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Identification of Marine Zooplankton in the Maheshkhali Channel, Cox's Bazar, Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The purpose of the study was to identify and characterize marine zooplankton in the Maheshkhali Channel, Cox's Bazar, Bangladesh. A total of 25 species were identified from the samples collected from the surface water during November, 2022. They were categorized into 4 major groups such as copepoda, crustaceans, ichthyoplankton and meroplankton. Copepods were the most dominant. Among the copepods*, Oithona sp., Oncaea sp., Calanus sp., Subeucalanus flemingeri, Cyclops sp., Acartia sp., Labidocera sp. and Canthocalanus* pauper were ubiquitous, with *Oithona brevicornis, Oithona nana, Acartia tonsa, Subeucalanus sp.* being moderately frequent. The presence of *Centropages sp., Paracalanus aculeatus, Paracalanus sp., Pseudodiaptomas sp. and Acartia (Odonticartia)* ohtsukai were rare. Shrimp larvae, crab zoea and ichthyoplankton were moderately found. Mysid shrimps were found to be highly prevalent whereas ctenophora larvae were less frequent. Copepod, naupliar larvae and copepodites were observed to be consistently present throughout the observed area. The identified species possess great

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significance in the marine food web. This investigation is the baseline study of marine zooplankton in the Maheshkhali Channel. Further research, therefore, is recommended to identify zooplankton species through microscopic and molecular methods in the coastal waters of Bangladesh.

Keywords: Copepoda; identifying characteristics; habitat; distribution; microscopic species; naupliar larvae; Pseudodiaptomas sp.; marine food; biogeochemical.

1. INTRODUCTION

Zooplankton are the primary consumers of the marine food web. They act as an important link for energy transfer between primary producers and higher trophic levels such as fish, shellfish and marine mammals [1,2,3]. They consistently influence ocean biogeochemical cycles through direct and indirect feedback loops [4]. These organisms are used as bioindicators for water quality and climate change due to their short life cycles and quick response to natural and anthropogenic perturbation [5,6]. Copepods, for instance, have been employed as indicators of pollution and increasing temperature [6,7]. Compiling the existing zooplankton and categorizing them, therefore, are necessary to obtain a distinct profile of the marine environment. For years, the identification and characterization of zooplankton is based on morphological analysis. However, in recent times, the integration of morphological information and molecular data has been approached to acquire more reliable results [8]. Modern techniques are applied for the assessment of the zooplankton community including protein profiling to distinguish between zooplankton species [9], comparison between cDNA and gDNA mitochondrial COI gene amplicon sequencing, and metatranscriptome sequencing [10].

The range from 32 to 55 zooplankton species was identified in the coastal waters of Bangladesh [6,11,12]. The dominant species were *Acartia tonsa, A. denae, Calanus glacialis, Acetes indius, Lucifer typus,* etc. The dominant groups were copepods, amphipoda, isopoda, crustaceans, ichthyoplankton and meroplankton. Although there are some studies on zooplankton ecology in several coastal areas of Bangladesh [6,11,12,13], the identification of zooplankton in many coastal areas of Bangladesh (which are also important for nursery and breeding ground for fisheries) remain undetermined.

The Maheshkhali Channel, situated at the south-eastern coast of the Bay of Bengal, is important for fish biodiversity, coastal aquaculture, and recreational purposes. It is a habitat of around 35 fin fish, 10 shrimp and 7 species of cephalopods [14,15,16]. This channel is also vulnerable to eutrophication as well as harmful algal species (i.e. *Dinophysis caudate*, *Alexandrium catenella*, *Gymnodinium coeruleum*, etc.) [17] due to agricultural, aquaculture and industrial discharges. Although there were some studies on phytoplankton in this channel [18, 19, 20], there has been limited studies on zooplankton. The purpose of the study was, therefore, to identify marine zooplanktons in Maheshkhali Channel of Cox's Bazar, Bangladesh. The identifying characteristics of zooplankton species and its distribution in the Bay of Bangla, Bangladesh and worldwide were also discussed.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted at the Maheshkahli Channel, situated at the south-eastern coast of the Bay of Bengal, Bangladesh (Fig. 1). The channel includes Bakkhali River in the north and the Bay of Bengal in the south. It holds significance as a large fishing ground and a center for recreation. Different traditional capture fisheries and commercial shrimp farms have developed around this estuary.

2.2 Identification of Zooplankton

The water sample was collected from the surface layer of the water column during November, 2022. The sample was preserved with lugol's solution in 250 ml plastic bottles. Zooplanktons were identified up to species level as possible. Taxonomic study was conducted based on Yamaguchi and Bell [21] and Al-Yamani et al. [22].

3. RESULTS AND DISCUSSION

A total of 25 species was identified (Table 1, Fig. 2). They were categorized into four major groups such as copepods, crustaceans, ichthyoplankton and meroplankton. Copepods were ubiquitous.

Crustaceans were also frequently found. This finding was consistently with some previous studies in Bangladesh [6, 11, 12]. For instance, 39 species were identified in northern Bay of Bengal, most of which were copepod and crustacean [6]. The range of 33-34 species were recorded in the Bakkhali River estuary, Cox's Bazar [11] and St. Martin's Island, Bangladesh [12] where copepods and crustaceans were dominant species.

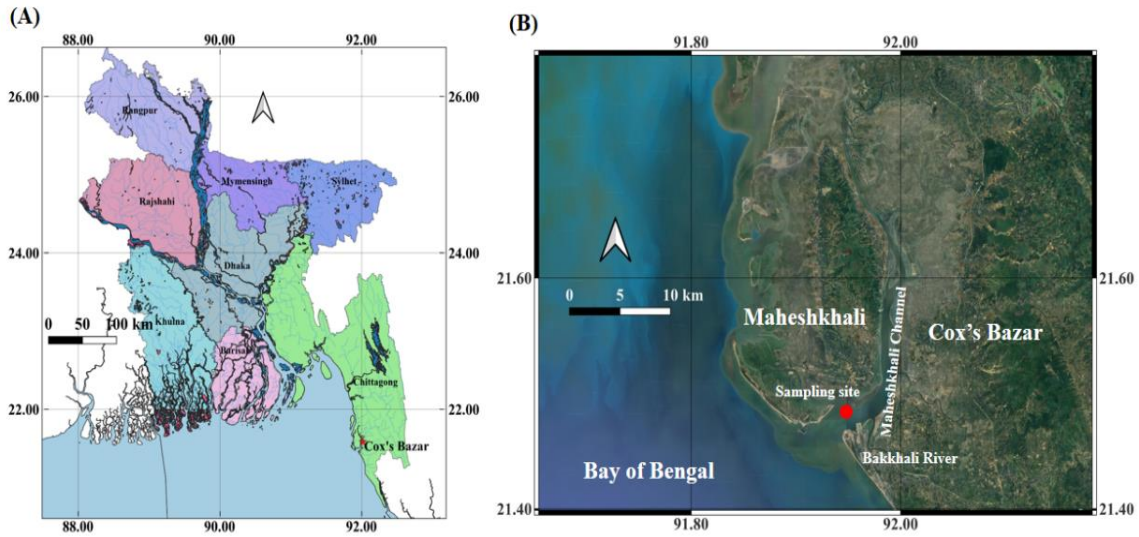

Fig. 1. Map showing (A) the entire Bangladesh and (B) the sampling stations in the Maheshkhali Channel, Cox's Bazar

Table 1. The list of zooplankton species was identified in the Maheshkhai Channel during November 2022

Group	Family	Genus	Species
Copepods	Centropagidae	*Centropages*	*Centropages sp.*
	Paracalanidae	*Paracalanus*	*Paracalanus aculeatus*
			Paracalanus sp.
		Acrocalanus	*Acrocalanus longicornis*
	Calanidae	*Calanus*	*Calanus sp.*
		Canthocalanus	*Canthocalanus pauper*
	Eucalanidae	*Subeucalanus*	*Subeucalanus sp.*
			Subeucalanus flemingeri
	Pontellidae	*Labidocera*	*Labidocera acuta*
	Pseudodiaptomidae	*Pseudodiaptomas*	*Pseudodiaptomas sp.*
	Oncaeidae	*Oncaea*	*Oncaea sp.*
	Cyclopidae	*Cyclops*	*Cyclops sp.*
	Acartiidae	*Acartia*	*Acartia sp.*
			Acartia (Odonticartia) ohtsukai
			Acartia tonsa
	Oithonidae	*Oithona*	*Oithona sp.*
			Oithona brevicornis
			Oithona nana
			Copepod naupliar larvae
			copepodite
Crustacean			Shrimp larvae
	Mysidae		Mysid shrimp
			Crab zoea
Ichtyoplankton			
Meroplankton			Ctenophora larvae

The copepods are pervasive in the study and most of the species look almost identical carrying very small distinguishable characteristics. To make their identification easier, keys to the order and families of copepoda are presented:

Key to the order of Copepoda:

1. Females with one median egg sac…….2 and 3

Females with two lateral egg sac……..3

2. First antenna is as long or longer than body…….Calanoida
3. Anterior body part is much broader than posterior part……4

Anterior body part is as broad as posterior part……5

4. First antenna is much shorter than body…..Cyclopoida
5. First antenna is very short…….Harpacticoida

Key to families of order of Calanoida:

1. Cephalosome and first pedigerous somite separate…….2

Cephalosome and first pedigerous somite may be combined or distinct……2

Cephalosome and first pedigerous somite combined…….2

2. Fourth and fifth pedigerous somite always blended together……..3

Fourth and fifth pedigerous somite may be combined or distinct …..3
Fourth and fifth pedigerous somite separate……...3 and 10

3. Fifth swimming leg uniramous…..4

Fifth swimming leg biramous……6 and 9

4. Single eye present……Acartiidae

One or two pairs of subcuticular eye……..Pontellidae

5. Caudal rami tend to be assymmetrical……..7 and 8
6. Antennule, exopod and endopod almost equal in size……..Centropagidae
7. Antennule symmetrical……Pseudodiaptomidae
8. Antennule and exopod shorter than endopod……Eucalanidae
9. Rostrum of two filaments…….Paracalanidae
10. Fifth swimming leg reduced to a small setae…….Calanidae

Key to the families of order Cyclopodia:

1. Urosome slender, of 5 somites…….2
2. Prosome short oval to long fusiform in dorsal view……3

Prosome elongate to elongate oval…….4

3. Anterior end of head quadrate, rounded or produced into pointed rostrum…….5
4. Rostrum fused to cephalosome……..6
5. Base tranversally elongated and fused to Endopod 1…….Oithonidae
6. Endopod absent……. Oncaeida

3.1 Identifying Characteristics, Habitat and Distribution of Marine Zooplankton in Maheshkhali Channel, Cox's Bazar, Bangladesh

3.1.1 *Acartia* sp. Dana, 1846

Identifying characteristics: This is a small copepod. Cephalosome and first pedigerous somite is distinguished; fourth and fifth pedigerous somite is combined. Antnnule is long and possess spiny appendages. Rostrum may be present, but carry two filaments if present.

Habitat: *Acartia* sp. can be found in estuarine and coastal waters that are warm throughout the year.

Distribution: *Acartia sp.* are found in estuaries and upwelling regions. This species was recorded at St. Martin Island [12], Bakkhali river estuary [11] and northern Bay of Bengal Bangladesh [6].

3.1.2 *Acartia (Odonticartia) ohtsukai* Ueda & Bucklin, 2006

Identifying characteristics: Cephalosome and first pedigerous somite are fused. Pedigerous somites possess small denticle-like spines posteriorly. Rostrum is present comprising of two filaments. Caudal rami is way longer in

comparison to width. Genital somite also carries two teeth-like spines.

Habitat: *Acartia (odonticartia) ohtsukai* is a brackish water calanoid copepod. They are epipelagic and zooplanktonic found throughout the oceans of the world, mostly in temperate regions.

Distribution: The species is found throughout the world, mostly in the regions of Indian Ocean.

3.1.3 *Acartia tonsa* Dana, 1849

Identifying characteristics: Length of urosomal part is very shorter than prosome. Urosome possess thin hair-like appenages. Antennule is long and possess large spines. Swimming legs are comprised by long setae. Caudal branches are observed to be uneven.

Habitat: *Acartia tonsa* is neritic species. It can be found in estuarine and coastal waters that are warm throughout the year.

Distribution: The species is cosmopolitan and found in Atlantic, Indo-Pacific Ocean [23]. It was found in the coastal waters of northern Bay of Bengal, Bangladesh [6].

3.1.4 *Acrocalanus longicornis* Giesbrecht, 1888

Identifying characteristics: The body is deeply curved from dorsal view and head is blunt. A large number of very small denticle structures is observed on swimming legs. Antennule is so long that sometimes it reaches past caudal rami. Urosome ends in a pointed process.

Habitat: The species is epipelagic. It mainly occurs in warm, tropical, subtropical neritic and oceanic waters.

Distribution: The species is found in Indian Ocean, China Sea, Mediterranean Sea and Black Sea.

3.1.5 *Calanus* sp. Leach, 1816

Identifying characteristics: Body is almost completely transparent. Body is ovoid shaped. Red color is observed on antennule and antenna. Prosome is longer in size than urosome. The length of antennule goes beyond body length.

Habitat: They are epipelagic, mostly live in surface waters.

Distribution: Most species live in temperate oceanic regions, but some are restricted to north Atlantic Ocean. The species was found in the Sitakunda coast of Chittagong [13], Bakkhali river estuary of Cox's Bazar in Bangladesh [11].

3.1.6 *Canthocalanus pauper* Giesbrecht, 1888

Identifying characteristics: Cephalosome and first pedigerous somite cannot be differentiated from each other. Rostrum is well defined and filamentous. Urosome is composed of four segments. Caudal rami carry strong thorny appendages. Setae are also observed on swimming legs.

Habitat: It is epipelagic. They live in oceanic, coastal and estuarine waters.

Distribution: They are distributed in the tropical and subtropical regions of Indian and Pacific Ocean. In Bangladesh, the species is found in northern Bay of Bengal [6, 24] and St. Martin Island [12].

3.1.7 *Centropages* sp.

Identifying characteristics: Head contains rostrum and cephalosome is curved at both sides. Cephalosome can be clearly distinguished from first pedigerous somite. Fifth pedigerous somite ends in a spiniform process. Urosome is three to five segmented varying in males and females. Caudal rami has strong spines.

Habitat: The species is epipelagic, found mostly in the estuarine waters of tropical regions.

Distribution: The species is widely distributed in warm waters, especially in Indian Ocean and China Sea. The species was recorded in Bakkhali river estuary of Cox's Bazar, Bangladesh [11].

3.1.8 Ctenophora larvae

Identifying characteristics: Their body is comprised of circular, ovoid or pear shape. The larvae is free swimming and swims with the help of cilia. Body is almost transparent.

Habitat: All ctenophores are confined to marine habitats. But ctenophores happen to be found in brackish waters at their early stages. They live in almost all oceanic regions, particularly in surface water nearshores.

Distribution: Ctenophores are distributed in all types of marine environments, for example, in coastal waters, estuaries mid oceans, polar regions, etc. In Bangladesh, ctenophora larvae was recorded in the Sitakunda coast [13], Bakkhali river estuary [11] and Northern Bay of Bengal [6, 24].

1.1.9 Copepodite

Identifying characteristics: It is the later stage of copepod naupliar larvae; at this stage the species looks a bit like adult copepod. Body is changed into cone shaped structure. Antennule is visible but not developed. Prosome and urosome are not well defined yet.

Habitat: As copepodite is the developed stage of copepod nauplii, it lives in water column as naupliar larvae does. Marine coepodites are found in the estuarine and coastal waters.

Distribution: Marine copepodites are distributed in all regions where adult copepodes live. In Bangladesh, marine copepodites are found in the estuaries, coastal and open waters of Bay of Bengal.

3.1.10 Copepod Nauplius larvae

Identifying characteristics: Nauplii does not resemble adult copepod; their body is round or ovoid. They do not possess any true thorax or abdomen. They have feather-like appendages which keep them floated on water surface. One black eye clearly visible.

Habitat: These larvae live in the water column as part of other zooplankton. Larvae of marine copepods are usually found in the nearer estuarine waters.

Distribution: Marine copepod larvae are distributed in all regions where adult copepodes live. In Bangladesh, marine copepodites are found in the estuaries, coastal and open waters of Bay of Bengal.

3.1.11 Crab zoea

Identifying characteristics: Crab zoea are free swimming. They have a round head which possess a spiny rostrum, the most significant feature of crab zoea. The abdominal part is thin and curvaceous. Thelson in bifurcate.

Habitat: Crab zoea prefers brackish estuarine water to live. They are pelagic.

Distribution: They are distributed in all the ocean surface waters and estuarine waters nearby the adult crab communities. In Bangladesh, crab zoea is found almost in all narrow marine regions, for example, Bakkhali estuary [11], Rezukhal estuary [25], Karnaphuli river estuary [26] and coastal waters of Northern Bay of Bengal [6, 24].

3.1.12 *Cyclops* sp.

Identifying characteristics: The prosome section is predominantly ovoid in shape and the urosome section is slender. Two protruding caudal appendages are observed. Antennule does not extend beyond body length. Cyclops have a red or black eye visible very precisely. The tail is forked and contains spines.

Habitat: They are epipelagic. They live in oceanic, coastal and estuarine water.

Distribution: The species is widely distributed in the estuarine and freshwater regions of the world. *Cyclops sp.* is distributed in various marine regions of Bangladesh, for example, coastal aquatic environment of Mathbaria [27] and Swatch of no ground of northern Bay of Bengal [28].

3.1.13 *Labidocera* sp. Al-Yamani & Prusova, 2003

Identifying characteristics: Body shape is bilaterally symmetrical and prosome ends in a spiniform process. Head is rounded and rostrum is deeply pointed. Urosome is composed of 3 to 5 somites varying in males and females. First urosome segment may contain small spines. Endopodite resembles as a claw.

Habitat: They are epipelagic. They live in oceanic, coastal and estuarine waters.

Distribution: The species is predominant in the regions of Indian Ocean. In Bangladesh, the species is found in the waters adjacent to St Martin Island [12] and Bakkhali river estuary [11].

3.1.14 Mysid Shrimp

Identifying characteristics: Mysid shrimp is very small, but can be seen in naked eye if the slide is hold against the light. It almost resembles true shrimp, but can be differentiated by a brood puch they carry. They have a pair of large

eyestalks. Their body is composed of eight thoracic segments, first segment of which is fused with cephalon. Thoracic segments possess maxillapeds and pleopods which are used for feeding and swimming respectively.

Habitat: Species within the order are found throughout the world in marine coastal and brackish waters.

Distribution: Mysids have a global distribution and are found in both marine and freshwater environments, the deep sea, estuaries, shallow coastal waters, and many other waterbodies. Mysids have a wide distribution in the waterbodies of Bangladesh including Bakkhali estuary [11], Rezukhal estuary of Cox's Bazar [25], coastal waters of Northern Bay of Bengal [6, 24].

3.1.15 *Oithona* sp. Baird, 1893

Identifying characteristics: Prosome is ovoid shaped and rostrum is blunt. Antennule is not very long. Length of urosome is almost equal to prosome. Caudal rami possess spines.

Habitat: *Oithona sp.* occur in marine, brackish and freshwater environments. *Oithona* is considered as ubiquitous and abundant copepod.

Distribution: *Oithona* is a cosmopolitan copepod and found worldwide in all oceans. In Bangladesh, *Oithona sp.* is found in the Bakkhali river estuary of Cox's Bazar [11], Sitakunda coast of Chittagong [13], and waters adjacent to St. Martin Island [12].

3.1.16 *Oithona brevicornis* Giesbrecht, 1891

Identifying characteristics: Head is rounded dorsally but pointed in ventral view. Rostrum is a little bit arched downward. Urosome is 5 segmented. Caudal rami possess long setae. Antennule is short, does not go beyond the length of prosome.

Habitat: *Oithona brevicornis* occurs in temperate and tropical waters. They are mostly found in coastal waters.

Distribution: The species is widespread along with the regions of Pacific, Indian and Atlantic oceans [29]. In Bangladesh, the species was found in the waters adjacent to St. Martin Island [12] and in the Swatch of No Ground of northern Bay of Bengal [28].

3.1.17 *Oithona nana* Giesbrecht, 1893

Identifying characteristics: Head is shortened and tapered from dorsal point of view. Rostrum is not observed from dorsal surface. Genital somite is significantly swollen than other urosomites. Body is wider than abdominal part and urosome length is as much as prosome. Caudal rami is longer than its width. Antennule is very short.

Habitat: The species is epipelagic and neritic. It is mostly found in coastal waters of temperate countries.

Distribution: The species is widespread in Pacific, Atlantic and Indian Ocean in warmer waters, Mediterranean and Red Sea [30]. The species was recorded in the waters adjacent to St. Martin Island in Bangladesh [12].

3.1.18 *Oncaea sp*.

Identifying characteristics: Cephalosome and first pedigerous somite can easily be separated. Prosome and urosome are precisely segmented and both of them are composed of 5 somites. Rostrum is blent with cephalosome. Antennule is very short. Caudal rami contain setae.

Habitat: They are epipelagic. It lives in oceanic, coastal and estuarine water.

Distribution: Excluding Arctic Ocean, *Oncaea sp.* has a cosmopolitan distribution, especially in Mediterranean Sea, Black Sea, Indian Ocean and Red Sea [31]. In Bangladesh, the species is distributed in the Sitakunda coast of Chittagong [13] and in St. Martin Island [12].

3.1.19 *Paracalanus aculeatus* Giesbrecht, 1888

Identifying characteristics: Antennule raches beyond body length. Prosome is way longer than urosome. Caudal rami is long and wide at the same proportion. Some leafy appendages can be observed in the fourth swimming leg. Fifth swimming leg is minute and sparse.

Habitat: The species is epipelagic, inhabiting in coastal and oceanic waters.

Distribution: The species is found worldwide except for northeast Pacific, north Atlantic and Arctic Ocean [32].

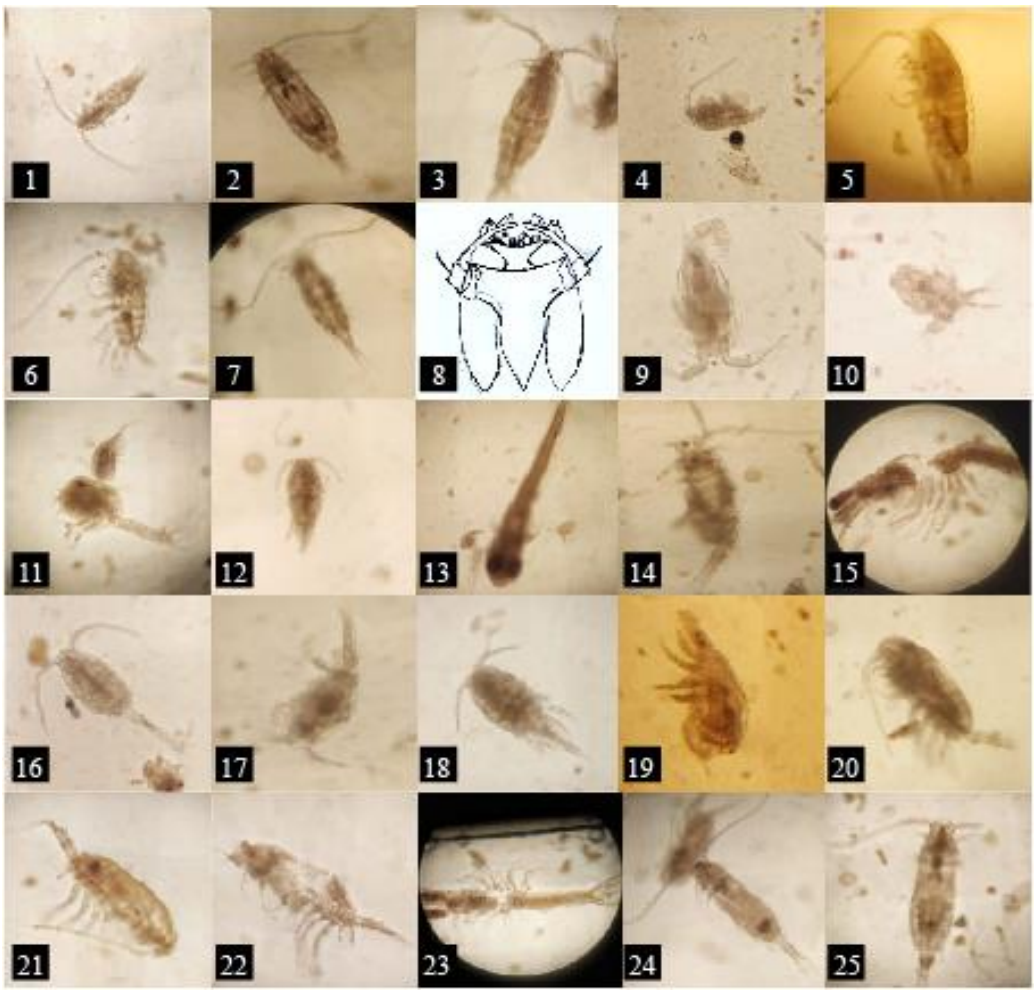

Fig. 2. The zooplankton species was identified in the Maheshkhai Channel during November 2022. 1. *Acartia* sp., 2. *Acartia (Odonticartia) ohtsukai,* 3. *Acatia tonsa,* 4. *Acrocalanus longicornis*, 5. *Calanus* sp., 6. *Canthocalanus pauper*, 7. *Centropages orsinii,* 8. Ctenophora larvae, 9. Copepodite, 10. Copepod nauplius larvae, 11. Crab zoea, 12. *Cyclops* sp., 13. Fish larvae, 14. *Labidocera* sp., 15. Mysid shrimp, 16. *Oithona* sp., 17. *Oithona brevicornis*, 18. *Oithona nana*, 19. *Oncaea* sp., 20. *Paracalanus aculeatus*, 21. *Paracalanus* sp., 22. *Pseudodiaptomus* sp., 23. Shrimp larvae, 24. *Subeucalanus subcrassus*, 25. *Subeucalanus flemingeri*

3.1.20 *Paracalanus* sp. Boeck, 1864

Identifying characteristics: Body is plumpy head is rounded and its surface is plain. Antennule is long but does not go beyond caudal rami. Rostrum is present and filamentous. Genital somite is larger than other urosomites. Swimming legs do not possess any appendages.

Habitat: The species is epipelagic, inhabiting in coastal and oceanic waters.
Distribution: The species is abundant in coastal and oceanic waters from temperate and tropical regions [32].

3.1.21 *Pseudodiaptomus* sp. Herrick, 1884

Identifying characteristics: Cephalosome and first pedigerous somite can easily be distinguished. Rostrum is not visible from dorsal view. Genital flap is observed in first urosomal segment in female. In female, urosome is four segmented; and five segmented in male. Caudal rami has spines.

Habitat: *Pseudodiaptomus arabicus* is a pelagic zooplankton, found in marine and estuarine waters.

Distribution: *Pseudodiaptomus* sp. have been found in *India, Indo-Pacific and eastern Atlantic Ocean* [33].

3.1.22 Shrimp Larvae

Identifying characteristics: Frontal organs are present and branched. Both rudimentary eyestalks are very close. Telson has spines. Third spine of telson is about 3 times as long as 4th one. Bay is almost transparent.

Habitat: They are epipelagic. They live in oceanic, coastal and estuarine waters.

Distribution: Most of the shrimp larvae are distributed in the estuarine and coastal waters of tropical and temperate regions, a few is found throughout the North Atlantic and Arctic Ocean. In Bangladesh, shrimp larvae is predominant in the southeast to southwest coast regions. The regions include coastal waters of northern Bay of Bengal [6, 24], Sitakunda coast of Chittagong [13], Bakkhali river estuary [11] and Rezukhal estuary of Cox's Bazar [25].

3.1.23 *Subeucalanus* sp.

Identifying characteristics: Cephalosome and first pedigerous somite are fused. Head is elongated in shape. Urosome is 3 segmented. Genital somite is slightly swollen, can easily be differentiated from other urosomites. Caudal rami is shorter than width.

Habitat: The species is pelagic, found in marine, coastal and estuarine waters.

Distribution: The species is widely distributed in the regions of Indian and Pacific Ocean [34]. In Bangladesh, the species was recorded in St. Martin's island [12].

3.1.24 *Subercalanus flemingeri* Prusova, Al Yamani & Al Mutairi, 2001

Identifying characteristics: Head is rounded and rostrum is easily distinguishable. Antennule is longer than body length. First four swimming legs are biramous and fifth one is uniramous. Genital somite is wider than other urosomites.
Habitat: The species is pelagic, found in marine water.

Distribution: The species is strictly distributed in the tropical regions of Indian Ocean [35]. The species was recorded in the St. Martin Island [12].

4. CONCLUSION

The diverse group of zooplanktons were identified in the Maheshkhali Channel. This study would be the baseline assessment to checklist the zooplankton species in the coastal waters that could further help in fisheries as well as aquatic resources management. This research is, therefore, recommended to identify zooplankton through traditional (microscopic) and molecular methods from the Maheshkhali Channel.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Pitois SG, Lynam CP, Jansen T, Halliday N, Edwards M. Bottom-up effects of climate on fish populations: Data from the continuous plankton recorder. Mar Ecol Prog Ser. 2012;456:169-186.
Available:https://doi.org/10.3354/meps09710
2. Ruzicka JJ, Brodeur RD, Emmett RL, Steele JH, Zamon JE, Morgan CA, Thomas AC, Wainwright TC. Interannual variability in the northern California current food web structure: changes in energy flow pathways and the role of forage fish, euphausiids, and jellyfish. Prog Oceanogr. 2012;102:19-41.
Available:https://doi.org/10.1016/j.pocean.2012.02.002
3. Heneghan RF, Everett JD, Blanchard JL, Richardson AJ. Zooplankton are not fish: improving zooplankton realism in size-spectrum models mediates energy transfer in food webs. Front Mar Sci. 2016;3:201.
Available:https://doi.org/10.3389/fmars.2016.00201
4. Schmidt K, Schlosser C, Atkinson A, Fielding S, Venables HJ, Waluda CM, Achterberg EP. Zooplankton gut passage mobilizes lithogenic iron for ocean productivity. Curr Biol. 2016;26:2667-2673.
Available:http://dx.doi.org/10.1016/j.cub.2016.07.058
5. Sullivan BK, Costello JH, Keuren DV. Seasonality of the copepods *Acartia hudsonica* and *Acartia tonsa* in Narrgansett Bay, RI, USA during a period of climate change. Estuar Coast Shelf Sci. 2017;73(1-2):259-267.

Available:https://doi.org/10.1016/j.ecss.2007.01.018
6. Al MA, Akhtar A, Rahman MF, AftabUddin, S, Modeo L. Temporal distribution of zooplankton communities in coastal waters of the northern Bay of Bengal, Bangladesh. Reg Stud Mar Sci. 2020;34:100993. Available:https://doi.org/10.1016/j.rsma.2019.100993
7. Hooff RC. Copepod biodiversity as an indicator of changes in ocean and climate conditions of the northern California current ecosystem. Limnol Oceanogr. 2006;51(6):2607-2620. Available:https://doi.org/10.4319/lo.2006.51.6.2607
8. McManus GB, Katz LA. Molecular and morphological methods for identifying plankton: What makes a successful marriage? J Plankton Res. 2009;31(10):1119-1129. Available:https://doi.org/10.1093/plankt/fbp061
9. Hynek R, Kuckova S, Cejnar P, Junková P, Přikryl I, Říhová Ambrožová J. Identification of freshwater zooplankton species using protein profiling and principal component analysis. Limnol Oceanogra-Meth. 2018;16(3):199-204. Available:https://doi.org/10.1002/lom3.10238
10. Machida RJ, Kurihara H, Nakajima R, Sakamaki T, Lin YY, Furusawa K. Comparative analysis of zooplankton diversities and compositions estimated from complement DNA and genomic DNA amplicons, metatranscriptomics, and morphological identifications. ICES J Mar Sci. 2021; 78(9):3428-3443. Available:https://doi.org/10.1093/icesjms/fsab084
11. MK AH, Idris MH, Johan I, Nesarul NH, Aysha A, Islam MS. Seasonal distribution of zooplankton composition and abundance in a sub-tropical mangrove and salt marsh estuary. Malays J Sci. 2016;35(2):275-289.
12. Alam MJ, Kamal AM, Ahmed MK, Khondker M, Fayyaz R. Spatial distribution and diversity of marine zooplankton adjacent to the St. Martin's Island, Bangladesh. J Ecol Eng. 2022;23(10): 154-163. Available:https://doi.org/10.12911/22998993/152435
13. Khan MSK, Uddin SA, Haque MA. Abundance and composition of zooplankton at sitakunda coast of chittagong, Bangladesh. Res Agric Lives Fish. 2015;2(1):151-160.
14. Abu Hena MK, Sharifuzzaman H, Aftabuddin MS, Haque MN. Coastal resources utilization and conservation issues in Cox's Bazar, Bangladesh. STREAM J. 2005;4:7-10.
15. Rashed-Un-Nabi M, Al-Mamun MA, Ullah MH, Mustafa MG. Temporal and spatial distribution of fish and shrimp assemblage in the Bakkhali river estuary of Bangladesh in relation to some water quality parameters. Mar Biol Res. 2011;7(5):436-452. Available:https://doi.org/10.1080/17451000.2010.527988
16. Kamal SA. Chad MNA, Hossain J, Ferdous A, Jahan R. Availability of marine fishes in cox's bazar, Bangladesh: A case study on the BFDC landing center. Croat J Fish. 2022;80:133-140. Available:https://doi.org/10.2478/cjf-2022-0014
17. Haque MM, Hossain MA, Khan S. Harmful algal blooms associated with mass mortality of fishes in the Bay of Bengal, Bangladesh. Proceedings of the 10th International Conference of Harmful Alage, Florida, USA; 2002.
18. Jewel MAS, Khan S, Haque MM. Seasonal dynamics in the occurrence and abundance of *Pseudo-nitzschia* species in the Maheshkhali channel of the bay of bengal, Bangladesh. Bangladesh J Fish Res. 2005;9(2):169-174.
19. Khan S, Jahan R, Ahmed MU, Rahman MA, Haque MM, Alom MZ. Dynamics of a heterotrophic dinoflagellate, *Protoperidinium divergens*, in the south-eastern coastal waters of the Bay of Bengal. Annu Res Rev Biol. 2019;33(6):1-9. Available:https://doi.org/10.9734/arrb/2019/v33i630140
20. Khan S, Jahan R, Rahman MA, Haque MM. Eutrophication enhances phytoplankton abundance in the Maheshkhali Channel, Bay of Bengal, Bangladesh. Aust J Sci Tech. 2019;3(3):141-147.
21. Yamaguchi E, Bell C. Zooplankton identification guide. The University of Georgia Marine Education Center and Aquarium; 2007.
22. Al-Yamani FY, Skryabin V, Gubanova A, Khvorov S, Prusova I. Marine zooplankton

practical guide. Kuwait Institute for Scientific Research Kuwait; 2011.

23. Figueroa NJ, Figueroa DF, Hicks D. Phylogeography of *Acartia tonsa* Dana, 1849 (Calanoida: Copepoda) and phylogenetic reconstruction of the genus *Acartia* Dana, 1846. Mar Biodivers. 2020;50:1-20. Available:https://doi.org/10.1007/s12526-020-01043-1
24. Al MA, Akhtar A, Kamal AHM, Islam MS, Uddin MM, Alam MD, Xu H. Seasonal pattern of zooplankton communities and their environmental response in subtropical maritime channels systems in the Bay of Bengal, Bangladesh. Acta Ecol Sin. 2018;38:316-324. Available:https://doi.org/10.1016/j.chnaes.2017.11.001
25. Iqbal MM, Islam MS, Haider MN. Heterogeneity of zooplankton of the rezukhal estuary, cox's bazar, Bangladesh with seasonal environmental effects. Int J Fish Aquat Stud. 2014;2(2):275-282.
26. Sharif ASM, Islam MS, Bhuyan MS. Spatio-temporal occurrence and distribution of copepod in the Karnaphuli river estuary, Bangladesh J Biodiver Environ Sci. 2017;10(1):271-282.
27. Mozumder PK, Naser MN, Alam M, Huq A. Abundance and seasonal diversity of zooplankton in coastal aquatic environments of Mathbaria, Bangladesh. Dhaka Univ J Biol Sci. 2011;20(2): 163-171. Available:https://doi.org/10.3329/dujbs.v20i2.8977
28. Sadia N, Ahmed MK, Khondkar MM, Rani S, Alam MJ, Al Karim A, Khan MI. Horizontal and vertical distribution and abundance of zooplankton around the swatch-of-no-ground of northern Bay of Bengal. Dhaka Univ J Ear Environ Sci. 2021;10(2):1-8. Available:https://doi.org/10.3329/dujees.v10i2.57510
29. Boxshall G, Boero F, Olenin S. Establishment of *Oithona brevicornis* Giesbrecht, 1892 (Copepoda: Cyclopoida) in the Black Sea. Aquat Invasions. 2007;2(4):407-410. DOI: 10.3391/ai.2007.2.4.10
30. Nishida S. Taxonomy and distribution of the family oithonidae (Copepoda, Cyclopoida) in the pacific and Indian Oceans. Bulletin of the Ocean Research Institute, University of Tokyo. 1985;20:1-167.
31. Sun R, Wang Y, Wang C, Xiang P, Chen X, Xing B. Research advance in the taxonomy and ecology of *Oncaeidae Giesbrecht*, 1893. Front. Mar Sci. 2022; 9:919877. Available:https://doi.org/10.3389/fmars.2022.919877
32. Khelifi-Touhami M, Ounissi M. *Paracalanus* Boeck, 1864. ICES Identification leaflets for plankton No. 199; 2023. Available:https://doi.org/10.17895/ices.pub.21724394
33. Rebello V, Narvekar J, Gadi P, Verenkar A, Gauns M, Kumar P. First record of the calanoid copepod *Pseudodiaptomus serricaudatus* (Scott, T. 1894), (Copepoda: Calanoida: Pseudodiaptomidae) in the equatorial Indian Ocean. Asian Fish Sci. 2014;27(2):149-159. Available:https://doi.org/10.33997.j.afs.2014.27.2.006
34. Goetze E, Ohman MD. Integrated molecular and morphological biogeography of the calanoid copepod family Eucalanidae. Deep-Sea Res II: Top Stud Oceanogr. 2010;57(24-26):2110-2129. Available:https://doi.org/10.1016/j.dsr2.2010.09.014
35. Prusova IY, Al-Yamani F, Al-Mutairi H. *Subeucalanus flemingeri* sp. n. from the Arabian Gulf (Copepoda: Eucalanidae). Zoosyst Ross. 2001;10(1):47-54.

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