. 2010; Zhou et al. 2010). Worldwide, mangrove vegetation covers an area of 137,760 km² (Giri et al. 2011) and the higher percent of mangrove vegetation occurs between 5 N and 5 S, 32 N and 38 S (Morrisey et al. 2010; Friess et al. 2012). Out of the total mangrove areas, around 42.0% occur in Asia, 21.0% in Africa, 15.0% in North/Central America, 12.0% in Oceania, and 11.0% in South America (Giri et al. 2010). Mangrove areas are considered as a wetland that include waterways such as estuaries, creeks, canals, lagoons, backwaters, mudflats, salt pans and islands (Kjerfve 1990; Wan Juliana et al. 2010). However, vegetation composition and structure of mangrove areas may vary from area to area or region to region depending on soil condition, rainfall pattern, and inflow of river water into the sea. Mangrove areas are rich in tree diversity that comprise about 69 true tree species that represent 27 genera and 20 families (Selvam et al. 2004). Mangrove trees are divided into three categories such as (i) true mangroves or mangrove exclusive, (ii) mangrove non-exclusive and (iii) mangrove associated (Wan Juliana et al. 2010).

1.1 *Mangrove Exclusive or Major Mangroves*

Tree species that are mainly restricted to the intertidal zone within deep water and high salinity include *Avicennia lanata*, *A. marina*, *A. officinalis*, *Bruguiera cylindrical*, *B. gymnorrhiza*, *B. parviflora*, *B. sexangula*, *Ceriops decandra*, *C. tagal*, *Kandelia candel*, *Lumnitzera littorea*, *Nypa fruticans*, *Rhizophora apiculata*, *R. stylosa*, *Sonneratia alba*, and *S. caseolaris*, etc. (Saenger et al. 1983; Tomlinson 1986; Rotaquio et al. 2007).

1.2 *Mangrove Non-exclusive or Minor Mangroves*

Tree species that tolerate low salinity and are restricted to shallow water where salinity fluctuates from time to time include *Acrostichum aureum*, *A. speciosum*, *Aegiceras*

corniculatum, *A. floridum*, *Excoecaria agallocha*, *Heritiera littoralis*, *Osbornia octodonta*, *Pemphis acidula*, *Planchonella obovata*, *Scyphiphora hydrophyllacea*, and *Xylocarpus granatum*, etc. (Saenger et al. 1983; Tomlinson 1986; NTG 2002; Rotaquio et al. 2007).

1.3 Mangrove Associated

Plant species that grow with mangrove tree species include grasses, epiphytes, pteridophytes, bryophytes, and parasitic plants, e.g. *Acanthus ilicifolius*, *A. volubilis*, *Barringtonia asiatica*, *B. racemosa*, *Brownlowia tersa*, *Cerbera odallam*, *C. manghas*, *Clerodendrum inerme*, *Crinum asiaticum*, *Dolichandrone spathacea*, *Inocarpus edulis*, *Hibiscus titiaceus*, *Morinda citrifolia*, etc. (Tomlinson 1986; Rotaquio et al. 2007).

2 Threats to Mangrove Fauna

Being an important habitat for wildlife species, about one-third of the mangrove area has been lost over the past two decades due to land reclamation, conversion into agricultural fields, deforestation, aquaculture, and urbanization, i.e. coastal development (Macintosh and Ashton 2002; Penha-Lopes et al. 2011). The habitat loss and degradation have caused serious threats to wildlife species, particularly bird species, i.e. 40.0% of the bird population has been decreased in mangrove areas (Sandilyan et al. 2010). In addition, 100% turtles species, 43% crocodiles species, 20% fish species, 37% mammal species, 21% bird species and 43% amphibians that directly or indirectly depend on mangroves, mudflats and estuarine habitats are globally critically endangered (Millennium Ecosystem Assessment 2005).

The major driven factors that cause population decrease of mangrove fauna are habitat loss (Tidwell and Allan 2001), over exploitation (FAO 2009), coastal degradation and climate change (Gracia and Rosenberg 2010), organic pollution and toxic contamination (Naylor et al. 2000; Gracia and Rosenberg 2010). These factors cause habitat degradation, reduced food resources, and destroy nursery grounds that ultimately affect the fauna population of mangrove habitats.

3 Economic Importance of Mangrove

The diverse vegetation structure and composition of mangroves with denser foliage (Stafford-Deitsch 1996) has created different layers of vegetation that offer heterogeneous habitats which support a variety of marine, freshwater and terrestrial wildlife species. The mangrove vegetation interacts with aquatic, inshore, upstream and

terrestrial ecosystems that also form intertidal habitats for birds, fishes, reptiles, amphibians, mammals and a variety of aquatic invertebrates such as insects, mollusk, i.e. gastropods (snails) and bivalves (mussels), crabs, shrimps, oysters, sponges, barnacles, and polychaetes (worms).

Some of the animals depend on mangrove areas their whole lives while others utilize them only during specific periods such foraging, shelter and breeding (Hutchings and Recher 1982; Hutchings and Saenger 1987; Yaez-Arancibia et al. 1988; Macintosh and Ashton 2002; Northern Territory Government 2002; Thu and Populus 2007; Han 2011; Talaat et al. 2011; Nyanti et al. 2012).

Mangrove fauna can be divided into three inhabitants such as (i) aquatic animals, i.e., fishes, amphibians, (ii) semi-aquatic animals (i.e., reptiles, amphibians and birds) and (iii) terrestrial animals based on their living behaviour (i.e., mammals and birds). These animal communities utilize mangrove areas for their daily activities such as foraging, breeding, and loafing. These animals play a significant role in the management of mangrove forests and in balancing nature in and around the mangrove areas (Spalding et al. 2010; Nyanti et al. 2012).

3.1 Mangroves as a Habitat for Avifauna

Mangrove areas are a favorable habitat for a variety of waterbirds (i.e., the bird species that entirely depend on water for a variety of activities such as foraging, nesting, loafing and moulting) as well as terrestrial birds (i.e., bird species that do not entirely depend on water but may visit some time in search of food, shelter and perch) (Table 1). This is due to the diversity of habitats such as mangroves, mudflats, estuaries and richness of food resources which includes fishes (Blaber 2000; White and Potter 2004; Martin 2005), turtles (Blanco et al. 1991), snake (Guinea et al. 2004), amphibians (Kathiresan and Bingham 2001; Nagelkerken et al. 2008), mammals (Nijman 2000; Angelici et al. 2005; Bordignon 2006), and invertebrates such as gastropods (Plaziat 1984; Jiang and Li 1995), bivalves (Lebata and Primavera 2001), prawn (Kenyon et al. 2004), nekton (Minello et al. 2003), crabs (Ashton 2002; Skov and Hartnoll 2002) and insects (Nagelkerken et al. 2008).

Noske (1996) reported that mangroves support more than 200 bird species that utilize mangrove forest, mudflats, estuaries and adjacent areas. Avifauna of mangrove can be divided into four categories including (i) aerial feeders, (ii) waders, (iii) surface/diving foragers and (iv) foliage gleaners.

3.1.1 Aerial Feeders or Sallying Birds

The bird species that catch their prey on wing i.e. Fish Eagles (Fig. 1) and Kites (Fig. 2) (Accipitridae), Wood Swallow (Artamidae) (Fig. 3), Swallows (Hirundinidae), Bee-eaters (Meropidae) (Fig. 4), Kingfisher (Alcedinidae) (Fig. 5), and Swiftlet (Apodidae) always hovers on mudflats and mangrove areas in search of

Table 1 List of bird species recorded in different areas of mangrove and adjacent habitat

Family	Scientific name	Common name	Habitat	Authors
Accipitridae	<i>Accipiter cooperii</i>	Cooper's Hawk	Mangrove	Gough et al. 1998; South Florida Aquatic Environments 2013
Accipitridae	<i>Buteo jamaicensis</i>	Red-tailed Hawk	Mangrove	Gough et al. 1998; SFAE 2013
Accipitridae	<i>Buteo lineatus</i>	Red-shouldered Hawk	Mangrove	Gough et al. 1998; SFAE 2013
Accipitridae	<i>Cathartes aura</i>	Turkey Vulture	Mangrove	Gough et al. 1998; SFAE 2013
Accipitridae	<i>Circus cyaneus</i>	Marsh Hawk	Mangrove and adjacent areas	Gough et al. 1998; SFAE 2013; Rajpar and Zakaria 2010
Accipitridae	<i>Coragyps atratus</i>	Black Vulture	Mangrove	Gough et al. 1998; SFAE 2013
Accipitridae	<i>Haliaeetus leucocephalus</i>	Bald Eagle	Mangrove	Gough et al. 1998; SFAE 2013
Accipitridae	<i>Haliaeetus leucogaster</i>	White-bellied Fish-Eagle	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Accipitridae	<i>Haliastur Indus</i>	Brahminy Kite	Mangrove and adjacent areas	Lim et al. 2001; Norhayati et al. 2009; Rajpar and Zakaria 2010
Accipitridae	<i>Pandion haliaetus</i>	Osprey	Mangrove	Gough et al. 1998; SFAE 2013
Alcedinidae	<i>Ceyx erithacus</i>	Oriental Dwarf Kingfisher	Mangrove	Norhayati et al. 2009
Alcedinidae	<i>Halcyon chloris</i>	Collared Kingfisher	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Alcedinidae	<i>Pelargopsis capensis</i>	Stork-billed Kingfisher	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Alcedinidae	<i>Halcyon pileata</i>	Black-capped Kingfisher	Mangrove	Norhayati et al. 2009
Alcedinidae	<i>Todirhamphus chloris</i>	Collard Kingfisher	Mangrove	Lim et al. 2001
Anatidae	<i>Anas platyrhynchos</i>	Eurasian Wigeon	Mangrove	Sabir 2011
Anatidae	<i>Anas acuta</i>	Mallard	Mangrove	Gough et al. 1998; SFAE 2013
Anatidae	<i>Anas affinis</i>	Pintail	Mangrove	Gough et al. 1998; SFAE 2013
Anatidae	<i>Aythya valisineria</i>	Lesser Scaup	Mangrove	Gough et al. 1998; SFAE 2013
Anatidae	<i>Tadorna tadorna</i>	Canvasback	Mangrove	Gough et al. 1998; SFAE 2013
Anhingidae	<i>Anhinga anhinga</i>	Common Shelduck	Mangrove	Sabir 2011
Anhingidae	<i>Anhinga melanogaster</i>	Snakebird/Darter/Water Turkey	Mangroves	Gough et al. 1998; SFAE 2013
Apodidae	<i>Collocalia esculenta</i>	Oriental Darter	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Aramidae	<i>Aramus guarana</i>	White-bellied Swiftlet	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Ardeidae	<i>Ardea cinerea</i>	Limpkin	Mangrove	Gough et al. 1998; SFAE 2013
Ardeidae		Grey Heron	Mangrove	Norhayati et al. 2009; Sabir 2011

Table 1 (continued)

Family	Scientific name	Common name	Habitat	Authors
Ardeidae	<i>Ardea herodias</i>	Great Blue Heron	Mangrove	Gough et al. 1998; SFAE 2013
Ardeidae	<i>Ardea purpurea</i>	Purple Heron	Mangrove	Lim et al. 2001; Han 2011; Sabir 2011
Ardeidae	<i>Ardeola grayi</i>	Indian Pond Heron	Mangrove	Sabir 2011
Ardeidae	<i>Bubulcus ibis</i>	Cattle Egret	Mangrove and adjacent areas	Macintosh and Ashton 2002
Ardeidae	<i>Butorides striatus</i>	Little Heron	Mangrove and adjacent areas	Lim et al. 2001; Northayati et al. 2009; Rajpar and Zakaria 2010
Ardeidae	<i>Butorides virescens</i>	Green Heron	Mangrove	Acevedo and Aide 2008
Ardeidae	<i>Casmerodius albus</i>	Great Egret	Mangroves	Gough et al. 1998; Han 2011; Sabir 2011; SFAE 2013
Ardeidae	<i>Egretta alba</i>	Great Egret	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Ardeidae	<i>Egretta eulophotes</i>	Chinese Egret	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Ardeidae	<i>Egretta garzetta</i>	Little Egret	Mangrove and adjacent areas	Lim et al. 2001; Rajpar and Zakaria 2010; Han 2011; Sabir 2011
Ardeidae	<i>Egretta gularis</i>	Western Reef Egret	Mangrove	Sabir 2011
Ardeidae	<i>Egretta intermedia</i>	Intermediate Egret	Mudflats, mangrove and adjacent areas	Han 2011; Rajpar and Zakaria 2010
Ardeidae	<i>Egretta rufescens</i>	Reddish Egret	Mangroves	Gough et al. 1998; SFAE 2013
Ardeidae	<i>Egretta thula</i>	Snowy Egret	Mangrove mudflats	Macintosh and Ashton 2002
Ardeidae	<i>Ixobrychus eurhythmus</i>	Schrenck's Bittern	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Ardeidae	<i>Nyctanassa violacea</i>	Yellow Crowned Night Heron	Mangroves	Gough et al. 1998; SFAE 2013
Ardeidae	<i>Nycticorax caledonicus</i>	Rufous Night-Heron	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Ardeidae	<i>Nycticorax nycticorax</i>	Black-crowned Nightheron	Mangrove	Lim et al. 2001; Sabir 2011
Artamidae	<i>Artamus leucorhynchus</i>	White-breasted Wood-Swallow	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Burhinidae	<i>Burhinus recurvirostris</i>	Great Thick-knee	Mangrove	Sabir 2011
Campephagidae	<i>Lalage nigra</i>	Pied Thriller	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Charadriidae	<i>Charadrius alexandrinus</i>	Kentish Plover	Mangrove	Sabir 2011
Charadriidae	<i>Charadrius dubius</i>	Little Ringed Plover	Mangrove and Adjacent areas	Rajpar and Zakaria 2010; Sabir 2011
Charadriidae	<i>Charadrius hiaticula</i>	Common Ringed Plover	Mangrove and adjacent areas	Rajpar and Zakaria 2010; Sabir 2011
Charadriidae	<i>Charadrius leschenaultia</i>	Greater Sand Plover	Mangrove	Sabir 2011

Table 1 (continued)

Family	Scientific name	Common name	Habitat	Authors
Charadriidae	<i>Charadrius mongolus</i>	Mongolian Plover	Mangrove	Sabir 2011
Charadriidae	<i>Pluvialis fulva</i>	Pacific Golden-Plover	Mudflats, mangrove and adjacent areas	Lim et al. 2001; Rajpar and Zakaria 2010
Charadriidae	<i>Pluvialis squatarola</i>	Grey Plover	Mangrove	Sabir 2011
Charadriidae	<i>Vanellus indicus</i>	Red-wattled Lapwing	Mangrove	Sabir 2011
Chloropseidae	<i>Aegithina tiphia</i>	Common Iora	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Ciconiidae	<i>Leptoptilos javanicus</i>	Lesser Adjutant	Mangrove and adjacent areas	Norhayati et al. 2009; Rajpar and Zakaria 2010
Ciconiidae	<i>Mycteria cinerea</i>	Milky Stork	Mangrove	Macintosh and Ashton 2002
Columbidae	<i>Ptilinopus jamba</i>	Jambu Fruit-Dove	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Columbidae	<i>Treron curvirostra</i>	Thick-billed Green Pigeon	Mangrove	Norhayati et al. 2009
Columbidae	<i>Treron olax</i>	Little Green-Pigeon	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Columbidae	<i>Treron vernans</i>	Pink-necked Green Pigeon	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Coraciidae	<i>Eurystomus orientalis</i>	Dollar Bird	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Cuculidae	<i>Centropus bengalensis</i>	Lesser Coucal	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Cuculidae	<i>Centropus sinensis</i>	Greater Coucal	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Cuculidae	<i>Chrysococcyx minutillus</i>	Malayan Bronze Cuckoo	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Cuculidae	<i>Coccyzus minor</i>	Mangrove Cuckoo	Mangrove	Acevedo and Aide 2008
Cuculidae	<i>Phaenicophaeus diardi</i>	Black-bellied Malkoha	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Cuculidae	<i>Phaenicophaeus sumatranus</i>	Chestnut-bellied Malkoha	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Dicaeidae	<i>Dicaeum curentatum</i>	Scarlet-backed Flowerpecker	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Dormitidae	<i>Dromas ardeola</i>	Crab Plover	Mangrove	Sabir 2011
Estrilidae	<i>Lonchura fuscans</i>	Dusky Munia	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Falconidae	<i>Falco columbarius</i>	Peregrine Falcon	Mangrove	Gough et al. 1998; SFAE 2013
Haematopodidae	<i>Haematopus ostralegus</i>	Eurasian Oystercatcher	Mangrove	Sabir 2011
Hemiprocniidae	<i>Hemiprocne comata</i>	Whiskered Treeswift	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Hirundinidae	<i>Hirundo tahitica</i>	Pacific Swallow	Mangrove and adjacent areas	Lim et al. 2001; Rajpar and Zakaria 2010
Icteridae	<i>Lonchura punctulata</i>	Nutmeg Mannikin	Mangrove	Acevedo and Aide 2008
Icteridae	<i>Quiscalus niger</i>	Great Antillean Grackle	Mangrove	Acevedo and Aide 2008

Table 1 (continued)

Family	Scientific name	Common name	Habitat	Authors
Laniidae	<i>Hemipus hirsudinaceus</i>	Black-winged Flycatcher-Shrike	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Laniidae	<i>Hemipus picatus</i>	Bar-winged Flycatcher-Shrike	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Lariidae	<i>Chroicocephalus genei</i>	Slender-billed Gull	Mangrove	Sabir 2011
Lariidae	<i>Chroicocephalus ridibundus</i>	Black-headed Gull	Mangrove	Sabir 2011
Lariidae	<i>Ichthyophaga ichthyophaga</i>	Greater Black-headed Gull	Mangrove	Sabir 2011
Lariidae	<i>Larus cachinnans</i>	Caspian Gull	Mangrove	Sabir 2011
Lariidae	<i>Larus canus</i>	Common Gull	Mangrove	Sabir 2011
Lariidae	<i>Larus heuglini</i>	Heuglini Gull	Mangrove	Sabir 2011
Lariidae	<i>Sterna albifrons</i>	Little Tern	Mangrove	Lim et al. 2001
Meropidae	<i>Merops philippinus</i>	Blue-tailed Bee-eater	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Meropidae	<i>Merops viridis</i>	Blue-throated Bee-eater	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Muscicapidae	<i>Cyornis rufigaster</i>	Mangrove Blue-Flycatcher	Mangrove and adjacent areas	Norhayati et al. 2009; Rajpar and Zakaria 2010
Muscicapidae	<i>Muscicapa danurica</i>	Asian Brown Flycatcher	Mangrove	Norhayati et al. 2009
Nectariniidae	<i>Anthreptes malacensis</i>	Brown-throated Sunbird	Mangrove and adjacent areas	Norhayati et al. 2009; Rajpar and Zakaria 2010
Nectariniidae	<i>Anthreptes simplex</i>	Plain Sunbird	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Nectariniidae	<i>Nectarinia calcostetha</i>	Copper-throated Sunbird	Mangrove	Norhayati et al. 2009
Nectariniidae	<i>Nectarinia jugularis</i>	Olive-backed Sunbird	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Nectariniidae	<i>Nectarinia sperata</i>	Purple-throated Sunbird	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Pachycephalidae	<i>Pachycephala grisola</i>	Mangrove Whistler	Mangrove and adjacent areas	Norhayati et al. 2009; Rajpar and Zakaria 2010
Parulidae	<i>Dendroica discolor</i>	Prarie Warbler	Mangrove	Acevedo and Aide 2008
Parulidae	<i>Mniotilta varia</i>	Black-and-white Warbler	Mangrove	Acevedo and Aide 2008
Parulidae	<i>Protonotaria citrea</i>	Prothonotary Warbler	Mangrove	Acevedo and Aide 2008
Parulidae	<i>Seiurus aurocapilla</i>	Ovenbird	Mangrove	Acevedo and Aide 2008
Parulidae	<i>Seiurus noveboracensis</i>	Northern Waterthrush	Mangrove	Acevedo and Aide 2008
Parulidae	<i>Setophaga ruticilla</i>	American Redstart	Mangrove	Acevedo and Aide 2008

Table 1 (continued)

Family	Scientific name	Common name	Habitat	Authors
Pelicanidae	<i>Pelecanus crispus</i>	Dalmation Pelican	Mangrove	Sabir 2011
Pelicanidae	<i>Pelecanus onocrotalus</i>	White Pelican	Mangrove	Sabir 2011
Pelicanidae	<i>Pelecanus occidentalis</i>	Brown Pelican	Mangrove	Gough et al. 1998; SFAE 2013
Phalacrocoracidae	<i>Phalacrocorax carbo</i>	Great Cormorant	Mangrove and adjacent areas	Rajpar and Zakaria 2010; Sabir 2011
Phalacrocoracidae	<i>Phalacrocorax niger</i>	Little Cormorant	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Phalacrocoracidae	<i>Phalacrocorax nigrogularis</i>	Sootra Cormorant	Mangrove	Sabir 2011
Phoenicopteridae	<i>Phoenicopterus ruber roseus</i>	Greater Flamingo	Mangrove	Sabir 2011
Picidae	<i>Blythipicus rubiginosus</i>	Maroon Woodpecker	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Picidae	<i>Dendrocopos moluccensis</i>	Sunda Woodpecker	Mangrove	Lim et al. 2001
Picidae	<i>Dinopium javanense</i>	Common Flameback	Mangrove and adjacent areas	Norhayati et al. 2009; Rajpar and Zakaria 2010
Picidae	<i>Dryocopus javensis</i>	White-bellied Woodpecker	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Picidae	<i>Picooides moluccensis</i>	Brown-capped Woodpecker	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Picidae	<i>Picumnus immominatus</i>	Speckled Piculet	Mangrove and adjacent areas	Rajpar and Zakaria 2013
Podipedidae	<i>Podiceps nigricollis</i>	Black-necked Grebe	Mangrove	Sabir 2011
Podipedidae	<i>Pediceps cristatus</i>	Great Crested Grebe	Mangrove	Sabir 2011
Psittacidae	<i>Loriculus galgulus</i>	Blue-crowned Hanging Parrot	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Rallidae	<i>Eulabeornis castaneoventris</i>	Chestnut Rail	Mangrove	MINS-BCC 2005
Rallidae	<i>Gallinule chloropus</i>	Eurasian Moorhen	Mangrove	Gough et al. 1998; SFAE 2013
Recurvirostridae	<i>Himantopus himantopus</i>	Black-winged Stilt	Mangrove	Sabir 2011
Recurvirostridae	<i>Recurvirostra himantopus</i>	Avocet	Mangrove	Sabir 2011
Rhipiduridae	<i>Rhipidura javanica</i>	Pied Fantail	Mangrove and adjacent areas	Lim et al. 2001; Norhayati et al. 2009; Rajpar and Zakaria 2010
Scolopacidae	<i>Actitis hypoleucos</i>	Common Sandpiper	Mangrove	Sabir 2011
Scolopacidae	<i>Arenaria interpres</i>	Ruddy turnstone	Mangrove	Sabir 2011
Scolopacidae	<i>Calidris alba</i>	Sanderling	Mangrove	Sabir 2011
Scolopacidae	<i>Calidris alpina</i>	Dunlin	Mangrove	Sabir 2011
Scolopacidae	<i>Calidris ferruginea</i>	Curlew Sandpiper	Mangrove	Sabir 2011
Scolopacidae	<i>Calidris minuta</i>	Little Stint	Mangrove	Sabir 2011

Table 1 (continued)

Family	Scientific name	Common name	Habitat	Authors
Scolopacidae	<i>Limicola falcinellus</i>	Broad-billed Sandpiper	Mangrove	Sabir 2011
Scolopacidae	<i>Limosa lapponica</i>	Bar-tailed Godwit	Mangrove	Sabir 2011
Scolopacidae	<i>Limosa limosa</i>	Black-tailed Godwit	Mangrove	Sabir 2011
Scolopacidae	<i>Numenius arquata</i>	Eurasian Curlew	Mangrove	Sabir 2011
Scolopacidae	<i>Numenius phaeopus</i>	Whimbrel	Mudflats, mangrove and adjacent areas	Lim et al. 2001; Rajpar and Zakaria 2010; Sabir 2011
Scolopacidae	<i>Philomachus pugnax</i>	Ruff	Mangrove	Sabir 2011
Scolopacidae	<i>Tringa brevipes</i>	Grey-tailed Tattler	Mangrove and Adjacent areas	Rajpar and Zakaria 2010
Scolopacidae	<i>Tringa guttifer</i>	Nordmann's Greenshank	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Scolopacidae	<i>Tringa hypoleucos</i>	Common Sandpiper	Mudflats, Mangrove and adjacent areas	Lim et al. 2001; Rajpar and Zakaria 2010; Han 2011
Scolopacidae	<i>Tringa nebularia</i>	Greenshank	Mangrove	Sabir 2011
Scolopacidae	<i>Tringa stagnatilis</i>	Marsh Sandpiper	Mangrove	Sabir 2011
Scolopacidae	<i>Tringa totanus</i>	Common Redshank	Mudflats, Mangrove and adjacent areas	Lim et al. 2001; Rajpar and Zakaria 2010; Sabir 2011
Scolopacidae	<i>Xenus cinereus</i>	Terek Sandpiper	Mangrove and adjacent areas	Rajpar and Zakaria 2010; Sabir 2011
Sittidae	<i>Sitta frontalis</i>	Velvet-fronted Nuthatch	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Sternidae	<i>Chlidonias hybridus</i>	Whiskered Tern	Mangrove	Sabir 2011
Sternidae	<i>Chlidonias leucopterus</i>	White-winged Black Tern	Mangrove	Sabir 2011
Sternidae	<i>Gelochelidon nilotica</i>	Gull-billed Tern	Mangrove	Sabir 2011
Sternidae	<i>Hydroprogne caspia</i>	Caspian Tern	Mangrove	Sabir 2011
Sternidae	<i>Onychoprion anaethetus</i>	Bridled Tern	Mangrove	Sabir 2011
Sternidae	<i>Sterna hirundo</i>	Common Tern	Mangrove	Sabir 2011
Sternidae	<i>Sterna repressa</i>	White-cheeked Tern	Mangrove	Sabir 2011
Sternidae	<i>Sterna saundersi</i>	Saunders Little Tern	Mangrove	Sabir 2011
Sternidae	<i>Thalasseus bengalensis</i>	Lesser Crested Tern	Mangrove	Sabir 2011
Sternidae	<i>Thalasseus bergii</i>	Great Crested Tern	Mangrove	Sabir 2011
Sternidae	<i>Thalasseus sandvicensis</i>	Sandwich Tern	Mangrove	Sabir 2011
Strigidae	<i>Bubo virginianus</i>	Great Horned Owl	Mangrove	Gough et al. 1998; SFAE 2013

Table 1 (continued)

Family	Scientific name	Common name	Habitat	Authors
Strigidae	<i>Strix varia</i>	Barred Owl	Mangrove	Gough et al. 1998; SFAE 2013
Strigidae	<i>Tyto alba</i>	Barn Owl	Mangrove	Gough et al. 1998; SFAE 2013
Sturnidae	<i>Aplonis panayensis</i>	Philippine Glossy Starling	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Sturnidae	<i>Gracula religiosa</i>	Hill Myna	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Sylviidae	<i>Orthotomus ruficeps</i>	Ashy Tailorbird	Mangrove and adjacent areas	Lim et al. 2001; Norhayati et al. 2009; Rajpar and Zakaria 2010
Sylviidae	<i>Orthotomus sericeus</i>	Rufous-tailed Tailorbird	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Thraupidae	<i>Spindalis portoricensis</i>	Puerto Rican Spindalis	Mangrove	Acevedo and Aide 2008
Threskiornithidae	<i>Ajaja ajaja</i>	Roseate Spoonbill	Mangrove	Gough et al. 1998; Macintosh and Ashton 2002; SFAE 2013
Threskiornithidae	<i>Eudocimus albus</i>	White Ibis	Mangrove	Gough et al. 1998; SFAE 2013
Threskiornithidae	<i>Eudocimus ruber</i>	Scarlet Ibis	Mangrove mudflats	Macintosh and Ashton 2002
Threskiornithidae	<i>Platalea leucordia</i>	Spoonbill	Mangrove	Sabir 2011
Timaliidae	<i>Macronus gularis</i>	Striped Tit-Babbler	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Trochilidae	<i>Anthracoceros viridis</i>	Green Mango	Mangrove	Acevedo and Aide 2008
Turdidae	<i>Copsychus saularis</i>	White-rumped Shama	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Turdidae	<i>Turdus plumbeus</i>	Red-legged Trush	Mangrove and adjacent areas	Rajpar and Zakaria 2010
Tyrannidae	<i>Tyrannus caudifasciatus</i>	Loggerhead Kingbird	Mangrove	Acevedo and Aide 2008
Tyrannidae	<i>Tyrannus dominicensis</i>	Gray Kingbird	Mangrove	Acevedo and Aide 2008
Vireonidae	<i>Vireo altiloquus</i>	Black-whiskered Vireo	Mangrove	Acevedo and Aide 2008
Zosteropidae	<i>Zosterops palpebrosa</i>	Oriental White-eye	Mangrove	Norhayati et al. 2009

Fig. 1 White-bellied Fish Eagle—*Haliaeetus leucogaster* hovers over mangrove area in search of food



Fig. 2 Brhaminy Kite—*Haliaster indus* hovers over mangrove area in search of food



Fig. 3 White-breasted Woodswallow—*Artamus leucorynchus* perching on the dead branches of *Rhizophora* sp

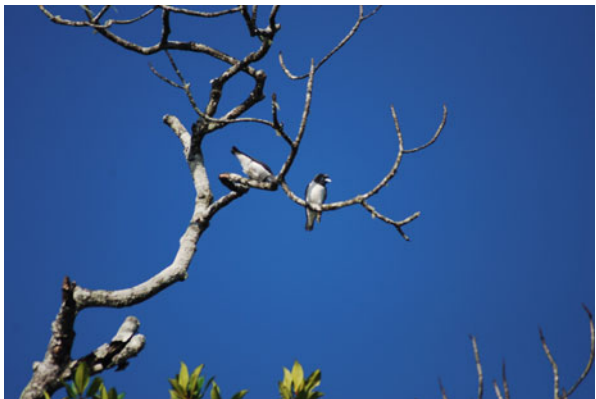


Fig. 4 Blue-throated Bee-eater—*Merops viridis* sitting in wire near mangrove area



food such as fishes, birds, monkeys, snakes, and insects. Raptor birds such eagles, hawks, kites and osprey extensively prey on fishes, small birds, small mammals, reptiles, amphibians and large invertebrates (Ridgely and Greenfield 2001; Solano-Ugalde et al. 2009; Alava et al. 2011) while swallows, bee-eaters and swiftlets catch flying insects on the wing over mangrove areas and roost within mangrove areas.

3.1.2 Wader Birds

These are a group of waterbird species that wade in shallow water (Fig. 6) to catch different food resources such as fishes, prawns, mollusks, crustaceans, polychaetes and other invertebrates during low tides or in soft mud such as Egrets, Herons, Bitterns (Ardeidae), Finfoots (Heliornithidae), Plovers (Charadriidae), Oystercatchers (Haematopodidae), Sandpipers, Curlews, Shanks (Fig. 7), Tattlers (Fig. 8), Stints, Ruffs, Godwits, Knots, Dowitchers, Turnstones, Whimbrel, Snipes, Oystercatchers (Scolopacidae), Stilts and Avicets (Recurvirostridae), Phalaropes (Phalaropidae), Gulls, Terns and Noddys (Laridae), Spoonbills, Ibis, and Storks (Ciconiidae), Frigate birds (Fregatidae) and Famingos (Phoenicopteridae) (Fig. 9). These bird species utilize mangrove areas for foraging, roosting, nesting and shelter from harsh weather and hide cover from predators. Habitat selection among bird species may vary depending upon the nature of food selection, shape of the bill and location of food resources. It has been reported that mangrove forests may harbour a variety of water as well as terrestrial bird through offering safe habitats, foraging and loafing sites (Jayson 2001; Laakkonen 2003; Berg and Angel 2006; Carvajal and Alava 2007; Saari and Ibrahim 2001).

3.1.3 Surface/Diving Foragers

Some bird species forage on the surface of water and sometimes dive into deep water to catch their prey especially fishes, amphibians, aquatic invertebrates, and



Fig. 5 Different Kingfisher species loafing in mangrove area

vegetable matter. For example, Pelicans (Pelecanidae) (Fig. 10), Ducks and Goose (Anatidae) mostly swim on the surface of water to forage small fishes, amphibians, aquatic invertebrates, and vegetable matter while Cormorants (Phalacrocoracidae), Darters (Anhingidae) (Fig. 11), Loons (Gaviidae), and Grebes (Podicipedidae) dive into deep water, particularly river beds, in search of food, mainly fishes and aquatic invertebrates such as mollusks.



Fig. 6 **a** Different wading birds searching for food in mudflat area. **b** Whimbrel—*Numenius phaeopus* foraging in shallow water during low tides. **c** Whimbrel—*Numenius phaeopus* loafing on mangrove tree

3.1.4 Foliage and Bark Gleaners

These are mostly terrestrial bird species which prefer to use mangrove vegetation, i.e. trees, shrubs, palms, and ferns for foraging, perching, nesting and roosting

Fig. 7 Shank species—*Tringa spp.* perch on soft mud under *Rhizophora* sp. during low tides



Fig. 8 Grey-tailed Tattler—*Tringa brevipes* loaf on the roots of *Rhizophora* sp. during low tides



Fig. 9 Greater Flamingo—*Phoenicopterus roseus* foraging in shallow water of estuary



Fig. 10 Juvenile of Great White Pelican—*Pelecanus onocrotalus* loafing on dead wood fallen into water



Fig. 11 Oriental Darter—*Anhinga melanogaster* perching on the dead branches of *Rhizophora* sp



(Fig. 12) such as woodpeckers (Picidae), Tailorbirds, Warblers, Flyeaters (Sylviidae), Flycatchers (Muscicapidae), Trush, Shama and Robins, (Turdidae), Nuthatch (Sittidae), Sunbirds Spiderhunters (Nectariniidae), Pigeons (Columbidae), Owls (Strigidae), Cuckoos and Malkohas (Cuculidae), Parrots (Psittacidae), Tits (Paridae), Orioles (Oriolidae), Drongos (Dicruridae), Ioras (Chloropseidae), Flycatcher Shrikes (Campephagidae) and Pittas (Pittidae). Some of them are frugivorous birds that feed on fruits such as pigeons and parrots, insectivorous birds that feed on insects such as woodpeckers, robins, warblers, tits, and nectarivorous birds that nip on the nectar such as sunbirds and spider-hunters, and carnivorous birds that forage on other animals such as owls.

Bird species are a bioindicator of a mangrove ecosystem and play a significant role in the management of vegetation. They control the population of insect pest that cause the defoliation among trees and reduce their growth and also cause damage to the seeds. For example, insect eating birds such as tailorbirds, shrikes, flycatchers, ioras, and robins prey on different insect species such as caterpillars, beetles, bugs, and aphids that may cause the defoliation, bark damage that vigorously decreased



Ashy Tailorbird – *Orthotomus*



Red-billed Malkoha – *Phaenicophaeus*



Great Tit – *Parus major*



Asian Brown Flycatcher – *Muscivora dauurica*



Laced Woodpecker - *Picus vittatus*



Thick-billed Green Pigeon - *Treron curvirostra*



Mangrove Blue Flycatcher - *Cyornis rufigaster*



White-rumped Shama - *Copsychus malabaricus*

Fig. 12 Different foliage and bark gleaning birds resting in mangrove area

the productivity and health of trees. Sunbirds and spider-hunters play a vector role in pollination, i.e., they transfer pollen from one flowering tree to another thus increasing the process of pollination that ultimately increases the seed production. Raptors such as eagles, falcons, and hawks prey on mammals such as monkeys and squirrels that foraged on fruits and tender leaves in the mangrove. Waterbirds are predators of fishes, amphibians, reptiles and a variety of aquatic invertebrates. They control their population and balance the mangrove and mudflat ecosystem. In addition, they are also an important source of food for other animals such as snakes, lizards, fishes, and crocodiles.

3.2 Mangrove as a Habitat for Reptiles

Mangroves are an ideal habitat and are rich in reptile fauna, which include snakes, turtles, crocodiles and alligators. The turtle species found in the mangrove area include Loggerhead Turtle—*Caretta caretta*, Green Sea Turtle—*Chelonia mydas*, Ornate Diamondback Terrapin—*Malaclemys terrapin macrospilota* (Laakkonen 2003; Boykin 2004; SPGMEC 2013), Mangrove Diamondback Terrapin—*Malaclemys terrapin rhizophorarum* (Burke 2000; Laakkonen 2003; Boykin 2004), Hawksbill Sea Turtle—*Eretmochelys imbricate*, Atlantic Ridley Sea Turtle—*Lepidochelys kempii* (Laakkonen 2003), Olive Ridley—*Lepidochelys olivacea*, and Leatherback turtle—*Dermochelys coriacea* (SPGMEC 2013). These turtle species utilize mangrove areas, estuaries and creeks for foraging and breeding purposes due to the richness and diversity of plankton and benthic food resources. They use sandy beaches for breeding purpose.

Mangrove areas are also rich and diverse in snake fauna which include, e.g., Dog-faced Water Snake—*Cerebus rynchops* (Lim et al. 2001; Han 2011), File Snake—*Acrochordus granulatus* (Lim et al. 2001), Mangrove Snake—*Boiga dendrophila* (Norhayati et al. 2009), Mangrove Pit-Viper—*Trimeresurus purpureomaculatus* (Lim et al. 2001), Mangrove Skin—*Emoia atrocostata* (Lim et al. 2001; Norhayati et al. 2009; Han 2011) and Green Pit Viper—*Vipera trimeresurus* (Macintosh and Ashton 2002). These snake species prey on a variety of animals such as birds, amphibians, small mammals and are also eaten by fishes, crocodiles and eagles.

Only a few crocodile species exist in mangroves, estuarine, and adjacent rivers, e.g., Saltwater/Estuary Crocodile—*Crocodylus porosus* (Fig. 13) (Macintosh and Ashton 2002; Foote 2013), Common Caiman—*Caiman crocodylus* (Macintosh and Ashton 2002) and Marsh Crocodile—*Crocodylus palustris* (Fig. 14) (SPGMEC 2013). These crocodile species prey on a wide array of animals such as birds, fishes, snakes and mammals.

Mangrove areas are also home to a few lizard species such as Mangrove Monitor Lizard—*Varanus indicus* (Fig. 15) and Malaysian Water Monitor Lizard—*Varanus salvator* (Fig. 16) (Lim et al. 2001; Macintosh and Ashton 2002; NTG 2002; Norhayati et al. 2009). These are predators of different animals such as birds, amphibians and small reptiles.

Fig. 13 Saltwater/Estuary Crocodile—*Crocodylus porosus* resting in mangrove roosts in shallow water



Fig. 14 Marsh Crocodile—*Crocodylus palustris* taking a sunbath on soft mud



Fig. 15 Mangrove Monitor Lizard—*Varanus indicus* search for food near mangrove roots in shallow water



Fig. 16 Malaysian Water Monitor Lizard—*Varanus salvator* resting in grasses near a mangrove area



Fig. 17 Giant Toad—*Bufo marinus* resting on soft soil



Fig. 18 Mangrove Frog—*Fejervarya cancrivora* resting on mangrove root



3.3 Mangrove as a Habitat for Amphibians

Only a few species of frogs occur in mangrove forests including Giant Toad—*Bufo marinus* (Fig. 17), Tree Frog—*Osteopilus septentrionalis* and Mangrove Frog—*Fejervarya cancrivora* (Fig. 18) (Dicroglossidae) Macintosh and Ashton 2002;

Fig. 19 Long-tailed Macaque—*Macaca fascicularis* sitting on mangrove tree



Fig. 20 Crab-eating Macaque—*Macaca fascicularis* swimming in mangrove area



Wright et al. 2004; Satheeshkumar 2011). The occurrence of such a few number of amphibians could be due to high salt contents of the water. Mangrove frogs are predators that may eat almost every small living thing such as insects (e.g., beetles, bees, ants, termites, crickets and bugs), snails, smaller toads, prawns, and fishes.

3.4 Mangrove as a Habitat for Mammals

Mangrove forests are rich in mammal species such as White-tailed Deer—*Odocoileus virginianus*, Key Deer—*Odocoileus virginianus clavium*, Bengal Tiger—*Panthera tigris*, Leopard—*Panthera pardus*, Spotted Deer—*Axis axis*, Long-tailed Macaque—*Macaca fascicularis* (Fig. 19), Crab-eating Macaque—*Macaca fascicularis* (Fig. 20), White-faced monkey—*Cebus capucinus*, Malaysian Proboscis Monkey—*Nasalis larvatus* (Fig. 21), Wild Pigs—*Sus scrofa* and Mousedeer—*Tragulus* sp., Long-tongued Nectar Bat—*Macroglossus minimus*, Lesser Dog-faced

Fig. 21 Malaysian Proboscis Monkey—*Nasalis larvatus* sitting on trees



Source: <http://borneoclimbanddive.com/wp-content/uploads/2013/03/Proboscis-Monkey-18.jpg>

Fruit Bat—*Cynopterus brachyotis*, Marsh Rabbit—*Sylvilagus palustris*, Cotton Rat—*Sigmodon hispidus*, and Marsh Rat—*Oryzomys palustris* (Table 2). In addition, Bottle-nosed Dolphin—*Tursiops truncatus*, Gangetic Dolphin—*Platanista gangetica*, Common Dolphin—*Delphinus delphis*, Manatees—*Trichechus* spp., Smooth Otter—*Lutrogale perspicillata*, Small-clawed Oriental Otter—*Amblonyx cinereus* and Manatees—*Trichechus manatus* are often observed swimming in canals, coastal rivers, and other waters close in proximity to mangroves (FAO 1984, 1994; Hogarth 1999; Ng and Sivasothi 2001; Laakkonen 2003; Warne 2013).

Mammals are a major source of food for a variety of animals such as raptor birds, snakes, crocodiles, and a significant component of mangrove ecosystems. Frugivore mammals such as monkeys, squirrels, and bats are also important as seed dispersal agents. Herbivorous mammals browse on young shoots of trees, shrubs and other vegetation; hence, they control the growth of shrubs and bushes that may compete for nutrition with trees.

3.5 Mangrove as a Habitat for Fish

Mangrove areas are rich in fish fauna (Table 3). For example, a total of 128 fish species were sampled in mangroves of Paglibao, Philippines (Pinto 1988), 119 fish species have been recorded in the mangrove of Selangor, Malaysia (Chong et al. 1990), 135 fish species in the mangrove estuary of Sikao Creek, Trang Province, Thailand (Prasert et al. 2002), 33 fish species in the mangrove river of Sarawak, Malaysia (Nyanti et al. 2012), and 105 fish species in the mangrove of India (Naik et al. 2013). In addition, mud skippers are one of the fish which live on the mud

Table 2 List of mammal species recorded in different areas of mangrove and adjacent habitat

Family	Scientific Name	Common Name	Habitat	Authors
Cercopithecidae	<i>Macaca fascicularis</i>	Long-tailed Macaque	Mangrove forest	Lim et al. 2001; Norhayati et al. 2009; Han 2011
Cercopithecidae	<i>Nasalis larvatus</i>	Proboscis/Long-nose Monkey	Mangrove	Ecology Asia 2001; Macintosh and Ashton 2002; Meijaard et al. 2008
Cercopithecidae	<i>Macaca fascicularis</i>	Crab-eating Macaque	Mangrove	Ong and Richardson 2008
Cercopithecidae	<i>Trachypithecus obscurus</i>	Dusky Leaf Monkey	Mangrove	Norhayati et al. 2009
Cercopithecidae	<i>Cercopithecus sp.</i>	Vervet Monkey	Mangrove	Macintosh and Ashton 2002
Felidae	<i>Panthera tigris</i>	Bengal Tiger	Mangrove	Macintosh and Ashton 2002
Mustelidae	<i>Amblyonyx cinereus</i>	Small-clawed Oriental Otter	Coastal areas	Lim et al. 2001
Mustelidae	<i>Lutrogale perspicillata</i>	Smooth Otter	Coastal areas	Lim et al. 2001
Pteropodidae	<i>Pteropus vampyrus</i>	Flying Fox	Mangrove Island	Bates et al. 2008; Norhayati et al. 2009
Pteropodidae	<i>Cynopterus brachyotis</i>	Lesser Dog-faced Fruit Bat	Mangrove	Lim et al. 2001; Macintosh and Ashton 2002
Pteropodidae	<i>Eonycteris spelaea</i>	Cave Fruit Bat	Mangrove	Macintosh and Ashton 2002
Pteropodidae	<i>Macroglossus minimus</i>	Long-tongued Nectar Bat	Mangrove	Lim et al. 2001; Norhayati et al. 2009
Sciuridae	<i>Callosciurus notatus</i>	Plantain Squirrel	Mangrove	Norhayati et al. 2009
Bovidae	<i>Tragelaphus spekii</i>	Swamp Antelope	Mangrove adjacent	Macintosh and Ashton 2002; IUCN 2008
Suidae	<i>Sus scrofa</i>	Wild Pig	Mangrove adjacent	Bhattacharya 2011; Macintosh and Ashton 2002

Table 3 List of fish species recorded in different areas of mangrove and adjacent habitat

Family	Scientific Name	Common Name	Habitat	Authors
Acanthuridae	<i>Acanthurus chirus</i>	Doctor Fish	Mangrove root	Osorio et al. 2011
Achiridae	<i>Trinectes paulistanus</i>	Slipper Sole Fish	Mangrove root	Osorio et al. 2011
Adrianchthyidae	<i>Aplocheilichthys panchax</i>	Whitespot	Mangrove	Lim et al. 2001
Adrianchthyidae	<i>Etroplus suratensis</i>	Green Chromide	The mangrove-lined estuaries	Lim et al. 2001
Ambassidae	<i>Ambassis gymnocephalus</i>	Glass Perchlet	Mangrove	Chong et al. 1990
Ambassidae	<i>Ambassis interrupta</i>	Long-spined Glass Perchlet	Mangrove river	Nyanti et al. 2012
Ambassidae	<i>Ambassis kopsii</i>	Freckled Hawkfish	Mangrove river	Nyanti et al. 2012
Ambassidae	<i>Ambassis urotaenia</i>	Banded-tail Glassy perchlet	Mangrove river	Nyanti et al. 2012
Anabantidae	<i>Anabas testudineus</i>	Gouramies Fish	Mangrove river	Nyanti et al. 2012
Apogonidae	<i>Apogon hyalsona</i>	Mangrove Cardinalfish	Mangrove roots	Lim et al. 2001
Apogonidae	<i>Apogon quadrifasciatus</i>	Cardinal Fish	Mangrove	Chong et al. 1990
Apogonidae	<i>Sphaeraemia orbicularis</i>	Orbi Cardinalfish	Mangrove river	Huxham et al. 2004
Ariidae	<i>Arius sagor</i>	Engraved Catfish	Mangrove	Chong et al. 1990; Nyanti et al. 2012
Ariidae	<i>Arius tonggol</i>	Catfish	Mangrove	Chong et al. 1990
Ariidae	<i>Arius venosus</i>	Veined Catfish	Mangrove	Chong et al. 1990
Ariidae	<i>Osteogenetosus militaris</i>	Solider/Sea Catfish	Mangrove	Chong et al. 1990
Atherinidae	<i>Atherinomorus duodecimalis</i>	Tropical Silverside	Mangrove	Lim et al. 2001
Atherinidae	<i>Hypoatherina temminckii</i>	Samoan Silverside	Mangrove river	Huxham et al. 2004
Bagridae	<i>Mystus gulio</i>	Estuarine Catfish	Mangrove	Lim et al. 2001; Nyanti et al. 2012
Bagridae	<i>Mystus sp.</i>	Long Whiskers Catfish	Mangrove	Chong et al. 1990
Batrachoidae	<i>Batrachoides surinamensis</i>	Pacuma Toadfish	Mangrove root	Osorio et al. 2011
Belontiidae	<i>Strongylura strongylura</i>	Spot-tail Needlefish	Mangrove	Lim et al. 2001
Bleniidae	<i>Antemablennius australis</i>	Moustached Rockskipper	Mangrove river	Huxham et al. 2004
Carangidae	<i>Caranx ignobilis</i>	Giant Trevally	Mangrove river	Chong et al. 1990
Centropomidae	<i>Lates calcarifer</i>	Sea Bass	Mangrove	Chong et al. 1990; Lim et al. 2001; Nyanti et al. 2012
Centropomidae	<i>Centropomus spp.</i>	Snook Fish	Mangrove root	Osorio et al. 2011
Chamidae	<i>Chanos chanos</i>	Milkfish	Mangrove river	Huxham et al. 2004
Clariidae	<i>Claris sp.</i>	Walking Catfish	Mangrove river	Nyanti et al. 2012
Clupeidae	<i>Sardinella melanura</i>	Tamban	Mangrove	Chong et al. 1990; Lim et al. 2001
Clupeidae	<i>Tenuulosa sinensis</i>	Hilsa	Mangrove	Chong et al. 1990

Table 3 (continued)

Family	Scientific Name	Common Name	Habitat	Authors
Cynoglossidae	<i>Cynoglossus macrolepidotus</i>	Flat Fish	Mangrove	Chong et al. 1990
Elopidae	<i>Elops machnata</i>	Elops Machnata	Mangrove river	Nyanti et al. 2012
Engraulidae	<i>Engraulis japonicus</i>	Japanese anchovy	Mangrove river	Huxham et al. 2004
Engraulidae	<i>Stolephorus dubiosus</i>	Indian Anchovy	Mangrove	Nyanti et al. 2012
Engraulidae	<i>Stolephorus indicus</i>	Indian Anchovy	Mangrove	Chong et al. 1990
Engraulidae	<i>Stolephorus tri</i>	Spined Anchovy	Mangrove	Chong et al. 1990
Engraulidae	<i>Thryssa hamiltonii</i>	Thryssa Fish	Mangrove	Chong et al. 1990
Engraulidae	<i>Thryssa kammalensis</i>	Kammal Thryssa	Mangrove	Chong et al. 1990
Ephippidae	<i>Chaetodipterus faber</i>	Spade Fish	Mangrove root	Osorio et al. 2011
Gerreidae	<i>Gerres filamentosus</i>	Whipfin Silver-biddy	Mangrove river	Nyanti et al. 2012
Gerreidae	<i>Gerres oyena</i>	Common Silver-biddy	Mangrove river	Huxham et al. 2004
Gerreidae	<i>Diapterus sp.</i>	Mojarra Fish	Mangrove root	Osorio et al. 2011
Gerreidae	<i>Euclinostomus melanopterus</i>	Flagfin Mojarra	Mangrove root	Osorio et al. 2011
Gobiidae	<i>Bathygobius cyclopterus</i>	Spotted Frillgoby Fish	Mangrove river	Nyanti et al. 2012
Gobiidae	<i>Boleophthalmus boddarti</i>	Blue-spotted Mudskipper	Mangrove and mudflats	Lim et al. 2001; Han 2011
Gobiidae	<i>Callogobius maculipinnis</i>	Ostrich Goby	Mangrove river	Huxham et al. 2004
Gobiidae	<i>Glossobitus aureus</i>	Golden Tank Goby	Mangrove river	Nyanti et al. 2012
Gobiidae	<i>Glossogobius givris</i>	Goby Fish	Mangrove	Chong et al. 1990
Gobiidae	<i>Gobius nebulosus</i>	Shadow Goby	Mangrove river	Huxham et al. 2004
Gobiidae	<i>Periophthalmodon schlosseri</i>	Giant Mudskipper	Mangrove and mudflats	Lim et al. 2001; Ecology Asia 2001
Gobiidae	<i>Periophthalmus novemradiatus</i>	Dwarf Indian Mudskipper	Estuarine mangrove swamp	Lim et al. 2001; NTG 2002
Gobiidae	<i>Periophthalmus variabilis</i>	Dusky-gilled Mudskipper	Landward mangrove	Lim et al. 2001
Gobiidae	<i>Bathygobius soporator</i>	Frillfin Goby	Mangrove root	Osorio et al. 2011
Haemulidae	<i>Pomadourus hasta</i>	Grunn Fish	Mangrove	Chong et al. 1990
Haemulidae	<i>Haemulon parra</i>	Sailor's Grunt	Mangrove root	Osorio et al. 2011
Hemiramphidae	<i>Hemiramphus far</i>	Barred Garfish	Mangrove river	Huxham et al. 2004
Hemiramphidae	<i>Zenarchopterus buffonis</i>	Striped-nose Halfbeak	Mangrove	Lim et al. 2001
Hemiramphidae	<i>Zenarchopterus candovittatus</i>	Striped-nosed Halfbeak	Mangrove	Chong et al. 1990
Lacepede	<i>Scomberoides commersonianus</i>	Queen Fish	Mangrove	Chong et al. 1990

Table 3 (continued)

Family	Scientific Name	Common Name	Habitat	Authors
Leiognathidae	<i>Leiognathus brevis</i>	Short-nosed Pony Fish	Mangrove	Chong et al. 1990
Leiognathidae	<i>Leiognathus daura</i>	Goldstripe Ponyfish	Mangrove	Chong et al. 1990
Leiognathidae	<i>Secutor insidiator</i>	Ponyfish	Mangrove	Chong et al. 1990
Lutjanidae	<i>Lutjanus argentimaculatus</i>	Mangrove Red Snapper	Mangrove river	Huxham et al. 2004; Nyanti et al. 2012
Lutjanidae	<i>Lutjanus bohar</i>	Two-spot Red Snapper	Mangrove river	Huxham et al. 2004
Lutjanidae	<i>Lutjanus ehrenbergi</i>	Blackspot Snapper	Mangrove river	Huxham et al. 2004
Lutjanidae	<i>Lutjanus alexandrei</i>	Brazilian Snapper	Mangrove root	Osorio et al. 2011
Lutjanidae	<i>Lutjanus cyanopterus</i>	Cubera Snapper	Mangrove root	Osorio et al. 2011
Lutjanidae	<i>Lutjanus jocu</i>	Dog Snapper	Mangrove river	Nyanti et al. 2012
Megalopidae	<i>Megalops scyrrinoides</i>	Indo-Pacific Tarpon	Mangrove river	Nyanti et al. 2012
Monodactylidae	<i>Monodactylus argenteus</i>	Silver Moony	Mangrove	Lim et al. 2001
Monodactylidae	<i>Monodactylus argenteus</i>	Silver Moony	Mangrove river	Huxham et al. 2004
Mugilidae	<i>Liza melimopteris</i>	Mullet Fish	Mangrove	Chong et al. 1990; Nyanti et al. 2012
Mugilidae	<i>Liza subviridis</i>	Mullet Fish	Mangrove	Chong et al. 1990
Mugilidae	<i>Mugil cephalus</i>	Greenback Mullet	Mangrove	Nyanti et al. 2012
Mugilidae	<i>Valamugil burchanani</i>	Blue-tail Mullet	Mangrove river	Nyanti et al. 2012
Mugilidae	<i>Valamugil seheli</i>	Bluespot mullet	Mangrove river	Huxham et al. 2004
Mullidae	<i>Upeneus sulphureus</i>	Sulphur Goatfish	Mangrove river	Chong et al. 1990; Huxham et al. 2004
Narrkidae	<i>Narke capensis</i>	Onefin Electric ray	Mangrove river	Huxham et al. 2004
Phallostethidae	<i>Neostethus sp.</i>	Pariapus Fish	Mangrove	Lim et al. 2001
Platycephalidae	<i>Platycephalus scaber</i>	Flathead Fish	Mangrove	Chong et al. 1990
Platycephalidae	<i>Sorsogona prionata</i>	Flathead Fish	Mangrove river	Huxham et al. 2004
Plotosidae	<i>Paraplotosus albilabris</i>	White-lipped Eel-tail Catfish	Mangrove river	Nyanti et al. 2012
Pristigasteridae	<i>Ilisha megaloptera</i>	Shad Fish	Mangrove	Chong et al. 1990
Scaridae	<i>Sparisoma sp.</i>	Parrot Fish	Mangrove root	Osorio et al. 2011
Scatophagidae	<i>Scatophagus argus</i>	Green/Ruby/Red Scat	Mangrove river	Nyanti et al. 2012
Scatophagidae	<i>Scatophagus sp.</i>	Scat Fish	Mangrove	Chong et al. 1990

Table 3 (continued)

Family	Scientific Name	Common Name	Habitat	Authors
Sciaenidae	<i>Johnius belangerii</i>	Belanger's Croaker	Mangrove	Chong et al. 1990
Sciaenidae	<i>Johnius trachycephalus</i>	Leaf-tailed Croaker	Mangrove river	Nyanti et al. 2012
Sciaenidae	<i>Johnius soldado</i>	Solider Croaker	Mangrove	Chong et al. 1990
Sciaenidae	<i>Johnius coiter</i>	Coiter Croaker	Mangrove	Chong et al. 1990
Sciaenidae	<i>Otolithes ruber</i>	Drums or Croaker Fish	Mangrove	Chong et al. 1990
Serranidae	<i>Epinephelus coioides</i>	Orange-spotted Grouper	Mangrove	Lim et al. 2001
Serranidae	<i>Mycteroperca bonaci</i>	Black Grouper	Mangrove root	Osorio et al. 2011
Sparidae	<i>Archosargus probatocephalus</i>	Sheep-head Fish	Mangrove root	Osorio et al. 2011
Sphyraenidae	<i>Sphyraena putnamiae</i>	Chevron Barracuda	Mangrove river	Huxham et al. 2004
Sphyraenidae	<i>Sphyraena sp.</i>	Barracuda Fish	Mangrove	Chong et al. 1990
Sphyraenidae	<i>Sphyraena barracuda</i>	Great Barracuda	Mangrove root	Osorio et al. 2011
Syngnathidae	<i>Hippocampus reidi</i>	Slender Seahorse	Mangrove root	Osorio et al. 2011
Synodontidae	<i>Harpodon nehereus</i>	Bombay Duck Fish	Mangrove	Chong et al. 1990
Synodontidae	<i>Saurida undosquamis</i>	Brushtooth Lizardfish	Mangrove river	Huxham et al. 2004
Tetraodontidae	<i>Arothron reticularis</i>	Reticulated Pufferfish	Mangrove river	Nyanti et al. 2012
Tetraodontidae	<i>Chelodan fluciatilis</i>	Green Puffer Fish	Mangrove	Chong et al. 1990
Tetraodontidae	<i>Tetraodon nigroviridis</i>	Spotted Green Puffer	Mangrove	Lim et al. 2001
Tetraodontidae	<i>Sphoeroides testudineus</i>	Checked Puffer	Mangrove root	Osorio et al. 2011
Theraponidae	<i>Therapon jarbua</i>	Crescent Perch, Tiger Bass	Mangrove river	Nyanti et al. 2012
Toxotidae	<i>Toxotes sp.</i>	Archerfish	Mangrove	Chong et al. 1990

Fig. 22 Mullet—*Liza* sp. caught in mangrove area



Fig. 23 Black Snapper—*Apsilus dentatus* caught in mangrove area



flats associated with mangrove shores. This indicates that a variety of fish species use mangrove areas for foraging, i.e. feed on amphipods, isopods, crabs, snails, insects, spiders, copepods, shrimp, and organic matter (Sasekumar et al. 1992; Ewel et al. 1998; Clayton 1993; Macintosh and Ashton 2002; Nagelkerken et al. 2008). Many scientists have reported that an array of fish species extensively use mangrove areas as breeding and nursery sites especially during early juvenile stages (Robertson and Duke 1987; Morton 1990; Chong et al. 1990; Laegdsgaard and Johnson 1995; Dorenbosch et al. 2007; Jaxion-Harm et al. 2012). This could be due to the abundance and richness of food resources (Nyanti et al. 2012) such as invertebrates that inhabit the vegetated area (Lubbers et al. 1990; Schneider and Mann 1991), and richness of benthic fauna (Laegdsgaard and Johnson 2001; Marlena 2005).

Fishes utilize a variety of aquatic habitats (Gratwicke et al. 2006) such as fresh water, brackish water and salt water. The fish fauna of mangrove areas include mud skippers, carangids, clupeids, serranids, mullets, hilsa, seabass, and milkfish (Naik et al. 2013). Some of the common fishes that may occur in mangrove area of southeast asia such as Malaysia include Mullet—*Liza* sp. (Fig. 22), Black Snapper—*Apsilus dentatus* (Fig. 23), Spottail Needle Fish—*Strongylura*

Fig. 24 Spottail Needle Fish—*Strongylura strongylura* caught in mangrove area



Fig. 25 One Spot Snapper—*Lutjanus monostigma* caught in mangrove area



Fig. 26 Orange Spotted Grouper—*Epinephelus coioides* caught in mangrove area



strongylura (Fig. 24), One Spot Snapper—*Lutjanus monostigma* (Fig. 25), Orange Spotted Grouper—*Epinephelus coioides* (Fig. 26), Snapper Fish—*Lutjanus* sp. (Fig. 27), Cloudy Grouper Fish—*Epinephelus erythrurus* (Fig. 28), Mangrove Red Snapper—*Lutjanus* sp. (Fig. 29), Garfish—*Hemiramphus* sp. (Fig. 30) and Whipfin Silver-biddy—*Whipfin mojarra* (Fig. 31).

Fig. 27 Snapper
Fish—*Lutjanus* sp. caught in
mangrove area



Fig. 28 Cloudy
Grouperfish—*Epinephelus*
erythrus caught in
mangrove area



Fig. 29 Mangrove Red
Snapper—*Lutjanus* sp. caught
in mangrove area



Fig. 30 Garfish—
Hemiramphus sp. caught in
mangrove area



Fig. 31 Whipfin Silver-biddy—*Whipfin mojarra* caught in mangrove area



However, the fish species composition and distribution may vary from area to area depending on the water quality, aquatic vegetation structure and composition (Pittman et al. 2004), richness of food resources, i.e. invertebrates, vertebrates and vegetable matter (Verweij et al. 2006), detritus (Naik et al. 2013), suitability of breeding sites (Almany 2004), habitat connectivity (Paris et al. 2007; Nakamura et al. 2008) and rate of predation (Chittaro et al. 2005).

The occurrence of a higher diversity of fish species in the mangrove area might be due to the richness and diversity of food resources (Nagelkerken et al. 2002; Aguilar-Perera and Appledoom 2007). The other reason could be due to the complex and extensive root system that reduces the risk of predation and provides safe breeding and nursery grounds, i.e. fishes lay their eggs in extensive roots of mangrove trees (Robertson and Duke 1987; Thayer et al. 1987; Laegdsgaard and Johnson 2001; Huxham et al. 2004; Naik et al. 2012), and after hatching they feed on detritus and other food resources which are easily available in mangrove areas. The water in mangrove areas is turbid and rich in detritus which provide instant food material for juvenile fishes and also reduced predator's vision (Abrahams and Kattenfeld 1997).

Fish is highly nutritious and a major source of human diet, i.e. proteins, vitamins and micronutrients, particularly for low income rural communities (Gracia and Rosenberg 2010). Mangrove supports 75–90 % of the commercial and subsistence fish industries (Lee 1999; Hoyle and Gibbons 2000; NTG 2002). It has been reported that almost 400 million low income people depend on fish as their food (Hortle 2007; Laurenti 2007). Globally, fishes provide around 16 % of animal protein for human beings (Tidwell and Allan 2001). They are economically important for humans, i.e. more than 200 million people directly or indirectly obtain income from the fish industry (Gracia and Newton 1997; FAO 2009).

In addition, fishes are sources of food for a variety of wildlife species such as birds, reptiles and amphibians, mammals, carnivore fishes and invertebrates (Battley et al. 2003; Yu-Seong et al. 2008; Liordos 2010).

3.6 Mangrove as a Habitat for Invertebrate Fauna

Mangrove vegetation has attracted diverse insect species (Macintosh and Ashton 2002) (Table 4) such as Tide-watching Moth—*Aucha velans*, Avicennia Seed Moth—*Autoba alabstrata*, Pneumatophore Moth—*Hymenoptychis sordid*, Common Aquatic Moth—*Erisena mangalis*, Mangrove Moth—*Odites* spp., Avicennia leaf Beetle—*Monolepta* spp., Rhizophora Root Borer—*Coccotrypes rhizophorae*, Sonneratia Weevil—*Rhynchites* sp., Ants—*Crematogaster* sp., and Mangrove Cricket—*Apterombius asahinai* (Lim et al. 2001). These insects play a significant role in the mangrove ecosystem such as pollinator and detritivore, and are a major source of food for birds, fishes and amphibians. It has been reported that *Rhizophora mucronata* and *Avicennia marina* support a higher abundance of crabs (Macintosh et al. 2002; Bosire et al. 2004; Walton et al. 2007).

Mangroves are also ideal habitats for a variety of crustaceans, e.g., prawn species such as Mangrove Snapping Prawn—*Alpheus* spp., Fiddler Shrimp—*Macrobrachium* sp., Glass Shrimp—*Palaemon stylifera*, Red-tailed Prawn—*Penaeus penicillatus*, Edible Prawn—*Metapenaeopsis affinis*, Small White Prawn—*Metapenaeus lysianassa*, Giant Tiger Prawn—*Penaeus monodon* and Mangrove Mud Shrimp—*Wolffogetia* sp. (Chong et al. 1990; Lim et al. 2001; Penha-Lopes et al. 2011; Nyanti et al. 2012) and crab species such as Mud Crab—*Scylla tranquebarica*, Mangrove Mud-hopper—*Microrchestia* sp., Sentinel Crabs—*Macrophthalmus* spp., Shen Crab—*Shenius anomalum*, Fiddler crab—*Uca* sp. (Fig. 32), Orange Mud Crab—*Scylla* spp., Tree Climbing Crab—*Episesarma* spp. and Mangrove Tree-dwelling (Lim et al. 2001; Skov et al. 2002; Penha-Lopes et al. 2009; Han 2011; Nyanti et al. 2012).

Aquatic invertebrates play an important role in the ecology of mangrove because they break down leaf litter that act as fertilizer (Robertson 1986; Smith 1987; Slim et al. 1997), increase surface area of mud through burrowing (Botto and Iribarne 2000; Macintosh and Ashton 2002; Kristensen 2008; Penha-Lopes et al. 2009) and increasing the diffusion rate of gases (Lee 1998; Gribsholt et al. 2003) that ultimately affect the growth and productivity of the mangrove vegetation (Smith et al. 1991; Nielsen et al. 2003; Kristensen and Alongi 2006). In addition, aquatic invertebrates are a major source of food for different animals such as monkeys, birds, snakes, fishes, and even for humans such as oysters and mussels (Macintosh and Ashton 2002) (Fig. 33).

4 Management of Mangrove Fauna

Mangrove is considered as the most productive natural wetland ecosystem on the earth (Ahmed 2008; Jusoff 2008) due to the richness of nutrients, as well as diversity of flora and fauna. They are rich and diverse in fauna species such as birds, mammals, reptiles, amphibians, fishes and aquatic invertebrates (gastropods, bivalves, echinoderms, arthropods, crustaceans, flatworms, etc.). The majority of fauna species

Table 4 List of invertebrate species recorded in different areas of mangrove and adjacent habitat

Family	Scientific name	Common name	Habitat	Authors
<i>Moths</i>				
Gracilariidae	<i>Catoplia scaedesma</i>	Kacang Putih Moth	Mangrove	Lim et al. 2001
Lyonetidae	<i>Lyonetia sp.</i>	Hammock Moth	Mangrove	Lim et al. 2001
Noctuidae	<i>Aucha velans</i>	Tide-watching Moth	Mangrove	Lim et al. 2001
Noctuidae	<i>Autoba alabstrata</i>	Avicennia Seed Moth	Mangrove	Lim et al. 2001
Phyllocnistidae	<i>Phyllocnistis spp.</i>	Leaf Minor Moth	Mangrove	Lim et al. 2001; Han 2011
Pyralidae	<i>Hymenopterychis sordida</i>	Pneumatophore Moth	Mangrove	Lim et al. 2001
Pyralidae	<i>Erisena mangalis</i>	Common Aquatic Moth	Mangrove	Lim et al. 2001
Tortricidae	<i>Capua endocypha</i>	Leaf Binder Moth	Mangrove	Lim et al. 2001
Tortricidae	<i>Euoptilia sp.</i>	Bud Worms	Mangrove	Lim et al. 2001
Xyloryctidae	<i>Oditex spp.</i>	Mangrove Moth	Mangrove	Lim et al. 2001
<i>Beetles</i>				
Atelabidae	<i>Rhynchites sp.</i>	Sonneratia Weevil	Mangrove	Lim et al. 2001
Cerambycidae	<i>Aeolesthes holoserices</i>	Mangrove Longicorn Beetle	Mangrove	Macintosh and Ashton 2002
Chrysomelidae	<i>Rhyparida wallacei</i>	Wallace's Leaf beetle	Mangrove	Lim et al. 2001
Chrysomelidae	<i>Monolepta spp.</i>	Avicennia leaf Beetle	Mangrove	Lim et al. 2001; Han 2011
Scolytidae	<i>Coccotrypes rhizophorae</i>	Rhizophora Root Borer	Mangrove	Lim et al. 2001
<i>Bugs</i>				
Margarodidae	<i>Icerya sp.</i>	Mealy Bug	Mangrove	Lim et al. 2001
Pentatomidae	<i>Calliphara nobilis</i>	Shield/Stink Bug	Mangrove	Lim et al. 2001
Pyrrhocoridae	<i>Dysdercus decussatus</i>	Cotton Stainer Bug	Mangrove	Lim et al. 2001
<i>Other insects</i>				
Formicidae	<i>Crematogaster sp.</i>	Ant	Mangrove	Lim et al. 2001
Formicidae	<i>Oecophylla smaragdina</i>	Weaver Ants	Mangrove	Macintosh and Ashton 2002
Formicidae	<i>Poltrachis sokolova</i>	Mangrove Ant	Mangrove	Nielsen, 1997
Gryllidae	<i>Apterombius asahinai</i>	Mangrove Cricket	Mangrove	Lim et al. 2001
Hebridae	<i>Hebrus mangrovensis</i>	Ground Feeding Insect	Mangrove	Lim et al. 2001
Lampyridae	<i>Pteroptyx spp</i>	Firefly	Mangrove	Macintosh and Ashton 2002
Mesoveliidae	<i>Nereivelia sp.</i>	Ground Feeding Insect	Mangrove	Lim et al. 2001

Table 4 (continued)

Family	Scientific name	Common name	Habitat	Authors
Pselaphidae	<i>Mangalobylthus furcifer</i>	Ground Feeding Insect	Mangrove	Lim et al. 2001
Pselaphidae	<i>Bertara bella</i>	Ground Feeding Insect	Mangrove	Lim et al. 2001
Salidae	<i>Saldoidea arrnata</i>	Ground Feeding Insect	Mangrove	Lim et al. 2001
Terphritidae	<i>Elleipsa quadrijasciata</i>	Excocaria Fruit Fly	Mangrove	Lim et al. 2001
Veliidae	<i>Xenobates sp.</i>	Mangrove Water Skater	Mangrove	Lim et al. 2001
<i>Ecnoderms</i>				
Amphiuroidae	<i>Ophiactis sp.</i>	Mangrove Brittle Star	Mangrove/Mudflats	Lim et al. 2001
Echinasteridae	<i>Echinaster spinulosus</i>	Orange/Sea Starfish	Mangrove roots	Gough et al. 1998
<i>Prawns</i>				
Alpheidae	<i>Alpheus spp.</i>	Mangrove Snapping Prawn	Mangrove	Lim et al. 2001
Atyidae	<i>Caridina sp.</i>	Mangrove hairy-handed Prawn	Mangrove	Lim et al. 2001
Palaemonidae	<i>Macrobrachium sp.</i>	Estuarine Prawn	Mangrove	Lim et al. 2001
Palaemonidae	<i>Macrobrachium sp.</i>	Fiddler/Tank Shrimp	Mangrove	Chong et al. 1990
Palaemonidae	<i>Palaemon stylifera</i>	Glass Shrimp	Mangrove	Chong et al. 1990; Penha-lobes et al. 2011
Penaeidae	<i>Penaeus penicillatus</i>	Red-tailed Prawn	Mangrove river	Chong et al. 1990
Penaeidae	<i>Metapenaeopsis stridulans</i>	Marbled Prawn	Mangrove	Nyanti et al. 2012
Penaeidae	<i>Metapenaeopsis affinis</i>	Edible Prawn	Mangrove	Chong et al. 1990
Penaeidae	<i>Metapenaeus brevicornis</i>	Yellow Prawn	Mangrove	Chong et al. 1990
Penaeidae	<i>Metapenaeus lysianassa</i>	Small White Prawn	Mangrove	Chong et al. 1990
Penaeidae	<i>Parapenaeopsis coramandelica</i>	Red Prawn	Mangrove	Chong et al. 1990
Penaeidae	<i>Parapenaeopsis gracillima</i>	Red Prawn	Mangrove	Chong et al. 1990
Penaeidae	<i>Parapenaeopsis hardwickii</i>	Spear Shrimp	Mangrove	Chong et al. 1990
Penaeidae	<i>Parapenaeopsis hungerfordii</i>	Torpedo Shrimp	Mangrove	Chong et al. 1990
Penaeidae	<i>Parapenaeopsis maxillipedo</i>	Sharp Rostrum Prawn	Mangrove	Chong et al. 1990
Penaeidae	<i>Parapenaeopsis sculptilis</i>	Rainbow Shrimp	Mangrove	Chong et al. 1990
Penaeidae	<i>Penaeus indicus</i>	Indian Prawn	Mangrove	Chong et al. 1990
Penaeidae	<i>Penaeus merguensis</i>	Banana Prawn	Mangrove	Chong et al. 1990
Penaeidae	<i>Penaeus monodon</i>	Giant Tiger Prawn	Mangrove	Chong et al. 1990; Nyanti et al. 2012
Penaeidae	<i>Solenocera subnuda</i>	Deepwater penaeid Prawn	Mangrove	Chong et al. 1990
Penaeidae	<i>Trachypenaeus fulvus</i>	Penaeid Shrimp	Mangrove	Chong et al. 1990
Upogebiidae	<i>Wolffoebia sp.</i>	Mangrove Mud Shrimp	Mangrove	Lim et al. 2001

Table 4 (continued)

Family	Scientific name	Common name	Habitat	Authors
<i>Crabs</i>				
Diogenidae	<i>Diogenes sp.</i>	Mangrove Hermit Crab	Mangrove	Lim et al. 2001
Gecarcinidae	<i>Gecarcinus quadrates</i>	Halloween/Red Land Crab	Mangrove roots	Gough et al. 1998
Grapsidae	<i>Metopograpsus spp.</i>	Purple Climber Crab	Mangrove	Lim et al. 2001
Grapsidae	<i>Sarmatium germaini</i>	Searmine Crab	Mangrove	Lim et al. 2001
Grapsidae	<i>Episesarma spp.</i>	Tree Climbing Crab	Mangrove	Lim et al. 2001
Grapsidae	<i>Selatium brockii</i>	Mangrove Tree-dwelling Crab	Mangrove	Lim et al. 2001
Grapsidae	<i>Metaplex elegans</i>	Orange Signaller Crab	Mudflats	Lim et al. 2001
Grapsidae	<i>Scylla spp.</i>	Orange Mud Crab	Mudflats	Lim et al. 2001
Ligiidae	<i>Ligia hawaiiensis</i>	Mangrove Sea Slater	Mangrove	Lim et al. 2001
Limulidae	<i>Tachyleus tridentatus</i>	Horseshoe Crab	Mangrove river	Nyanti et al. 2012
Ocypodidae	<i>Uca burgersi</i>	Fiddler crab	Mangrove roots	Lim et al. 2001; Skov et al. 2002; Penha-lobes et al. 2009; Han 2011
Ocypodidae	<i>Dotilla myctiroides</i>	Solider Crab	Mangrove fringe	Lim et al. 2001
Ocypodidae	<i>Macrophthalmus spp.</i>	Sentinel Crabs	Mudflats	Lim et al. 2001
Ocypodidae	<i>Shenius anomalum</i>	Shen Crab	Mudflats and mangrove roots	Lim et al. 2001
Portunidae	<i>Scylla olvacea</i>	Mud Crab	Mangrove river	Nyanti et al. 2012
Portunidae	<i>Scylla tranquebarica</i>	Mud Crab	Mangrove river	Nyanti et al. 2012
Talitridae	<i>Microrchestia sp.</i>	Mangrove Mud-hopper	Mangrove	Lim et al. 2001
<i>Flatworms</i>				
Stylochidae	<i>Limnostylochus sp.</i>	Reddish-brown Flatworm	Wet areas	Lim et al. 2001
Stylochidae	<i>Meixneria furva</i>	Large Grey Mangrove Flatworm	Mud lobster mounds	Lim et al. 2001

Fig. 32 Fiddler crab—*Uca burgersi* feeding in mudflat area



Fig. 33 Bivalve mollusc in muddy soil of mangrove area



depend exclusively on mangrove for their whole life while others utilize this area in search of food, shelter and breeding purposes.

Nowadays, mangrove areas are decreasing at an alarming rate due to anthropogenic activities such as over-exploitation for fuel wood and fodder, conversion into urbanization, agricultural fields, aquaculture and fish farming, diversion of rivers due to construction of the water reservoirs which decrease inflow of fresh water into mangrove areas, pollution (oil spills, domestic and industrial sewage) and reclamation of inter-tidal areas (Barter 2002; Barbier and Cox 2004; Mineau et al. 2005). These activities have negatively affected the fauna population of the mangrove. In addition, natural causes can also affect the population of wildlife species such as global warming (Robinson et al. 2009) and diseases outbreak (Rocke et al. 2005; Boyce et al. 2009). Pullin et al. (2013) argued that species extinction and vulnerability is associated with habitat loss and over-exploitation that may cause the loss of ecosystem functions. Mangrove fauna are under severe pressure, and therefore they need protection and proper management to sustain their population in the future.

4.1 Management Through Habitat Restoration

The regeneration of mangrove vegetation in previously exited areas which have been degraded or destroyed can be done through artificial plantations by the relevant agencies (e.g. Forestry Department and NGOs). This will successfully restore the disturbed mangrove ecosystem into its preexisting condition and also strengthen its capacity to adapt change over time. In addition, the areas devoid of vegetation should be planted with economic and ecologically important mangrove tree species on a large scale to compensate the loss of vegetated areas. This will trap sediments, improve water quality and provide a crucial habitat for a variety of fauna.

4.2 Management Through the Involvement of Local Communities

Involvement of local communities residing near the vicinity of mangrove areas and directly dependent on mangrove goods and service for their livelihood is an essential element in sustainable management and conservation of mangrove fauna. A mass awareness programme should be launched in local communities to create awareness among the people about the benefits, economic and social importance of mangrove fauna. Local communities should be involved in the decision of restoration and management activities. Their involvement and collaboration with stakeholder and government agencies will be fruitful and effective for conservation and management of mangrove fauna in the future.

5 Conclusion and Future Perspectives

The current review indicated that mangrove areas are ideal habitat for a variety of fauna such as birds, fishes, reptiles, amphibians, mammals and aquatic as well as terrestrial invertebrates. These fauna are an important component of the food web and play a significant role in the mangrove ecosystem. In this review we focused on the various fauna of mangrove and adjacent area, threats and their important roles in the ecosystem. We have found that these fauna species are facing overwhelming pressure due to habitat loss and degradation. Furthermore, the current information on the various fauna such as reptiles, mammals, invertebrates, and fishes is not sufficient; thus, there is a need to conduct a more detailed research on various aspects of fauna such as species richness, diversity, distribution and the association of fauna with water quality, food resources and habitats. We hope the findings will provide the ways and means to conserve the fauna in and around mangrove areas.

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