CHAPTER 1
GENERAL INTRODUCTION

"Science is a wonderful thing if one does not have to earn one’s living at it."

Albert Einstein
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Animals belong to the class Asciidiacea are commonly known as ascidians. The name of the class derived from the Greek word ‘Ascoids’ means sac; as the animals have the sac like body with two siphons. These animals are also known as sea squirts as they eject waters from their siphons to protect themselves when they are disturbed although some species produced thick mucus when they are disturbed. Ascidians come under subphylum Urochordata or Tunicata. These primitive invertebrate chordates are considered as the sister group of vertebrates (Jeffery et al., 1998; Satoh, 2009). Urochordates are closer relative to vertebrates rather than Cephalochordates (Satoh, 2009). There are two other classes under this subphylum such as Appendicularia/ Larvacea and Thaliacea though it is considered that phylogenetically the members of Appendicularia/ Larvacea and Thaliacea originate prior to the ascidians (Kurabayashi et al., 2003; Satoh, 2009). Fossils of ascidians are very less and confusing with other chordates (Brookfield, 1988) as most of them do not have any hard exoskeleton. Some Lower Cambrian, Mesozoic particularly Triassic, Tertiary, Plio-Quaternary and Late Pliocene fossils of ascidians and their spicules are recorded by Chen et al. (2003), Brookfield (1988), Varol and Houghton (1996), Sagular (2009). These exclusively marine animals display a wide range of habitat from intertidal zone to about 6500 meters (Kott, 1969).

**Morphology:** Size of the ascidians vary greatly from few millimeters to more than 15 cm. Mostly colonial ascidians are smaller in size and solitaries are larger. Solitary ascidians differ from colonial ascidians in shape and size. Appearance of ascidians may like a seed, grape, peach, potato and sometimes irregular shape also found. Depending on the shape, size and colour of few ascidians are known as sea peaches, sea grapes etc. One side of the body is attached with substratum and anterior part contains two openings branchial and atrial siphons through which water currents enter inside and expel outside respectively. Sac-like sessile transparent or opaque bodied ascidians are filter-feeder and feeds upon mostly planktons and the branchial sac of the ascidians act as sieve. A few active predatory ascidians are also found like *Megalodicopia hians* Oka, 1918; these are the particularly deep sea ascidians and found from 200-1000 meters. Some colonial ascidians possess unicellular photosymbiotic algae and prokaryotic bacteria (Olson, 1983). Ascidians are enclosed
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in test or tunic made up of tunicin a kind of cellulose with various kinds of proteins and carbohydrates. The tunic is usually thick but varies from a soft, delicate consistency to one that is tough and similar to cartilage. Tunicin fibres are arranged in a manner similar to some arthropod cuticles that results the toughness and strength of test or tunic.

Irregular mat-like colonial forms of ascidians are differing from each other by their designs, degree of zooidal integration. In colonial ascidians zooids are may tightly embedded in test or may be connected loosely by stolons or may be fused to the lower part of the tunics (Ruppert et al., 2004). The colonies which have tightly embedded zooids, have individual branchial openings but atrial openings are common and atrial openings can be one to few depending upon the orientation and size and those characters are variable depending on the species. Size of the zooids of colonial species ranging from few millimeters to several centimeters though the size of colonies may be more than a meter (Kott, 1985, 1990, 1992, 2001). Internally, body of individual can be divided as anterior thoracic region containing pharynx, a middle abdominal region containing the digestive tract and associated structures and the posterior postabdominal region containing heart and reproductive organs. Apart from some aplousobranch ascidians, others lack either postabdomen or both postabdomen and abdomen (Rocha et al., 2012). Branchial siphon opens internally into pharynx, the mouth of pharynx is encircled by tentacles which are may be branched or unbranched. Pharynx is perforated by small, ciliated gill slits known as stigma or stigmata. Endostyle is present along the length of pharynx, on the ventral side of the pharynx opposite to the atrial aperture. Endostyle divided at the junction of the branchial aperture and pharynx into two ciliated pharyngeal bands that encircle the opening of pharynx and re-joins in dorsal midline to form dorsal lamina. Atrium is present surrounding the pharynx and opens to exterior through the atrial aperture. The cavity just inside the atrial siphon is sometimes called the cloaca because it receives both waste from the anus and gametes from the gonoducts. Blood cells of ascidians are mainly with diversified hemocytes. Categories of hemocytes are totipotent lymphocytes, amebocytes including phagocytic macrophages and vacuolated cells including morula cells and nephrocytes. Morula cells can concentrate heavy metals like iron, niobium, tantalum, vanadium etc. (Ruppert et al., 2004). Vanadium helps in polymerization of tunicin filaments and also discourages predation on ascidians by its
toxicity along with unpalatability of sulphuric acid. Heart is short, curved cylindrical in structure and situated at the base of gut loop or postabdomen (Ruppert et al., 2004). Blood vessels lack endothelia and are simple channel in connective tissue. Ascidians have heartbeat reversal in every few minutes because of their tissues are arranged in a series rather than parallel. Tunic contains tunic hemocytes which help the tunic to grow as ascidians do not molt though they residing in a thick exoskeleton.

**Nervous system:** A hollow cerebral ganglion and a neural gland represent the dorsal hollow nerve cord in the adult ascidians. Nerves are arising from the cerebral ganglion are supply to both the apertures and other important body organs. Though neurons are absent but they may have rhythmic electrical activity and conductive ability. Neural gland lies beneath the cerebral ganglion and also originates from the embryonic neural tube like cerebral ganglion (Ruppert et al., 2004). A ciliated duct extends from the anterior end of the neural gland and opens into the pharynx in a large, generally complexly coiled, ciliated modified neuropore known as dorsal tubercle (Ruppert et al., 2004). The dorsal tubercle, ciliated duct and neural gland act together to restore and maintain the fluid volume of the blood and functionally similar to madreporite, stone canal and Tiedemann’s bodies of some echinoderms. The neural gland is an evolutionary precursor of the vertebrate pituitary gland (Ruppert et al., 2004). Specific sensory organ is absent in adult ascidians, there is abundance of sensory cells on the external and internal surface of the both siphons, tentacles and in atrium.

**Reproduction:** All the ascidians are hermaphrodite in nature but they avoid self-fertilization by maturing sperm and ova in different time. Both sexual and asexual (budding) reproductions are found in ascidians. Mostly solitary species are reproduce sexually and colonial are reproduce asexually although sexual reproduction can also found in colonial species. Like other lower chordates they also have a great regeneration power and regenerate their siphon when removed (Auger et al., 2010) as some of them can regenerate their neural ganglion (Tio zoo et al., 2008). Cross-fertilization occurs generally but a few shows self-fertilization. Single testis and ovary, sometimes combined into ovo-testis, are present in gut loop or one to many gonads can be embedded in the body wall. Fertilizations of solitary ascidians are external whereas colonial species shows vivi-parity and internal fertilization; they
incubated the larvae in the colony and releases tadpole larvae for a very short time to find the settlement sites (Shepherd and Edgar, 2013). Gametes of the ascidians are discharged through the atrial siphons in solitary forms and sometimes through rupturing the body wall in some colonial form (Pechenik, 2000). Colonial ascidians often proliferate by vegetative reproduction. Vegetative reproduction takes place by budding from the thorax region (Berrill, 1948; Kott, 2001) during active replication in adult colony. In all ascidians, development is lecithotrophic and cleavage holoblastic and bilateral. Larval life of ascidians are very short ranging from a minute to 36 hours generally though this free swimming larval phase can persists to months (Tsukamoto et al., 1999). Tadpole larvae of ascidians display all the key characters of chordate traits except it does not feed. Body of tadpole larvae divided into visceral trunk and locomotory tail. Side by side tail movements (Pechenik, 2000) are controlled by the larval nervous system (Zega et al., 2006). At the end of the free swimming larval stage they are attached to a suitable substratum with their anterior adhesive papillae and metamorphosed into sessile ascidians. During metamorphosis as a result of rapid growth of the region between adhesive papillae and buccal siphon, the body rotates 90° which results the upward positions of siphons. Ascidian larvae display phototactic, photokinetic and geotactic responses. Their phototactic and photokinetic behaviour helps to seek out dark habitats (Cloney et al., 2002) due to this reason few colonial ascidians release their larvae in response to light. The family Didemnidae has all colonial species, have the highest prolific replication rates in the class Ascidicea. ASC I D IA NS shows several peculiarities as they displaying retrogressive metamorphosis i.e. losses their larval chordate characters as they becomes adult. For their peculiarities in development they have a great importance to evolutionary and developmental biology.

**Bio-fouling:** Ascidians have great ecological importance as they are considered as bio-fouling species. They are easily found in the jetties, ship hulls, buoys etc. (Shenkar, 2008; Meenakshi, 2010). *Didemnum vexillum* Kott, 2002 reported from Andaman and Nicobar Islands (Ananthan, 2014), known as invasive species across the globe. It is also evident that the ecological impact as invasive species is not recorded from Indian waters till now. Ecology of ascidians are studied world-wide (Shenkar and Loya, 2008; Shankar, 2008; Rocha et al., 2009; Valentine et al., 2007;
Lambert, 2002). In India ecology of ascidians are studied by several workers (Ananthan et al., 2012; Swami and Chappgar, 2002; Venkat et al., 1995).

Ascidians are also considered as the marine bio-indicators of polluted area as they can accumulate various heavy metals in their blood cells and test cells like vanadium, zinc etc. (Naranjo et al., 1996) and act as cleaner and purifier of wastewaters. Concentration of vanadium found in ascidian blood cells 100 million times more than in seawater (Ruppert et al., 2004). On the other hand photo-symbiotic ascidians are act as bio-indicator of pollution free marine water (Su et al., 2013). As ascidians have bio-fouling nature, they cause the economic loss by fouling in mussel and oyster beds, sewage system etc. Now-a-day’s it has been discovered the ascidians have a great pharmacological importance (Gopalakrishnan et al., 2012 & 2013; Koplovitz et al., 2009; Meenakshi et al., 2012a, 2013; Sekine et al., 2013; Prabhu et al., 2011).

The studies on ascidians in Andaman and Nicobar Islands are scanty while the studies on reef associated ascidians are not made previously and remain lesser known animal faunal group of these islands. The present studies were made to explore the ascidian faunal groups with the following major aims and objectives.

1. Taxonomy of Reef Associated Ascidians
2. Diversity and Distribution of Ascidians
3. Settlement of Ascidian Larvae
4. Food and Feeding Habits of Ascidians
5. Epibiotic and Symbiotic Association of Ascidians