3.1 INTRODUCTION

The marine ecosystem is widely recognized as the most diversified ecosystem on Earth. Due to its high diversity and unique characteristics, it necessitates careful attention and comprehensive knowledge to understand its complex structures and functions. This is primarily attributed to the fact that the marine ecosystem serves as a habitat for a wide range of distinct and varied floral and faunal communities (Shukla et al., 2013). The coastal environment offers a diverse array of habitats, such as estuaries, lagoons, mangroves, salt marshes, rocky coasts, sandy stretches, and coral reefs. This variety of habitats has the ability to support a higher level of biodiversity (Shet et al., 2016). Marine species are of significant importance in the field of biodiversity studies. Aquaculture relies on this principle as a fundamental component, and it serves as a cornerstone for the provision of ecosystem services (Varadharajan et al., 2013). The marine environment is separated into distinct categories based on its proximity to the shoreline, including the pelagic and benthic zones.

Intertidal mudflats inside the benthic zone exhibit a high level of productivity and have significant ecological and socio-economic importance. Soft-sedimented areas have a crucial role in providing necessary habitats for a diverse range of species, including shorebirds, commercially valuable shellfish, shrimps, crabs, and fishes. Nevertheless, the intertidal mudflats are experiencing a rapid decrease on a worldwide level as a result of human-induced factors (Murray et al., 2019).

Crustaceans, particularly those belonging to the infraorder Brachyura, constitute a significant component of macrobenthic fauna. Out of the total number of documented Crustacea species, which currently stands at 2934, the majority (94.85%) are marine species. Crustaceans have a broad evolutionary lineage and exhibit notable adaptability (Varadharajan and Soundarapandian, 2014). Crustaceans hold significant importance within benthic communities due to their substantial representation in terms of species available for human consumption, as well as their diverse array of tiny species that contribute to the intricate

structure and functioning of ecosystems (Sakthivel and Fernando, 2012). Crustaceans hold significant value as they play a crucial part in the global seafood sector (Varadharajan et al., 2013).

Macrobenthic crustaceans, specifically brachyuran crabs, are significant and integral faunal constituents of estuarine, marine, and mangrove ecosystems. They encompass a considerable diversity, with around 1439 genera and 7400 species reported worldwide (Ng, unpublished data, as quoted in Trivedi et al., 2018a). Given their substantial abundance, it is possible to see them as a highly significant assemblage within the marine benthos, with respect to both biomass and community structure (Bertini et al., 2004). Species diversity is a valuable metric for comparing communities affected by biotic disturbances or assessing the status of succession and stability within a community. The measure of species richness, which refers to the total number of species, currently serves as the most frequently used metric of biodiversity (Varadharajan et al., 2013).

The taxonomical study of brachyuran crabs in India is quite glorious and interesting. Recently, Trivedi *et al.* (2018a) compiled a checklist of marine brachyuran crabs in India and recorded 910 species inhabiting different marine habitats along the Indian coastline. In India, brachyuran crab taxonomical studies were initiated by Fabricius (1775–1793), and during his research work, he recorded crab species like *Philyra globosus, Philyra craniollaris,* and *Matuta victor* from the Malabar Coast of the western region of India. Later, Henderson (1893) studied brachyuran crabs of the eastern coast of India, while Milne Edwards (1834–1837) and de Man (1888 a, b) studied the deep-sea brachyuran fauna of Indian seas. Later, Alcock carried out extensive work on brachyuran crab taxonomy. He investigated brachyuran crabs in the Indian Museum and also visited different fields for brachyuran crab collection in the coastal areas of the eastern and western coasts of India. He has described many new species, which were published in a series of research papers (Alcock, 1895a, b, 1896, 1898, 1899, 1900a, b, 1901).

In the last decade, however, there have been growing efforts to address this gap. Many records (Kumar et al., 2013; Padate et al., 2013; Trivedi and

Vachhrajani, 2013, 2016; Trivedi et al., 2014, 2015b; Ng et al., 2015; Trivedi et al., 2020; Bhat et al., 2021; Prema et al., 2021; Trivedi et al., 2023) as well as new species (Padate et al., 2010; Kumar et al., 2013; Ng and Kumar, 2015a, b, 2016; Velip and Rivonker, 2015; Trivedi et al., 2015c; Trivedi et al., 2016; Ng et al., 2018) have been published from India, and this will probably increase over the years.

The brachyuran fauna of Gujarat State has been studied by different researchers over different time periods. Hornell (1916) has studied the marine zoology of Okhamandal and identified a few species of brachyuran occurring in coastal areas of Okha situated on the southern side of the Gulf of Kachchh. The first comprehensive work on brachyuran crabs in Gujarat state was carried out by Chhapgar (1957a, b, 1958) in different parts of Gujarat. He has reported 42 species of brachyuran crabs from different sites like Okha, Kodinar, Umarsadi, Kolak, and Udwada. Later, several other scientists have conducted studies on brachyuran crab diversity and its distribution in various parts of Gujarat state (Pandya and Vachhrajani, 2013; Trivedi and Vachhrajani, 2012; Shukla et al., 2013; Raval et al., 2020; Tandel et al., 2022).

The ecosystem diversity is very rich in the Gulf of Khambhat, comprising mangroves, estuaries, creeks, and vast intertidal mud flats. The present investigation's aim is to estimate the number of species of intertidal brachyuran crab in the study region. It also shows the composition of families and genera along the zoogeographical provinces and sub-provinces already recognized (Pandya and Vachhrajani, 2013).

The detail methodology for data collection has been described in materials and methods chapter (page no. 27). Following flow chart shows summary of methodology used in the present chapter.

3.2 RESULTS

In the present study, a total of 10 species belonging to 7 families and 9 genera were recorded from the study site. Out of these, families Ocypodidae Rafinesque, 1815 (1 genera), Dotillidae Stimpson, 1858 (2 genera) and Pilumnidae Samouelle, 1819 (2 genera) have contributed two species. Whereas, Matutidae De Haan, 1835, Sesarmidae Dana, 1851, Macrophthalmidae Dana, 1851 and Portunidae Rafinesque, 1815 have contributed one species of brachyuran crab (Table 3.1).

Table 3.1: List of the brachyuran crab species recorded

Family	**Species**
Dotillidae Stimpson, 1858	*Dotilla blanfordi* Alcock, 1900
	Ilyoplax sayajiraoi JN Trivedi, Soni, DJ Trivedi & Vachhrajani, 2015
Macrophthalmidae Dana, 1851	*Macrophthalmus sulcatus* H. Milne Edwards, 1852
Matutidae De Haan, 1835	*Ashtoret lunaris* (Forskål, 1775)
Ocypodidae Rafinesque, 1815	*Austruca iranica* (Pretzmann, 1971)
	Austruca sindensis (Alcock, 1900)
PilumnidaeSamouelle, 1819	*Eurycarcinus orientalis* A. Milne-Edwards, 1867
	Heteropanope glabra Stimpson, 1858
Portunidae Rafinesque, 1815	*Scylla serrata* (Forskål, 1775)
Sesarmidae Dana, 1851	*Parasesarma persicum* Naderloo & Schubart, 2010

3.2.1 Description of the species recorded from Kamboi Coast, Gulf of Khambhat, Gujarat, India

Kingdom: Animalia
Phylum: Arthropoda
Subphylum: Crustacea
Superclass: Multicrustacea
Class: Malacostraca
Subclass: Eumalacostraca
Superorder: Eucarida
Order: Decapoda
Suborder: Pleocyemata

Infraorder: Brachyura
Section: Eubrachyura
Subsection: Thoracotremata
Superfamily: Ocypodoidea Rafinesque, 1815
Family: Dotillidae Stimpson, 1858

***Dotilla blanfordi* Alcock, 1900**

Material examined: A total of six specimens were examined to record their carapace length and carapace width (Fig. 3.1A, B).

Average size of male crab: 4.18 ± 1.02 mm CL; 5.18 ± 1.87 mm CW
Average size of female: 5.09 ± 2.65 mm CL; 6.78 ± 2.08 mm CW

The carapace of the smaller crab exhibited a greater width compared to its length. It was noticed that their colour, which blended in with the surrounding substratum, was yellowish brown. A mid-dorsal groove was found running from the frontal region to the posterior border. The gastric region (central part) has five distinctly marked tubercles, separated by grooves. There are four tubercles that are the same size, while the fifth tubercle is slightly smaller and located between the protogastric regions.

Distribution in India: Gujarat (Shukla et al., 2013; Pandya and Vachhrajani, 2013); Maharashtra (Kemp, 1919a; Pati et al., 2012); Andhra Pradesh (Dev Roy

and Nandi, 2007a; Dev Roy, 2008); Orissa (Dev Roy and Rath, 2017); West Bengal (Mandal and Nandi, 1989; Bairagi, 1995; Khan, 2003)

Habitat: High intertidal, substrate sandy (Naderloo, 2017)

Ilyoplax sayajiraoi JN Trivedi, Soni, DJ Trivedi & Vachhrajani, 2015

Material examined: A total of 13 specimens were examined to record their carapace length and carapace width (Fig. 3.3C, D).

Average size of male crab: 6.23 ± 2.15 mm CL; 8.34 ± 1.87 mm CW
Average size of female: 7.09 ± 1.15 mm CL; 9.06 ± 1.36 mm CW

The carapace exhibits a transverse oblong shape, featuring a slightly convex upper surface and a fairly sculpted upper surface. Eye stalk generally long and slender, but not extending from the orbits. The anterior portion has an oblique bending, while the apex displays a wide, rounded shape. Chela is equally shaped, thin, and not overly sculptured which are well-adapted for the purpose of sediment scraping and feeding.

Distribution in India: Gujarat (Trivedi et al., 2015c)

Habitat: Muddy Intertidal Zone

Family: Ocypodidae Rafinesque, 1815

Austruca iranica (Pretzmann, 1971)

Material examined: A total of two male specimens were examined to record their carapace length and carapace width (Fig. 3.5A).

Average size of male crab: 9.37 ± 3.11 mm CL; 12.58 ± 3.91mm CW

The carapace is smooth. The front side is wide and, ventrolateral margin is almost straight, with a clear ridge. The margin on the sides of the posterior part is also ridged and curves backward. The exorbital angle is triangular and turns forward. The upper margin of the orbit is sinuous and has two crests, while the

lower margin is consistently granulated. The size of the granules increases towards the outer margin.

Distribution in India: Gujarat (Trivedi and Vachhrajani, 2018; Jatav et al., 2023)

Austruca sindensis (Alcock, 1900)

Material examined: A total of 23 specimens were examined to record their carapace length and carapace width (Fig. 3.2C, D).

Average size of male: 8.37 ± 2.45 mm CL; 11.34 ± 2.15mm CW
Average size of female: 7.39 ± 1.12 mm CL; 10.65 ± 2.41 mm CW

Carapace is broader than the longer. Frontal region is narrow almost 1/10 of CW. The male giant chelipeds lack a subdistal finger that can be moved. The male abdomen does not have a locking apparatus. The G1 has a tiny subdistal process.

Distribution in India: Gujarat (Chhapgar, 1958; Dev Roy, 2013; Maheta and Vachhrajani, 2023); Maharashtra (Chhapgar, 1958; Dev Roy, 2013).

Family: Macrophthalmidae Dana, 1851

Macrophthalmus sulcatus H. Milne Edwards, 1852

Material examined: A total of three male specimens were examined to record their carapace length and carapace width (Fig. 3.1C, D).

Average size of male crab: 8.31 ± 2.34 mm CL; 19.39 ± 3.91mm CW

The carapace of this species is wider than long and relatively convex, bearing small granules. It has two rows of large granules on the epibranchial region, with a transverse line of small granules on the posterior region. The regions are well defined, with furrows defining gastric and epibranchial regions remarkably deep. The frontal region is smooth and deflexed, while the front is narrow and about 0.12 times as wide as the carapace. The lateral margin has three distinct teeth, with the first being smaller than the second and elongated triangular. The eyestalks are narrow and long, with the upper orbital margin convex and regularly granular.

Distribution in India: Gujarat (Chhapgar, 1957b, c; Shukla et al., 2013; Pandya and Vachhrajani, 2013; Dabhi and Gohil, 2022); Maharashtra (Chhapgar, 1957b, c; Pati et al., 2012); West Bengal (Patra et al., 2017); Andaman and Nicobar Islands (Alcock, 1900b; Kemp, 1919b)

Habitat: Intertidal, substrate muddy-sand (Naderloo, 2017).

Superfamily: Grapsoidea MacLeay, 1838
Family: Sesarmidae Dana, 1851

***Parasesarma persicum* Naderloo & Schubart, 2010**

Material examined: A total of nine specimens were examined to record their carapace length and carapace width (Fig. 3.4A, B).

Average size of male crab: 15 ± 3.67 mm CL; 18.73 ± 4.31mm CW
Average size of male crab: 17.34 mm CL; 21.78 mm CW

The carapace has a square shape and a smooth, slightly curved upper surface. The different regions of the carapace are clearly defined. The front of the carapace is bent downwards and has four lobes. These lobes are separated by narrow and deep grooves. Eye stalk length is somewhat short. The cheliped, equal to sub equal. The ischium of the cheliped has tiny granules on its anterior margin.

Subsection: Heterotremata
Superfamily: Calappoidea De Haan, 1833
Family: Matutidae De Haan, 1835

***Ashtoret lunaris* (Forskål, 1775)**

Material examined: A total of three male specimens were examined to record their carapace length and carapace width (Fig. 3.2A, B).

Average size of male crab: 26.34 ± 1.34 mm CL; 27.8 ± 0.91mm CW

The carapace is minutely granulating with coarser granules laterally and around six dorsal tubercles. The front has straight lobes and a slightly emarginate rostrum. The anterolateral margins are crenulate with five small tubercles and

three large triangular tubercles. The upper external surface of the palm has two rows of granulate tubercles, a five-lobed ridge, and a row of molariform tubercles.

Distribution in India: Gujarat (Chhapgar, 1957a, c; Chhapgar et al., 2004; Dev Roy, 2013); Maharashtra (Chhapgar, 1956, 1957a, c; Dev Roy, 2013); Karnataka (Chhapgar, 1957a, c; Dev Roy, 2013; Bandekar and Kakati, 2021); Kerala (Dev Roy, 2013; Shet et al., 2016); Andhra Pradesh (Alcock, 1896; Dev Roy and Bhadra, 2001; Dev Roy and Nandi, 2007a; Rath and Dev Roy, 2009, 2010); Orissa (Alcock, 1896; Deb, 1999; Pal and Khora, 1999; Sahoo et al., 2008; Rath and Dev Roy, 2011; Rao and Rath, 2014); Tamil Nadu (Henderson, 1893; Gravely, 1927; Thomas, 1969; Venkataraman et al., 2002; Dev Roy and Nandi, 2007b; Krishnamoorthy, 2007, 2009; Dev Roy and Bhadra, 2011; Varadharajan and Soundarapandian, 2014; Vidhya et al., 2017); Orissa (Dev Roy and Rath, 2017); West Bengal (Alcock, 1896; Chopra, 1933; Sewell, 1934; Deb, 1999); Lakshadweep Islands (Rao et al., 1989; Suvarna Devi et al., 2014); Andaman and Nicobar islands (Alcock, 1896; Sankarankutty, 1962; Thomas, 1969; Dev Roy and Das, 2000; Dev Roy and Nandi, 2008; Raghunathan, 2015; Kumaralingam et al., 2017)

Habitat: Shallow subtidal, substrate sandy (Naderloo, 2017).

Superfamily: Pilumnoidea Samouelle, 1819
Family: Pilumnidae Samouelle, 1819

Eurycarcinus orientalis A. Milne-Edwards, 1867

Material examined: A total of five specimens were examined to record their carapace length and carapace width (Fig. 3.3A, B).

Average size of male crab: 22.09 ± 5.24 mm CL; 35.21 ± 6.3 mm CW
Average size of female crab: 21.5 ± 3.37 mm CL; 31.49 ± 4.22 mm CW

The carapace of the specimen is characterized by its smooth texture and unique oval shape, with a width that is much more than its length. The colour of the specimen is a light buff pink shade, with the presence of light violet markings located at the center. The anterior orbital margin extends beyond fifty percent of the carapace's greatest width. The carapace has an oval shape. The eyestalk

exhibits a truncated morphology, characterized by a wide orbital region. The chelipeds exhibit asymmetry, wherein the larger chela possesses a tooth at the base of its thumb.

Distribution in India: Gujarat (Chhapgar, 1957a, c; Trivedi et al., 2012; Pandya and Vachhrajani, 2013; Jatav et al., 2023); Maharashtra (Chhapgar, 1956, 1957a, c; Pati et al., 2012); Goa (Dev Roy and Bhadra, 2008; Dev Roy, 2013); Karnataka (Chhapgar, 1957a, c; Haragi et al., 2010; Bandekar and Kakati, 2021); Kerala (Dev Roy, 2013); Andhra Pradesh (Dev Roy and Nandi 2007b; Dev Roy, 2008; Rath and Dev Roy, 2009); Orissa (Dev Roy and Rath, 2017); West Bengal (Dev Roy and Nandi, 2012); Andaman and Nicobar islands (Dev Roy and Nandi, 2012)

Habitat: Intertidal, substrates muddy and mangroves (Naderloo, 2017).

Heteropanope glabra Stimpson, 1858

Material examined: Only one specimen was examined to record their carapace length and carapace width (Fig. 3.5B).

Average size of male crab: 8.09 mm CL; 12.21 mm CW

The posterior surface of the carapace is generally smooth, lacking bristle-like structures, and the different parts are not well defined. The front part is wide and divided into two lobes, without any smaller lobes on the sides. The infraorbital border is rather flat and lacks a prominent tooth that can be seen from the top surface of the carapace.

Distribution in India: Gujarat (Trivedi et al., 2015b); Kerala (Shet et al., 2016); West Bengal (Deb, 1999; Venkataraman et al., 2004); Andaman and Nicobar Islands (Thomas 1969; Dev Roy and Nandi, 2012)

Superfamily: Portunoidea Rafinesque, 1815
Family: Portunidae Rafinesque, 1815

Scylla serrata (Forskål, 1775)

Material examined: A total of three specimen were examined to record their carapace length and carapace width (Fig. 3.4C, D).

Average size of male crab: 55 ± 9 mm CL; 69 ± 12 mm CW

Buff yellowish-coloured carapace. Anterolateral half of the carapace cut into 9 anterior lateral spines on the starting from the upper center half. The first median spine is prominently shown, exhibiting an expansion on the carapace. Frontal spines are located between the eyestalks. The eyestalk is short and robust. The interdigital spaces of the fingers exhibit significant nodular features.

Distribution in India: Gujarat (Chhapgar, 1957a, c; Trivedi and Vachhrajani, 2013b; Dev Roy, 2013); Maharashtra (Henderson, 1893; Chhapgar, 1956, 1957a, c; Dev Roy, 2013; Pawar, 2017); Goa (Dev Roy and Bhadra, 2008; Dev Roy, 2013); Karnataka (Haragi et al., 2010; Dev Roy, 2013); Kerala (Dev Roy and Nandi, 2008, Dev Roy et al., 2009; Dev Roy, 2013; Shet et al., 2016); Tamil Nadu (Gravely, 1927; Thomas, 1969; Ravichandran and Kannupandi, 2007; Dev Roy and Nandi, 2008; Krishnamoorthy, 2009; Varadharajan and Soundarapandian, 2014; Sruthi et al., 2014; Vidhya et al., 2017); Andhra Pradesh (Murthy and Rao, 1993; Dev Roy and Bhadra, 2001; Rath and Dev Roy, 2009, 2010); Orissa (Rao et al., 1992; Deb, 1999; Mitra and Misra, 2006; Dev Roy and Nandi, 2008; Sahoo et al., 2008; Mitra et al., 2010; Rath and Dev Roy, 2011; Rao and Rath, 2013, 2014; Dev Roy et al., 2017; Dev Roy and Rath, 2017; Rath and Nandi, 2017); West Bengal (Parisi, 1916; Sewell, 1934; Dev Roy and Nandi, 1989; Bhadra, 1995, 1998; Ramakrishna et al., 2003; Khan, 2003; Patra et al., 2017); Andaman and Nicobar islands (Thomas, 1969; Das and Dev Roy, 1989; Dev Roy and Das, 2000; Dev Roy and Nandi, 2008; Kumaralingam et al., 2017; Raghunathan, 2015)

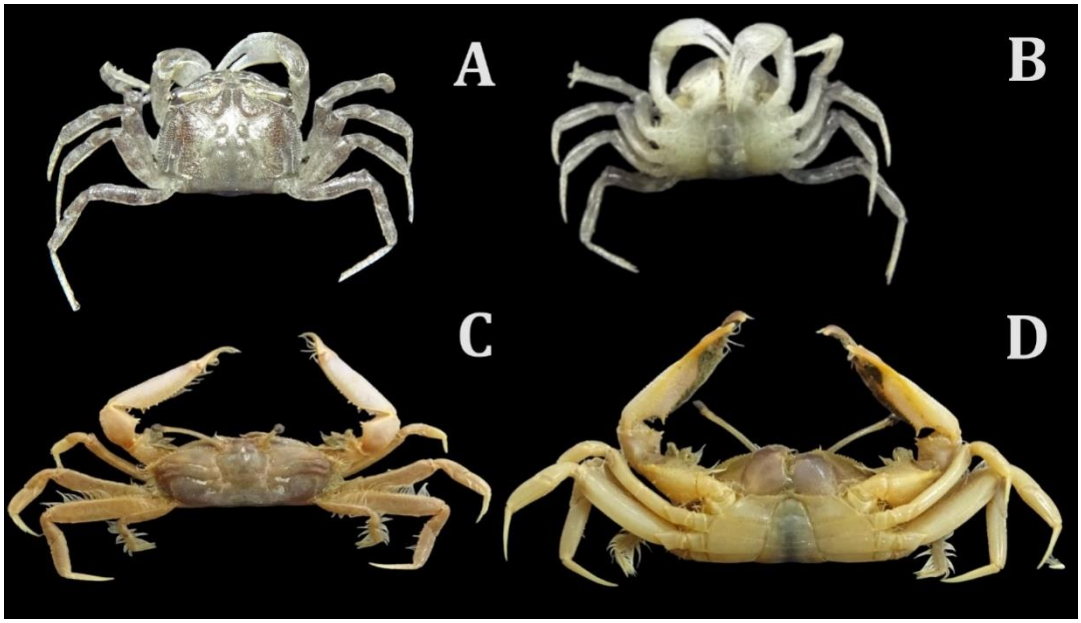

Figure 3.1: *Dotilla blanfordi* Alcock, 1900 (A-Dorsal surface; B-Ventral surface); *Macrophthalmus sulcatus* H. Milne Edwards, 1852 (C-Dorsal surface; D- Ventral surface)

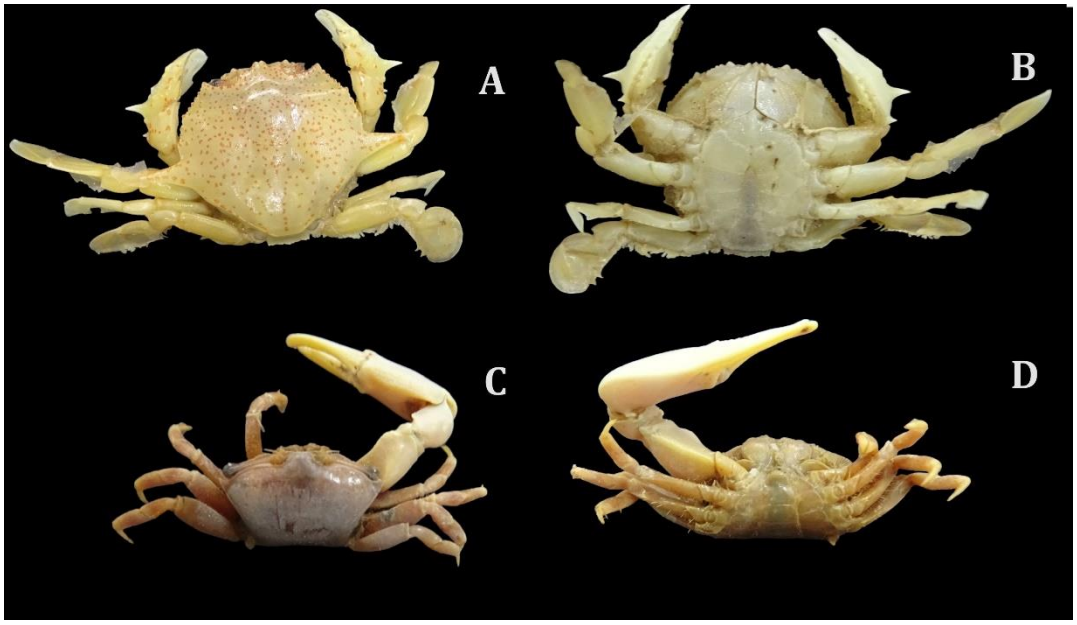

Figure 3.2: *Ashtoret lunaris* (Forskål, 1775) (A-Dorsal surface; B-Ventral surface); *Austruca sindensis* (Alcock, 1900) (C-Dorsal surface; D- Ventral surface)

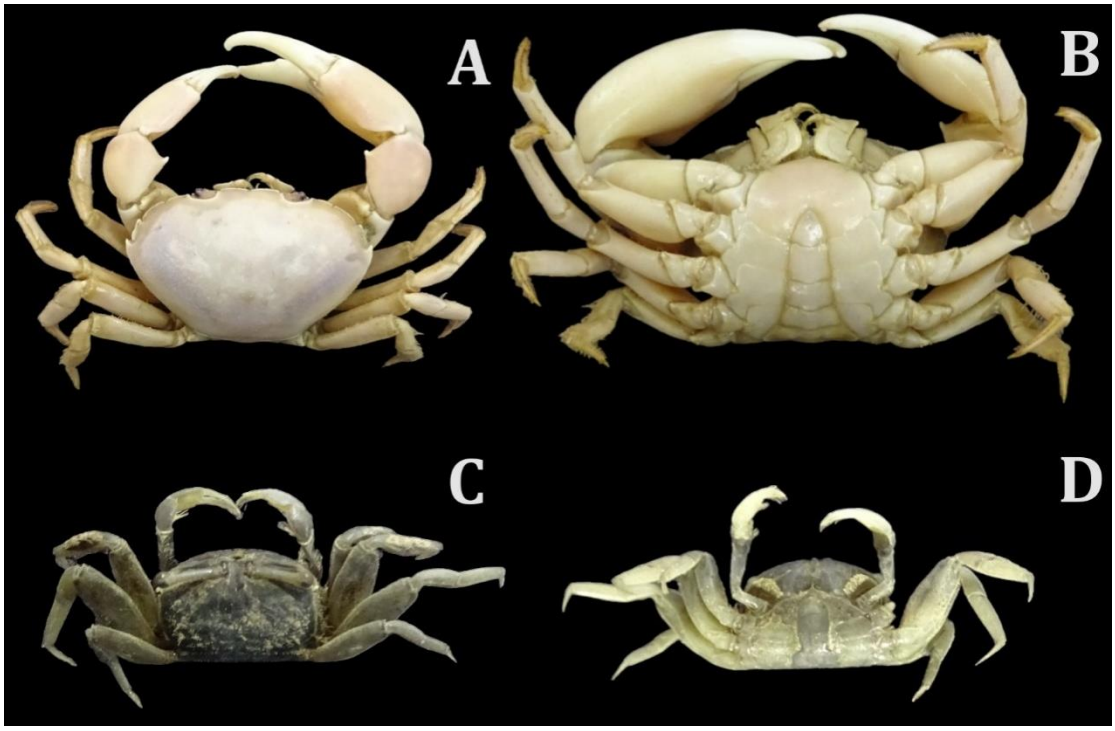

Figure 3.3: *Eurycarcinus orientalis* A. Milne-Edwards, 1867 (A-Dorsal surface; B-Ventral surface); *Ilyoplax sayajiraoi* JN Trivedi, Soni, DJ Trivedi & Vachhrajani, 2015 (C-Dorsal surface; D- Ventral surface)

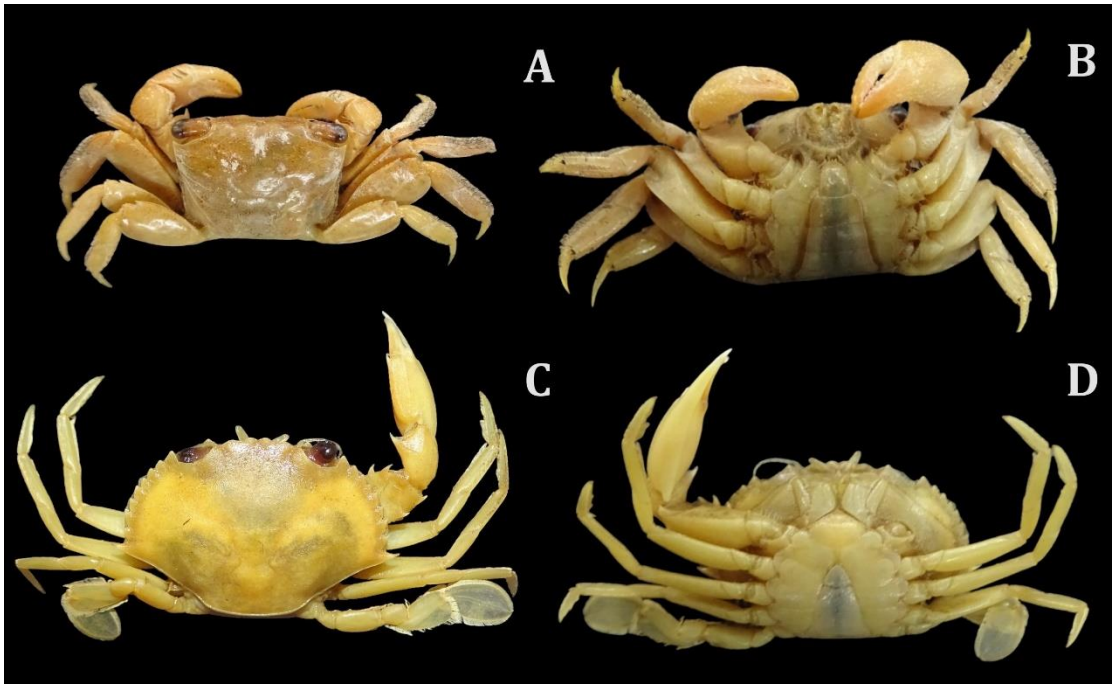

Figure 3.4: *Parasesarma persicum* Naderloo & Schubart, 2010 (A-Dorsal surface; B-Ventral surface); *Scylla serrata* (Forskål, 1775) (C-Dorsal surface; D- Ventral surface)

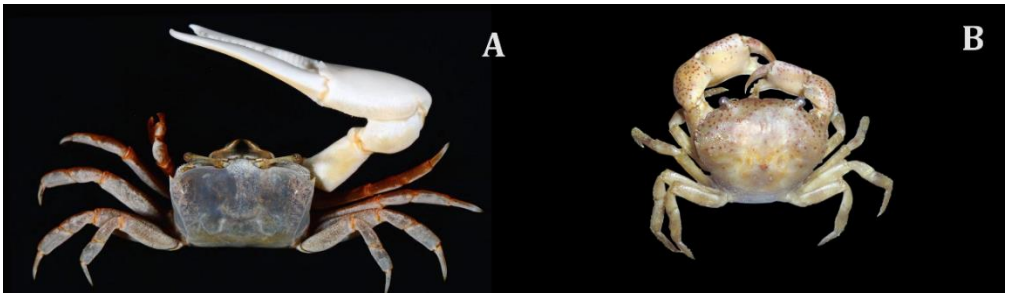

Figure 3.5: A. *Austruca iranica* Alcock 1900; B. *Heteropanope glabra* Stimpson, 1958

3.3 DISCUSSION

Baseline listing and diversity studies have become an indispensable tool for assessing ecology, species extinction, and the rate of human pressure on the ecosystem (Naeem et al., 1994). There is a limited amount of material available on the diversity of brachyuran crabs in Gujarat, particularly in the Gulf of Khambhat. The current study recorded a total of 10 brachyuran crab species from the upper Gulf of Khambhat and estuary areas. Furthermore, the study corroborated the previous investigation on the habitat preference of particular species within the intertidal zone (Ribeiro et al., 2005). Chhapgar and his colleague (1957a-c, 1985, 1995, 2004) provided a significant contribution to the study of brachyuran fauna on the west coast. However, this work has not received any further additions or updates from the research community.

The brachyuran crab diversity in mangrove ecosystems has been extensively researched. Priyadarshani et al. (2008) have documented the presence of six species of brachyuran crab in the Negombo estuary, which is comparatively lower in number when compared to the findings of the current study. In their study, Tan and Ng (2012) documented a total of 100 distinct species of brachyuran crabs found within the mangrove forests of Malaysia and Singapore. In India, extensive research has been conducted on the mangroves in Pondicherry and Pichavaram to examine the diversity of brachyuran crabs. The findings revealed a total of 15 species of brachyuran crabs in Pondicherry (Satheeshkumar and Khan, 2010) and 23 species in Pichavaram (Ravichandran et al., 2001).

In present study, a total of 10 species of brachyuran crabs belonging to 9 genera and 7 families. Similarly, Pandya and Vachhrajani (2013), have recorded 10 species of brachyuran crabs belonging to eight genera and eight families from study site. In that study, they have recorded of *Uca (Austruca) lactea annulipes* De Haan, 1835; *Uca (Tubuca) dussumieri* H. Milne Edwards, 1852; *Macrophthalmus (Mareotis) depressus* (Rüppell, 1830); *Macrophthalmus (Macrophthalmus) brevis* Herbst, 1804; *Dotilla intermedia* De Man, 1888; *Scylla serrata* Forskal, 1775; *Cardisoma carnifex* Herbst, 1796; *Ashtoret lunaris* Forskål, 1775; *Parasesarma pictum* De Haan, 1835; *Metopograpsus frontalis* Miers, 1880. In present

investigation, *M. depressus* was identified as *I. sayajiraoi*, *M. brevis* as *M. sulcatus*, *D. intermedia* as *D. blanfrodi*, *C. carnifex* as *E. orientalis*, and *P. pictum* as *P. persicum*.

In 2015, Trivedi et al. prepared checklist of crustacean fauna of Gujarat state. Where they have listed 22 species of brachyuran crabs belonging to 16 genera and 12 families from gulf of Khambhat region. The variation in the diversity of both the studies is may be because, that Trivedi et al. (2015a) prepared a checklist from entire gulf region while present investigation was carried out only on the uppermost area of eastern bank of Gulf of Khambhat. Pandya and Vachhrajani (2013) subsequently provided a detailed account of the diversity, distribution, and ecological characteristics of benthic macrofauna in the upper region of the Gulf of Khambhat. Similar observation was also made by other published research from same area as well as different areas (Pandya and Vachhrajani, 2010; Trivedi et al., 2012).