

## Chapter 2

# Shell Habitats of Goa

**Abstract** Goa presents wide-ranging habitats to a diverse array of shells. Tropical climate with warmer temperatures and waters, ample rainfall, good intertidal ranges, suitable salinity influences, abundant sunlight, and mangrove forests with distinct ecosystem flora offer ideal conditions for a variety of molluscan species in Goa. Diverse shell habitats such as sandy beaches, rocky shores, mangrove patches and mud flats exist in Goa. Mangrove forests, sand dunes and *Khazan* lands are important coastal ecosystems of Goa. Rich mangroves are found along the coastal and estuarine areas. Most of the rivers of Goa are estuarine, having tidal influences up to several kms of the riverine system. Different salinity ranges along the length of the rivers provide different ecological conditions. This results in different flora and fauna that includes a wide array of molluscan species. Gastropoda and bivalvia are the most prominent classes of Mollusca found in Goa. The shells found on Goan beaches are attractive with different colours, shapes, ornamentation and sculpture. This chapter presents a description of entire coastline of Goa and ecological features of different beaches that harbour different molluscan shells.

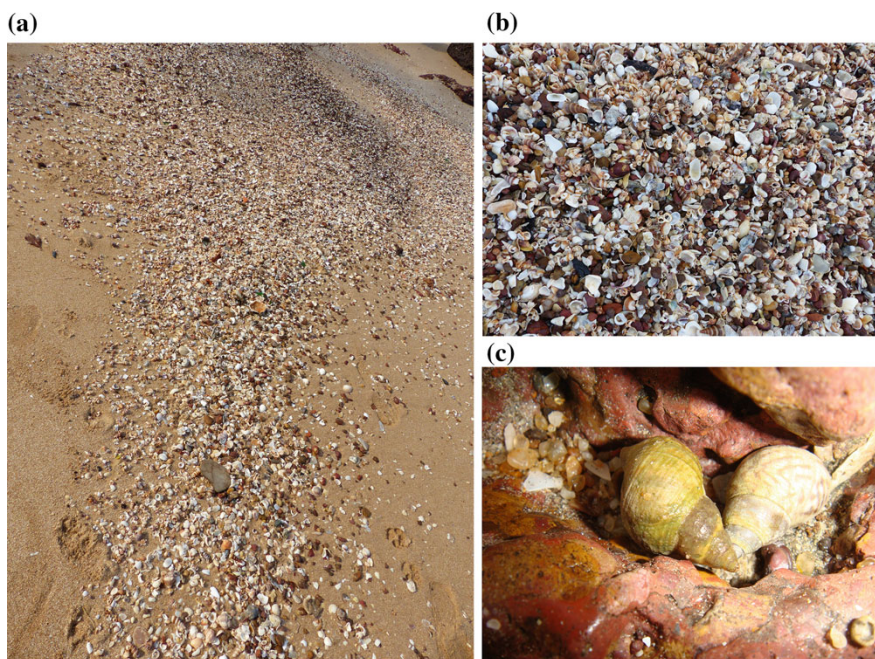
**Keywords** Shells • Coastline • Beaches • Mangroves • Salinity range

### 2.1 Introduction to Goa

Silver sands of Goa are well known for their rich medley of seascapes and landscapes. Goa is highly acknowledged for her diverse ecology that varies from aquamarine waters of Arabian Sea to shimmering white beaches, often tucked in the red laterite rocks. Goa is also recognized for her rich complexes of marine and terrestrial ecosystems that range from diverse coastal and marine fisheries to large patches of mangrove forests, which attract several species of birds (Fig. 2.1a–d). Goa is famed for its three ‘S’s that is the Sea, Sand and Sun. However, the fourth ‘S’ in the series of Sun, Sand and Sea; that is glistening ‘shells’, which are spread on silvery white sand and in sparkling sea waters of Goa (Fig. 2.2a, b) are far lesser



**Fig. 2.1** Several species of birds found in Goa. **a** Purple heron (*Ardea purpurea*). **b** Bronze Winged Jacana (*Metopidius indicus*). **c** Purple moorhen (*Porphyrio porphyrio*). **d** White-bellied Sea Eagle (*Haliaeetus leucogaster*)



**Fig. 2.2** **a** Shells spread on Goan sand. **b** Magnified view of the shells spread on Goan sand **c** Molluscan species attached to intertidal rocks

known to the international communities. Goa is in fact, a paradise for conchologists and malacologists.

Goa presents wide-ranging habitats to a diverse array of shells. Her beaches; rocky, muddy and sandy, prominently exhibit and showcase different types of molluscan species with colourful shells. Tropical climate with warmer temperatures and waters, ample rainfall, good intertidal ranges, suitable salinity influences, abundant sunlight, and mangrove forests with distinct ecosystem flora offer ideal conditions for a variety of molluscan species in Goa, the 'Pearl of the Orient'. Diverse shell habitats also nurture diverse molluscan species and therefore diverse types of shells. Gastropoda and bivalvia are the most prominent classes of Mollusca found in Goa. The shells found on Goan beaches are attractive with different colours, shapes, ornamentation and sculpture.

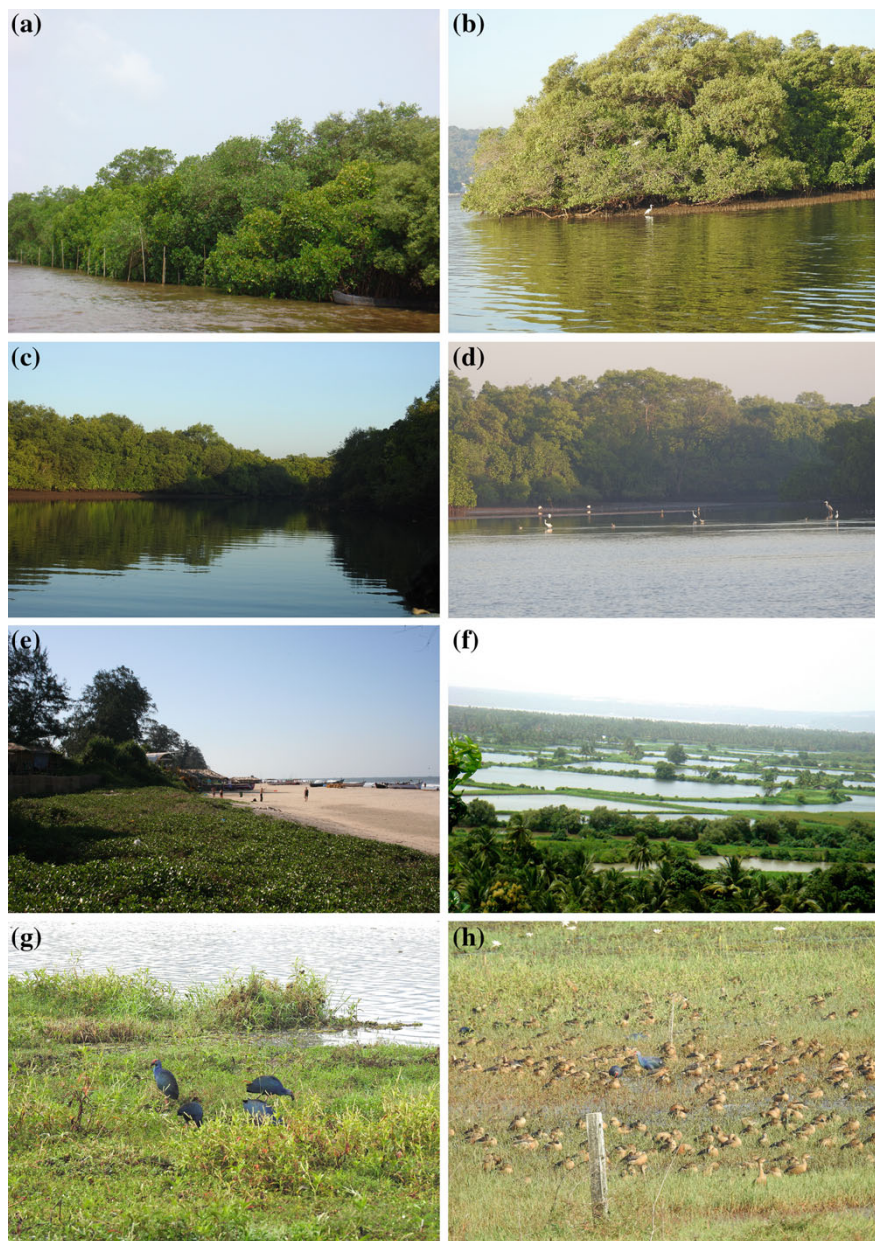
## 2.2 Ecology of Goa

Goa is a small state on the West Coast of India with a long geological history that dates back to pre-Cambrian Era. The state forms part of the Indian pre-Cambrian shield. According to the theories of continental drift put forward first by Alfred Wegener (1880–1930) and plate tectonics, the West Coast of India emerged about 150 ma (Million years Ago) during migration of the Indian plate Northwards (Sonak 2014). Over the past few millennia, Goa evolved her own vibrant ecosystems, well-defined geographical boundaries providing her a distinct geographical identity, and its beaches with diverse landscapes and biota. Today, Goa is a small state on the West Coast of India covering an area of about 3702 km<sup>2</sup>. The State is 105 km long in the North–South direction and 65 km wide in the East–West direction. It lies between 14°53'57" to 15°47'59" North and 73°40'54" to 74°20'11" East. Goa, though small, is replete with natural resources as well as rich heritage. The State is part of Konkan coast of India. Western Ghats bordering Goa, which were formed due to the seismic activity during northward movement of the Indian plate, are one of the biodiversity hotspots and have several endemic species of significant importance to global biodiversity. According to Strong et al. (2008) the Western Ghats in India is particularly known as the hot spot of gastropod diversity. Coastline of Goa forms a major geographical belt of the Western Ghats. Some of the oldest rocks such as trondhjemitic gneiss dating back to 3.4 ba (billion years ago) are found in Goa (Dhondial et al. 1987). These rocks have a history far richer than which is learnt in any history books; they tell us a story far more interesting than which is found in any story books. They are testimony to the rich geological legacy bequeathed by Goa. Perhaps seashells of Goa, too, have some interesting stories, which yet remain to be unfolded. Though some studies have been conducted to map our coastal biodiversity, a comprehensive database on coastal and marine molluscs of Goa is not yet available in public domain. This book, therefore, attempts to document some shells of marine molluscan species found in Goa.

As written earlier, diverse shell habitats exist in Goa. These are sandy beaches, rocky shores, mangrove patches and mud flats. Abundant coral reefs are not present in Goa. But the shells dislodged from coral reefs from nearby places often splatter on the Goan shores. It is well accepted that occurrence and dominance of any species in a place is determined by feeding grounds and habits, salinity ranges, water temperatures, light conditions, and presence of substratum. As the tidal influence is seen over a long range in river waters of Goa, brackishwater with different salinities is found to harbour different species of molluscs. Sandy beaches with tidal influxes provide intertidal habitat shelter to molluscan species that are adapted for burrowing. In the supra-littoral zone, bivalve species such as *Donax*, razor clams, *Arca*, olive and some moon shells are found, whereas, in the midlittoral zone, species such as *Littorina*, *Natica*, *Trochus*, *Conus*, *Bursa*, *Nassarius* and *Drupa* are found. *Tibia* species and conchs occur in deeper waters. Rocky shores provide adequate protection to molluscan species and also provide substratum for attachment. Hence, molluscan species are abundant on rocky shores attached to rocks (Fig. 2.2c). Limpets, chitons, cowries, frog shells, whelks, periwinkles, oysters, barnacles are abundant on rocky shores.

Mangroves are generally present in tropical intertidal regions. These highly productive ecosystems of the world are believed to be next, only to coral reefs. They serve as breeding and feeding grounds to many fishes and play critical role in life cycle of diadromous species that require different salinity conditions in different phases of their life. Mangrove forests and sand dunes are important coastal ecosystems of Goa. Rich mangroves grow along the coastal and estuarine areas (Fig. 2.3a–d). The mangrove flora of Goa consists of 15 species belonging to 10 genera. Various species of mangrove plants found in Goa are *Rhizophora mucronata*, *Rhizophora apiculata*, *Avicennia officinalis*, *Avicennia alba*, *Avicennia marina*, *Sonneratia alba*, *Sonneratia caseolaris*, *Bruguiera cylindrica*, *Bruguiera gymnorrhiza*, *Kandelia candel*, *Aegiceras corniculatum*, *Excoecaria agallocha*, *Ceriops tagal*, *Acanthus ilicifolius* and *Lumnitzera racemosa* (Alvares 2002). Of these, *R. mucronata*, *S. alba* and *A. officinalis* are the dominant ones, whereas *B. gymnorrhiza*, *L. racemosa* and *C. tagal* are rarely seen. It is well known that each of the different species of mangrove plant presents a different structural environment in relation to number of stems, root/rhizome biomass and stem basal area (Capehart and Hackney 1989) and therefore harbour different species of molluscs. Mangroves provide shelter to a number of molluscs, especially detritus feeders such as telescopium, periwinkles, cerithids and some bivalves. Sand dune vegetation of Goa (Fig. 2.3e) comprises about 156 species of plants recorded by Desai and Untawale (2002). Prominent among these are *Spinifex*, *Ipomoea*, *Acanthus*, *Clerodendron*, *Vitex*, *Spermacosea*, *Urginea*, *Dioscorea*, *Pandanus*, *Crotolaria*, *Duranta*, *Leucus*, *Cypreus*, etc. In addition to mangroves and sand dune vegetation, *khazans* (Fig. 2.3f), which are rice and fish fields reclaimed from the mangrove forests of





**Fig. 2.3** (a–d) Mangroves along the coastal and estuarine areas. **e** Sand dune ecosystems on the shores of Goa. **f** Indigenous *khazan* ecosystems of Goa. **g** Marshes near fields and lakes. **h** Estuarine wetlands with different salinity ranges. **i** Mudflats near mangrove ecosystems sheltering diverse species. **j** Intertidal waters near mangrove ecosystems harbouring wide marine flora. **k** Shells attached to rocky shores



**Fig. 2.3** (continued)

Goa with indigenous traditional technology (Sonak 2014), as well as many wetlands, marshes, mudflats exist in Goa (Fig. 2.3g–i). Shells are also found in estuarine and intertidal waters of different salinities (Fig. 2.3j) as well as attached to rocks in intertidal waters (Fig 2.3k). Each of these habitats have unique biodiversity of their own. Different species of molluscan species are sheltered by different ecosystems and associated vegetation found in Goa. For example, *Telescopium* sp. is found only in mangroves, whereas *Volegalea cochlidium* is found in mangroves and on rocky shores attached to rocks.

Though Goa was formed about 150 ma (million years ago), it was secluded from human influences for a long time. Goa was an immaculate paradise when hippies discovered it in 1970s. Until then, Goa was in isolation, only an impeccable small state on the West (Konkan) Coast of India. Its liberation from Portuguese colonial rule in 1961 and mingling with Indian culture imparted Goa an image of a state with unique blend of Oriental and Western culture. Pristine beaches, ample sunlight, thick mangrove cover placed Goa on the world tourism map. Goan cuisine and hospitality helped Goa become a popular destination for international tourists. Goan sun, sand and sea lure many tourists to visit Goan beaches every year.

Most beaches in Goa are full of tourists and their activities. Some of the beaches, away from the tourist activities, see action from local fishermen. As they collect fish from ‘rampon’ (shore seine net), some of the invertebrates are also collected in the nets. Presently, there are no legal restrictions on collection of sea shells in Goa,

though some species such as window pane oysters, *Placuna placenta*, are categorized as protected species and there is prohibition to collect these species or their shells (see Chap. 4).

Sea fish (in as well as out of the sea) is as much an integral part of Goan culture as sun, sand, sea and shells. Like most other coastal parts of the world, fish, rice and coconuts are quintessential ingredients of Goan cuisine. Many beaches in Goa are fringed by coconut palms. Estuarine waters of Goan rivers irrigate indigenous coastal agricultural lands called '*Khazans*' that grow rice and fish (Sonak 2014). Edible shellfish belonging to Bivalvia is often collected by locals from estuarine river or intertidal waters of the sea (Fig. 2.4a–d). Locals collecting shellfish by a traditional method called '*ponsheta*' is an enthralling site. Shellfish is collected, mainly from intertidal and estuarine waters, cleaned at home and cut into the two valves using a locally made sickle-like tool called '*Adoli*' or '*vili*' (Fig. 2.4e).



**Fig. 2.4** a–d Locals collecting shell fish from intertidal waters. e Sickle-like tool called '*Adoli*' used to cut shell fish. f, g Cutting of a shell fish using '*adoli*'. h Woman cutting oysters from intertidal rocks. i Woman selling oysters in Goa





**Fig. 2.4** (continued)

The person who cuts open the bivalve, usually a homemaker or a domestic help, sits on the wooden seat to which is attached the sickle (Fig. 2.4f, g). The tool (Fig. 2.4e) has two parts, one to cut fish and the other, in front of the sickle, to scrap coconut from the shell. Shellfish is cut fresh without using any boiled water or freezing them. Oyster fishery is also prominent in Goa (Fig. 2.4h, i). Many delicious dishes such as *dangre*, *kalva fry*, *xacxac*, *xacuti*, *suke*, *sambare (human)*, etc., are prepared from shellfish and oysters. Goan beaches display shimmering shells. Huge waves that splash the shores bring colourful glistening shells with them. These are scattered on the shores and often engage fascinated tourists in their collection as memento of a perfect Goan beach holiday. My son, Eeshan, whose help in collection of these shells is immense, writes about his childhood memories of shells on Goan beaches (Box 2.1).



**Box 2.1 My memories of shells by Eeshan M. Sonak**

As a child, I always liked collecting. Things like colourful rocks, shiny beads, and many other peculiar objects were all in my collection. Living in Goa, I would often be taken on visits to beaches.

My first few visits to beaches as a child were truly amusing, not only to the spectators present there but also to myself as I now reflect. It would be difficult for my parents to take me back home from the beach as I would devise all forms of protest. The azure blue water, the course brown sand, the faraway horizon and a huge open area to play made the beach a perfectly idyllic place for me.

As I grew, my love for beaches did not lessen. I would delightedly visit the beach looking for these colourful objects of all shapes and sizes called shells. The beach had something new to offer every day I visited it.

Aged 8 years, I went with my parents to Europe. Out of the places we visited, my most memorable experience was Ria Formosa Beach. The shells found here were completely different from what I used to get back home in Goa. They were large shells with wavy patterns and beautiful shades of orange, maroon, purple and brown. I was spell bound. I spent the rest of that morning vigilantly looking out for shells and selecting only the best few. The experience was fascinating ... a small deserted island, pleasant climate, cerulean blue sea with waves crashing against the fine white sand, and to top it all, shells; colourful and beautiful.

Now, though I am a boy of 15, my enthusiasm for shells and their collection has not faded. I still love going to the lovely beaches of Goa and enjoying myself while looking around for shells.

## 2.3 Coastline of Goa

While peninsular India is a result of continental drift and northward movement of Indian plate, the coastal morphology of Goa is formed as a result of various factors such as wave action, current direction, eustatic changes, rock structure and rock formations.

Geologically located between the latitudes 14°53'54" N and 15°40'00" N and longitudes 73°40'33" E and 74°20'13" E, Goa encompasses an area of 3702 km<sup>2</sup>. Goa has a tropical monsoon climate that is moderately hot and humid weather with a short spell of copious amounts of rainfall by the South West Monsoon Winds.

Rivers flowing in Goa typically originate in Western Ghats and meet the Arabian Sea. Most of the rivers of Goa are estuarine having tidal influences up to several kms of the riverine system. A detailed account of riverine system of Goa, in particular, Mandovi and Zuari estuarine network, has been presented by Alvares (2002), Shetye et al. (2007) and Kamat (2009). Goa is drained by nine major rivers

with many tributaries. Among these, Mandovi and Zuari are the principal rivers, Mandovi being the biggest. River Mandovi has a length of 87 km draining an area of 1580 km<sup>2</sup> and provides maximum quantity of fresh water supply to Goa. Its length within the state is 52 km and that within the salinity zone is 36 km. River Zuari has a length of 145 km and drains an area of 973 km<sup>2</sup> with 42 km of its length within the salinity zone. Waters of these two major rivers of Goa are connected by Cumbarjua canal. Other rivers are Tirakhol, Chapora, Baga, Sal, Saleri, Talpona and Galgibaga. Due to the characteristic topography of Goa, tidal effects are experienced up to 40 km upstream and thus most parts of Goa are under tidal influence. Goan coast experiences semi-diurnal tides that is two high tides and two low tides everyday. Tidal amplitude is 1.5–2 m. Salinity range of Goa's estuaries is very wide and extends from 0 ppt (parts of NaCl per thousand) in monsoons to 37 ppt in summer months. Different salinity ranges along the length of the rivers provide different ecological conditions that harbour diverse flora and fauna, including a wide array of molluscan species.

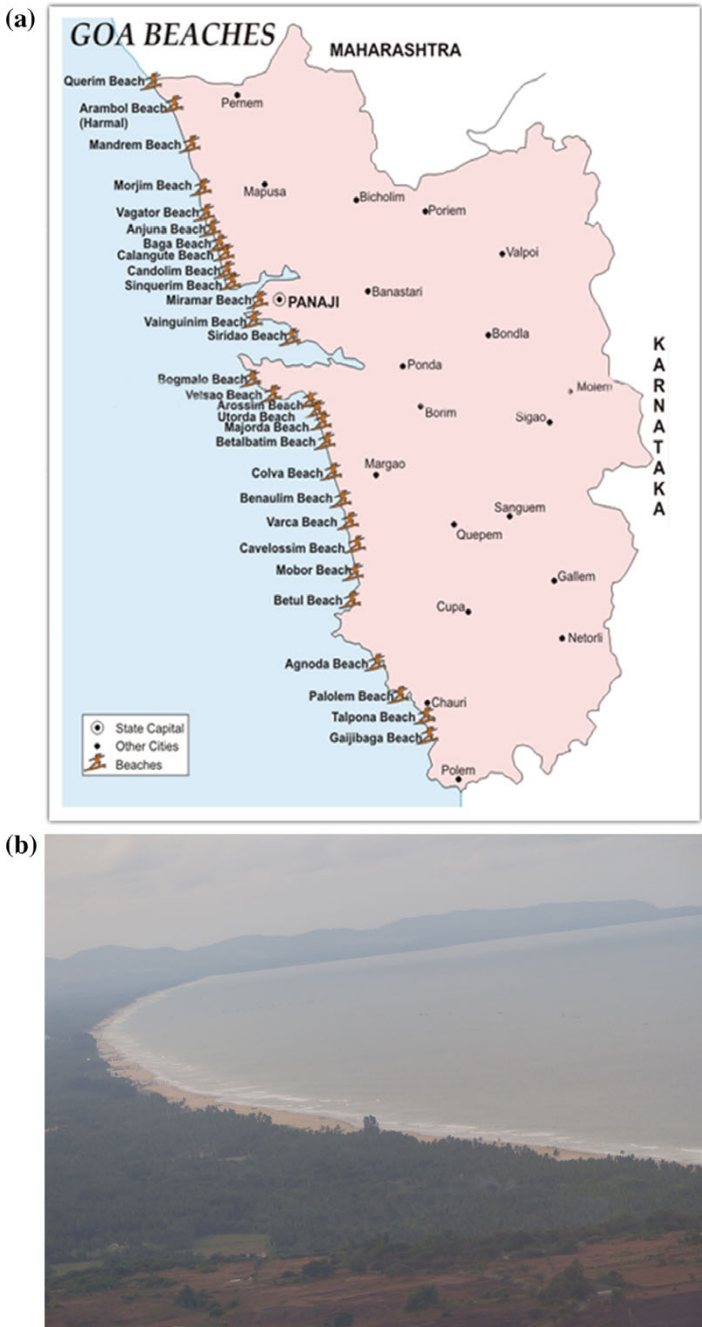
### 2.3.1 *Beaches of Goa*

Goa has a coastline (Fig. 2.5a, b) that stretches to about 105 km in the North South direction. Towards her west is the Arabian Sea. The coastal plains comprise of wetlands, tidal marshes, cultivated lands intersected by seven estuaries, canals, inland lakes, bays, lagoons and creeks. It has eight marine, more than forty estuarine and about ninety riverine islands. Narrow riverine plains fringe the coastline of Goa. Major rivers receive waters from the Western Ghats and flow Westwards to the Arabian Sea. Goan beaches overlook an endless expanse of aquamarine waters of Arabian Sea. Smartly tucked in the Western Ghats on the Eastern side and elegantly hemmed in the clear waters of Arabian Sea on the Western side, shores of Goa stretch from Tirakhol in the North to Polem in the South. Goa has a continuous coastline on the western side in the north–south direction, which is intermittently interrupted by high rocks. Goa's coastline can be divided into six sectors. These are as follows:

1. Tirakhol or Querim (Keri), Arambol (Harmal), Mandre, Morji
2. Vagator, Anjuna, Chapora, Baga, Calangute, Candolim, Siquerim
3. Miramar, Dona Paula, Vaiguinim, Bambolim, Siridao
4. Bogmalo, Velsao, Uttorda, Majorda, Betalbatim
5. Colva, Benaulim, Varca, Cavelossim, Mobor, Betul
6. Agonda, Palole, Talpona, Galjibag, Polem

#### 1. **Tirakhol or Querim (Keri), Arambol (Harmal), Mandre, Morji Stretch**

At the northern tip of Goa, River Tirakhol meets the Arabian Sea (Fig. 2.6). Tirakhol gets its name from its deep shore waters; *Tir* in local language denotes bank of the river and *khol* implies deep; Tirakhol literally means deep bank of the river. Major tributaries of River Tirakhol are Torshe, Khadshi and Pernem, which are named after



**Fig. 2.5** **a** Map of the coastline of Goa. **b** Aerial view of the coastline of Goa



the villages through which the river runs, as is usually the practice in Goa for most rivers and their tributaries. The river marks the northernmost boundary of Goa for some distance separating it from the neighbouring State, Maharashtra. River Tirakhol rises at Manohargad in the Western Ghats and flows in a south-westerly direction to meet the Arabian Sea. Fort Tirakhol is located here at the confluence of the river and the Sea. The fort imparts a commanding view of the Arabian Sea and is a strategic location for maritime defence. River Tirakhol and the Fort on its banks are landmarks not only in the geography but also in the history of Goa. Originally built by a Maratha king, Maharaja Khem Sawant Bhosle, from Royal family of Sawantwadi near Goa in the seventeenth century, it was conquered by Portuguese in 1746. Over the years, the fort witnessed many battles and revolts against Portuguese regime. It was ceded to British in 1819, but Portuguese took it over again. The fort is a silent spectator to many valiant legends as it was a major activity site for protests against Portuguese atrocities by *Satyagrahis* or freedom fighters from Goa. The fort has witnessed Goa's struggle for freedom from the 451 years of Portuguese rule. Indian tricolour flag *Tiranga* was unfurled here for the first time in Goa in 1954. The fort remained a Portuguese stronghold until December 1961. On 19 December 1961, Indian army entered Goa and as a part of 'Operation Vijay', Indian soldiers seized the Fort and liberated Goa from the Portuguese colonial yolk. Tirakhol Fort, thus, has historical importance and is a landmark monument in the history of Goa. Part of the fort is accessible to visitors, though a larger part is converted into a heritage hotel. Tirakhol beach has a panoramic view of the Arabian Sea (Fig. 2.6). It is one of the few remaining wild, unspoiled, paradise beaches of Goa, splendidly isolated from thronging tourists visiting Goa.

Tirakhol and Arambol beaches are at northernmost tip of Goa. Adorned with silvery white sands, Tirakhol and Arambol beaches are yet quite pristine. Harnal River originating from Korgao hills of Goa discharges into Arabian Sea here after travelling a distance of 11 km. A traditional fishing hamlet is located quite close to



**Fig. 2.6** Aerial view of Tirakhol Beach

the beaches. Both these beaches are marked by rocky and sandy terrains and also hold some isolated stretches and quiet bays that fascinate tourists' and locals' long strolls and invite them to collect attractive shells. Their meandering waterways twist and turn past sandy shores and shady palms. These bays offer perfect privacy to solitude seeking tourists. Bivalves of different species and attached mollusks are found on these beaches.

Sheltered by coconut palm groves, Mandre and Ashvem beaches are more secluded and much less accessible than other beaches of Goa. They are not so frequently visited by tourists, particularly local tourists. Near the main Mandre beach, is formed a sand spit by meandering Mandre river that flows into Arabian Sea (Fig. 2.7a). Though Morjim beach still remains quite a secluded beach, in recent years, it witnesses influx of international tourists, mainly from Europe, coming to Goa in chartered flights (Fig. 2.7b). The beach hosts some Russian immigrants, who have settled in Goa. The sea front here often sees low budget international tourists wondering around. One can commonly see hammocks swing between the coconut trees. Shacks built up of various parts of coconut trees are also a common sight. The beach is also famous as nesting site of Olive Ridley Turtles. The state forest department with the help of some environmentally active individuals has taken up initiatives to protect Olive Ridley Turtle nesting from poaching activities (Fig. 2.7c). The beach is mostly sandy and showcases molluscan species of intertidal range such as bivalves.



**Fig. 2.7** **a** Sand spit by meandering Mandre river at Mandre beach. **b** Morjim beach getting prepared for the new tourist season. **c** Forest department initiative to protect Olive Ridley turtles

## 2. Vagator, Anjuna, Chapora, Baga, Calangute, Candolim, Sinquerim

The stretch from Vagator to Candolim beach, which includes Vagator, Anjuna, Baga, Calangute Candolim and Sinquerim beaches, is the most populated by tourists and the most popular stretch of tourism activity in Goa (Fig. 2.8a, b, c). River Chapora, originating in the Ramghat hills of Karnataka and entering Goa at Ibrampur village, meets Arabian Sea here after covering a distance of 32 km. Aquqmarine waters of Arabian Sea get a brownish tinge here indicating high levels of human interference. Sal nallah, Kalna, Virnoda and Parsem are the tributaries of River Chapora. The entire stretch is well spread out. It is a broad strip of white sand hemmed in, on both sides, by steep rocky cliffs, which separate one beach from another neighbouring beach. The beaches are mostly sandy giving shelter to



**Fig. 2.8** Stretch of the coastline busiest with tourists; **a** Calangute, **b** Cadolim, **c** Beach segment busy with international tourists. **d** Rocky shores of Vagator beach, North Goa. **e** Vendors selling Indian goods on beaches



intertidal molluscan species. Rocky shores on some stretches provide refuge to molluscan species that attach to rocks. Vagator is a tranquil and serene beach with clean waters and some stretches of rocky shore (Fig. 2.8d). Anjuna's Wednesday flea market and binge parties have made it a popular destination as a hippy hangout. Vendors' selling Indian goods is also a common sight on most beaches of Goa (Fig. 2.8e). The stretch exhibits a blend of Western and Eastern culture and flaunts Goa's busiest night life.

Chapora, Baga, Candolim and Sinqueri beaches are shell collectors' paradise. Chapora beach is dominated by ramparts of a stately fort built during Portuguese regime. Chapora River, one of the main rivers in Goa, traverses here and meets the Arabian Sea. Chapora Fort overlooks mouth of River Chapora and magnificent view of its waters entering the Arabian Sea. The beach is rocky and quite secluded from tourists, though fishing and boat building activities make it a busy shore (Fig. 2.9). Shores near aquamarine sea of Chapora also embrace some coconut palms providing shade to tourists on an otherwise sunny beach. Blending of an imposing fort, coconut palms, dazzling sand and splashing waters of Arabian Sea create an enthralling setting. Baga is a clean beach with white sand. Baga River originating in the dense forests of Assagao flows into Arabian Sea here. Tempting fishy smells often waft out from the shacks that line along the beach to entertain tourists. Away from these touristic activities, one finds coconut palms along the sand and a small hillock along the beach. This portion is more active with local fishermen and fishing activities than much touristic activity. Further away, is Candolim beach, which is the birthplace of Abe Faria, a Goan freedom fighter and 'Father of Hypnotism'. Sinqueri beach at Aguada Bay has white sand. River



**Fig. 2.9** Chapora beach with fishing activities



**Fig. 2.10** **a** Sandy beach of Sinqueri, North Goa. **b** Rocky stretch of Sinqueri beach, North Goa

Sinqueri is a tributary of River Mandovi and joins the main river, River Mandovi at Aguada Bay. River Mandovi is widest near Aguada Bay; the width being approximately 4 km. Presence of Fort Aguada here is an enthralling site. Built by Portuguese in 1612, the fort has become a magnificent monument of historical importance. Currently, it is used as a jail to imprison convicts. Fort Aguada overlooks splendid view of aquamarine Arabian Sea waters. Crescent-shaped beach line of Sinqueri with lush green coconut palms along the sand can be seen from the Fort (Fig. 2.10a). Erosional activity along the coast is also apparent. The beach, with calm shore, has both sandy and rocky habitats (Fig. 2.10b) sheltering both benthic and attached molluscan flora.

As one comes towards Panaji along this stretch, on the main road itself is splendid Reis Magos Fort. Renovated recently as a fine piece of architecture, the Fort can be seen from Campal beach on the other side of River Mandovi. Along this road, one can find moon shells, nerites and Babylon shells on some small stretches of sand close to Reis Magos Fort. These shells are also found on some quiet sandy beach segments such as Kek de Velho beach near Nerul.

### 3. Miramar, Dona Paula, Vaiguinim, Bambolim, Siridao

The stretch around capital city Panaji, encompasses Campal along the mouth of River Mandovi, Miramar beach facing the endless expanse of the Arabian Sea, Caranzalem and Dona Paula along the confluence of Rivers Mandovi and Zuari, and small slices of bays all along the sea front. Molluscan diversity on this segment is very high. Edible clams are collected by locals at Campal in large numbers (Fig. 2.11a, b, c). Many species of edible bivalves such as *Macra* sp., *Donax* sp. etc. can be collected from Campal beach. Molluscs are known to make up a major component of fouling communities on ships. Molluscs, themselves may be a subject to overgrowth by other creatures such as bryozoans. One such *Macra* shell found on Campal beach is overgrown by bryozoans and barnacles (Fig. 2.12). Dominating the horizon here is Reis Magos Fort, regal and imperial, draped in green palms (Fig. 2.13). The backdrop of these magnificent views of Reis Magos Fort seen from Campal beach dignifies the entire waterscape here. A number of



**Fig. 2.11** a, b Edible bivalves collected by locals from Campal beach. c Net used to collect edible bivalves. d Oysters separated from the shells with a sickle (*Koiti*)



**Fig. 2.12** Bivalve shell overgrown by bryozoans





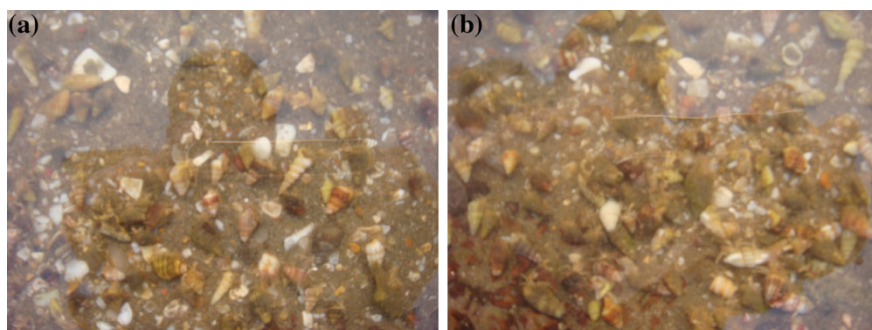
**Fig. 2.13** View of Reis Magos Fort from Campal, Panaji

shells from deep sea entangled in fishing nets and thrown at the shores by local fishers are often seen on this stretch. Shells of *Thais* sp. are particularly found at Campal. Miramar and Caranzalem beaches shelter various species of bivalves. Rocky shores around Dona Paula (Fig. 2.14) harbour different species of oysters, mussels and clams. A few years back, shells of edible species of a mussel *Perna viridis* were collected from here in large numbers. Numbers of the species have dwindled drastically in the past few years. Though the cause is not yet known, this could be because of overharvesting of the species even from the core region. Pollution of surrounding waters could also play a role. Locally known as ‘*shinane*’, this shellfish formed major part of Goan cuisine as a delicacy with mouth-watering recipes served and liked by locals and tourists. Small fragments of beaches such as Hawaii beach at Dona Paula also retain deep seashells that are splashed on the rocks during windy nights. Beautiful shells, such as those of *Chicoreus virgineus* sp. were collected from the rocks of Hawaii beach. Hawaii beach also has mussel shells such as *Perna viridis* and tellin shells. Closer to Hawaii is a small cosy bay with Vaiguinim beach, which has a five-star resort. Marvellously located amidst rocks, cliffs and sandy shores, these waters support a virtual nursery of diverse molluscan species (Fig. 2.15a, b). One can watch fun play with several small shells fighting with each other when the waters are clear. Cowries, moon shells, turrítela and nerites are predominantly found here.

A little further from this stretch is another segment of sandy and rocky shores, mudflats and areas with mangrove cover. This fragment covering Bambolim and



**Fig. 2.14** Rocky shores around Dona Paula, North Goa



**Fig. 2.15** Live molluscs with their shells seen in intertidal waters

Siridao beaches are small parts along Arabian Sea and tributaries of River Zuari. Beautifully set in the midst of the cliffs and soft white sand, Bambolim beach near Goa University is home to Babylon shells, moon shells, nerites and cowries. An extension of Bambolim beach is Siridao, which is a picturesque beach (Fig. 2.16). An ancient port of Goa ‘Gopakapatna’ was located on the northern banks of River Zuari near Siridao (Tripathi et al. 2013). A section of Siridao beach with coconut palms and sandy shore predominantly shelters window pane oysters (*Placuna placenta*) in large numbers. Window pane oysters had great demand for shell crafts



**Fig. 2.16** View of Siridao beach, North Goa

in Goa in the past. Since ancient times, shells of *P placenta* have been used in external windows of the houses and are believed to filter harmful UV rays of the sun from entering the house (Refer to Chap. 4 of this book for further information). Traditionally, they are also used in Goan crafts such as lampshades and chandeliers. Collection of the shells of these species in large numbers had greatly reduced the species population creating a need for immediate regulations. The species is currently protected and collection of the shells of these species is legally banned in Goa. Shells of window pane oysters are found in large mounds on the sandy shore of Siridao beach buried under sand. Rocky shores of Siridao harbours *Thais* sp. whereas, *Pugilina* sp. dominate in the mangrove patch of Siridao. Closer to the fishing hamlet of Siridao, heaps of corkscrew shells (*Turritellidae*) are seen, thrown abundantly on the beach. Goa, particularly Siridao beach near the fishing hamlet, is rich in different species of *Turritella*.

#### 4. Bogmalo, Velsao, Uttorda, Majorda, Betalbatim

The coastline from Bogmalo to Betalbatim is a long stretch of clean white sand quite secluded from swarms of Goan tourists. Vast stretches of coconut palms adorn this stretch. Away from touristic activities, this stretch displays a wide variety of marine life. The beaches are often carpeted with shells that entice visitors. The medley of red laterite, white sand, green palms, clear sparkling waters and colourful shells produce an alluring effect along this entire spell. The stretch also brings a sense of tranquillity that is inherent to Goan culture to visitors' mind, body and



**Fig. 2.17** Fishermen with their boat at Uttorda beach, South Goa

soul. Nestled in such calm and peaceful surroundings, Bogmalo beach is a paradise for tourists and locals alike.

With its clear waters a little isolation and a lot of sunshine, Velsao can offer a perfect escape. Thick coconut palms line the beach and provide a gorgeous retreat to those, who look for seclusion. With miles of sand to lounge on, the retreat is truly relaxing and can be rewarding to those who look out for shells. Bivalves belonging to the families Veneridae and Donacidae are common along this sandy stretch.

Uttorda and Majorda beaches, though not very crowded support high-budget tourism activities. A little away from these busy segments, however, one can get glimpses of some quaint, charming old world sights. Perfectly preserved fishing hamlets can be hit upon along this fragment. Fishing activities in traditional styles, crafts and gears by local fishers can be spotted along this part (Fig. 2.17). Often seen on the beaches, are some deep seashells that were caught in the nets by the fishers and then thrown on the beach. One could be lucky to make an uncommon find. Sand dune vegetation on the sandy shores may offer a perfect hideout to some marine organisms.

Owing to its proximity to the crowded beaches of South Goa, Betalbatim is no longer a well-maintained secret (Fig. 2.18). But this fraction of the coastline offers just enough privacy, while exhibiting a flavour of a true Goan coast.

### **5. Colva, Benaulim, Varca, Cavellossim, Mobor, Betul**

Colva, Benaulim, Varca, Cavellossim, Mobor and Betul stretch is popular tourist area of South Goa. These beaches are mostly sandy (Fig. 2.19). The sand here is





**Fig. 2.18** Serene stretch of Betalbatim beach in South Goa



**Fig. 2.19** Sandy beach of Colva, South Goa

silvery white. The shells found here are mostly bivalves and *Turritella* species. Colva is by far the most crowded beach of South Goa. The beach is loaded with shells. As the waves of Arabian Sea gently lap against the sand, one can see crowd of tourists, some of them collecting fascinating shells on this beach.

Benaulim is slightly away (about 2 km) from Colva beach. It is much less crowded with a very clean sandy beach. However, lesser shells are seen on this beach. River Benaulim joins River Sal here. A legend relating to formation of Goa and Benaulim beach is very famous (Sonak 2014). It is believed that Lord Parshurama, a sage created Goa by throwing some arrows in the Sea and ordering Lord Sea to retreat up to the place where arrows were shot and create place for him. The place, where arrows were hit, came to be called as Benaulim (*Ban* is arrow and *auli* is row in local language). Benaulim village is located between the River Sal and the Arabian Sea. The village is peaceful, tranquil and emanates Goan landscape in its true spirit. This stretch of coast line has mostly sandy beaches fringed with coconut palms. Burrowing molluscan species are commonly found here.

At a small distance from Benaulim is the pristine, peaceful beach of Varca. This is a quiet and calm beach. This is a sandy beach with brilliant white sand. The beach hosts many species of Bivalvia, particularly species belonging to Cardidae and Donacidae are found in large numbers.

Cavelossim beach is full of high-budget tourist resorts and tourist crowd. The sand is now discoloured from its original dazzling white shine. The beach is home to many species of bivalves, which are however, picked up by the locals and tourists alike. Edible species of bivalves are collected by locals for consumption and tourism market, whereas, fine, beautiful shells are collected by tourists as souvenirs from Goan beaches. The beach, however, does not generally display a large number of diverse shells.

Mobor beach is very clean with white sand. It is calm and less crowded by tourists. The stretch is lined by beach shacks. There are some stretches, which boast of high budget tourism resorts. This stretch of Mobor beach is actually formed due to sand deposition created by the estuarine waters of River Sal. A lagoon formed by waters from River Sal enhances beauty of this segment, which is generally a sandy terrain.

Coconut palms and huge rocks adorn many stretches along Betul beach. River Sal, after having a meandering course along this stretch of the coastline, joins Arabian Sea here at Betul. Though it has not yet made entry on the tourist's map of Goa, Betul Beach is an exquisitely enchanting beach of Goa. The beach remains isolated from tourists, but provides sanctuary to eclectic marine life. Around this segment of Goa's coastline, Cabo de Rama is another captivating beach (Fig. 2.20). Red rocky hills topped with green coconut palms screen this stretch from the central shoreline of Goa. Hidden from the main coastline, this stretch, too, remains yet undiscovered by tourists. However, the beach is often frequented by local picnickers. The beach presents one of the most tantalizing experiences of natural



**Fig. 2.20** Captivating view of red rocky hills topped with green coconut palms at Cabo de Rama beach

beauty to be had. On the rocky shore of this beach, are found oysters, which are sold in the local market and are locally consumed as delicacies. Rocky shores dominate this fragment and consequently attached mollusks are more common here.

## 6. Agonda, Palole, Talpona, Galgibag, Pole

To the southernmost part of Goa bordering with Karnataka state are some of the yet so pristine beaches of Canacona taluka of Goa such as Agonda, Palole, Galgibag, Pole. Agonda and Galgibag are famous as nesting sites of Olive Ridley turtles. These beaches have beautiful promenade with tranquil village setting (Fig. 2.21). Goa's coastline is at its most melodiously picturesque here. The coast in this southernmost part of Goa has a hilly terrain showcasing rich lateritic rocks. Throughout this segment, one can see small rivulets from Canacona and Talpona River system that meander through Canacona and emerge along the coastline to meet Arabian Sea (Fig. 2.22a, b). Near the mouth of the river, fishermen are generally busy with their nets (Fig. 2.22c). A splendid sweep of brilliant white sand tucked in gorgeous red lateritic rocks tender these beaches (Agonda, Palole, Galgibag, Pole) most spectacular sites. Silvery white clouds scudding across the sky add splendour to this stunning panorama (Fig. 2.23).

Near Galgibag, the main Galgibaga River originating in the dense forests of Karnataka and entering Goa near Mule discharges into Arabian Sea. A little further towards South, in close proximity to Galgibag beach, is Pole beach, which is the southernmost tip of Goa's coastline. Sandy beaches here are haven for several



**Fig. 2.21** Tranquil village setting at Agonda



**Fig. 2.22** a, b River Canacona meeting the Arabian Sea. c Fishermen busy with their nets at Canacona





**Fig. 2.23** Spectacular view of Palole beach

bivalve species. Quaint and enticing, this part of Goa's coastline is sure to offer any visitor one of the most mesmerizing experiences. Green shades of coconut palms on rich red lateritic hills line the white shores of this segment.

Embroidered in the white sand of these beaches are colourful shells, which often remain unpicked on the unspoilt beaches of this segment. With many rivers meandering through the entire stretch to meet Arabian Sea, tidal influences generate various salinity ranges harbouring an array of mollusks with different colourful and ornamented shells. The segment exhibits this elegant shell tapestry on the brilliant white sand curtain very magnificently. Shells of different species of gastropoda and bivalvia are seen. This segment marks the end of Goa's coastline with Pole at its southernmost tip.

## 2.4 History of Shells of Goa

Coastline of Goa was formed about 150 ma in the Jurassic period, when Indian plate split from the main Gondwana land and moved northwards (Sonak 2014). West Coast of India, Arabian Sea and Western Ghats were all formed after the split. However, Goa has some of the oldest rocks in the world, such as trondhjemitic gneiss of Anmod Ghat dating back to 3.4 ba (billion years ago). Below the lateritic cover of many rocks, are found very old metamorphic and igneous rocks, older than 2500 million years. Alluvium and sand are major geological formations in the coastal belt

of Goa. According to Glikson (1982), Indian pre-Cambrian shield is believed to be made up of old, fused proto-continental masses that formed in the Archaean Eon (4000–2500 ma). Three phases of folding are observed in the Goa group of rocks (Gokul et al. 1985). Extensive pre-Cambrian rock formations are still seen exposed near the coasts of Goa (Mascarenhas and Kalavampara 2009). However, lateritic layers are common in younger rocks.

Molluscs first appeared and proliferated on Earth about 540 ma in the Early Cambrian Era. During northwards movement of the Indian plate, major volcanic eruptions took place resulting into the formation of Western Ghats that runs parallel to the coastline of Goa. According to one school of thought, these volcanic activities were primarily responsible for the mass extinction of a number of species about 65 ma, including that of dinosaurs. These volcanic activities also had major influence on bio-geomorphology of peninsular India. The laterite in the coastal part of Goa is developed upon the late Cretaceous–early Palaeocene (100.5–66 ma) Deccan basement, which comprises Archaean–Proterozoic age (4000–542 ma) geomorphology (Texeira 1965; Widdowson 2009). Autochthonous lateritic profile of coastal Goa can be studied to understand alterations in the parent rock and biogeomorphological conditions existing over several millennia. In some areas in coastal Goa, laterite cover is absent due to weathering and original rocks are exposed. Indian Geological Society has studied content of the laterite capped table lands of coastal Goa by digging boreholes. A series of plant-rich clays and sands belonging to mid to late Miocene age have been found.

Considering the history of formation of the Coast, historical movement of Indian plate in the northwards direction, tectonic activities in the course of these movements and mass extinction of species during the period, it is likely that some old, extinct species of molluscs are fossilized in this geographical area. Unfortunately, not much comprehensive work has been done on molluscan palaeontology in Goa or to find fossil shells of Goa. This remains a challenge to conchologists, malacologists and palaeontologists of the world in near future.

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