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Distribution of Pteropods (Thecosomata and Gymnosomata) from the coastal waters of Orissa and Andhra Pradesh

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ABSTRACT: This paper deals with the collection of planktonic pteropods from the coastal waters of southern Orissa and Northern Andhra Pradesh coast during winter monsoon. The collection of pteropods comprising about 6 species belonging to three genera and three family. Among the 6 species, *Creseis virgula* and *Creseis chierchiae* were not reported previously from the coastal waters of northern Bay of Bengal. So these 2 species are new records from the east coast of India.

Key words: Zooplankton, Pteropoda, Thecosomata, Bay of Bengal.

INTRODUCTION

Pteropods (Thecosomata & Gymnosomata) are the group of holoplanktonic molluscs belonging to the Class Gastropoda. They are commonly called sea butterflies and found very fewer numbers in the zooplankton collections. They are small zooplankton that drifts through ocean waters consuming smaller plankton. They either graze on phytoplankton or prey on smaller zooplankton and are themselves food for larger organisms like sea birds, whales and commercially important fish mackerel, herring, salmon. Therefore these planktonic pteropods have a significant role in the food web of marine ecosystem and the ecology of epipelagic marine communities. Among zooplankton, the most abundant group of gastropod is pteropod and is adapted to the pelagic free swimming life. Of the approximately 50,000 marine species of gastropods, only 244 species are holoplanktonic (van der Spoel *et al*., 1997). They are wide spread in the surface waters of open oceans of the tropical, subtropical latitudes (Bé and Gilmer, 1977; Hunt & Hosie 2003) and temperate seas (Hunt *et al*., 2008). Their shells are thin, fragile and made up of aragonite and calcium carbonate (Jannsen, 1990a). During their life time they constitute significantly to the zooplankton population and upon death their shells sink to the ocean bed. Empty shells of pteropods constitute a major portion of shallow marine sediments, especially in the tropical and subtropical regions (Herman, 1968).

The distribution of pteropods is mainly influenced by the depth of the ocean (Van straten, 1972). The abundance of pteropods within different water masses depend upon specific physico-chemical properties and by the adaptive potential of different individual species. Thecosome pteropods depend on the process of calcification to grow their shells which consist of aragonite and calcium carbonate. Hence the saturation of carbonate ions in the water is vital to their survival. Their body is made up of an aragonite and calcium carbonate shell; they are very sensitive to ocean acidification driven by the increase of anthropogenic CO_2 emissions and other oceanic processes (Comeau *et al*., 2009) and also play a key role in the cycling of carbon and carbonate. The recent research on pteropods is mainly focus on their susceptibility to ocean acidification Fabry *et al*. (2008).

The studies of pelagic pteropods from the Arabian Sea and Bay of Bengal were very meagre and most of the studies are concentrated on ecological or fossil studies not in a taxonomic point of view. Most of the fossil studies of pteropods are from the Arabian Sea or from the Andaman Sea within the EEZ of India (Berner, 1977). Geological survey of India was also generated a lot of information on pteropods through the examination of sea bed samples collected in the Andaman Sea. In the Bay of Bengal, the pelagic studies were done by Aiyer *et al*. (1929) from Off Madras, Arabian Sea (Sakthivel, 1976a), Eastern Bay of Bengal, around Tillachang Island and the paleontological studies from the Andaman Sea (Bandopadhay *et al*., 1991; Bhattacharjee & Bandopadhyay, 2002).

The species distribution of pteropods dealt in this paper are from the collections made during the winter monsoon survey of the project entitled 'Marine faunal diversity along the Orissa and Andhra Pradesh coast' under the IndOBIS programme funded by the Ministry of Earth Sciences, CMLRE. The collection locations are presented in the map (Fig. 1). The details of the species and its collection localities are described (Table 1). The voucher specimens of pteropods are deposited in the Zoological Survey of India, Kolkata under IndOBIS/ZSI collections.

METHODOLOGY

The study area is located in the coastal waters of southern Orissa and northern Andhra Pradesh coast. The zooplankton collections were made from 10 m depth to 30 m depth of each transect from southern Orissa to northern Andhra Pradesh coast by one degree interval (i.e., 19^0 N to 16^0 N) during the winter monsoon survey of the project Marine faunal diversity along the Orissa and Andhra Pradesh coast under the IndOBIS programme (Table 1).

Mesozooplankton was collected at all stations (10 m, 20 m, and 30 m) from each transect with a Bongo net. The Bongo net is connected with a flow meter and the diameter of net is 60 cm and a mesh size of 200 µM. To study the pelagic pteropod assemblage from the coastal waters of Orissa and Andhra Pradesh, the mesozooplankton samples were collected from each station and were immediately preserved in 4% formalin. On return to lab, the zooplankton samples were sorted out into individual groups and the Pteropod abundance were estimated by counting all the individuals present in the sample. The species identification of pteropods was based on the standard works of d'Orbigny, (1836-1846), Janssen (2012) van der Spoel (1967; 1973), Sakthivel (1976a).

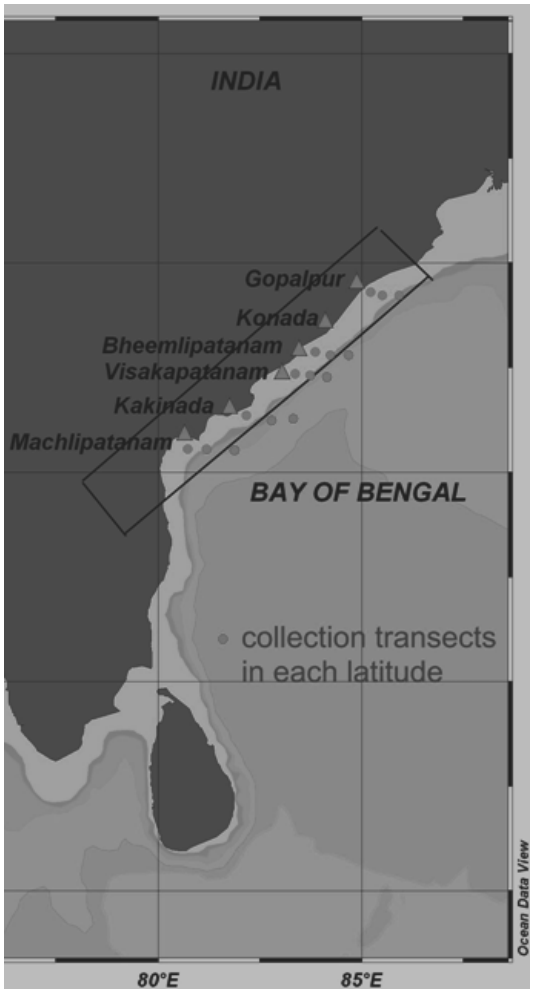

Fig.1. Map showing the coastal stations along the Orissa and Andhra Pradesh coasts. Collected stations of pteropods are represented with black circles (●).

Table 1: Distribution details of pteropods from the coastal region of Orissa and Andhra Pradesh.

S. No.	Species	Locality	Depth	Longitude	Latitude
1	*Cavolinia tridentata* (Forsskål in Niebuhr, 1775).	GP *	10 m	84° 51' 87"	19° 12' 59"
2	*Cavolinia uncinata* (d'Orbigny, 1834)	GP *	10 m	84° 51' 87"	19° 12' 59"
3	*Creseis virgula* (Rang, 1828)	VSKP*	30m	83° 20' 67"	17° 41' 27"
4	*Creseis chierchiae* (Boas, 1886)	VSKP*	30m	83° 20' 67"	17° 41' 27"
5	*Creseis clava* (Rang, 1828)	VSKP *	30m	83° 20' 67"	17° 41' 27"
6	*Heliconoides inflatus* (d'Orbigny, 1834)	VSKP *	30m	83° 20' 67"	17° 41' 27"

*GP- Gopalpur, *VSKP- Visakapatanam

RESULTS

SYSTEMATIC ACCOUNT

PHYLUM Mollusca
CLASS Gastropoda
SUBCLASS Heterobranchia
INFRACLASS Opisthobranchia
ORDER Thecosomata Blainville, 1824
SUBORDER Euthecosomata Meisenheimer, 1905
SUPERFAMILY Cavolinioidea Gray, 1850 (1815)
FAMILY Cavoliniidae Gray, 1850 (1815)
GENUS *Cavolinia* Abildgaard, 1791

(i) *Cavolinia uncinata* (d'Orbigny, 1834)

Type species*: Cavolina (Hyalaea) globulosa* Gray, 1850
1829. *Hyalea uncinata Rang, Manuel de l'Histoire Naturelle des Mollusqueset de leurs Coquilles. Paris (Roret):* 16.pp 390.
1834. *Hyalaea uncinata* d'Orbigny, *In: R. de la Sagra. Histoire physique, politiqueetnaturelle de l'Ile de Cuba. Paris (Bertrand):* 376.
1880. *Hyalaea uncinatiformis* Pfeffer, *Abhandlu. Naturwissensch. Ver. Hamburg* 7: 69-99.
1967. *Cavolinia pulsata*van der Spoel, *J. Noorduyn and Zn*, Gorinchem, 375.
1969. *Cavolinia uncinata* f. *roperi*van der Spoel, *Beaufortia*, 16 (220): 185-198.
1971. *Cavolinia uncinatapulsatapusilla* van der Spoel, *Beaufortia*, 19 (243): 1-20.

Materials examined: Gopalpur 10 m (Lat. 19° 12' 593") (Long. 84° 51' 876"), Orissa, Bay of Bengal, (Fig.1, Pl. a & b). 2 specimens from the zooplankton sample of winter monsoon, Coll. Dr. Jasmine and party.

Diagnosis: This species is large and uncoiled the cosomatous pteropod, 0.8 cm long. Though the specimen is small in size, the most typical characters are the long caudal spine which is curved dorsally, the flat dorsal surface and the five less developed dorsal ribs present. The lateral spines are towards the caudal portion and the line between the tips of caudal and lateral spines is not regularly curved. There is a band at the base of the ventral lip. The caudal spines curved and relatively long. The ventral side is clearly vaulted. Faint growth lines and transverse striation near the aperture is present on the shell. The dorsal lip curves over the aperture.

Indian Distribution: Shelf off Northern Kerala Arabian Sea (Singh & Rajaram, 1997), Eastern Bay of Bengal (Nair, 1981), Porto Novo Bay of Bengal (Krishnamurthy, 1967).

Other Distribution: Cape Verde, Aruba, Caribbean Sea, Indo-Pacific, New Zealand Exclusive Economic Zone.

(ii) *Cavolinia tridentata* (Forsskål, 1775).

Type species: *Cavolinia tridentata* forma *bermudensis* Van der Spoel, 1974
1775. *Anomia tridentata* Forsskål in Niebuhr, *Descr. animaliumavium, amphibiorum, piscium, insectorum, vermium quae in itinereorientaliobservavit Petrus Forskål, prof. Haun., post mortem auctorisedidit Carsten Niebuhr. Hauniae [Copengagen], Möller, pp. 1-19.*
1775. *Cavolinia tridentata* f. *tridentata* (Forsskål in Niebuhr).
1791. *Cavolinia natans* Abildgaard *Skrifter af Naturhistorie-Selskabet* 1(2): 171-175.
1801. *Hyalaea cornea* Lamarck *Histoire naturelle des animaux sans vertèbres.*, Paris, 1-343.
1813. *Hyalaea chemnitziana* Lesueur, *Nouv. Bull. de Sci. Paris* 3: 281-285.
1813. *Hyalaea peronei* Lesueur, *Nouv. Bull.de Sci.Paris* 3: 281-285.
1816. *Hyalaea teniobranchea* Lamarck, *Hist. nat. des animaux sans vertèbres. Paris*, 1-343.
1821. *Hyalaea forskalii* deBlainville, Hyale, *Hyalæa* (Malacoz.), *in*: Dictionnaire des Sciences Naturelles (F. Cuvier, ed.), *Levrault, Paris*, 1-647.
1830. *Hyalaea rangii* Deshayes *Histoire des mollusques. Paris (J. B. Bailliere)*: 1-736.
1836. *Cavolinia tridentata* f. *affinis* (d'Orbigny) *Bull. Malacol.* 48 (suppl. 9): 1-105.
1854. *Cleodora trifilis* Troschel, *Arch. Naturgeschichte* 20(1): 196-241.
1854. *Pleuropus longifilis Troschel, Arch. Naturgeschichte* 20(1): 196-241.

1855. *Hyalaea complanata* Gegenbaur, *Thiere. Wilhelm Engelmann, Leipzig* 228.
1878. *Hyalaea cumingii* Sowerby, *Conchologiaiconica III or illustrations of shells of molluscous animals. In: Reeve, L. A.: Monograph of the genus Pteropoda*, 20.
1880. *Cavolinia uncinatiformis* Pfeffer, *Abhandlu. Naturwissensch. Ver. Hamburg* 7: 69-99.
1908. *Cavolina occidentalis* Dall, *Bull. Mus. of Comp. Zool.*, 43(6): 205-487.
1948. *Cavolinia tridentataplatea* Tesch, *The Indo-Pacific. Dana Rep.*30: 1-45.
1974. *Cavolinia tridentata* var. *bermudensis* van der Spoel *Bijdr. Dierk.* 44 (1): 100-112.
1974. *Cavolinia tridentata* var. *teschi*van der Spoel *Bijdr. Dierk.* 44 (1): 100-112.
Material examined: Gopalpur, 10 m (Lat. 19° 12' 59") (Long. 84° 51' 87"), Orissa, Bay of Bengal, (Fig.2, Pl. c & d). 5 specimens from the zooplankton sample of winter monsoon, 2014. Coll. Dr. Jasmine and Party.
Diagnosis: This is a large thecosomatous pteropod, 2 cm long, living at moderate depths. The hyaline or opaque shell shows a slightly vaulted dorsal surface, with developed ribs. The dorsal lip is separated from the dorsal surface with a developed arch shaped rib. The rounded upper aperture lip is present. The shell has a flat dorsal side. The caudal spine is straight. The ventral side is moderately vaulted. The shell sculpture consists of faint growth lines and faint transverse striation.
Indian Distribution: Andaman Sea, Car Nicobar Island (Bhattacharjee *et al.,* 1999).
Other Distribution: Caribbean Sea, Gulf of Mexico, Mascarene Basin, Greek Exclusive Economic Zone, Mexico, European waters, United Kingdom Exclusive Economic Zone, Atlantic, Canadian Exclusive Economic Zone, Indo-Pacific waters, New Zealand Exclusive Economic Zone, North East Pacific.

FAMILY **Creseidae**
GENUS ***Creseis* (Rang, 1828)**

(iii) *Creseis virgula* (Rang, 1828)
Type species: *Cleodora (Creseis) acicula* Rang, 1828
1828. *Creseis virgula virgula* Rang, *Ann. Sci. Nat.* 13: 302-319.
1834. *Hyalaea corniformis* d'Orbigny, *Tomecinquième, troisièmepartie*: *Mollusques*. 1-758.
1879. *Cleodora flexa* Pfeffer, *Akad. Wiss. Berlin* (1879): 230-246.
1886. *Creseis virgulata* Locard, *In*: A. Milne-Edwards (ed.). *Expédition scientifique du Travailleuret du Talisman pendant les années* 1880, 1881, 1882, 1883. Paris (Masson and Cie): i-vi, 1-516.
2002. *Creseis virgula frontier* Rampal, *Zoosystema,* 24(2): 209-258.
Materials examined: Vishakapatanam 30 m (Lat. 17° 41' 27") (Long. 83° 20' 67") (Fig.1, Pl.e). 10 specimens from the zooplankton sample of winter monsoon, Coll. Dr. Jasmine and party.
Diagnosis: The shell is 7 mm long; with an aperture-diameter of about 1 mm. The adult shell is colourless. The anterior part of the shell is straight, only the posterior tip is curved dorsally. The soft parts are characterised by the wing appendages. A short columellar muscle is present.
Indian Distribution: Eastern Arabian Sea (Singh *et al*., 2006), Eastern Bay of Bengal (Nair, 1981), Andaman Sea (Panchanag *et al.*, 2007).
Other Distribution: East Coast of South Africa,Cape Verde.

(iv) *Creseis clava* (Rang, 1828)
Type species*: Creseis clava* (Rang, 1828).
1828. *Cleodora (Creseis) acicula* Rang, *Ann. Sci. Nat.* 13: 302-319.
1828. *Cleodora (Creseis) clava* Rang, *Ann. Sci. Nat.* 13: 302-319.
1828. *Cleodora clava* Rang, *Ann. Sci. Nat.* 13: 302-319.
1834. *Hyalaea aciculata* d'Orbigny, *Tome cinquième, troisièmepartie*: Mollusques 1-758.
1843. *Creseis spiniformis* Benoit, *Farfalletta, Opera periodica scientific letter ariaartistica*11, 16: (6).
1850. *Creseis recta* Gray, *Catalogue of the Mollusca in the collection of the British Museum, 2. Pteropoda. London (British Museum, E. Newman)*: iv + 45 pp.
Materials examined: Vishakapatanam 30 m (Lat. 17° 41' 27") (Long. 83° 20' 67") (Fig.2, Pl.f). 8 specimens from the zooplankton sample of winter monsoon, Coll. Dr. Jasmine and party.
Diagnosis: The animal is connected with the columellar muscle to the caudal tip of the shell. This muscle disappears quickly above its attachment to the shell in the visceral mass, only a small part of it runs free in the shell lumen. The embryonic shell is never darker than the rest of the shell. The wings have a wing protrusion and opposite a wing gland.
The shell is straight, up to 6 mm long, with a diameter at the aperture of about 1 mm.
Indian Distribution: Shelf off North Kerala, Arabian Sea (Singh & Rajaram, 1997), Eastern Bay of Bengal (Nair, 1981), Off Madras Bay of Bengal (Aiyer *et al*., 1936). **Other Distribution:** Pacific Ocean, Atlantic Ocean.

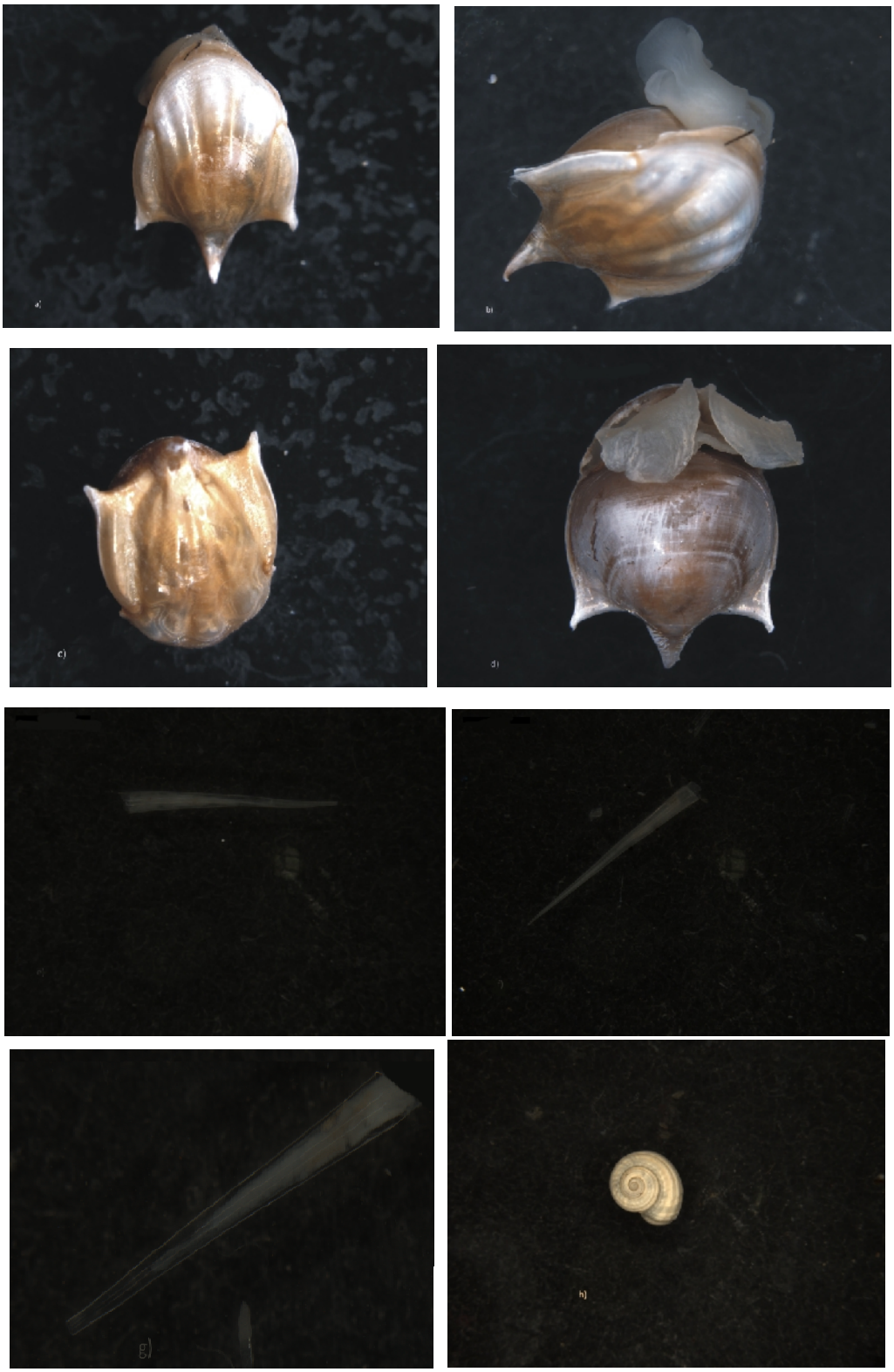

Fig. 2. Pteropods collected from the coastal waters of Orissa and Andhra Pradesh coasts. *Cavolinia uncinata dorsal* & ventral view (Pl. a & b) *Cavolinia tridentata* dorsal & ventral view (Pl. c & d).) *Creseis virgula* (Pl. e) *Creseis clava (*Pl. f) *Creseis chierchiae* (Pl. g) *Heliconoides inflatus* (Pl. h).

(v) *Creseis chierchiae* (Boas, 1886)

Type species: *Cleodora chierchiae* Boas, 1886

1886. *Cleodora chierchiae* Boas, *Selsk. Skr. (6 Raekke) naturv. math.* IV (1): 1-231.

1964. *Creseis chierchiae f. constricta* Chen & Bé, *Bull. Mar. Sci. Gulf. Caribb.* 14 (2): 185-220.

1974. *Creseis bulgia* Sakthivel, *Curr. Sci.* 43 (19): 619-620.

Materials examined: Vishakapatanam 30 m (Long 83° 20.677'), (Lat 17° 41.278'), (Fig. 2, Pl.g). 2 specimens from the zooplankton sample of winter monsoon, Coll. Dr. Jasmine and party.

Diagnosis: The shell is straight, but clearly becoming broader towards the aperture. Shell length is 1.4-1.6 mm. The shell aperture is round. Aperture oval without a beak. Shell usually transversely striated. A wing protrusion is present.

Indian Distribution: Arabian Sea off North Kerala coast (Singh *et al.,* 2006), Andaman Sea middle Andaman Island (Bhattacharjee, *et al.*, 2002).

Other Distribution: Mediterranean Sea, Red Sea.

SUPER FAMILY- Limacinoidea Gray, 1840
FAMILY- Limacinidae Gray, 1840
GENUS - Heliconoides d'Orbigny, 1835

(vi) ***Heliconoides inflatus* (d'Orbigny, 1834)**

1834. *Atlanta inflata* d'Orbigny *Mollusques*. Paris. 5 (3).

1834. *Embolus inflatus* d'Orbigny, *Mollusques*. Paris. 5(3).

1834. *Limacina inflata* d'Orbigny, *Mollusques*. Paris. 5(3).

1834. *Spiratella inflata* d'Orbigny, *Mollusques*. Paris. 5(3).

1840. *Spirialis rostralis* Eydoux & Souleyet, *Revue. Zool. Soc.* Cuvier. Paris: 235-239.

Material examined: Visakapatanam 30 m (Lat. 17° 41' 27") (Long. 83° 20' 67") (Fig.2, Pl.h). 3 specimens from the zooplankton sample of winter monsoon, Coll. Dr. Jasmine and party.

Diagnosis: This is a very small shelled pteropod, coiled nearly in one level. The shell is coiled in one level and has up to three whorls. In this specimen the rib starts at the underside of the whorl, running parallel to the aperture border and coming together in the middle of the last whorl to form the tooth. Brown spots occur in the vicinity of the tooth and umbilicus. The operculum is transparent, very thin and horny, coiled and slightly conical. The shell diameter is 1 mm; the operculum has 4.5 whorls in the operculum. The nucleus is centrally placed and the growth striations are clearly visible.

Indian Distribution: Arabian Sea, Bay of Bengal, Andaman Sea (Panchanag *et al*.2007).

Other Distribution: Belize, Cape Verde, Aruba, Bonaire, Caribbean Sea, Gulf of Mexico.

SUMMARY

Zooplankton samples from the winter monsoon collection along the southern Odisha and northern Andhra Pradesh coast at the depths of 10 m to 30 m stations revealed 6 species of pteropods belonging to three families and three genera. The *Creseis* spp. was predominant at 30 m depth stations whereas *Cavolinia* spp. was predominant at the stations of 10 m. Previous studies showed that *Creseis chierchiae* and *Creseis acicula clava* is mainly distributed at 30 m to 200 m water depth (Singh *et al.,* 2002). Higher numbers of pteropods were found in deeper layer of waters (Bhattacharjee *et al.,* 2005) but this survey collection was from the shallow waters (10 m to 30 m) of northern Bay of Bengal. Till date, *Creseis virgula*, *Creseis chierchiae* were not reported from the Orissa and Andhra Pradesh coasts of Bay of Bengal (Panchang *et al.*, 2007). *Creseis virgula*, *Creseis chierchiae* were present in the winter monsoon collection of southern Orissa and Andhra Pradesh at 30 m water depth. So these 2 species are new records from these coasts of Bay of Bengal.

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REFERENCES

Aiyar, R.G., Menon, M.G.K. (1936). Plankton records for the year 1929 and 1930. *Journal of Madras University*, **8**: 97-139.

Be, A.W.H, Gilmer R.W. (1977). A zoographic and taxonomic review of euthecosomatous pteropoda. In: Ramsay ATS (ed.) *Oceanic micropalaeontology. Academic Press, London,* p. 733–808.

Berner, R. A. (1977). Sedimentation and dissolution of pteropods in the Ocean. *In: Andersen, N. R. and Mala- hoff, A., eds., The Fate of Fossil Fuel CO_2 in the Oceans. Plenum Press, New York,* p. 323-343.

Bhattacharjee, D., Ghosh, S.K., Rakshit, S. & Mallik, T.K. (2002). Evidence of late Quaternary climatic changes revealed by pteropod record around Car Nicobar Island, Andaman Sea, Gondwana *Geol. Magz. Spl.* **4**: 157-167.

Bhattacharjee, D. (2005). Pteropod preservation profiles in seabed sediments off Middle Andaman Island in Andaman Sea, *Indian Journal of Marine Science*, **34**: 259-266.

Costa, O.G. (1861). Microdoridemediterranea e descrizione de poco ben conosciutiodaffattoignotiviventiminuti e microscropicidel Mediterraneo. *Napoli (Iride*): xviii + 80 pp., pls. 1A, 1-12.

Comeau, S., Gorsky, G., Jeffree, R., Teyssie, J.L. & Gattuso, J.P. (2009). Impact of ocean acidification on a key Arctic pelagic mollusc (*Limacina helicina*). *Biogeosciences.* **6**: 1877-1882.

Dall W.H. (1908). Reports on the Mollusca and Brachiopoda. *Bulletin of the Museum of Comparative Zoology*, **43**(6): 205-487.

Fabry, V. J., Seibel, B. A., Feely, R. A., and Orr, J. C. (2008). Impacts of ocean acidification on marine fauna and ecosystem processes. *ICES Journal of Marine Science,* **65**(3): 414-432.

Goswami, S.C. & Padmavati, G. (1996). Zooplankton production, composition and diversity in the coastal waters of Goa. *Indian Journal of Marine Sciences,* **25**, 91-97.

Hunt B.P.V. &Hosie G.W. (2003). The continuous Plankton Recorder in the Southern ocean: a comparative analysis of zooplankton communities sampled by the CPR and vertical net hauls along 140˚ E. *Journal of Plankton Research,* **25**(12): 1-19.

Hunt, B. P. V., Pakhomov, E. A., Hosie, G. W., Siegel, V., Ward, P., and Bernard, K (2008). Pteropods in Southern Ocean ecosystems. *Progress in Oceanography*, 78: 193–221.

Herman, Y., (1968). Evidence of Climatic changes in Red sea cores. *7th INQUA Congress Proceedings*, **8**: 325.

Janssen A.W. (2012). Late Quaternary to Recent holoplanktonic Mollusca (Gastropoda) from bottom samples of the eastern Mediterranean Sea: systematics, morphology. *Bollettino Malacologico*, **48** (suppl. 9): 1-105.

Janssen, A.W., (1990a). Pteropoda (Gastropoda, Euthecosomata) from the Australian Cainozoic. *Scripta Geologica*, **91**: 1-76.

Krishnamurthy, K., (1967). Seasonal Variation in the plankton of Porto Novo waters (India). *Hydrobiologia*, **29**: 226-238.

Mohan, R., Verma, K., Mergulhao, L.P., Sinha, D.K., Shanvas, S. & Guptha, M.V.S. (2006). Seasonal variation of pteropods from the Western Arabian Sea sediment trap. *Geo-Marine Letters*, **26**(5), 265-273.

Niebuhr C. (ed.) (1775). Descriptiones animaliumavium, amphibiorum, piscium, insectorum, vermium quae in itinereorientali observavit Petrus Forskål, prof. Haun., post mortem auctorisedidit Carsten Niebuhr. *Hauniae [Copengagen], Möller*, pp. 1-19.

Orbigny, A. d', (1836-1846). Voyage dansl'Amériqueméridionale (le Brésil, la républiqueorientale de l'Uruguay, la république Argentine, la Patagonie, la république du Chili, la république de Bolivia, la république du Pérou), exécuté pendant les années 1826, 1827, 1828, 1829, 1830, 1831, 1832 et1833, *Mollusques. Paris (Bertrand)*, 5(3).

Singh, A.D. & Rajaram (1997). Distribution of Pteropods in surface sediments from the continental shelf of north Kerala. *Journal of Geological society of India,* **49**: 81-84.

Singh, A.D., Kroon, D. & Ganeshram, R.S. (2006). Millennial scale variations in productivity and OMZ intensity in the eastern Arabian Sea. *Journal of Geological society of India,* **68**: 369-377.

Singh, A.D., Ramachandran, K.K., Samusuddin, M., Nisha, N.R. & Haneeshkumar, V. (2001). Significance of pteropods in deciphering the late Quaternary sea-level history along the south western Indian shelf. *Geo-Marine Letters*, **20**: 243-251.

Sing A.D., Nisha, N.R & Joydas T.V. (2002). Distribution patterns of recent pteropods in surface sediments of the western continental shelf of India. *Journal of Micropaleontology* **24**: 39-54.

Sakthivel, M. (1976a). Geographical and seasonal distribution of Euthecosomata (Pteropoda, Gastropoda) in the Indian Ocean. *Meteor Forsch. Ergebniss*, **23**: 1-22.

Van Straaten, L. M. J. U., (1972). Holocene stages of oxygen depletion in deep waters of Adriatic Sea, in: Stanley, D.J. (ed.), The Mediterranean Sea; *A natural sedimentation laboratory, Dowden, Hutchison & Ross, Inc., Stroudsburg*, p.631-643.

Van der Spoel S, Newman LJ, Estep KW (1997) Pelagic molluscs of the world: *ETI world biodiversity CD-ROM series-version 1*.

Van der Spoel, S. (1967). "Euthecosomata, a group with remarkable developmental stages (Gastropoda, Pteropoda)". *J. Noorduyn and Zn, Gorinchem*, 1-375.