Monitoring and Mitigating the Impacts of Mumbai Trans-Harbour Link on Flamingos and Other Avifauna and Formulating a Conservation Blueprint for the Sewri–Nhava Seascape

October 2018 to September 2019

Second Year Report

Submitted to

Mangrove and Marine Biodiversity Conservation Foundation of Maharashtra

Submitted by

BNHS India — Conserving Nature Since 1883

"Conservation of nature, primarily biological diversity, through action based on research, education and public awareness."

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Note: The findings are a summary of annual observations only. Final analysis will only be performed after completion of the project tenure. Thus the findings of the report cannot be used as standalone piece of information.

CONTENTS

Abbreviations

MTHL	Mumbai Trans-Harbour Link
MMRDA	Mumbai Metropolitan Region Development Authority
BNHS	Bombay Natural History Society
WCS	Wetland Count Surveys
TCS	Transect Count Surveys
FCS	Flamingo Count Surveys
NRI	Non-Resident Indian Complex
TSC	Training Ship Chanakya
BPS	Bhandup Pumping Station
SD	Standard Deviation
DPS	Dehli Public School
P	Phytoplankton
Z	Zooplankton

Summary

Habitats along the west coast of India such as creeks, mangroves, mudflats, salt marshes and wetlands harbour rich coastal and marine biodiversity. Therefore, it is the main wintering grounds for the waders migrating from Central or South Asia. To assess the possible effects of the MTHL (Mumbai Trans-Harbour Link) on waterbirds and their habitats in the eastern sea-front of Mumbai, MMRDA (Mumbai Metropolitan Region Development Authority) approached BNHS to monitor the impacts of the bridge on flamingos and other avifauna and marine fauna and suggest mitigation plan for the conservation of waterbirds and their habitats. The duration of study is ten years (2017–2027). The target taxa of study are waterbirds and marine benthic fauna. In the second year of the study (October 2018 – September 2019), we focused on the understanding of waterbirds and marine faunal abundance with respect to its spatial and temporal distribution along the study area. Our goals for the second year were as follows:

1. To estimate abundance of birds in high-tide roosting sites (wetlands) through wetland count surveys (WCS).
2. To estimate abundance of birds in the Thane Creek through transect count surveys (TCS).
3. To estimate Greater and Lesser Flamingo abundance in the Creek through flamingo count surveys (FCS).
4. To estimate richness, abundance and biomass of benthos in the different strata of the mudflats considering the beak length of waders.
5. To estimate richness and abundance of planktons.

Chapter 1 - Birds study

Introduction

In the second year of the study (2018–2019), we observed a steep decline in the abundance of migratory shorebirds in all wetlands after November–December, which was expected as migratory shorebirds use these wetlands as stopover sites. A similar trend was seen in the non-migratory shorebirds, which is intriguing and may be an indication of the decrease in benthic abundance in the wetlands or the local movement of the birds to other feeding or breeding sites. The high abundance of migratory shorebirds in Panje and TSC could be related to several factors like their wide expanse, closeness to the shore, variable water depths and openness of the habitats. Similarly, the preference of flamingos for NRI, TSC and BPS wetlands could be associated with the high water level in these wetlands.

A high abundance of migratory birds at the Thane Creek in November and December points to the fact that the migratory birds use these mudflats as refuelling sites. Our preliminary observations indicate positive association between the abundance of waders and benthic fauna. The high abundance of birds and benthic fauna on the east bank of the Creek could be associated with the nutrients load that can be inferred from the relatively low values of dissolved oxygen recorded at the east bank.

A relatively stable population of Greater Flamingos *Phoenicopterus roseus* could be either because most of the flamingos were overwintering in the study area or their migration period was very short (June/July to August/September). The latter reason, however, could not be supported with further evidence as surveys were not conducted in the monsoon season due to rough sea conditions and hence, changes in the population could not be reflected. On the other hand, observations of the adult Lesser Flamingos *Phoeniconaias minor* clearly showed that in January 2019, a large number of the flamingos joined the already existing population in the Creek. Interestingly, the subadult population did not show any sudden increase; it was either stable or decreasing. These observations further strengthen the possibility of overwintering populations of adult and subadult Lesser Flamingos.

Methodology

Study Area

The study area included the East and the West bank of the Thane Creek and Sewri Jetty (Fig. 1)

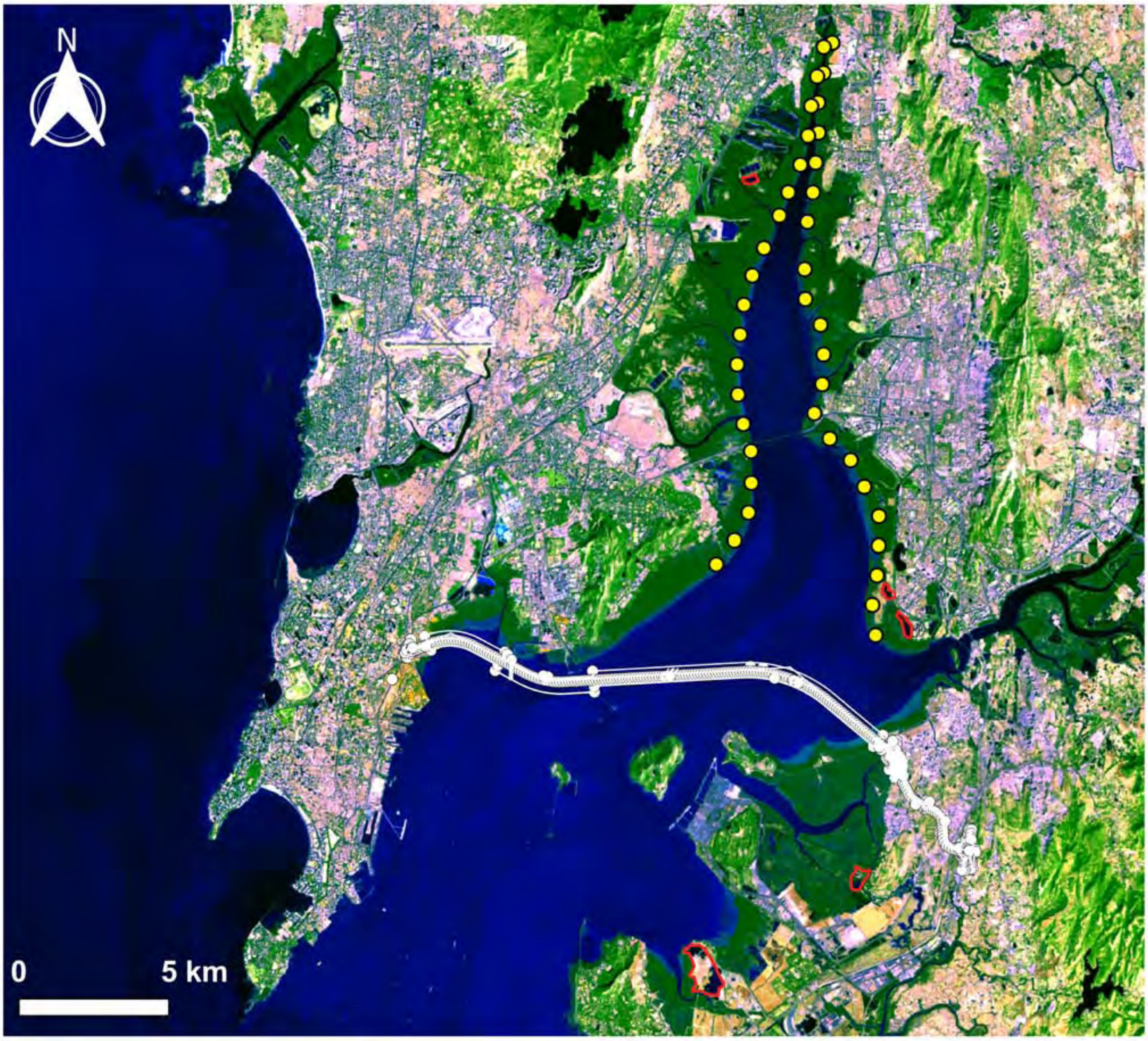

Fig.1. Land use and land cover map of the study area developed using Landsat 8 satellite imagery colour composite (January 2018; band combinations = 7, 5 and 3). Wetlands highlighted in red polygons and transects, in yellow circles; white circles are sea link (bridge) pillar locations. Forest and mangroves appear in shades of green, the darker colour indicating healthy and dense vegetation; urban areas displayed in cyan or purple; soil varies from dark to light brown, moist soil being darker in colour.

Bird Sampling

We counted shorebirds at high-tide roost sites following WCS protocol. In the Creek, we conducted flamingo count surveys following FCS protocol and shorebirds count surveys following TCS protocol. In addition, we also conducted bird behaviour surveys at high-tide roosting sites and feeding sites, and bird ringing at high-tide roosting sites (for details of the sampling, refer to Apte et al. 2018). All these surveys were carried out between October 2018 to July 2019.

Observations

Wetland (high-tide roosting sites)

In all, we recorded 47 migratory and 33 residential shorebird species in the wetlands. We found that the migratory shorebird population decreased gradually from October 2018 to January 2019 (54%) and then it declined significantly (95%) in March, 2019. Overall, the highest number of migratory shorebirds were recorded in October 2018 (24812 individuals) and lowest in March 2019 (1573 individuals) (Fig. 2). Among the wetlands, Panje and TSC had a substantially high number of shorebirds (Fig.3). Non-migratory shorebirds showed low relative abundance in wetlands (2–11% that of the migratory birds). Except for fluctuations at TSC, their numbers also decreased after January 2019. The highest count of non-migratory shorebirds was recorded in November (919) and lowest in March (188) (Fig. 4&5). Species richness of migratory birds was high from October 2018 to February 2019 (mean=18.8, SD=7.17) and was low between March to May 2018 (14.55, SD=6.71) (Fig.6).

Greater Flamingos were dominant in Belpada and BPS whereas Lesser Flamingos predominated the remaining wetlands. It appeared that the flamingos preferred NRI followed by TSC; the maximum number of flamingos counted at NRI in January was 13909 (Lesser Flamingo = 9985 and Greater Flamingo = 3924).

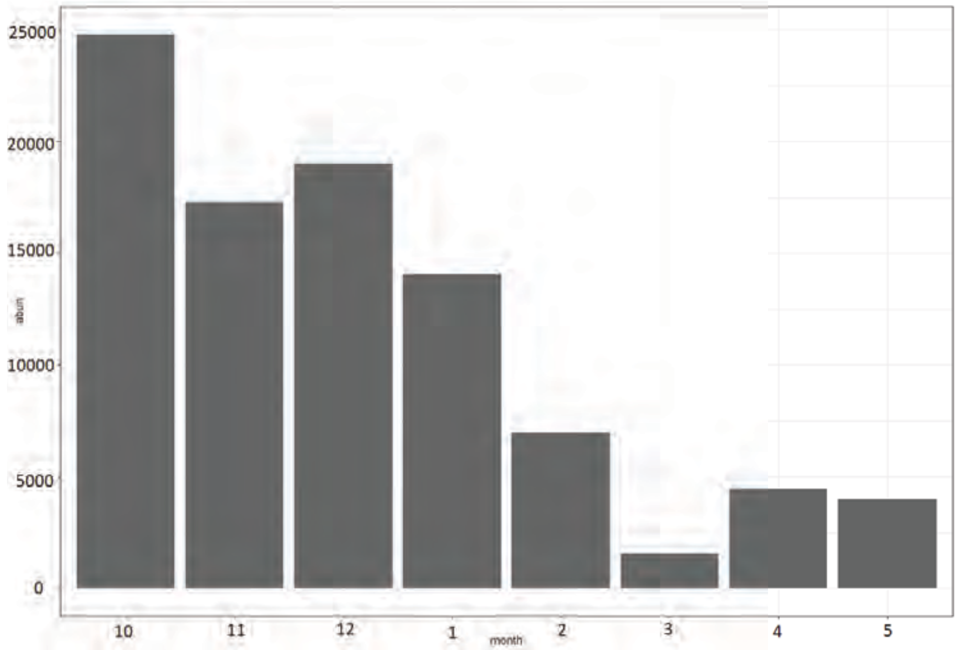

Fig. 2. Abundance of the migratory shorebirds in the wetlands

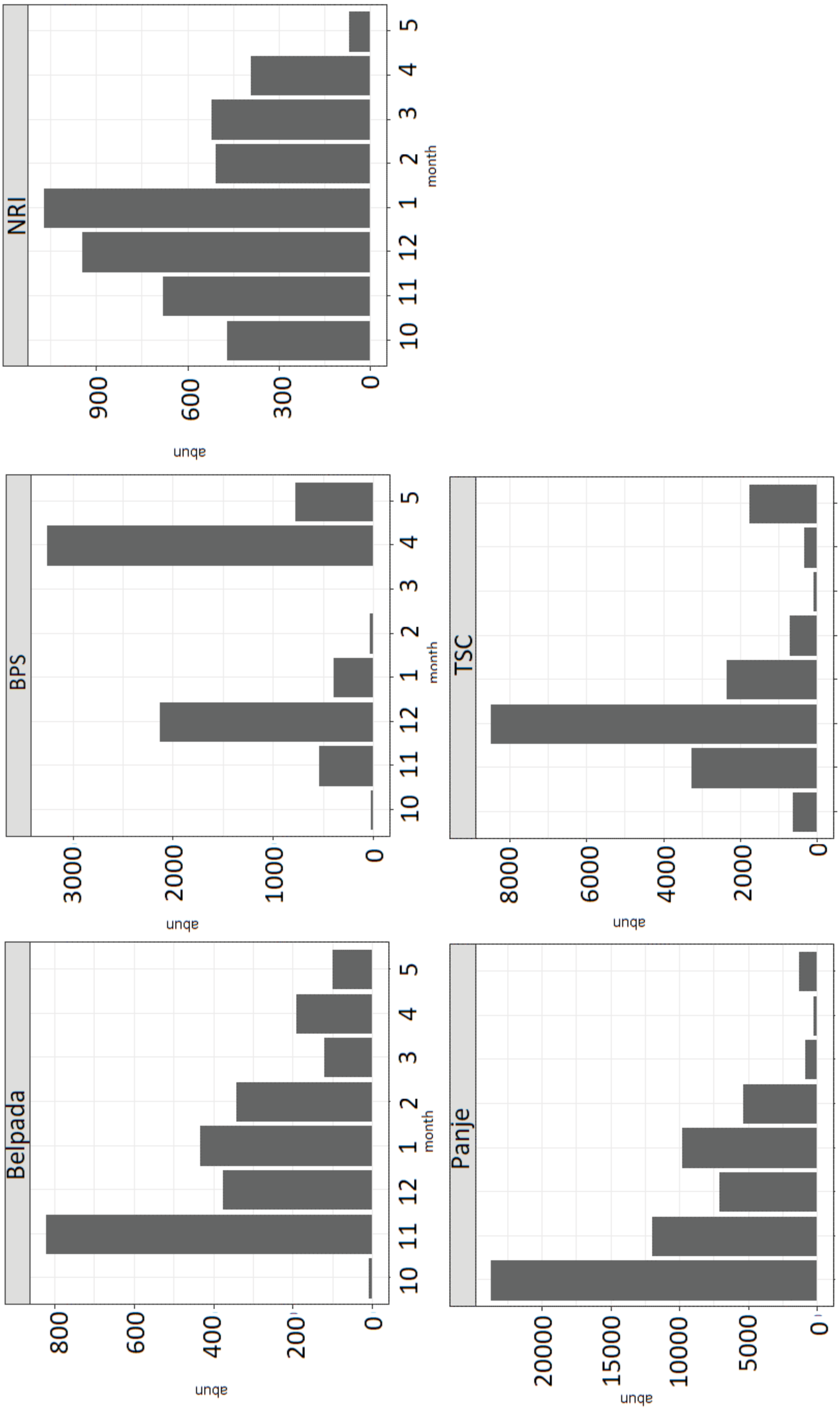

Fig. 3. Site-specific abundance of the shorebirds in the wetlands

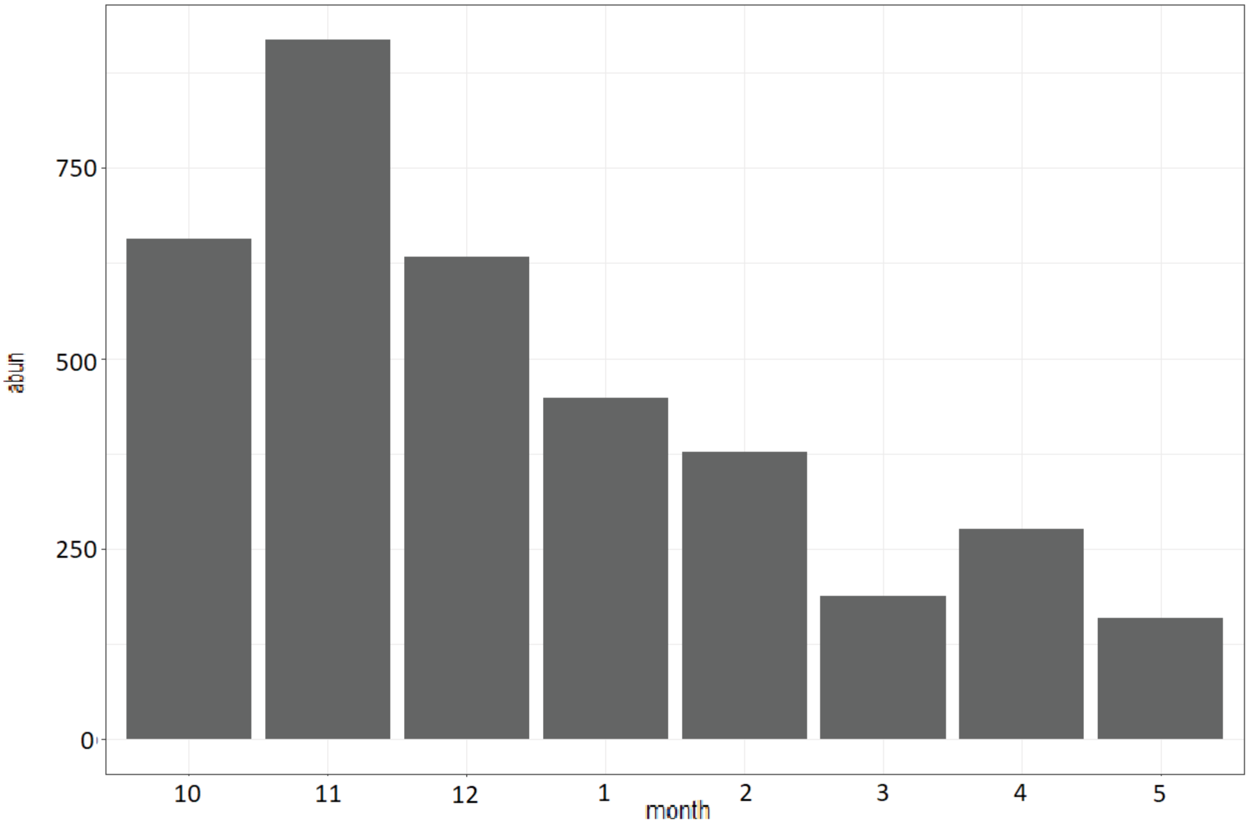

Fig. 4. Abundance of the residential shorebirds in the wetlands

The Thane Creek

In total, 89 species of shorebirds were recorded in the Creek, of which 60 were migratory and 29, non-migratory. We counted the highest number of migratory shorebirds in November and December (68038 and 64536 respectively) and lowest, in May (4315). In contrast, non-migratory birds were recorded in low numbers (compared to migratory birds) with relative abundance ranging from 2–13%. Migratory shorebirds showed high abundance from November 2018 to February 2019; their numbers dropped significantly (96%) from February to May 2019. Interestingly, non-migratory birds also depicted a gradual decline in numbers from November 2019, with the lowest recorded in May 2019 (557) (Fig. 7 & 8).

Overall, species richness of migratory birds was high from October 2018 to February 2019 (mean=7, SD=3.32) than from March to May 2019 (mean=4, SD=3) (Fig. 9). The spatial plots of the abundance of waders showed that the birds preferred the East bank of the Thane Creek. Their abundance was high in the Creek areas near Airoli Bridge and near NRI and TSC wetlands (Fig. 10)

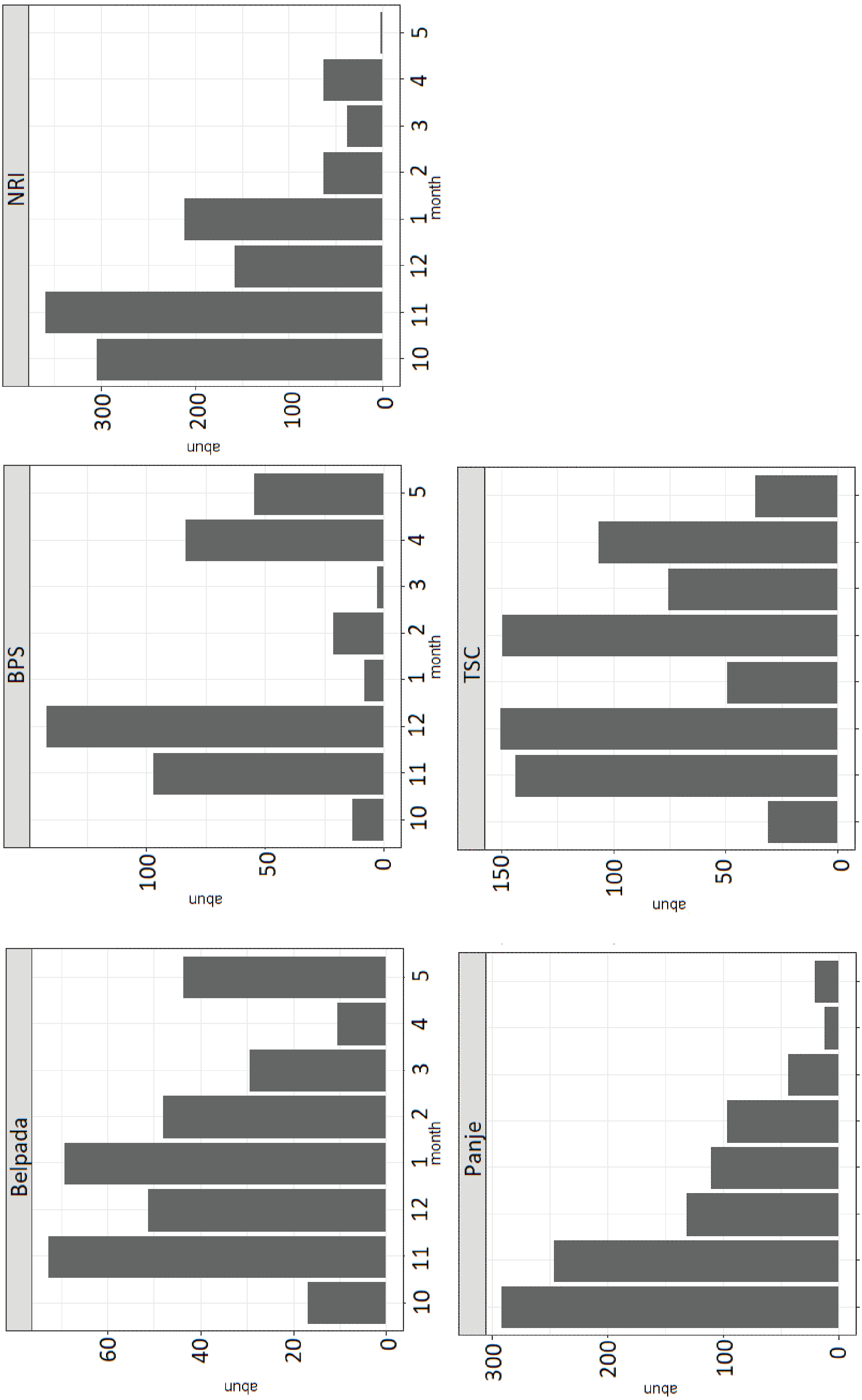

Fig. 5. Site-specific abundance of the migratory shorebirds in the wetlands

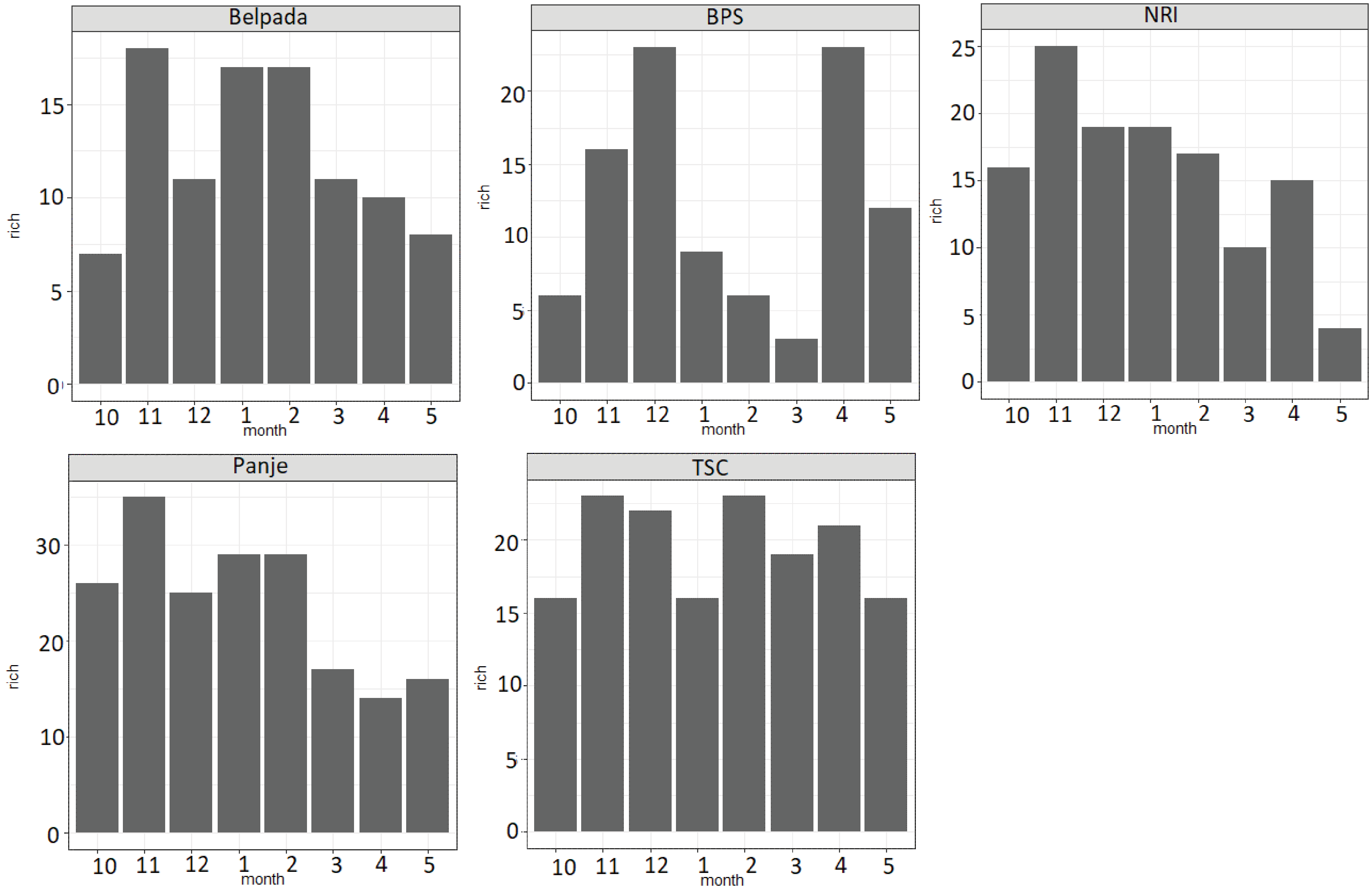

Fig. 6 Species richness of the migratory shorebirds observed in the different wetlands against months

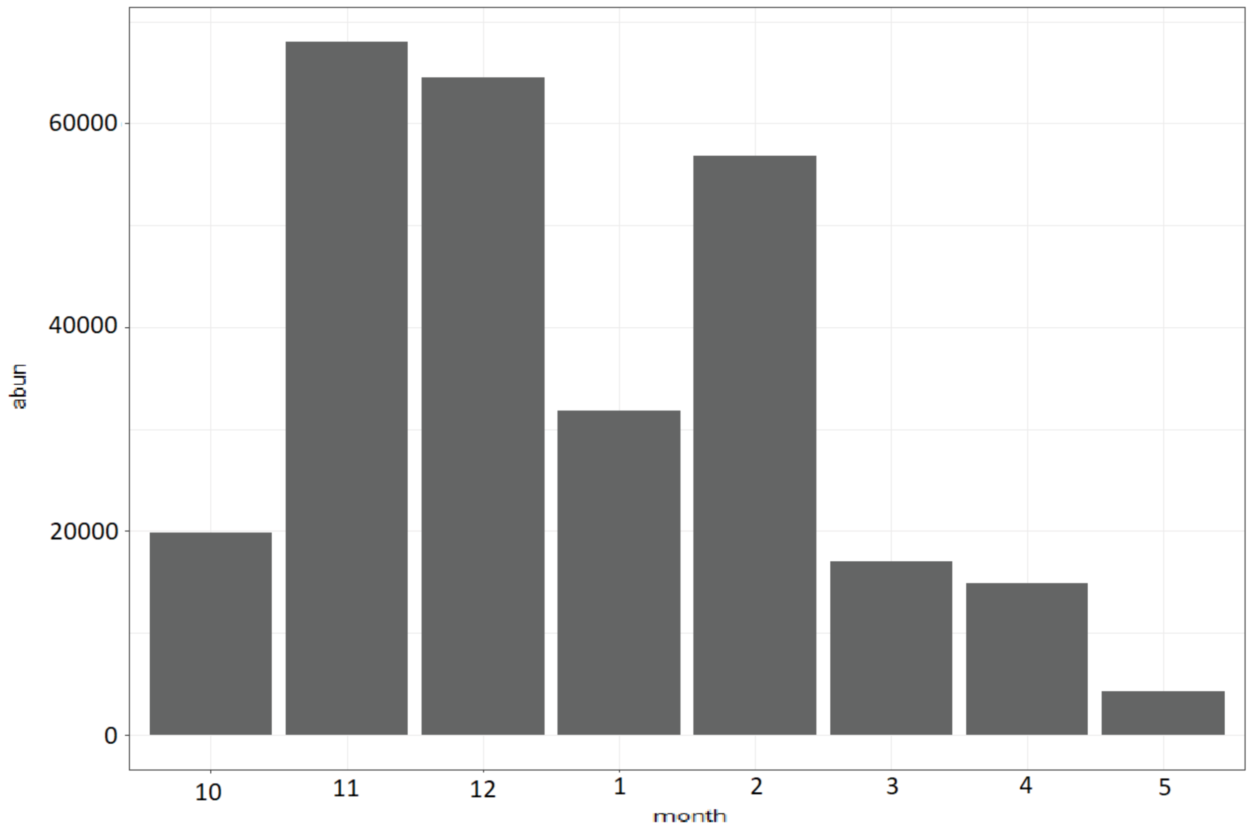

Fig. 7. Abundance of the migratory shorebirds in the Creek

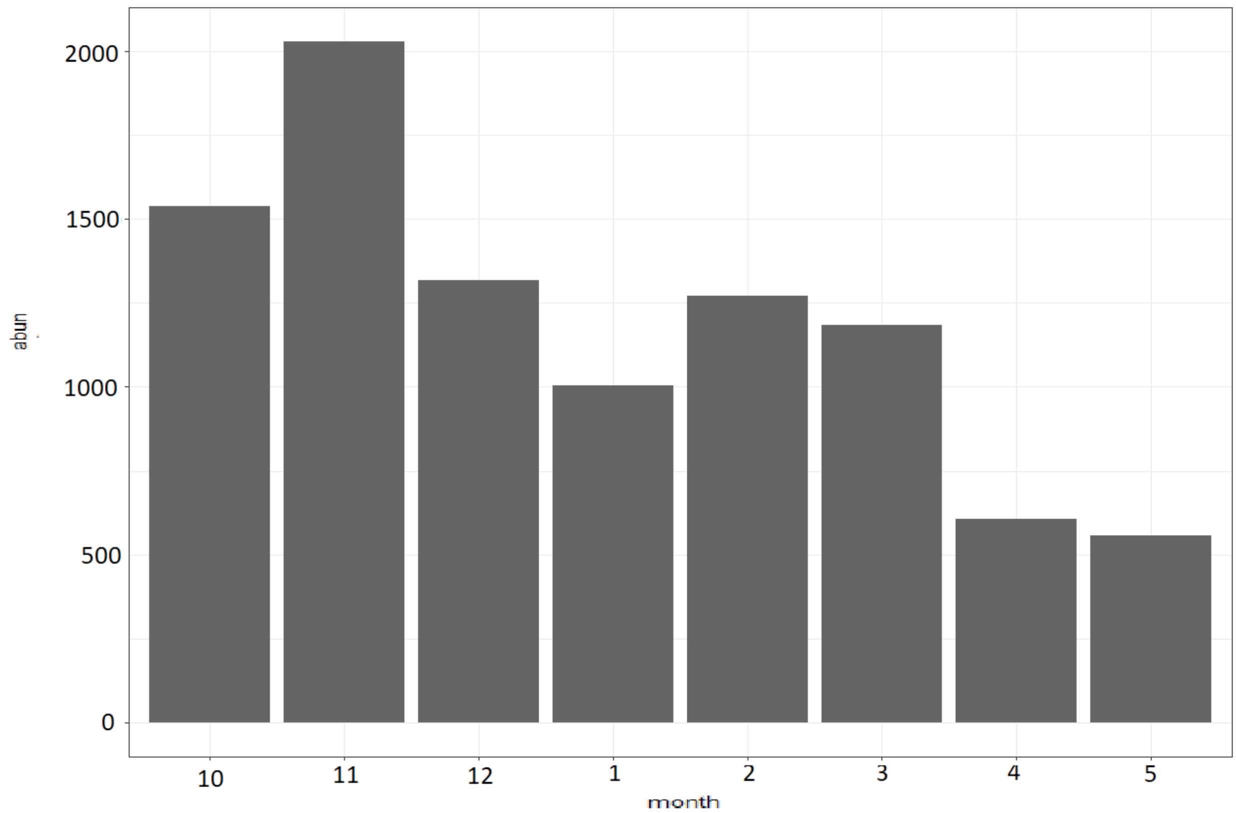

Fig. 8. Abundance of the residential shorebird species in the Creek

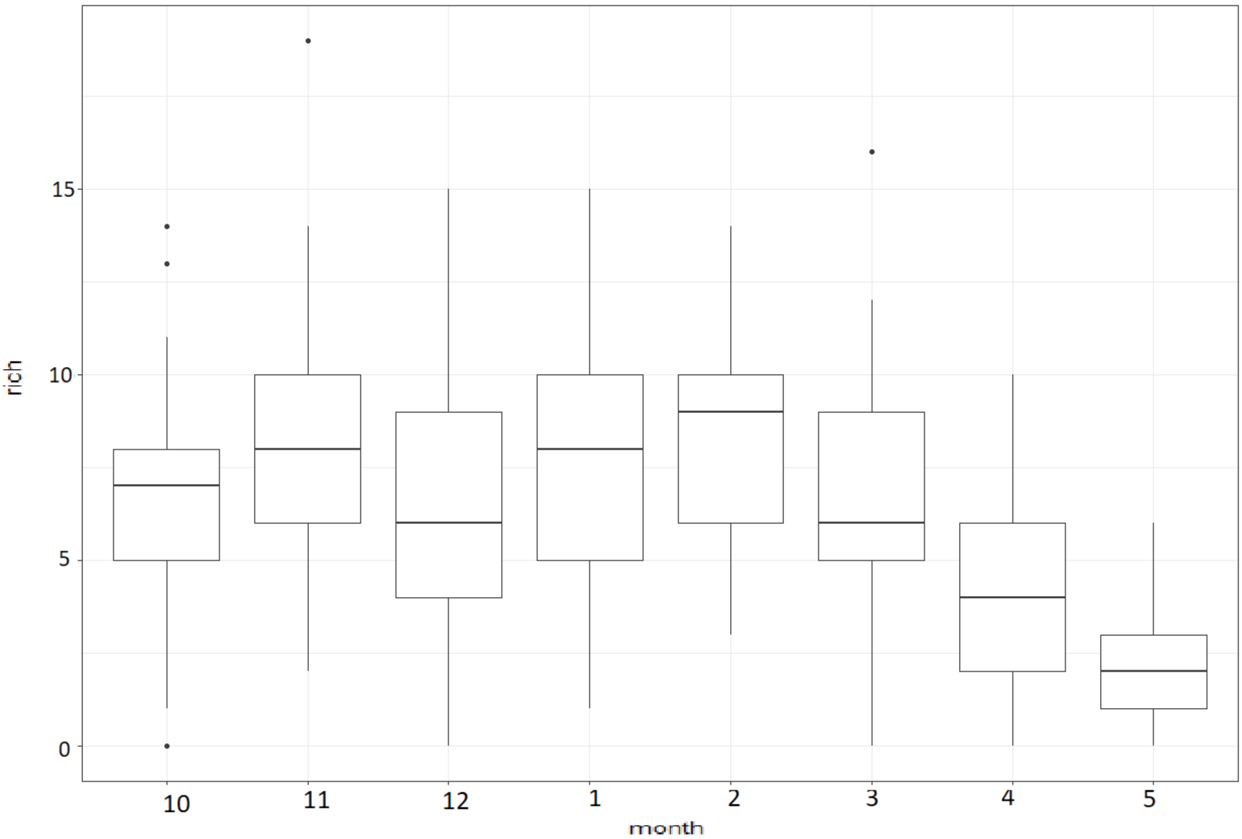

Fig. 9. Box plot of species richness across the months in the Creek

Flamingos

The highest number of Greater Flamingos were counted in October 2018 (25093) and the lowest, in May 2019 (9768). Except for May 2019, the population was relatively stable throughout the study period. The proportion of sub-adults ranged between 25% to 36%. In contrast, the Lesser Flamingo population increased gradually from October to December 2018, but in January 2019, it increased sharply by almost three fold (107343 individuals) and attained its peak in March 2019 (118661 individuals), thereafter population declined slightly. The proportion of sub-adults was comparatively lower, varying from 0.31% to 7.74% (Fig. 11).

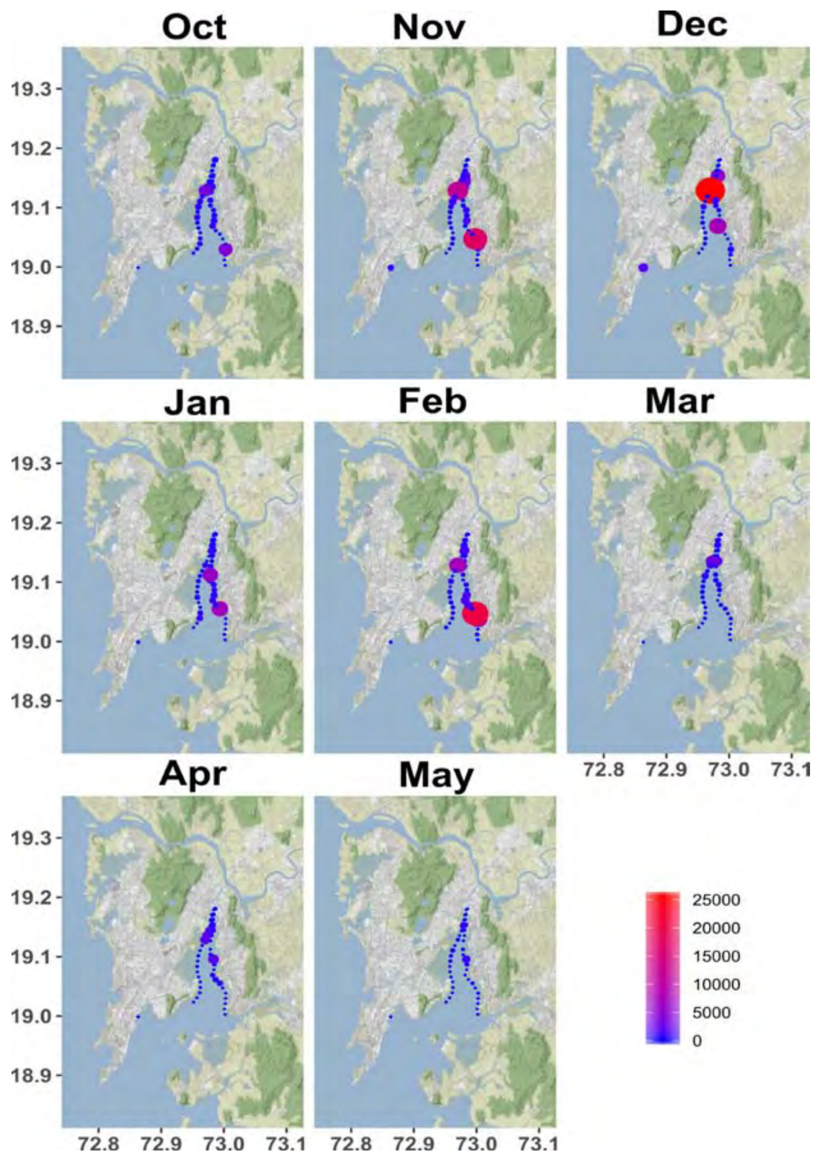

Fig. 10. Spatio-temporal distribution of the migratory shorebirds in the Creek

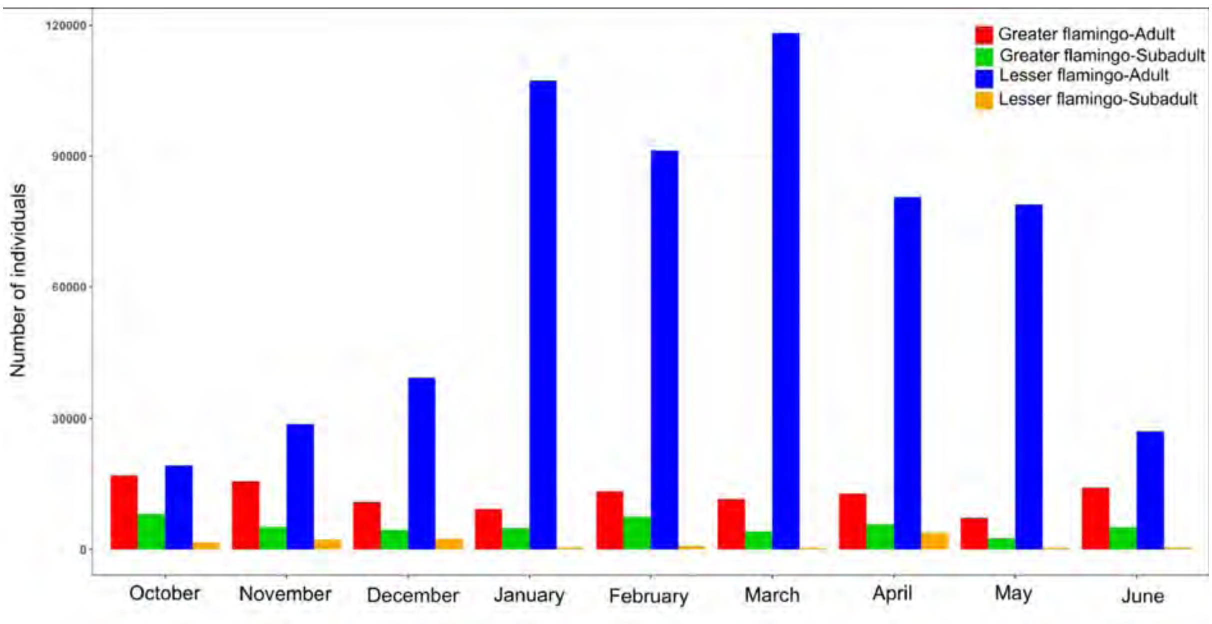

Fig. 11. Abundance of the flamingos across various month in the Creek

Spatial plots showed that Greater Flamingos were congregated in areas of high benthos density in the East bank of the Thane Creek. Interestingly, sub-adults populated the upstream of the Creek, in areas around the Airoli Bridge, whereas adults dominated the downstream of the Creek, in areas around Ghansoli and further down towards Vashi Bridge. In the summer (March–May 2019), the sub-adults seemed to have moved and populated downstream mudflats (Fig. 12). We found that the spatiotemporal pattern was more prominent in Lesser Flamingos. For example, from October to December 2018 both adults and sub-adults had occupied upstream mudflats while from January 2019 adults moved downward and populated downstream mudflats of the Creek, especially those in the East bank of the Creek. The population of Lesser Flamingos in Sewri Mudflat was low and stable between October to December 2018; soon after, it increased almost four times in January 2019 and became highly fluctuating until May 2019. The highest count was recorded in March 2019 with 59236 individuals (Fig. 13).

Bird Ringing

We carried out 77 ringing sessions from June 2018 to May 2019 at different sites: Panje Wetland (21 wader net sessions and 6 noose trap sessions); NRI Wetland (7 noose trap sessions); TSC Wetland (25 wader net sessions and 4 noose trap sessions), Ghansoli Jetty area (2 wader net sessions); DPS Wetland (1 wader net session); and BPS Wetland (11 wader net sessions). Among these, 60 sessions were for waders using wader nets and 17 sessions were for flamingos using noose traps.

We trapped 3947 shorebirds belonging to 36 species, of which 39 were flamingos. We also got 121 recaptures and 176 re-sighting records during these trapping sessions. Interestingly, only 23 individuals were recaptured or resighted at sites other than the capture sites (e.g. seven individuals tagged at Panje Wetland were recaptured at TSC Wetland; one individual was resighted in Kerala and one in Ghansoli jetty; seven individuals tagged at TSC Wetland were recaptured at BPS Wetland and three at DPS Wetland; four individuals tagged at NRI Wetland in 2015 were recaptured at DPS wetland after four years (Table 1, 2, 3).

Table 1 Ringing of shorebirds in various months

Month	No. of individuals ringed	Recaptures
August	149	3
September	400	9
October	111	2
November	0	0
December	108	5
January	229	8
February	93	0
March	1412	41
April	1088	38
May	358	15
June	0	0
July	0	0
Total	**3947**	**121**

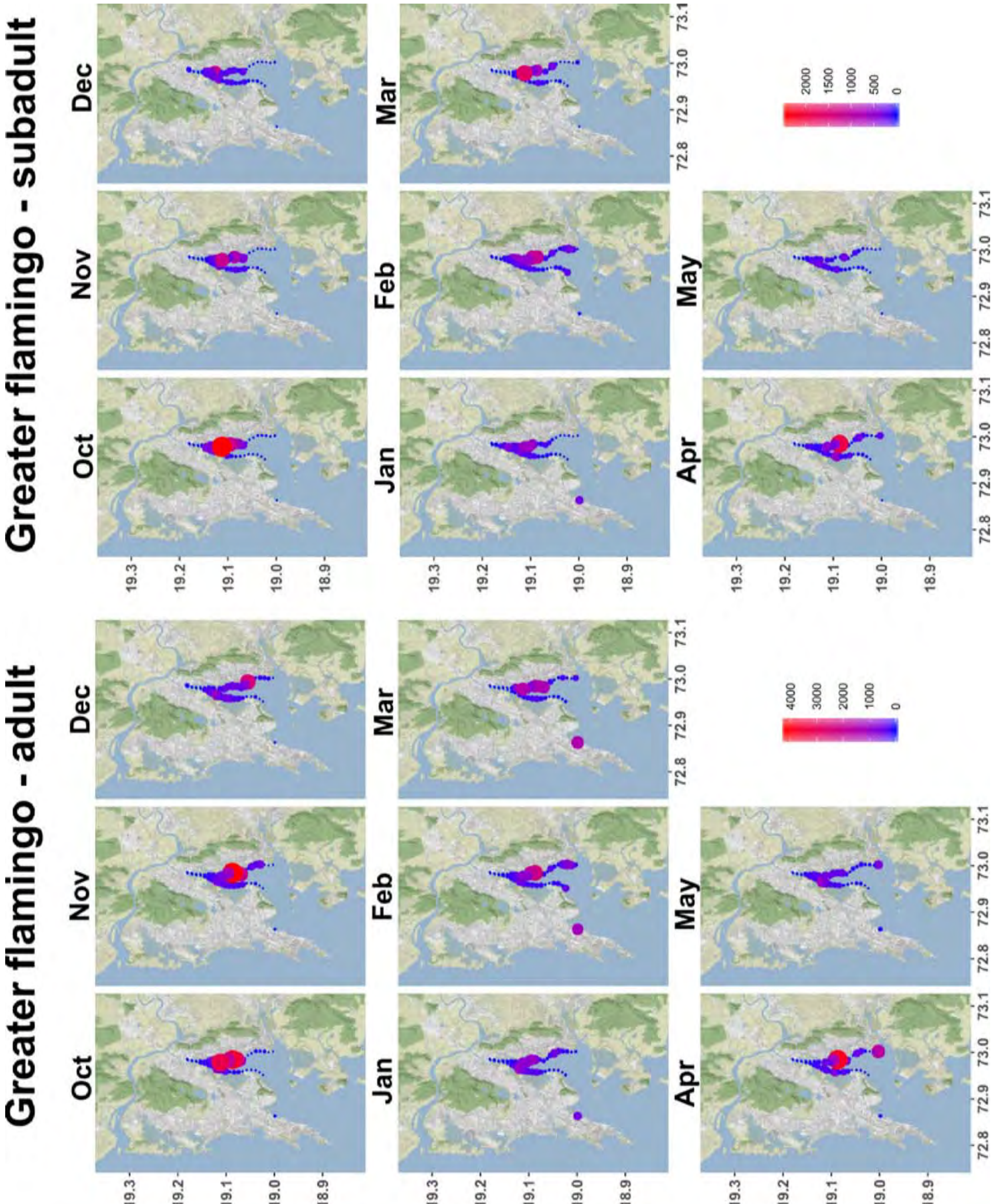

Fig. 12. Spatio-temporal abundance pattern of Greater Flamingo in the Creek

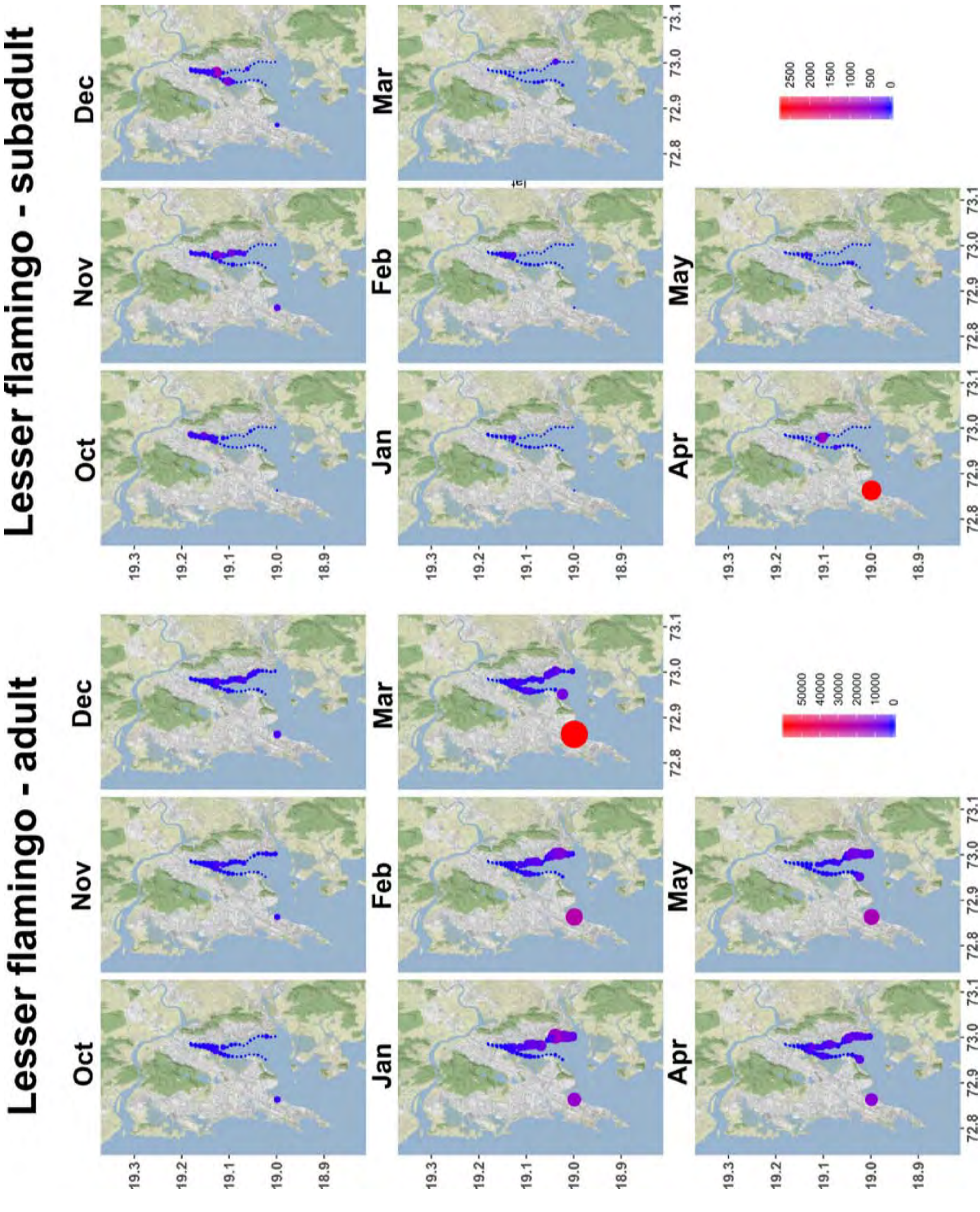

Fig. 13. Spatio-temporal abundance pattern of Greater Flamingo in the Creek

Table 2 Species-specific details of ringing

Sr. No.	Common name	Scientific name	Total number of birds	Ringed only	Ringed and flagged
1	Black-tailed Godwit	*Limosa limosa*	2	0	2
2	Broad-billed Sandpiper	*Calidris falcinellus*	68	27	41
3	Common Greenshank	*Tringa nebularia*	14	2	12
4	Common Redshank	*Tringa totanus*	535	98	437
5	Common Sandpiper	*Actitis hypoleucos*	52	20	32
6	Curlew Sandpiper	*Calidris ferruginea*	1033	251	782
7	Dunlin	*Calidris alpina*	64	23	41
8	Eurasian Curlew	*Numenius arquata*	2	2	0
9	Glossy Ibis	*Plegadis falcinellus*	1	1	0
10	Greater Flamingo	*Phoenicopterus roseus*	12	0	12
11	Greater Sandplover	*Charadrius leschenaultii*	106	20	86
12	Grey Plover	*Pluvialis squatarola*	13	2	11
13	Gull-billed tern	*Gelochelidon nilotica*	17	17	0
14	Kentish plover	*Charadrius alexandrinus*	10	7	3
15	Lesser Flamingo	*Pheoniconaias minor*	27	0	27
16	Lesser Sandplover	*Charadrius mongolus*	740	98	642
17	Little Stint	*Calidris minuta*	827	789	38
18	Little Tern	*Sternula albifrons*	2	1	1
19	Little Ringed Plover	*Charadrius dubius*	1	0	1
20	Marsh Sandpiper	*Tringa stagnatilis*	53	11	42
21	Northern Shoveler	*Spatula clypeata*	1	1	0
22	Pacific Golden Plover	*Pluvialis fulva*	2	0	2
23	Pied Avocet	*Recurvirostra avosetta*	1	0	1
24	Red-necked Phalarope	*Phalaropus lobatus*	1	0	1
25	Red-wattled Lapwing	*Vanellus indicus*	6	6	0
26	River Tern	*Sterna aurantia*	1	1	0
27	Ruddy Turnstone	*Arenaria interpres*	1	0	1
28	Ruff	*Calidris pugnax*	5	0	5
29	Spotted Redshank	*Tringa erythropus*	1	1	0
30	Temminck's Stint	*Calidris temminckii*	5	4	1
31	Terek Sandpiper	*Xenus cinereus*	284	279	5
32	Whimbrel	*Numenius phaeopus*	2	0	2
33	Whiskered Tern	*Chlidonias hybrida*	36	24	12
34	Wood Sandpiper	*Tringa glareola*	22	3	19
Total			3947	1688	2259

Table 3 Site-specific details of ringing

Common Name	Scientific Name	BPS	DPS	Ghansoli	NRI	Panje	TSC	Total
Black-tailed Godwit	*Limosa limosa*	2	0	0	0	0	0	2
Broad-billed Sandpiper	*Limicola falcinellus*	12	8	0	0	13	35	68
Common Greenshank	*Tringa nebularia*	0	2	0	0	3	9	14
Common Redshank	*Tringa totanus*	85	31	0	0	36	383	535
Common Sandpiper	*Actiti shypoleucos*	31	0	1	0	14	6	52
Curlew Sandpiper	*Calidris ferruginea*	233	52	0	0	184	564	1033
Dunlin	*Calidris alpina*	0	1	0	0	33	30	64
Eurasian Curlew	*Numenius arquata*	0	0	0	0	2	0	2
Glossy Ibis	*Plegadis falcinellus*	0	0	0	0	1	0	1
Greater Flamingo	*Phoenicopterus roseus*	0	0	0	3	9	0	12
Greater Sand Plover	*Charadrius leschenaultii*	49	0	5	0	5	47	106
Grey Plover	*Pluvialis squatarola*	5	0	0	0	3	5	13
Gull-billed Tern	*Gelochelidon nilotica*	0	0	0	0	13	4	17
Kentish Plover	*Charadrius alexandrius*	0	0	0	0	8	2	10
Lesser Flamingo	*Pheoniconaias minor*	0	0	0	12	8	7	27
Lesser Sand Plover	*Charadrius mongolus*	239	3	5	0	163	330	740
Little Stint	*Calidris minuta*	306	34	4	0	245	238	827
Little tern	*Sternula albifrons*	0	0	0	0	2	0	2
Little-ringed plover	*Charadrius dubins*	0	0	0	0	0	1	1
Marsh Sandpiper	*Tringa stagnatilis*	6	1	0	0	6	40	53
Northern Shoveller	*Anas clypeata*	0	0	0	1	0	0	1
Pacific Golden-Plover	*Pluvalis fulva*	1	0	0	0	0	1	2
Pied Avocet	*Recurvirostra avosetta*	0	0	0	1	0	0	1
Red-necked Phalarope	*Phalaropus lobatus*	0	0	0	0	1	0	1
Red-wattled Lapwing	*Vanellus indicus*	0	0	0	0	4	2	6
River Tern	*Sterna aurantia*	0	0	0	0	1	0	1
Ruddy Turnstone	*Arenaria interpres*	0	0	0	0	0	1	1
Ruff	*Philomachus pugnax*	0	0	0	0	5	0	5
Spotted Redshank	*Tringa erythropus*	0	0	0	0	1	0	1
Temminck's Stint	*Calidris temminckii*	2	0	0	0	0	3	5
Terek Sandpiper	*Xenus cinereus*	219	1	0	0	5	59	284
Whimbrel	*Numerius phaeopus*	0	0	0	0	0	2	2
Whiskered Tern	*Chlidonias hybrida*	0	0	0	0	36	0	36
Wood Sandpiper	*Tringa glareola*	6	0	0	0	0	16	22
	Grand Total	**1196**	**133**	**15**	**17**	**801**	**1785**	**3947**

Reference

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Brown-headed Gulls roosting at Panje wetland

Mix flock of waders roosting at TSC

Duck congregation at Panje

Congregation of Black-tailed Godwit at the Thane Creek

Panje wetland habitata in November, 2018

Construction activity at Sewri mudflat

Chapter 2 – Marine study

Introduction

In the case of coastal development, apart from the many changes it may cause to the physio-chemical properties of a water body and bed sediment, the ultimate concern is invariably the biological resource. The present study aims to understand the ways in which MTHL bridge (Fig. 1) may affect the macrobenthos and the planktons. The intertidal mudflats are considered important for the congregation of shorebirds and their survival. Their ability to host a large number of shorebirds depends on the benthic richness of the mudflats, which is the main food resource for the birds (P0nsero et al. 2016). These macrobenthic fauna constitute key organisms such as Polychaetes and Gastropods that condition and influence all the benthos-bird trophic interactions. Therefore, a study of benthos accessible to shorebirds, through an analysis of its vertical distribution in the sediment, constitutes the first step in better understanding the importance of these benthic invertebrates in the diet of the waders (Touhami et al., 2017).

These communities are the main food source for the migratory birds preferring shorelines and hence studying them is an important aspect of this investigation.

Methodology

The marine groups considered in this assessment are phytoplankton, zooplankton and macrobenthos. The first two reflects the productivity of the water column at the primary and secondary levels. Benthic organisms closely associated with the mudflats not only play a crucial role in the coastal food web but also together become an indicator for the presence and threshold of if any sort of stress.

Macrobenthic species are animals with a body size larger than 0.5 mm. Macrobenthic samples were collected from the intertidal mudflats of the Thane Creek, Sewri, Nhava and wetlands from October 2018 to June 2019. Due to rough weather conditions the Creek, Sewri and Nhava were sampled only until May 2019. Panje and Belpada Wetlands were not sampled during June 2019 due to permission issues. The sampling period was divided into four seasons: October (Phase shift-I), winter (November, December and January), February (Phase Shift-II) and summer (March, April and May). The Thane Creek was divided into forty transects (Tr) at an interval of 1km along both banks of the Creek for the estimation of macrobenthic density, biomass and composition. Two transects from Sewri were sampled monthly during the study period whereas sampling for Nhava in two transects started from April and May 2019. Intertidal mudflats were divided into 3 zones i.e. mangrove line (Zone A), mid-water line (Zone B), and low-water line (Zone C), to study the macrobenthic distribution at different tide levels. Spatial distribution of shorebirds in mudflats largely correlates with the abundance of benthic food. Therefore, to explore the feeding ecology of shorebirds, the core was sectioned into five strata i.e. 2cm, 4cm, 8cm, 11cm and 15cm with respect to the beak size of the shorebirds inhabiting these mudflats. Due to the hard substratum of wetlands, quadrate (25x25cm) was used to collect sediment samples from four different corners of the wetland. Overall, the macrobenthic density and biomass variation in the Creek during the study period was represented in terms of individuals/1000cm^3 and g/1000cm^3 area whereas the transect data for each season was represented as individuals/unit area and g/unit area.

Phytoplankton and zooplankton collection was carried out using standard nets during early morning high tides. Five sampling stations (P1/Z1-Transect (Tr.) 1, P2/Z2-Transect 4, P3/Z3-Transect 8, P4/Z4-Transect 34, P5/Z5- Transect 38) were selected for plankton collection. The nets were hauled for 10 minutes at constant boat speed (4 km/h). The collected zooplankton samples were preserved in 5% formalin and phytoplankton samples were stained with 2–3 drops of Lugol's iodine. Preserved and labelled samples were outsourced to an expert laboratory for further analysis. The samples were evaluated to determine the diversity and species composition of the phytoplankton and zooplankton. Species-level and group-level data was obtained for phytoplankton and zooplankton respectively.

Observations

The Thane Creek

A seasonal pattern was observed in the spatial distribution of macrobenthic fauna. Macrobenthic density decreased seasonally, from highest in October (123 individuals per 1000 cm^3 area; Tr. 40) to minimum in summer (8 individuals per 1000cm^3 area; Tr. 38). A similar trend was observed in the macrobenthic biomass over the period, with an exceptional increase in benthic biomass during February. The highest macrobenthic biomass was found during October (0.33 g per 1000 cm^3 area; Tr. 24) and lowest during summer (0.0152 g per 1000 cm^3 area; Tr. 19). The East bank of Thane Creek had a higher macrobenthic density than the West bank (Fig 1.1). The highest macrobenthic density in the Creek, irrespective of the season, was observed in the East bank along Tr. 32 (1725 individuals per unit area in October), Tr. 39 (1506 individuals per unit area in winter), Tr. 1 (1000 individuals per unit area; February) and Tr. 38 (260 individuals per unit area in summer). Poor macrobenthic abundance was reported from the mouth of the Creek during the entire study period (e.g. Tr. 6 and Tr. 7). No pattern was found in macrobenthic biomass; East bank contributed more in benthic biomass but high biomass was observed in Tr. 24 (9.148 g per unit area in October 2018), Tr. 22 (8.719 g per unit area in winter), Tr. 21 (10.155 g per unit area in February 2019) and Tr. 22 (10.01 g per unit area in summer [Table 4–7]).

In this study, overall 11 invertebrate phylum and 27 groups were observed in the Creek (Table 4–7). We had the highest macrobenthic richness in the winter (11 individuals) followed by October 2018 (9 individuals) and February 2019 (7 individuals); lowest, in summer 2019 (6

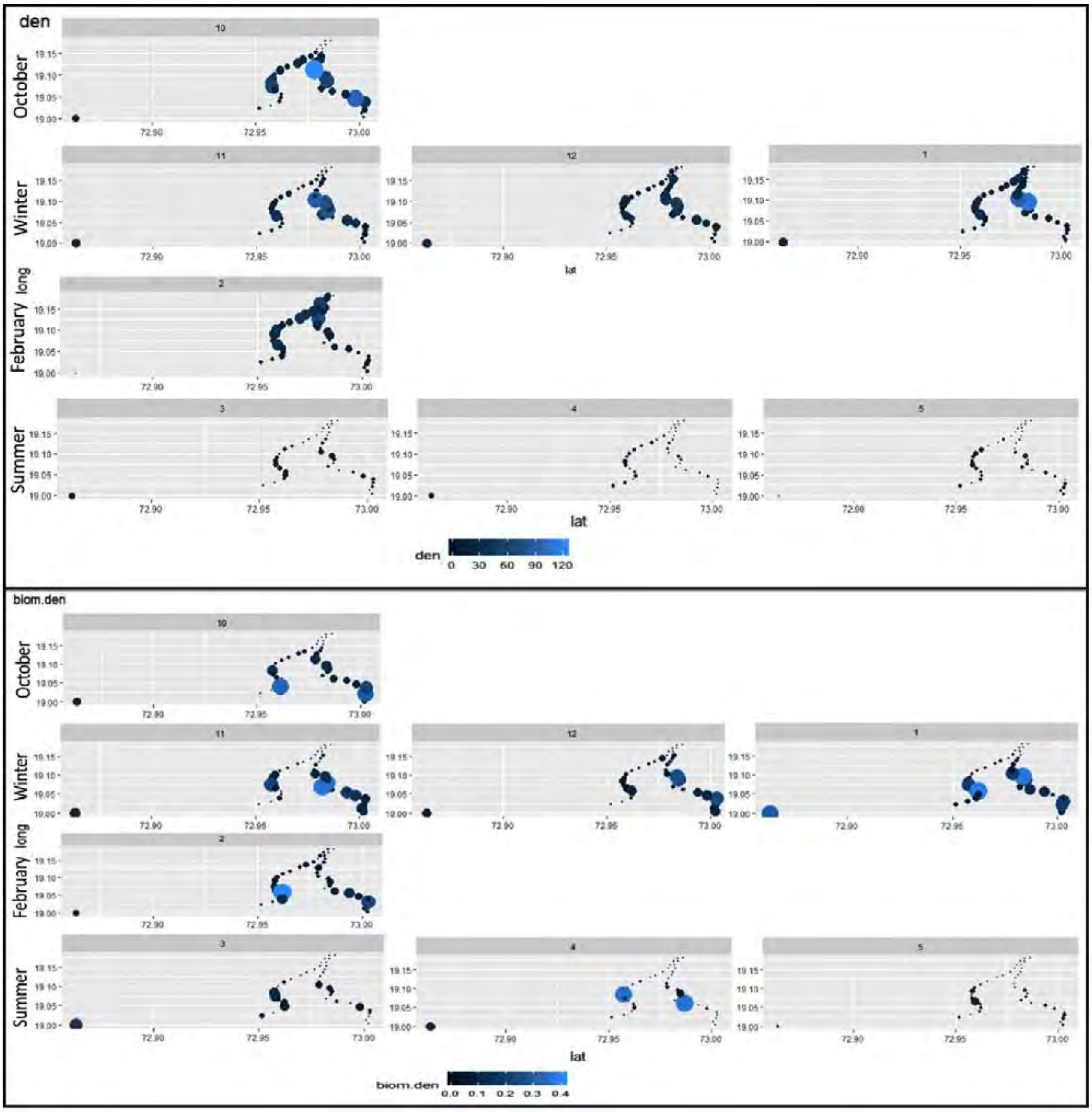


Fig.1.1. Spatio-temporal variations in macrobenthic density and biomass in the Thane Creek and Sewri (* Numbers on the top of the graph represent the sampling month)

individuals). Polychaete, Gastropoda, Bivalvia and Phoronida were the major contributors to the macrobenthic composition. Polychaete dominated in terms of density in the Thane Creek during all the seasons followed by Gastropoda, Bivalvia and Phoronida (Fig 1.2). Gastropoda contributed maximum to the benthic biomass during all the seasons followed by Bivalvia and Polychaete during winter, February 2019, and summer. In October 2018, Gastropoda was followed by Chordata and Polychaete in terms of biomass (Fig 1.3).

Overall, a total of 20 Polychaete families were observed in the Thane Creek during this study. A maximum number of families were observed in October 2018 (16 families) and minimum, during summer (14 families). Winter and February 2019 exhibited the same number of Polychaete families (15 families). The first 20 transects, i.e., towards the mouth of the Creek

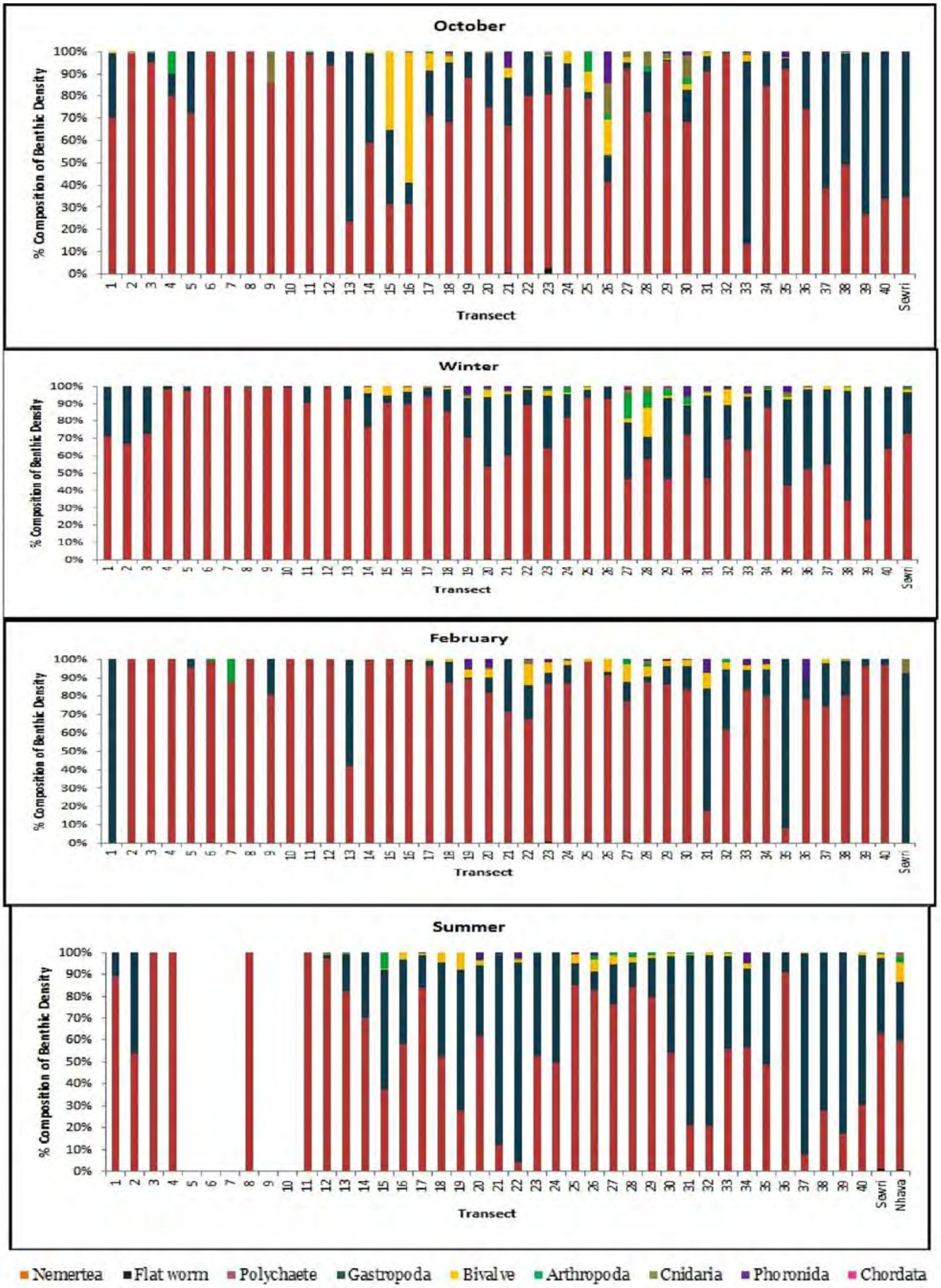


Fig.1.2. Seasonal variation in the percentage composition of macrobenthic density in different transects of the Thane Creek, Sewri and Nhava

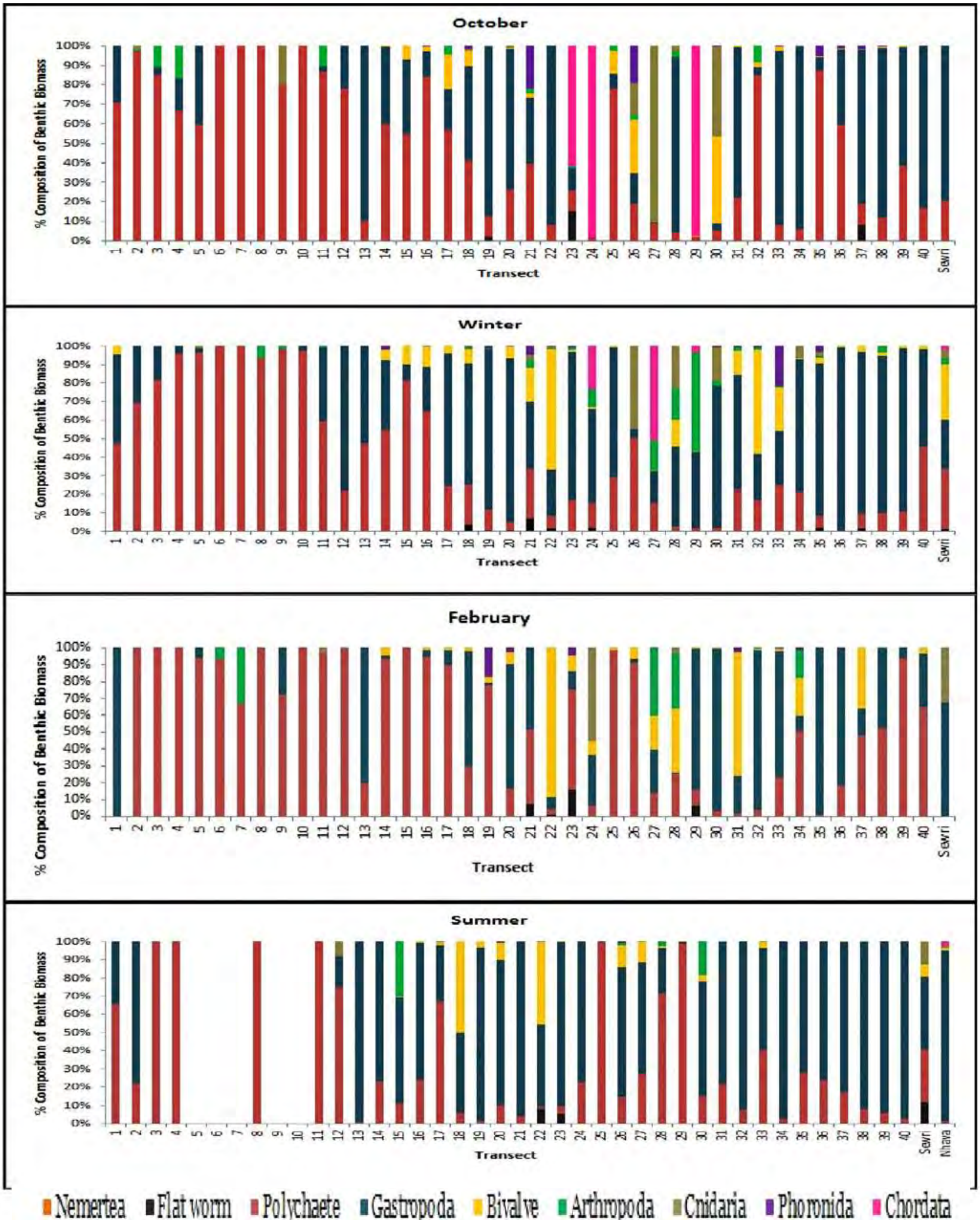


Fig.1.3. Seasonal variation in the percentage composition of macrobenthic biomass in different transects of the Thane Creek, Sewri and Nhava

and West bank of the middle stream exhibited less diversity in all seasons. Five families were abundant in the Creek throughout the study period viz., Spionidae, Nereidae, Nephytidae, Pilargidaeand Capitellidae, and the remaining polycheate families contributed minimally to the diversity at the Creek.(Table 4-7). Spionidae was the dominating family in the study area

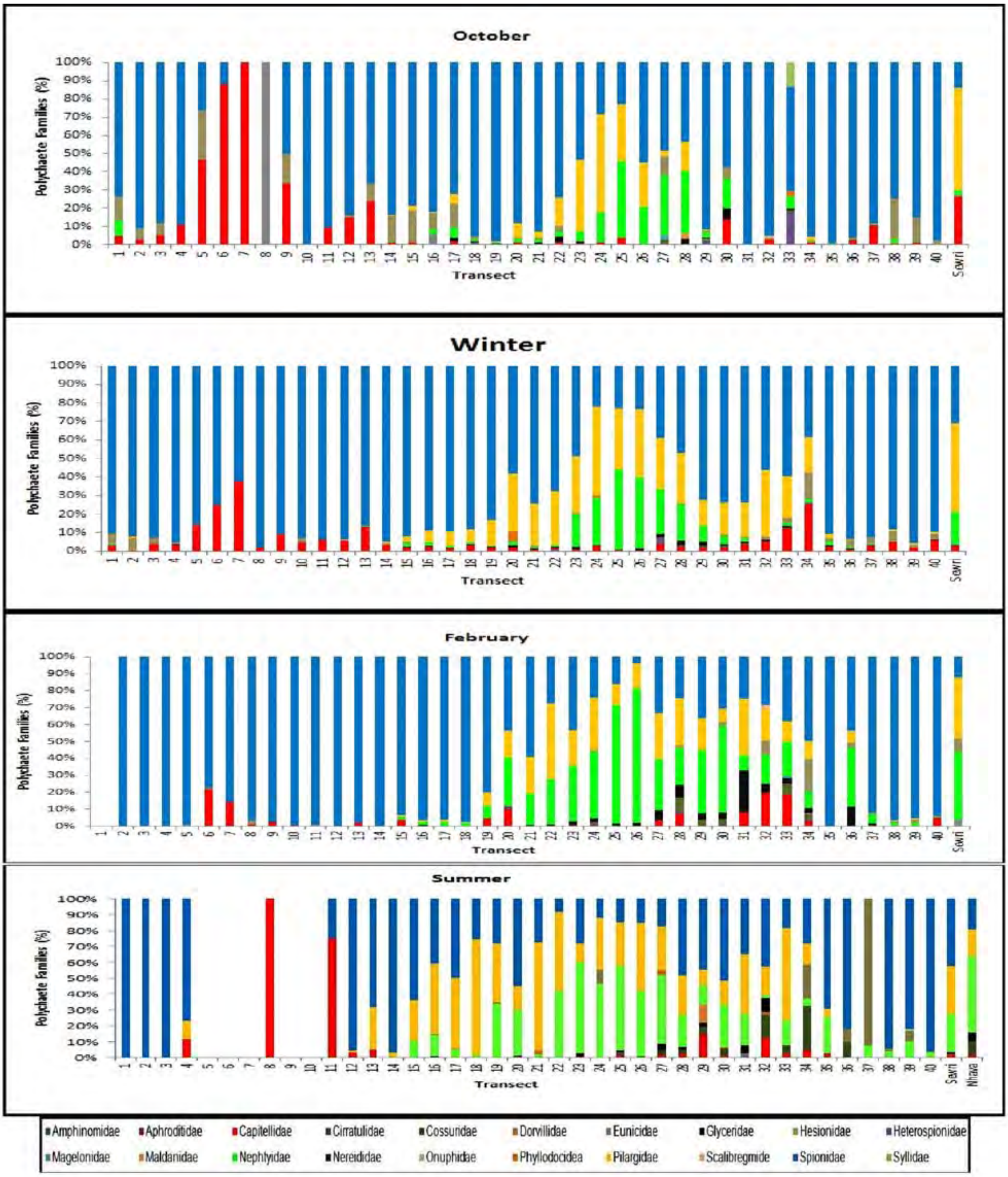


Fig.1.4. Seasonal variation in the percentage composition of Polychaete family diversity in different transects of the Thane Creek, Sewri and Nhava

throughout the sampling period. Spionidae contributed to Polychaete composition by 90% followed by Nereidae (3%) and Capitellidae (2.5%) during October 2018. The contribution of family Spionidae to Polychaete composition declined to 50% in the summer. Pilargidae and Nephytidaehave replaced the dominance of Nereidae and Capitellidae during February 2019 and the summer. During the winter, Pilargidae was the second dominating family (2%) followed by Capitellidae (0.7%) and Nephytidae (0.3%). Percentage composition of Pilargidae increased from 1% (October) to 24 % (summer), barring a decline in February 2019 (5%). Percentage

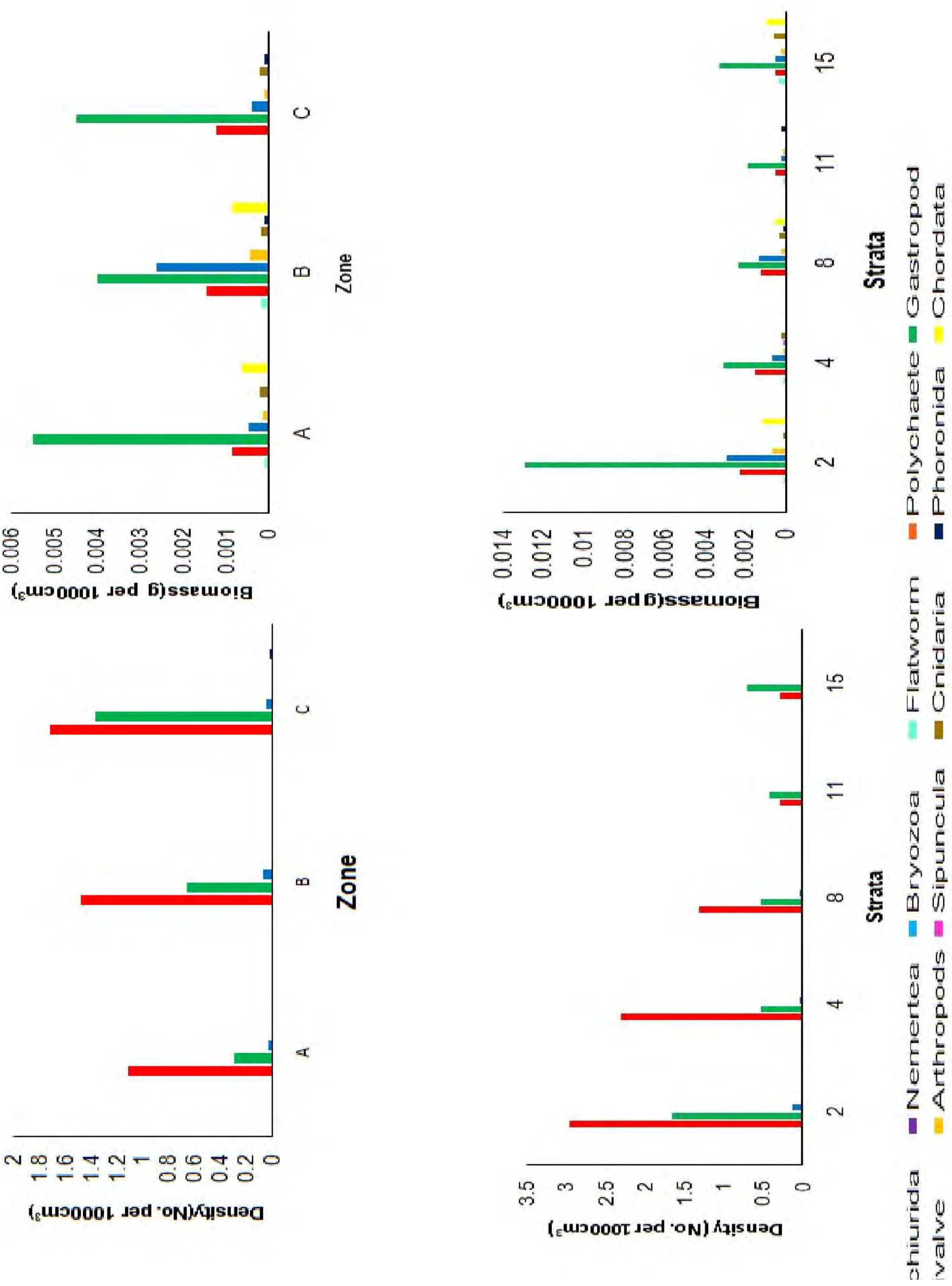


Fig.1.5. Variation in macrobenthic density, biomass and faunal groups with respect to different mudflat zones and varies strata of the Thane Creek

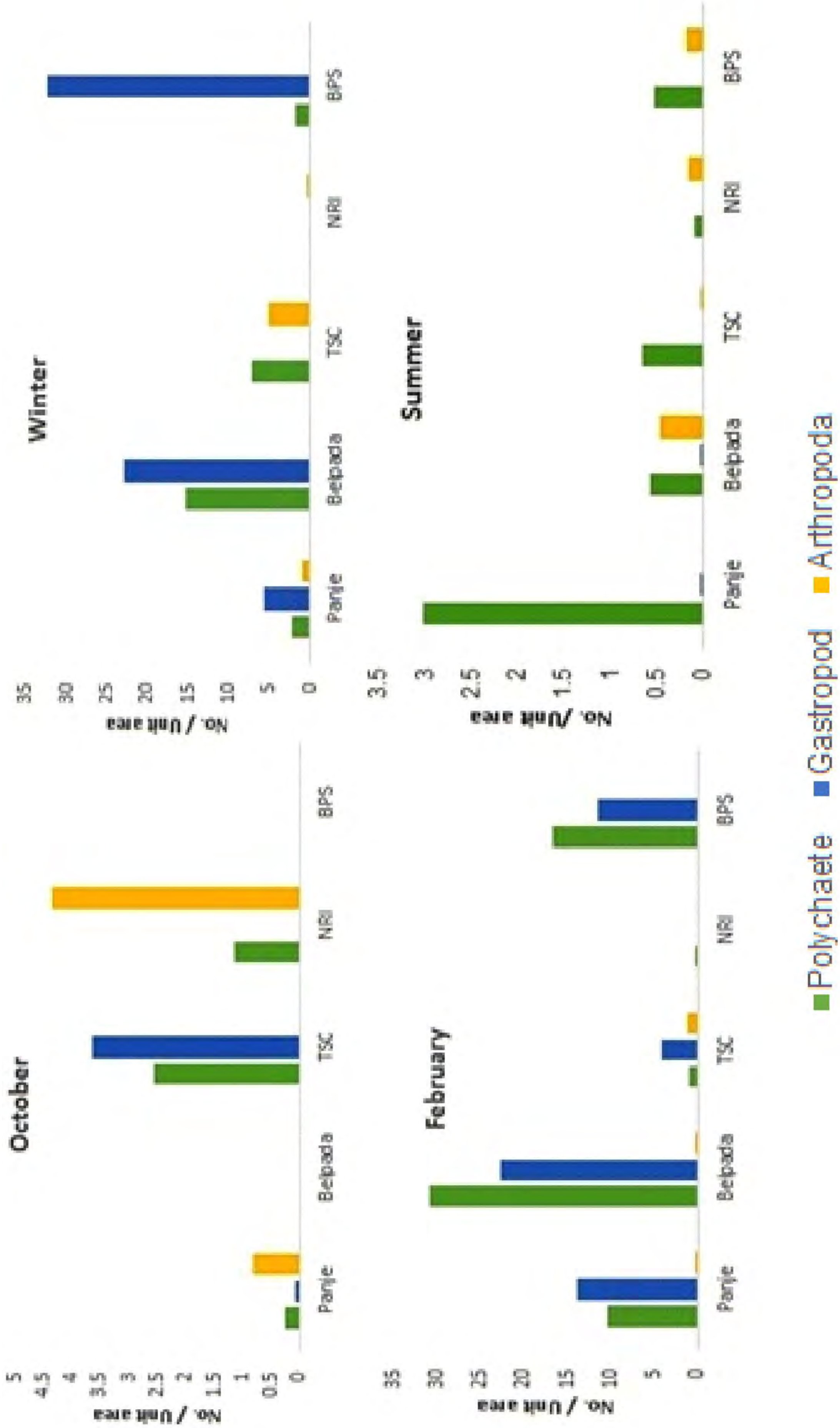


Fig. 1.6. Seasonal variation in the abudance of the different macrobenthic fauna in the wetlands

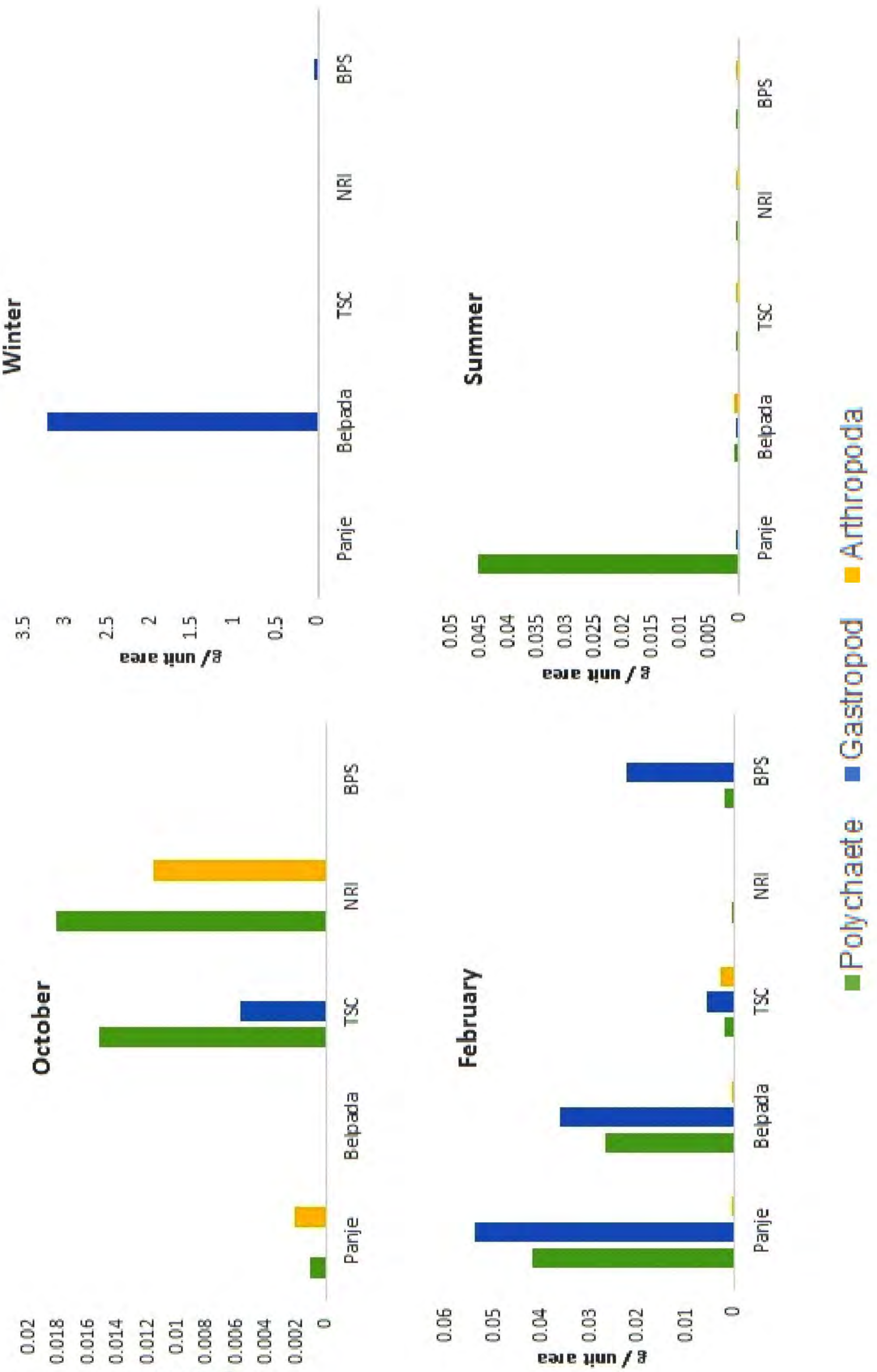


Fig. 1.7. Seasonal variation in the biomass of the different macrobenthic fauna in the wetlands

composition of Nephytidae increased from 1% (October 2018) to 18 % (summer). Decrease in Pilargidae during February 2019 and its replacement by Nephytidae displays community shift in terms of change in the dominance of different Polychaete families. However, more seasonal data is required to throw light on this pattern (Fig 1.4).

Macrobenthic diversity varied with respect to the zones and different stratum. Overall, in abundance, Polychaetes were dominant followed by Gastropoda and Bivalvia; on the other hand, Gastropoda contributed more to the biomass (Fig. 1.5).

We found that Zone C had high richness, with the presence of 12 different groups, followed by Zone A; Zone B had high biomass compared to Zone A and Zone C.

Macrobenthic diversity declined vertically and was dominated by Polychaeta and Gastropoda at a lower stratum. The abundance of Polychaetes decreased with depth whereas comparatively less variations were observed in the abundance of Gastropods. Uppermost stratum (2cm) showed highest macrobenthic density due to higher Polychaete abundance followed by Gastropoda, Bivalvia and Phoronida. Polychaetes were dominant in benthic composition followed by Gastropoda in stratum 2 cm , 4 cm and 8 cm whereas the opposite pattern was observed in stratum 11 cm and 15 cm.

Sewri and Nhava

The seasonal variations in benthos were observed in Sewri i.e, macrobenthic density and biomass were highest in the winter (26 individuals per 1000cm^3 area and 0.169 g per 1000cm^3 area respectively) followed by October 2018 (16 individuals per 1000cm^3 area and 0.09 g per 1000cm^3 area) and summer (8 individuals per 1000cm^3 area and 0.08 g per 1000cm^3 area) (Fig. 1.1). The highest richness was seen in the winter (8 individuals) followed by the summer (6 individuals) and October 2018 (4 individuals). In February 2019 however, we found the lowest macrobenthic density and biomass (1 individual per 1000cm^3 area; and 0.04 g per 1000cm^3 area) as well as poor richness (2 individuals) (Fig. 1.2 and 1.3). At Sewri, 11 Polychaete families were observed in the four seasons. Winter had the maximum Polychaete family richness (7 families) and other seasons showed an equal number of families (5 families). Pilargidae dominated the Polychaete diversity in October 2018 and in the winter, Nephytidaepre was dominant in the February 2019 and Spionidae, in the summer (Fig. 1.4).

Nhava was sampled only during summer (April and May 2019.) Macrobenthic density observed was 22 individuals per unit area, with the dominance of Polychaete. Gastropoda contributed more to macrobenthic biomass (3 g per unit area) (Fig. 1.2 and 1.3). Overall, 7 Polychaete families were found during the summer, with the dominance of Nephytidae followed by Spionidae (Fig. 1.4).

Wetlands

We did not find any seasonal pattern in the density of the benthos or its biomass in the wetlands. The lowest macrobenthic density was observed in October 2018 in all wetlands (as mentioned in chapter 1) with the exception of NRI. The highest macrobenthic density (14 individuals per unit area) and biomass (0.54 g per unit area) were observed in Panje in February 2019. Gastropoda was dominant in both density and biomass, followed by Polychaeta.

Belpada and BPS showed maximum density during February 2019 due to the dominance of Polychaeta, whereas the biomass was highest during winter with a major contribution of Gastropoda. TSC showed the highest macrobenthic density during the winter (31 individuals per unit area) and biomass during October (0.02 g per unit area). In NRI, we found the highest density (4 individuals per unit area) and biomass (0.02 g per unit area) in October. Polychaeta was the dominant group followed by Gastropoda. Whereas Arthropoda dominated in NRI during October 2018. Arthropoda comprised insect larvae, Amphipoda and Isopoda. Insect larvae was observed in all the seasons whereas Amphipoda was found only in the winter, in TSC wetland (Fig. 1.6 and 1.7).

Plankton studies

Phytoplankton constitutes minute and microscopic plants passively drifting in natural waters and mostly confined to the illuminated zone. Overall, 39 phytoplankton species were observed during this study. Two most dominant species were *Odentella* sp. and *Skeletonema costatum*. Richness was highest in summer (28 species) followed by the winter (21 species), February 2019 (17 species) and October 2018 (16). Species exhibited a phase shift from winter to summer.

Coscinodiscus sp. (33%) were most abundant in October 2018 and least abundant in the summer. *Odentella* sp. was the most dominating species during the other three seasons. Overall, the percentage composition of *Odentella* sp. (19%–14%) and *Skeletonema costatum* (16%–11%) decreased from winter to summer. *Pseudo-nitzschia* was observed only during summer and contributed maximum to the percentage composition of phytoplankton after *Odentella* sp. *Nitzschia* sp. and *Rhizosolenia* sp. also contributed to species diversity during February 2019 (Fig. 1.8).

In total, 20 species of zooplankton were observed during the study. We found a seasonal pattern in the abundance and composition of the zooplankton community. For example, Medusa dominated in October 2018, Copepod in the winter whereas aquatic insects dominated during February 2019 and the summer. Copepods exhibited uniform distribution, irrespective of the season. Higher group diversity was observed at Z3, Z4 during October 2018 whereas Z1 and Z2 exhibited higher diversity during the winter. Overall, lower diversity was observed during February 2019. Summer witnessed the most diverse season (16 species) followed by winter (15 species). October 2019 showed the highest diversity with 13 species, whereas February 2019 with 8 species exhibited a phase shift from winter to summer (Fig. 1.9).

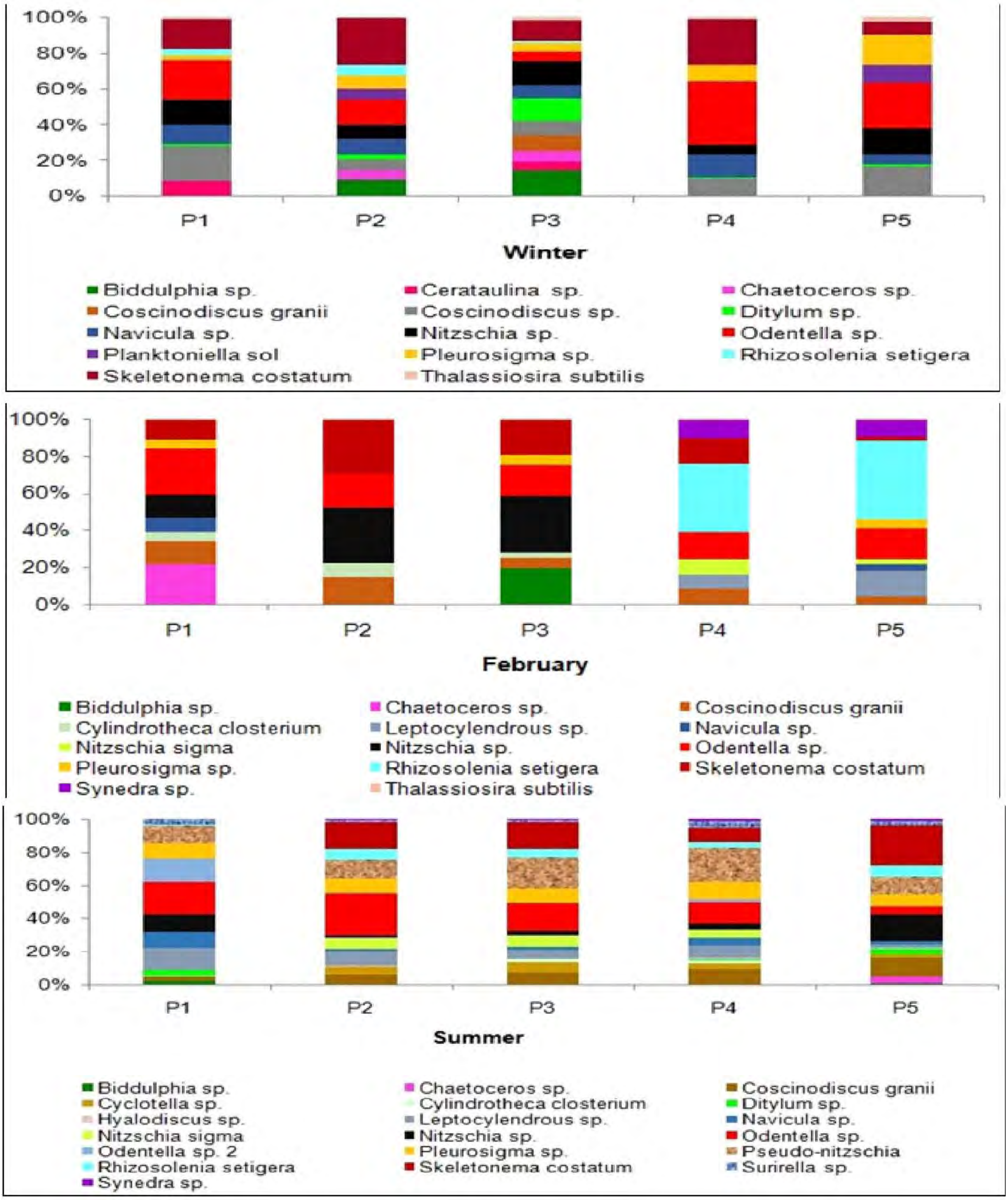


Fig 1.8. Seasonal variation in the percentage composition of the Phytoplankton species in the Thane Creek

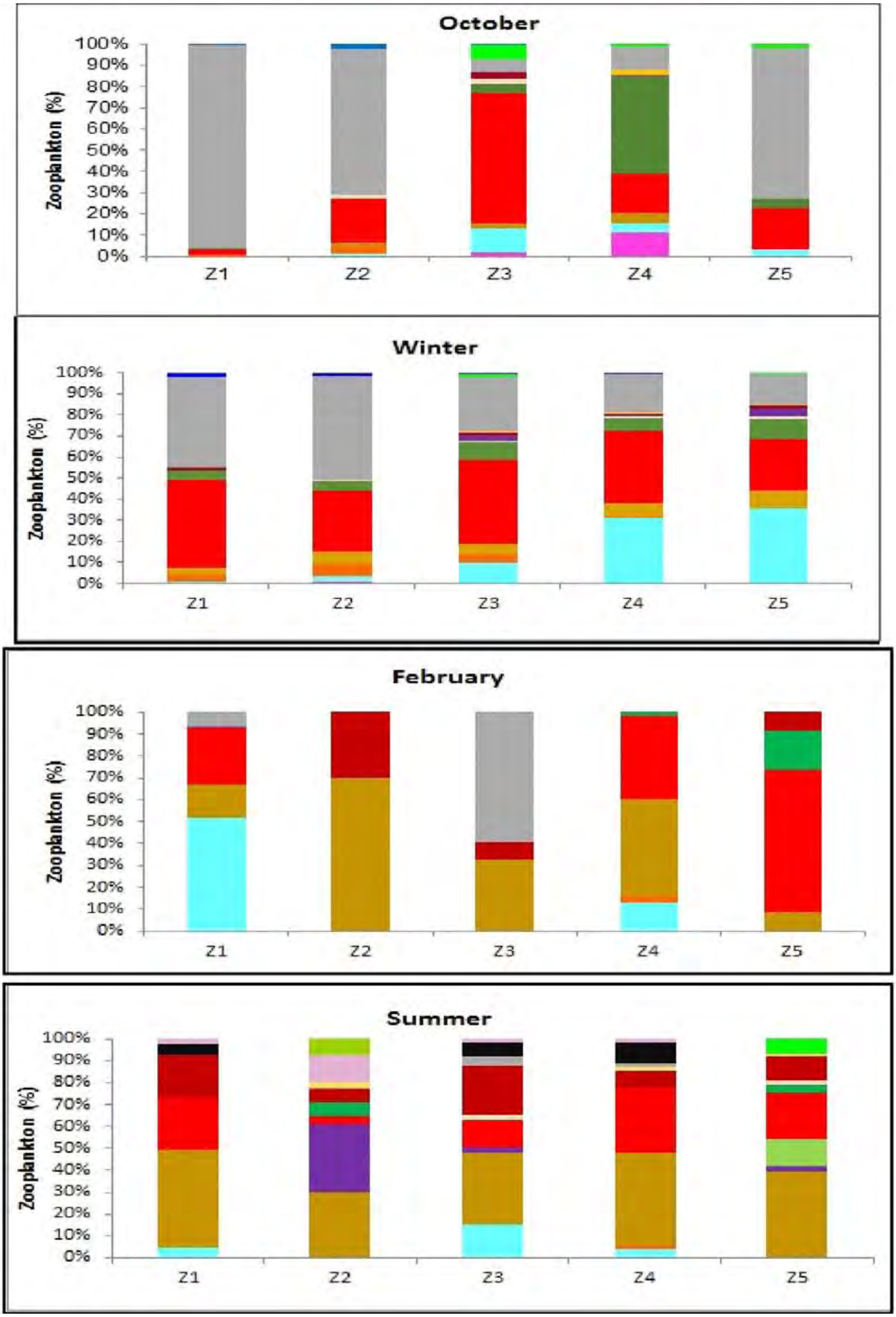


Fig 1.9. Seasonal variation in the percentage composition of the different zooplankton groups in the Thane Creek

Table 4 Spatial variations in macrobenthic abundance, biomass, faunal diversity and Polychaete diversity in the Thane Creek and Sewri in October 2018

Transect	Abundance (Individuals in unit area)	Biomass (g per unit area)	Faunal Diversity								Polychaete Families
			Polychaeta	Gastropoda	Bivalvia	Phoronida	Arthropoda	Cnidaria	Chordata	Minor groups	
Tr-1	0-365	0-0.314	+	+	-	-	-	-	-	-	4
Tr-2	0-312	0-0.299	+	+	+	-	+	+	-	-	4
Tr-3	0-214	0-0.058	+	+	-	-	+	+	-	-	3
Tr-4	0-4	0-0.001	+	+	-	-	+	-	-	-	2
Tr-5	0-7	0-0.014	+	+	-	-	-	-	-	-	3
Tr-6	0-8	0-0.005	+	-	-	-	-	-	-	-	2
Tr-7	1-2	0-0.001	+	-	-	-	-	-	-	-	1
Tr-8	1-5	0-0.013	+	-	-	-	-	-	-	-	1
Tr-9	0-9	0-0.001	+	-	-	-	-	+	-	-	3
Tr-10	0-4	0-0.004	+	-	-	-	-	-	-	-	2
Tr-11	0-80	0-0.013	+	+	-	-	+	-	-	-	2
Tr-12	0-167	0-0.041	+	+	-	-	-	-	-	-	3
Tr-13	0-204	0-0.2	+	+	-	-	-	-	-	-	3
Tr-14	0-191	0-0.209	+	+	+	-	-	-	-	-	6
Tr-15	0-63	0-0.42	+	+	+	-	-	-	-	-	4
Tr-16	0-350	0-0.013	+	+	+	+	-	-	-	-	5
Tr-17	0-58	0-0.027	+	+	+	+	+	-	-	-	6
Tr-18	0-143	0-0.083	+	+	+	+	-	+	-	-	8
Tr-19	0-548	0-1.199	+	+	-	+	-	+	-	+	5
Tr-20	0-612	0-0.248	+	+	+	-	-	+	-	-	5
Tr-21	0-202	0-0.163	+	+	+	+	+	-	-	-	5
Tr-22	0-36	0-0.345	+	+	-	-	-	-	-	-	6
Tr-23	0-21	0-0.288	+	+	+	-	+	-	-	+	5
Tr-24	0-26	0-9.148	+	+	+	-	-	-	+	-	4
Tr-25	0-6	0-0.014	+	+	+	-	+	-	-	-	4
Tr-26	0-11	0-0.018	+	+	+	+	+	+	-	-	3
Tr-27	0-15	0-1.222	+	+	+	-	-	+	-	-	6
Tr-28	0-11	0-1.147	+	+	-	-	+	+	-	-	5
Tr-29	0-198	0-8.18	+	+	+	+	+	+	+	+	9
Tr-30	0-26	0-0.949	+	+	+	+	+	+	-	-	5
Tr-31	0-469	0-1.21	+	+	+	+	-	+	-	-	4
Tr-32	0-1725	0-0.977	+	+	+	+	+	+	-	-	6
Tr-33	0-377	0-0.472	+	+	+	+	-	+	-	-	7
Tr-34	0-167	0-0.896	+	+	-	+	+	-	-	-	6
Tr-35	0-232	0-0.234	+	+	+	+	-	+	-	-	8
Tr-36	0-219	0-0.173	+	+	-	+	-	+	-	-	7
Tr-37	0-810	0-1.09	+	+	-	+	+	+	+	+	4
Tr-38	0-441	0-1.623	+	+	+	+	+	+	-	-	5
Tr-39	2-450	0.002-0.231	+	+	+	+	-	-	-	-	7
Tr-40	0-890	0-0.781	+	-	-	-	-	-	-	-	5
Sewri	0-121	0-0.847	+	+	+	-	+	+	-	+	5

Table 5 Spatial variations in macrobenthic abundance, biomass, faunal diversity and Polychaete diversity in the Thane Creek and Sewri during the winter

Transect	Abundance (Individuals in unit area)	Biomass (g per unit area)	Faunal Diversity								Polychaete Families
			Polychaeta	Gastropoda	Bivalvia	Phoronida	Arthropoda	Cnidaria	Chordata	Minor groups	
Tr-1	0-135	0 - 0.285	+	+	+	-	-	-	-	+	4
Tr-2	0 - 192	0-0.183	+	+	-	-	-	-	-	-	4
Tr-3	0 - 148	0-0.124	+	+	-	-	-	+	-	-	3
Tr-4	0-228	0.0-0.21	+	+	-	-	-	-	-	-	3
Tr-5	0 - 64	0 - 0.046	+	+	-	-	-	+	-	-	2
Tr-6	0 - 15	0-0.001	+	-	-	-	-	-	-	-	1
Tr-7	0 - 15	0-0.005	+	-	-	-	-	-	-	-	1
Tr-8	0-55	0-0.012	+	-	-	-	-	-	-	-	1
Tr-9	0-139	0-0.03	+	-	-	-	+	-	-	-	3
Tr-10	0-56	0-0.01	+	+	-	-	-	-	-	-	2
Tr-11	0-337	0-0.039	+	+	-	-	+	-	-	-	2
Tr-12	0-206	0-1.17	+	+	-	-	+	-	-	-	4
Tr-13	0-97	0-0.9	+	+	-	-	+	-	-	-	3
Tr-14	0-179	0-0.043	+	+	+	+	-	-	-	-	3
Tr-15	0-105	0-0.6	+	+	+	-	-	-	-	-	5
Tr-16	0-91	0-0.084	+	+	+	+	-	-	-	-	4
Tr-17	0-155	0-0.9	+	+	+	+	+	+	-	-	5
Tr-18	0-278	0-0.839	+	+	+	+	+	+	-	+	6
Tr-19	0-132	0-2.255	+	+	+	+	+	+	-	+	4
Tr-20	0-79	0-1.794	+	+	+	+	+	+	-	+	5
Tr-21	0-560	0-0.58	+	+	+	+	+	+	-	+	6
Tr-22	0-97	0-8.719	+	+	+	+	+	+	-	+	4
Tr-23	0-53	0-0.973	+	+	+	+	+	-	-	-	4
Tr-24	0-24	0-0.672	+	+	+	-	+	-	+	+	5
Tr-25	0-33	0-0.659	+	+	+	-	+	-	-	-	4
Tr-26	0-26	0-0.366	+	+	-	-	-	-	-	-	4
Tr-27	0-55	0-1.67	+	+	+	+	+	+	+	+	5
Tr-28	0-21	0-1.95	+	+	+	-	+	+	-	-	5
Tr-29	0-73	0-1.53	+	+	+	+	+	+	+	-	6
Tr-30	0-39	0-3.073	+	+	+	+	+	+	-	+	6
Tr-31	0-151	0-4.931	+	+	+	+	+	+	-	+	6
Tr-32	0-170	0-1.957	+	+	+	+	+	+	-	+	5
Tr-33	0-157	0-1.87	+	+	+	+	+	+	-	+	6
Tr-34	0-47	0-2.724	+	+	+	+	+	+	-	+	6
Tr-35	0-628	0-2.248	+	+	+	+	+	+	-	+	6
Tr-36	0-538	0-0.575	+	+	+	+	+	+	-	+	5
Tr-37	0-245	0-4.943	+	+	+	+	-	+	-	+	4
Tr-38	0-817	0-4.338	+	+	+	+	+	+	-	-	4
Tr-39	0-1506	0-2.534	+	+	+	-	-	+	-	-	4
Tr-40	0-230	0-0.234	+	+	+	-	-	-	-	-	5
Sewri	0-163	0-0.932	+	+	+	-	+	+	+	-	7

Table 6 Spatial variations in macrobenthic abundance, biomass, faunal diversity and Polychaete diversity in the Thane Creek and Sewri in February 2019

Transect	Abundance (Individuals in unit area)	Biomass (g per unit area)	Faunal Diversity								Polychaete Families
			Polychaeta	Gastropoda	Bivalvia	Phoronida	Arthropoda	Cnidaria	Chordata	Minor groups	
Tr-1	0 - 1000	0 - 0.512	-	+	+	-	-	-	-	-	
Tr-2	0 - 2	0 - 0.001	+	-	-	-	-	-	-	-	1
Tr-3	0 - 113	0 - 0.079	+	-	-	-	-	-	-	-	2
Tr-4	0 - 169	0 - 0.076	+	-	-	-	-	-	-	-	1
Tr-5	0 - 131	0 - 0.064	+	+	-	-	-	-	-	-	2
Tr-6	0 - 66	0 - 0.024	+	-	-	-	+	-	-	-	3
Tr-7	0 - 5	0 - 0.002	+	-	-	-	+	-	-	-	2
Tr-8	0 - 164	0 - 0.083	+	-	-	-	-	-	-	-	3
Tr-9	0 - 101	0 - 0.07	+	+	-	-	-	-	-	-	2
Tr-10	3 - 537	0 - 0.113	+	-	-	-	-	-	-	-	2
Tr-11	0 - 80	0 - 0.02	+	-	-	-	-	-	-	-	2
Tr-12	2 - 328	0 - 0.152	+	-	-	-	-	+	-	-	2
Tr-13	0 - 226	0 - 0.412	+	+	-	-	-	+	-	-	2
Tr-14	0 - 252	0 - 0.118	+	+	+	-	-	-	-	-	3
Tr-15	0 - 230	0 - 0.161	+	-	-	-	-	-	-	-	4
Tr-16	0 - 152	0 - 0.081	+	+	-	-	-	-	-	-	5
Tr-17	0 - 182	0 - 0.146	+	+	+	-	-	-	-	-	4
Tr-18	0 - 294	0 - 0.379	+	+	+	-	-	-	-	-	4
Tr-19	0 - 68	0 - 0.063	+	+	+	+	-	-	-	-	4
Tr-20	0 - 186	0 - 0.596	+	+	+	+	-	+	-	-	7
Tr-21	0 - 245	0 - 0.945	+	+	+	+	-	-	-	+	5
Tr-22	0 - 143	0 - 10.155	+	+	+	+	-	+	-	-	4
Tr-23	1-41	0 - 0.047	+	+	+	+	-	-	-	-	5
Tr-24	3-66	0 - 0.825	+	+	+	+	-	+	-	-	8
Tr-25	0 - 59	0 - 0.091	+	-	+	-	-	-	-	-	4
Tr-26	0 - 64	0 - 0.089	+	+	+	-	-	-	-	-	4
Tr-27	0 - 19	0 - 0.144	+	+	+	-	+	-	-	-	5
Tr-28	0 - 18	0 - 0.249	+	+	+	+	+	+	-	+	8
Tr-29	1-78	0.001 - 1.801	+	+	+	+	-	-	-	+	5
Tr-30	0 - 68	0 - 5.509	+	+	+	+	-	-	-	-	7
Tr-31	0 - 21	0 - 0.266	+	+	+	+	-	-	-	-	5
Tr-32	0 - 39	0 - 1.648	+	+	+	-	+	-	-	-	7
Tr-33	0 - 141	0 - 2.498	+	+	+	+	-	-	-	-	9
Tr-34	0 - 57	0 - 0.34	+	+	+	+	+	-	-	+	9
Tr-35	0 - 25	0 - 0.057	+	+	-	-	-	-	-	-	1
Tr-36	0 - 20	0 - 0.555	+	+	-	+	-	-	-	-	5
Tr-37	0 - 78	0 - 0.551	+	+	+	-	-	-	-	-	7
Tr-38	0 - 132	0 - 0.142	+	+	+	-	+	+	-	-	4
Tr-39	0 - 72	0 - 0.056	+	+	-	-	-	-	-	-	4
Tr-40	0 - 278	0 - 0.131	+	+	+	-	-	-	-	-	5
Sewri	0 - 9	0 - 0.086	+	+	-	-	-	+	-	-	5

Table 7 Spatial variations in macrobenthic abundance, biomass, faunal diversity and Polychaete diversity in the Thane Creek and Sewri in summer

Transect	Abundance (Individuals in unit area)	Biomass (g per unit area)	Faunal Diversity								Polychaete Families
			Polychaeta	Gastropoda	Bivalvia	Phoronida	Arthropoda	Cnidaria	Chordata	Minor groups	
Tr-1	0-39	0-0.41	+	+	-	-	-	-	-	-	1
Tr-2	0-15	0-0.021	+	+	-	-	-	-	-	-	1
Tr-3	0-8	0-0.001	+	-	-	-	-	-	-	-	1
Tr-4	0-20	0-0.003	+	-	-	-	-	-	-	-	1
Tr-5	0	0	-	-	-	-	-	-	-	-	-
Tr-6	0	0	-	-	-	-	-	-	-	-	-
Tr-7	0	0	-	-	-	-	-	-	-	-	-
Tr-8	0-1	0-0.001	+	-	-	-	-	-	-	-	1
Tr-9	0	0	-	-	-	-	-	-	-	-	-
Tr-10	0	0	-	-	-	-	-	-	-	-	-
Tr-11	0-12	0-0.003	+	-	-	-	-	-	-	-	2
Tr-12	0-36	0-0.007	+	+	-	-	-	+	-	-	3
Tr-13	0-23	0-0.01	+	+	-	-	-	+	-	-	3
Tr-14	0-60	0-0.02	+	+	+	-	-	-	-	-	2
Tr-15	0-23	0-0.06	+	+	+	-	-	-	-	-	3
Tr-16	0-76	0-0.169	+	+	+	-	-	-	-	-	4
Tr-17	0-40	0-0.081	+	+	+	-	-	-	-	-	3
Tr-18	0-32	0-1.081	+	+	+	-	-	-	-	-	3
Tr-19	0-64	0-3.498	+	+	+	-	-	-	-	-	3
Tr-20	0-116	0-2.403	+	+	+	-	-	-	-	-	5
Tr-21	0-72	0-0.162	+	+	-	-	-	-	-	-	3
Tr-22	0-95	0-0.838	+	+	+	+	-	+	-	+	3
Tr-23	0-61	0-1.396	+	+	+	-	-	-	-	-	5
Tr-24	0-16	0-0.21	+	+	-	-	-	-	-	-	4
Tr-25	0-40	0-10.001	+	+	+	-	-	-	-	-	6
Tr-26	0-31	0-0.862	+	+	+	+	-	-	-	-	4
Tr-27	0-11	0-0.07	+	+	+	-	+	-	-	-	6
Tr-28	0-6	0-0.014	+	+	+	-	+	-	-	-	5
Tr-29	0-18	0-6.004	+	+	+	-	+	-	-	-	6
Tr-30	0-30	0-0.105	+	+	+	-	+	-	-	-	5
Tr-31	0-48	0-0.109	+	+	-	-	-	-	-	-	5
Tr-32	0-29	0-1.3	+	+	+	-	+	-	-	-	6
Tr-33	0-64	0-0.127	+	+	+	-	+	-	-	-	4
Tr-34	0-11	0-10.006	+	+	+	-	-	-	-	-	4
Tr-35	0-25	0-0.074	+	+	-	-	-	-	-	-	3
Tr-36	0-75	0-0.169	+	+	-	-	-	-	-	-	2
Tr-37	0-25	0-1.582	+	+	-	-	-	-	-	-	2
Tr-38	0-260	0-2.61	+	+	-	-	+	-	-	-	5
Tr-39	0-137	0-1.168	+	+	-	-	-	-	-	-	4
Tr-40	0-14	0-0.148	+	+	-	-	-	-	-	-	2
Sewri	0-128	0-1.829	+	+	-	-	+	-	-	+	5
Nhava	0-22	0-3	+	+	-	-	-	+	-	-	5

Plate 1

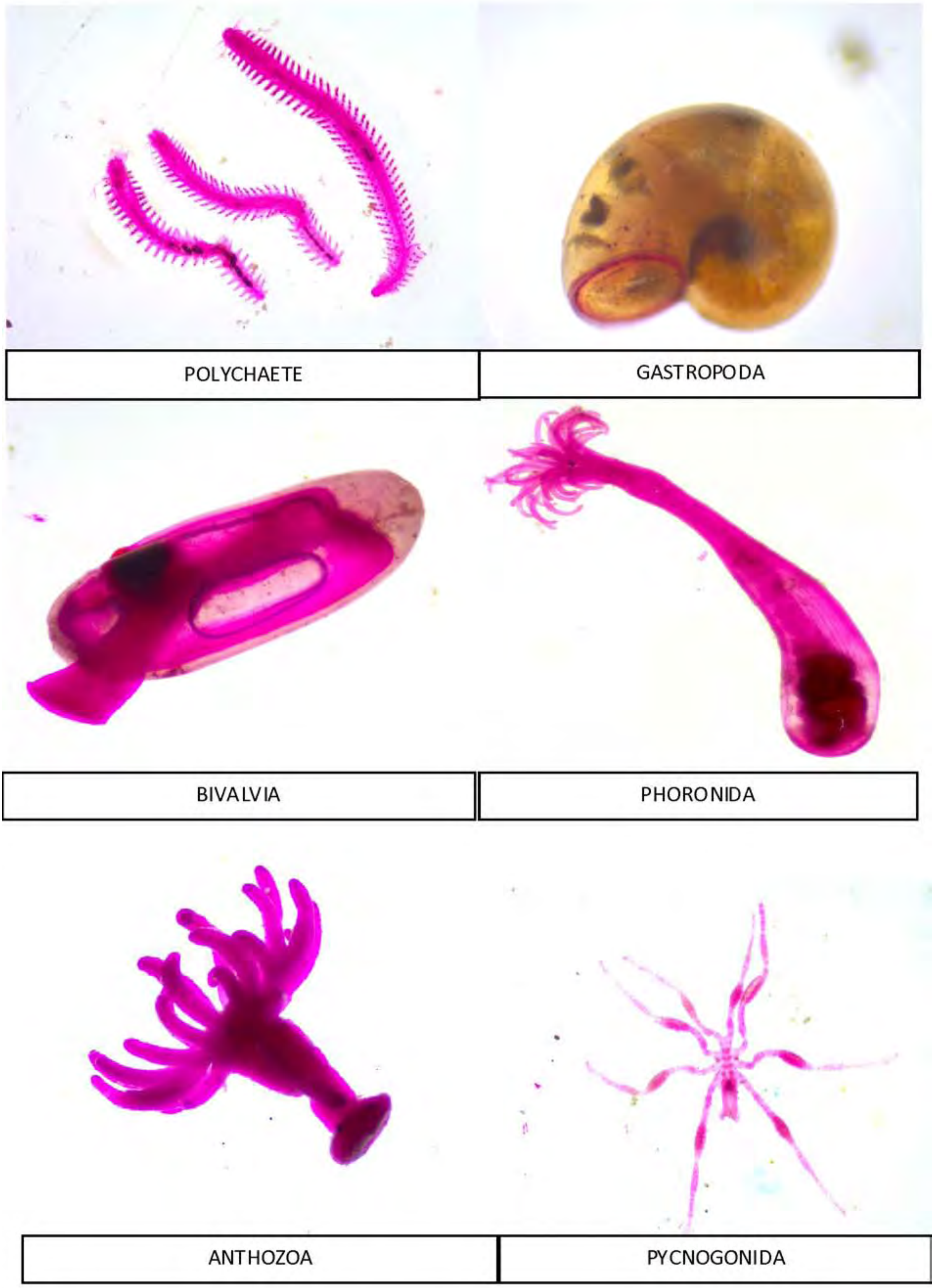
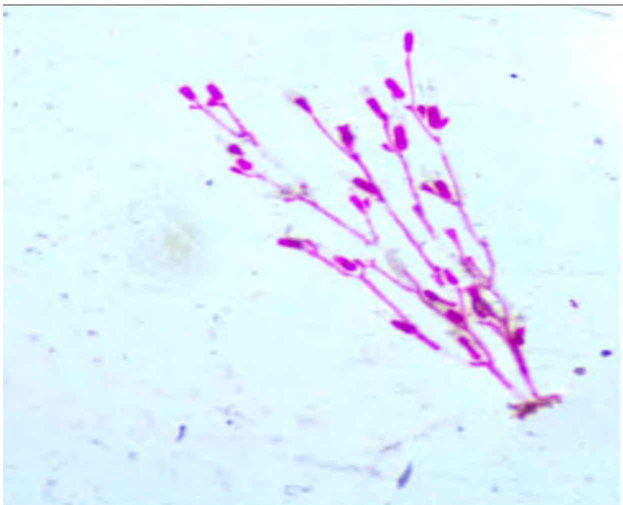

POLYCHAETE
GASTROPODA
BIVALVIA
PHORONIDA
ANTHOZOA
PYCNOGONIDA

Plate 2

BRACHYURAN

AMPHIPODA



HYDROID

Plate 3

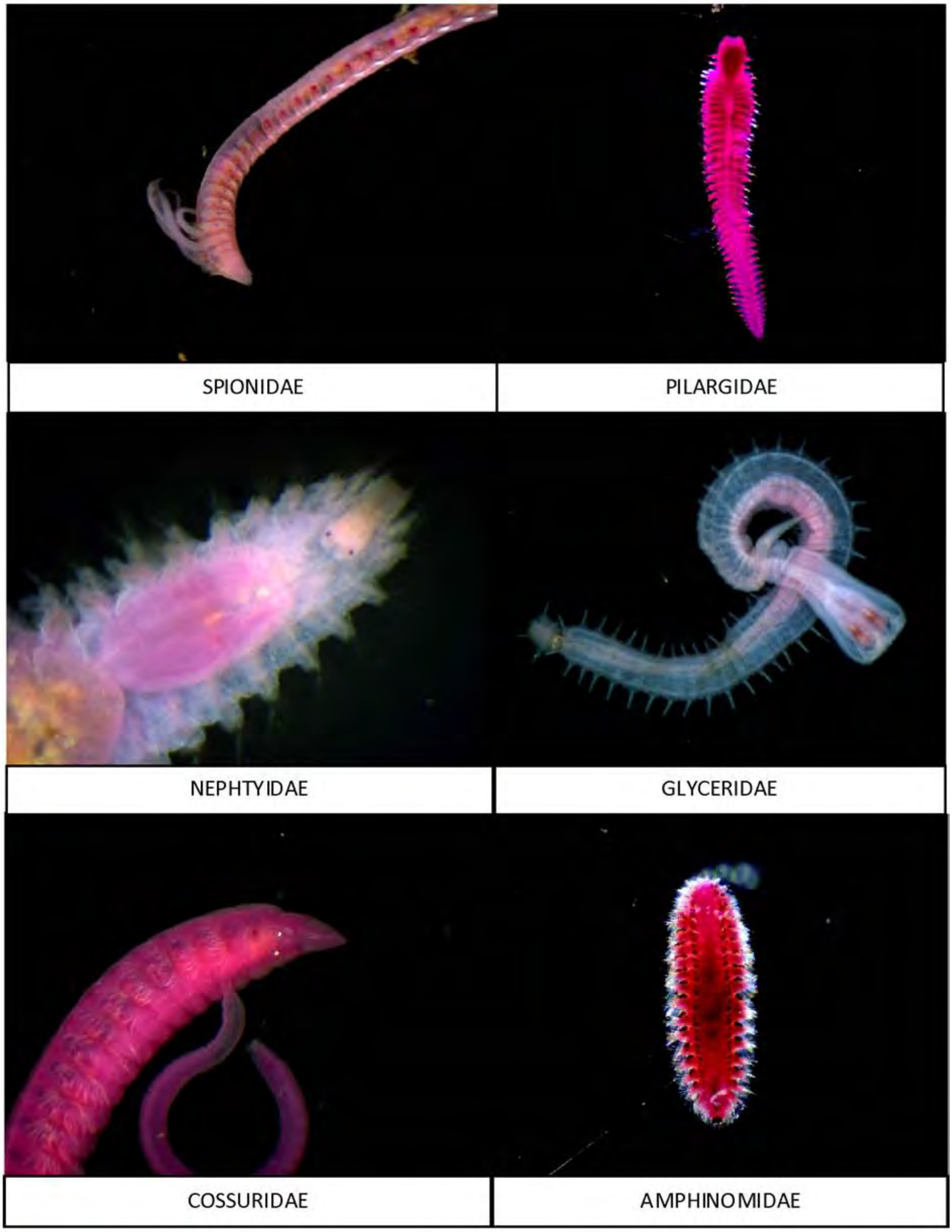
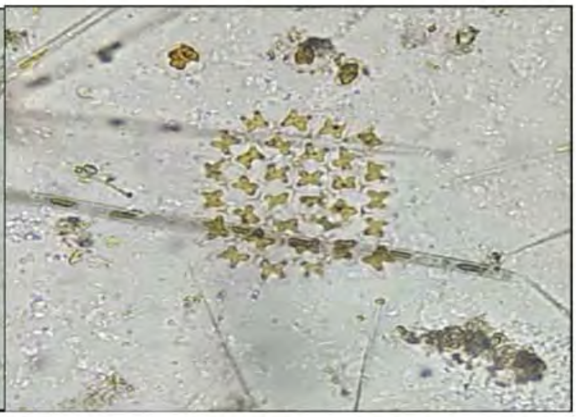

SPIONIDAE
PILARGIDAE
NEPHTYIDAE
GLYCERIDAE
COSSURIDAE
AMPHINOMIDAE

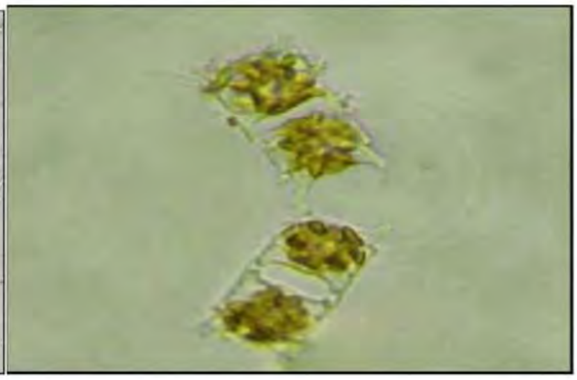
Plate 4

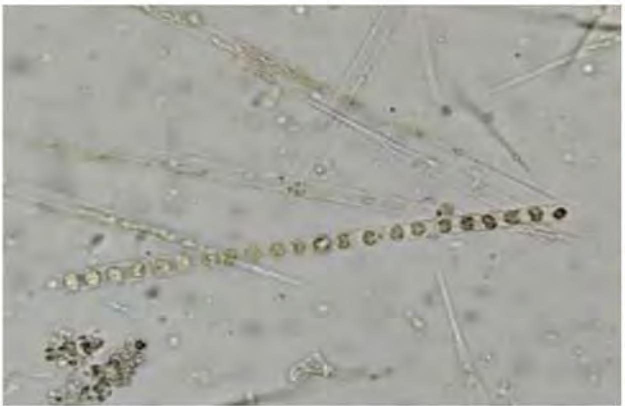
COSCINODISCUS



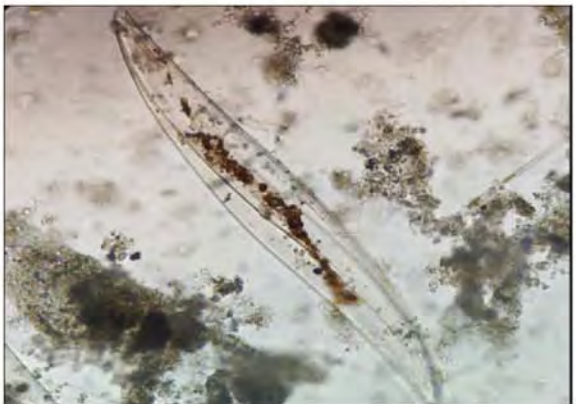
PEDIASTRUM

SCENEDESMUS





SKELETONEMA



PLEUROSIGMA

Plate 5

NEMATODE LARVA

ZOEA LARVA

COPEPODA

DECAPOD LARVAE

References

Ponsero A, A. Sturbois, N. Desroy, P. Le Mao, A. Jones, J. Fournier (2016): How do macrobenthic resources concentrate foraging waders in large megatidal sandflats? Estuarine Coastal and Shelf Science 178:120–128.

Touhami, F., H. Bazairi, B. Badaoui, A. Benhoussa (2017): Vertical distribution of benthic macrofauna in intertidal habitats frequented by shorebirds at Merja Zerga Lagoon. *Thalassas* 34: 255-265.

Annexure 1 Checklist of shorebirds in the creek and wetlands

Common Name	Scientific name	IUCN status	Migrant/Resident status
Asian Openbill	*Anastomus oscitans*	LC	R
Asian Woollyneck	*Ciconia episcopus*	VU	R
Bar-tailed Godwit	*Limosa lapponica*	NT	M
Black Bittern	*Ixobrychus flavicollis*	LC	R
Black-capped Kingfisher	*Halcyon pileata*	LC	R
Black Kite	*Milvus migrans*	LC	R
Black-headed Gull	*Larus ridibundus*	LC	M
Black-headed Ibis	*Threskiornis melanocephalus*	NT	R
Black-tailed Godwit	*Limosa limosa*	NT	M
Black-winged Kite	*Elanus caeruleus*	LC	R
Black-winged Stilt	*Himantopus himantopus*	LC	R
Brahminy Kite	*Haliastur indus*	LC	R
Broad-billed Sandpiper	*Calidris falcinellus*	LC	M
Brown-headed Gull	*Larus brunnicephalus*	LC	M
Caspian Tern	*Hydroprogne caspia*	LC	M
Cattle Egret	*Bubulcus ibis*	LC	R
Common Greenshank	*Tringa nebularia*	LC	M
Common Kingfisher	*Alcedo atthis*	LC	R
Common Moorhen	*Gallinula chloropus*	LC	R
Common Redshank	*Tringa totanus*	LC	M
Common Sandpiper	*Actitis hypoleucos*	LC	M
Common Snipe	*Gallinago gallinago*	LC	M
Common Teal	*Anas crecca*	LC	M
Common Tern	*Sterna hirundo*	LC	M
Curlew Sandpiper	*Calidris ferruginea*	NT	M
Dunlin	*Calidris alpina*	LC	M
Eurasian Coot	*Fulica atra*	LC	R
Eurasian Curlew	*Numenius arquata*	NT	M

Annexure 1 Checklist of shorebirds in the creek and wetlands (contd.)

Common Name	Scientific name	IUCN status	Migrant/Resident status
Eurasian Spoonbill	*Platalea leucorodia*	LC	M
Eurasian Wigeon	*Mareca penelope*	LC	M
Gadwall	*Mareca strepera*	LC	M
Garganey	*Spatula querquedula*	LC	M
Glossy Ibis	*Plegadis falcinellus*	LC	M
Great Egret	*Casmerodius albus*	LC	R
Great Knot	*Calidris tenuirostris*	EN	M
Greater Flamingo	*Phoenicopterus roseus*	LC	M
Greater Sandplover	*Charadrius leschenaultii*	LC	M
Greater Spotted Eagle	*Clanga clanga*	V	M
Grey Heron	*Ardea cinerea*	LC	R
Grey Plover	*Pluvialis squatarola*	LC	M
Gull-billed Tern	*Gelochelidon nilotica*	LC	M
Heuglin's Gull	*Larus heuglini*	LC	M
Indian Cormorant	*Phalacrocorax fuscicollis*	LC	R
Indian Pond Heron	*Ardeola grayii*	LC	R
Indian Skimmer	*Rynchops albicollis*	V	M
Indian Spot-billed Duck	*Anas poecilorhyncha*	LC	R
Indian Spotted Eagle	*Clanga hastata*	LC	R
Intermediate Egret	*Ardea intermedia*	LC	R
Kentish Plover	*Charadrius alexandrinus*	LC	M
African Comb Duck	*Sarkidiornis melanotos*	LC	M
Lesser Flamingo	*Phoeniconaias minor*	NT	M
Lesser Sandplover	*Charadrius mongolus*	LC	M
Lesser Whistling Duck	*Dendrocygna javanica*	LC	M
Little Cormorant	*Microcarbo niger*	LC	R
Little Egret	*Egretta garzetta*	LC	R
Little Grebe	*Tachybaptus ruficollis*	LC	R
Little Ringed Plover	*Charadrius dubius*	LC	M
Little Stint	*Calidris minuta*	LC	M
Little Tern	*Sternula albifrons*	LC	M
Marsh Sandpiper	*Tringa stagnatilis*	LC	M
Northern Pintail	*Anas acuta*	LC	M
Northern Shoveller	*Spatula clypeata*	LC	M
Osprey	*Pandion haliaetus*	LC	M
Pacific Golden Plover	*Pluvialis fulva*	LC	M
Painted Stork	*Mycteria leucocephala*	NT	R
Pallas's Gull	*Larus ichthyaetus*	LC	M
Pied Avocet	*Recurvirostra avosetta*	LC	M

Annexure 1 Checklist of shorebirds in the creek and wetlands (contd.)

Common Name	Scientific name	IUCN status	Migrant/Resident status
Pied Kingfisher	*Ceryle rudis*	LC	R
Purple Heron	*Ardea purpurea*	LC	R
Purple Swamphen	*Porphyrio porphyrio*	LC	R
Red-necked Falcon	*Falco chicquera*	NT	R
Red-necked Phalarope	*Phalaropus lobatus*	LC	M
Red-wattled Lapwing	*Vanellus indicus*	LC	R
Ruddy Shelduck	*Tadorna ferruginea*	LC	M
Ruddy Turnstone	*Arenaria interpres*	LC	M
Ruff	*Calidris pugnax*	LC	M
Shikra	*Accipiter badius*	LC	M
Slender-billed Gull	*Larus genei*	LC	M
Green-backed Heron	*Butorides striata*	LC	R
Temminck's Stint	*Calidris temminckii*	LC	M
Terek sandpiper	*Xenus cinereus*	LC	M
Western Marsh-Harrier	*Circus aeruginosus*	LC	M
Western Reef-Egret	*Egretta gularis*	LC	R
Whimbrel	*Numenius phaeopus*	LC	M
Whiskered Tern	*Chlidonias hybrida*	LC	M
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	LC	R
White-breasted Waterhen	*Amaurornis phoenicurus*	LC	R
White-throated Kingfisher	*Halcyon smyrnensis*	LC	R
Wood Sandpiper	*Tringa glareola*	LC	M