CHAPTER 2
REVIEW OF LITERATURE

"Study nature, love nature, stay close to nature. It will never fail you."
Frank Lloyd Wright
Ascidians were recognized as a distinct group as early as Aristotle (Shenkar and Swalla, 2011). The first clear description of an ascidian was coined by Schlosser in 1756 (Shenkar and Swalla, 2011). However, it was mentioned as a different kind of mollusc by both of them. In 1767, Linnaeus named the genus *Ascidia* and identified some species under different genera. In 1816, Lamarck coined the term ‘Tunicers’ but he thought the faunal group is more close to the holothurians among echinoderms. In 1824, Blainville coined the term ‘Ascidiae’ but not as a class but as one family of the mollusc. In 1866, Kowalevsky discovered the tailed ascidian larva with notochord, nerve cord and tail muscles and named the subphylum as Urochordata to suggest their chordate affinities. In 1886, Lahille classified the tunicates and divided ascidians into three orders Phlebobranchia, Stolidobranchia and Aplousobranchia based on the structure of branchial sac (Sebastian and Kurian, 1981). Although Perrier (1898) divided the class into two orders viz. Enterogona and Pleurogona depending upon the origin of atrial cavity and considered Lahille’s orders as suborder of the class. Now-a-day’s Lahille’s classification is accepted and considered as the order of the class Asciidiacea. Savigny, Phillipi, Herdman and Sluiter are the renowned scientists who worked in pre-1900s on ascidians. In 1904, Sluiter identified some new genus from the collections from *Siboga Expedition*. Subsequently in 1912, Hartmeyer worked on the ascidians collected by *Deutsch Tiefsee Expedition* along with the collections of *Dr. E. Mjoberg’s Swedish Scientific Expeditions* to Australia in 1919. Hastings (1931) studied the collections of *Great Barrier Reef Expedition*. Van Name (1902, 1918, 1921, 1931 and 1945) prepared monographs on ascidians of Bermuda, North and South America, West Indian region and Southern United States, Philippines and adjacent waters which are valuable in ascidian taxonomy till date. Arnbak (1924-1949), Berrill (1928-1950), Peres (1947-1960), Brewin (1948-1959), Goodbody (1984-2004), Millar (1949-1985), and Michaelsen (1905-1934) made great contribution to identify ascidians. A checklist containing 302 species of ascidians was made from Japan by Tokioka (1949, 1963). The biology of ascidians was studied and described from ascidians in the Zoological Museum of Copenhagen from the Indo-West Pacific region by Millar (1960, 1971, 1975). Extensive works on ascidian taxonomy was carried out by Kott over fifty years and discovered many new species and described their identifying characters with distribution, diversity and endemicity.
Aplosobranchia. Descriptions of 117 species from the Caribbean were summarized with the distribution by Goodbody (2000). Mastrotortaro and Tursi (2010) updated the Italian checklist of ascidians provided by Tursi in 1995 and reported 129 species (4.48%). Collin et al. (2005) reported 32 ascidians from Panama. Monniot and Monniot (1997) reported 31 species from Tanzania. Croxall (1972) made a checklist of New Zealand ascidians and mentioned 130 species. A total of 31 Ascidians of Bermuda Island (Berrill, 1932), 117 species from Guam (Lambert, 2003) and 12 species from Brazil (Bonnet and Rocha, 2011a, b) have also been reported. As ascidians held a great position in evolution, studies on these animals were also conducted by several researchers to study the process of adaptation. After the discovery of notochord and nervercord by Kowalevsky (1866), Garstang proposed the evolution of chordate took place from an adult ancestor similar to the larva of hemichordate or echinoderm in 1894 and proposed a sessile, tentaculate ancestor, like a pterobranch hemichordate or a solitary ascidian with tentacles, arguing that subsequently the larva of this animal acquired a muscular tail and, by paedomorphism (neoteny), became a prematurely sexual, vertebrate-like adult. In 1998, Wada proposed a phylogenetic tree based on 18S RNA sequencing depicting that cephalochordates are sister group of vertebrates. Satoh (2003) established the tunicates are closer to the vertebrates than cephalochordates according to the same genetic expression patterns in the embryonic stage of the vertebrates and tunicates. Schubert et al. (2006) placed them in between cephalochordates and vertebrates according to phylogeny of heart origin where tunicate heart contains striated muscles instead of smooth muscles as found in cephalochordates and also enclosed in the pericardium as in vertebrate heart. Blair and Hedges (2005), and Delsuc et al. (2008) placed the tunicates close to vertebrates rather than cephalochordates as per the molecular phylogeny. In 2009, Satoh established that the filter-feeding evolution in tunicates. In 2015, Lemaire and Pietti established that the tunicates are sister group of vertebrates and the Class Asciidiacea is a polyphyletic class. The phylogeny of ascidians was studied by several ascidiologists. In 1885, Seeliger proposed a phylogeny for tunicates and gave the theory that the ascidians were evolved three times as in the form of monoascidians, social ascidians and synascidians. In 1978, Plough supported Berrill’s hypothesis proposed in 1936 based on the morphology of branchial basket and stated that that all ascidians are evolved from the Cionidae like
ascidians (Stach and Turbeville, 2002). Zeng and Swalla (2005) proposed a phylogenetic tree of the three families of the order Stolidobranchia and also constructed the phylogentic tree of phlebobranchia in which they placed few species of Thaliacea. In 2008, Moreno and Rocha proposed a phylogenetic tree of Aplousobranchia order based on the morphology of the genera. In 1962, Kott suggested a phylogeny of ascidians based on the morphology which is not supported by the molecular phylogeny of the researchers now a days (Moreno and Rocha, 2008; Turon and Lopez-Gentil, 2004). Although Shenkar et al. (2016) established that the Rhopalaea belongs to the order Aplosobranchia not in Phlebobranchia.

Indian work on ascidians was initiated by Herdman in 1906 as he described the ascidians from Gulf of Mannar region while most of the areas come under Sri Lankan territory except few study sites, followed by Oka in 1915. The works after the said period was very limited and scanty. Sebastian and Kurian (1981) published a book on Indian Ascidians. Description of Aplidium multipicatum and a new species Sidnyum indicum was made from Indian Ocean by Renganathan and Monniot (1984). Ecology of ascidians at New Mangalore port was studied by Venkat et al. (1995). In 2003, Meenakshi reported about 360 species of ascidians from Peninsular Indian coasts as a result of three years survey. Later on in 2013, Meenakshi and Senthamarai reported 372 species from the Gulf of Mannar. A total of 76 species were reported from the West coast of India (Meenakshi et al., 2003; Jafarali et al., 2010; Swami et al., 2011; I.C.H., 2013) among them only one species is reported from Gulf of Kuchchh (I.C.H., 2013). Studies on the food and feeding habitat of Herdmania pallida and nutritional value of Microcosmus exasperates (Karthikeyan et al., 2009, 2010), which is considered as invasive species in India (Jafferali et al., 2014) have also been made in recent years. Swami et al. (2011) studied the biodiversity of fouling species in Karanja jetty and found 3 ascidian species as fouler including a newly recorded species. In 2009, Erulan and Anantha reported Polyclinum indicum from Vellar estuary. Natarajan et al. (2010) and Bragadeeswaran et al. (2010) studied antibacterial activity of crude extract from Polyclinum madrasensis, and Phallusia nigra. In 2011, Ganesan et al. studied the antibacterial activity of Polyandrocarpa indica and Phallusia arabica from Tuticorin coast. Twenty five species of ascidians along with their diversity, distribution and seasonal variations was documented by Tamilselvi et al. (2012) from Thoothukudi coast. Recently, Ravinesh and Bijukumar
(2013) reported seven ascidians species from Kerala coast and a new species and three new records of ascidians were also documented from eastern coast of India (Meenakshi and Senthamarai, 2013). Only one species of ascidian was studied by Oka (1915) from the Andaman and Nicobar Islands during the R.I.M.S. Investigation Expedition. After this work, no reports are available from these regions until 2012. Venkataraman et al. (2012) reported 7 species of ascidians from Andaman group of Islands. Later on Ananthan (2014) and Ananthan et al. (2015) reported 21 ascidians fauna from the Great Nicobar Island. Jhimli et al. (2015) reported 32 species of ascidians from Andaman and Nicobar Islands and 20 species of ascidians from the Great Nicobar Island (Jhimli and Raghunathan, in press). Jhimli et al. also described two new species of ascidians and some non-indigenous ascidians from this region (Jhimli et al., 2016; 2017a, b).