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Zooplankton composition and structure in the Indus River Estuary, Sindh, Pakistan

***Mushaiyada Mairaj*[1], *Sher khan Panhwar**[1] *and Fatima Hayat Shaheen Zafar* [2]**

[1]Centre of Excellence in Marine Biology, University of Karachi- 75270, Sindh, Pakistan.
[2]Department of Zoology, Federal Urdu University of Arts, Science and Technology, Karachi, Pakistan.
*Corresponding Author.

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Abstract

In this study abundance and composition of zooplanktons in the Indus River Estuary was conducted to examine habitat characteristics and its impact on tiny organisms. Overall 30,656 individuals were identified and segregated into seven major groups including Copepods, Cnidarians, Decapods, Mollusk, Pisces, Amphipods and Chaetognaths. For better understanding they were further divided into eighteen planktonic categories. Among them Lucifer spp. comprises of 52.21% was the most abundant group with a peak appeared in March whereas Chaetognaths were rarely observed in the entire study period. Species diversity exhibited a mixed trend with the highest values (0.776) of dominance observed in spring (March). The results of Canonical Correspondence Analysis (CCA) indicate (60.2% and 39.79%) variability among first II axis. On this basis of the result it is obvious that water turbidity is trigger of the abundance and distribution whereas total dissolved solids (TDS) showed minimal influence deduced from CCA analysis.

Keywords: Canonical Correspondence Analysis, Heterotrophs,Indus River Estuary, trophic level, Zooplanktons.

Introduction

Autotrophs and heterotrophs in an aquatic system occupy central role in energy shift and exclusively involved in maintaining food web dynamics. Rich diversity of such organism is passably delineating water quality, ecosystem health, and energy transfer up-to higher trophic levels. A zooplankton community ecosystem produces a significant relation of aquatic food web and performs important biological processes[1]. Zooplankton considered as indicator of estuarine conditions because they have the potential to remain in the water body at appropriate salinities[2]. The decreasing trends of zooplankton diversity noticed when exposed to hypoxic / anoxic conditions related to polluted systems[3]. Moreover, quantitative damage due to pollution is rather than qualitative changes in heterotroph communities in neritic zone penetrate the estuaries[3]. The estuaries, lagoons and bays are characterized by the soar productivity, functions as filters or decanters, accumulating nutrients, sediment transportation, receive contaminants carried by rivers, ocean atmosphere and create a unique ecosystem[4]. Therefore, their reorganization, ecological status and environmental inconsistency would help in planning and monitoring estuarine and coastal ecosystems[5]. Heterotrophs help to transport energy produced by the autotrophs through photosynthesis to other trophic levels and subsequently assist ecological processes of food-web dynamics[6,7]. Keeping in mind scarce of

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information pertinent to the zooplanktons inhabiting in the IRE, this research was intended to characterize assemblage structure, dynamics and interaction with environment during amphidromy in the IRE.

Materials and Methods

Study area

The sampling was conducted from fixed locations (2400203.6" N 6702846.0" E) in the Indus River Estuary from September 2017 to May 2018 (Fig. 1).

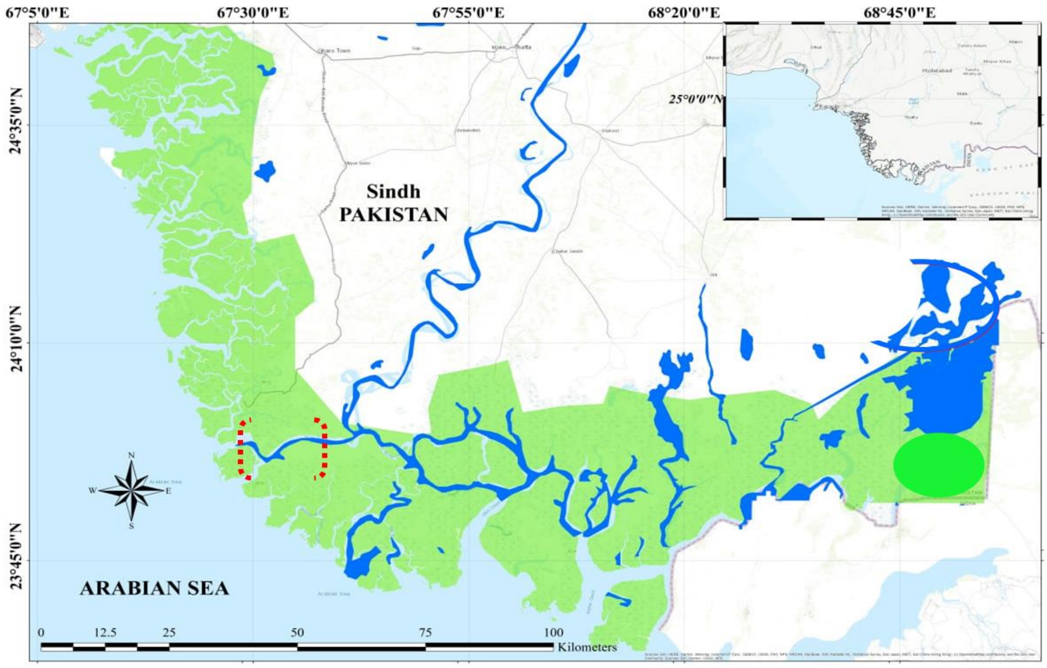

Figure 1. Sampling locations are highlighted within *Red dotted* area, Indus River Estuary Sampling and measurement

Plankton net with 300-micron mesh size was toed horizontally with a medium size fishing boat for 15 minutes in the main creek of Indus River Estuary in 2017-18. Samples were immediately preserved in 4% buffered formalin seawater solution and transported to the laboratory for further analysis. The qualitative and quantitative analysis of zooplankton, Molluscan larvae was made from subsamples of 50ml (25% of the whole sample i.e., 200 ml) examined under a binocular microscope SMZ-1270, Nikon by pouring sample into a sorting tray. The zooplanktons were identified according to the guide / book published on marine zooplankton practical guide for northern Arabian Sea.After an average count, the wet weight of each sample was taken following gravimetric method through filtering the sample on pre-weighed filter papers; moreover, water was carefully dried out using blotting filter papers. The estimation of biomass was recorded in grams and standing stock values are converted into per cubic meter and calculated as: Volume of zooplankton sample (ml / m^3) = Total volume of zooplankton / Volume of water filtered (V). Wet weight of zooplankton sample (g / m^3) = Total wet weight of zooplankton/Volume of water filtered (V). Coincident with zooplankton samples water quality parameters include temperature, salinity, conductivity, dissolved oxygen, and pH were recorded by using Hydrolab-HL4 USA.

Statistical analysis

A comparative diversity indices analysis was conducted to determine fitness of the data and robustness. For this purpose, Simpson's diversity

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index (S), Dominance (D), Shannon (H), Evenness (e^H/S), Menhinick, Margalef, Equitability (J) and Fisher (alpha) was calculated.

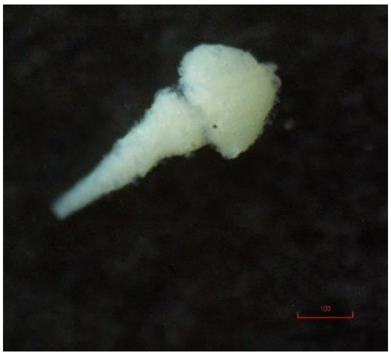
Multivariate approach of canonical correspondence analysis (CCA) was applied on the data of those taxa that consisted more than 0.5% in the entire sampled diversity was used to understand relationship, similarities and distances between zooplankton and environmental variables.

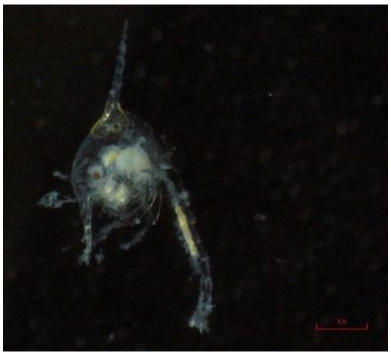
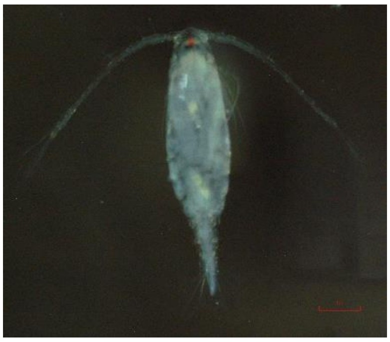
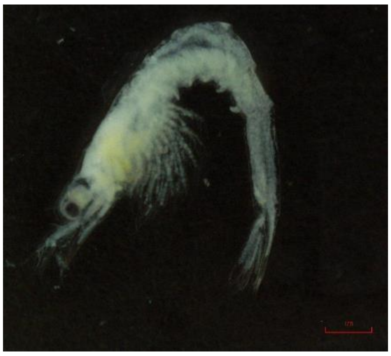
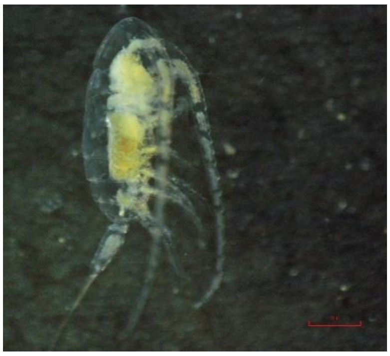
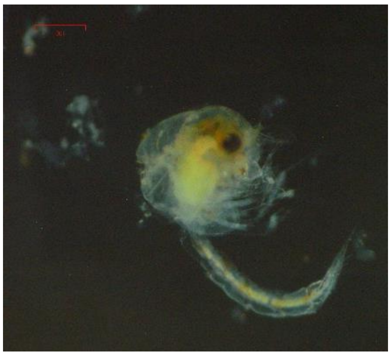
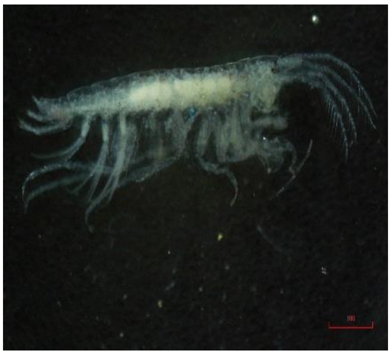
Results and Discussion

The samples were analyzed and categorized into eighteen planktonic categories, which were further classified into seven major Taxa, namely Cnidaria, Crustacea,Copepoda, Amphipoda, Decapoda, Mollusca and Chaetognatha.

The results of the study are presented in Fig. 2, which provides a visual representation of the taxonomic distribution of the identified zooplankton categories.Hence, revealed interesting patterns in the species composition among the eighteen planktonic categories.

The most abundant group was found to be *Lucifer* spp., comprising 52.21% of the total zooplankton population, and were observed in all sampling months with a peak in March. This finding suggests that *Lucifer* spp. may be an important and persistent member of the plankton community in the study area. Additionally, decapods, specifically crabs in the Zoea stage IV, were the second most abundant group, accounting for 18.21% of the total population. The abundance of crab Zoea stage IV was observed to be higher in November, while Zoea VI was more abundant in October. This may be attributed to the spawning season, recruitment, or hydrographical habitat changes. However, taxonomic similarities among all zooplankton groups made it challenging to identify them up to the species level. Furthermore, members of the Chaetognatha were rarely seen, while gastropod larvae were observed in the sample. Calanoid copepods, which comprised 7.28% of the total population, were also observed, and their abundance peaked in February. The peak may be due to favorable physicochemical parameters during that time (Fig. 3).

		
Jelly fish juvenile (Cnidaria)	Crab zoea III	Crab zoea VI

		
Crab zoea IV	Crab larva; megalopa	Calanoida sp.
		
Calanoida sp.	Shrimp larva	Calanoida sp.
		
Crab pre-zoea	*Lucifer* sp.	Amphipod sp.

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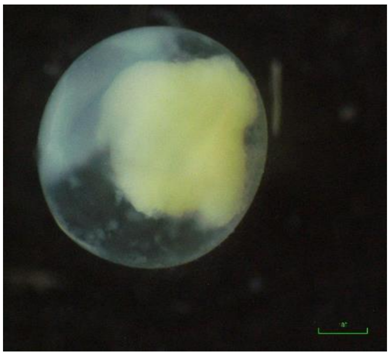
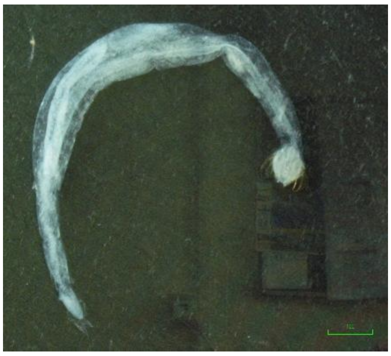
Gastropod larva	Gastropod larvae	Cyprid larva
		
Shrimp juvenile	Hermit crab juvenile	Fish egg
		
Chaetognatha (*Sagitta* sp.)	Fish larva	Fish larva

Figure 2. Inventory of the zooplanktons netted in the Indus River Estuary in 2017-18.

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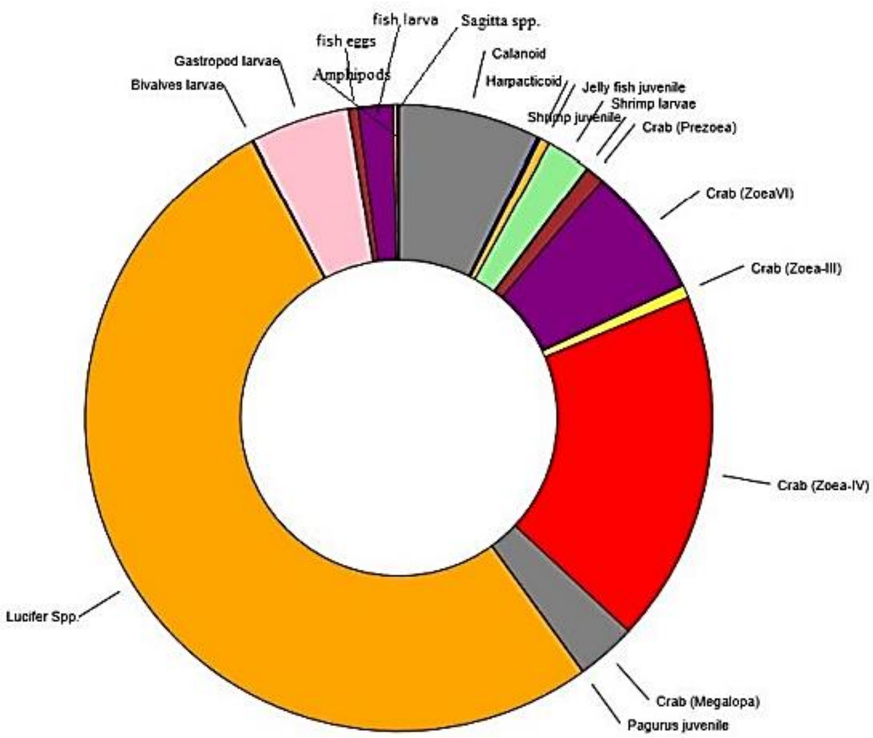

Figure 3. Graphical representation of species composition of the eighteen zooplankton groups netted in nine months from Indus River Estuary.

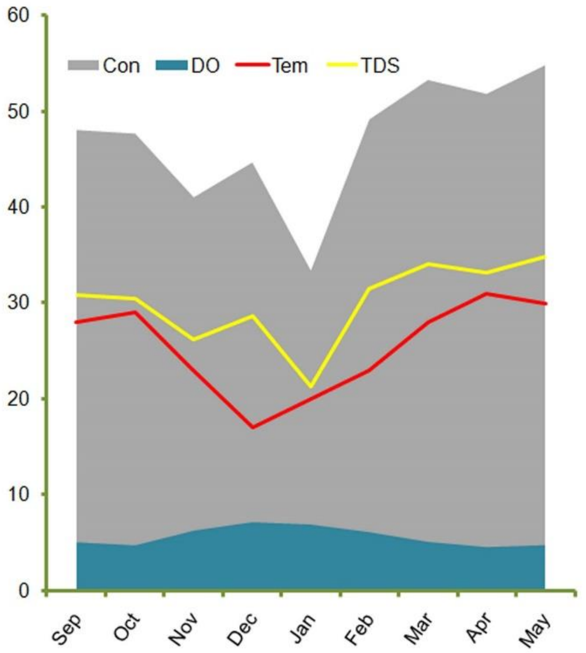

Figure 4. Water quality parameters temperature C^{o}, DO mg/l, conductivity cm^{2} and TDS ppm) recorded in 2017-18 using Hydrolab-HL4, USA.

Multiple diversity indices were applied on the pooled data to establish robust estimates of species diversity (Table 1). Summary of the eight diversity indices applied on the monthly zooplankton data (bolded value indicates highest in respective indices).

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Table 1. Summary of the eight diversity indices applied on the monthly zooplankton data (bolded value indicates highest in respective indices).

Diversity Indices	Sep 2017	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May 2018
Dominance (D)	0.440	0.701	0.455	0.144	0.774	0.413	**0.776**	0.432	0.151
Simpson (1-D)	0.560	0.299	0.545	**0.856**	0.226	0.587	0.224	0.568	0.849
Shannon (H)	**1.226**	0.685	1.154	2.029	0.425	1.254	0.545	1.352	2.013
Evenness (e^H/S)	0.379	0.221	0.396	**0.845**	0.510	0.389	0.288	0.387	0.748
Menhinick	0.212	0.119	0.162	**0.431**	0.189	0.238	0.047	0.267	0.361
Margalef	1.068	0.924	0.898	1.316	0.362	1.101	0.515	1.241	**1.355**
Equitability (J)	0.558	0.312	0.555	**0.924**	0.386	0.571	0.304	0.587	0.874
Fisher (alpha)	1.236	1.045	1.029	1.605	0.479	1.283	0.586	1.454	**1.623**

A mixed trend of species diversity was observed for instance highest values of dominances was observed in the month of March (0.776), Shannon and Simpson diversity estimates were pole apart. Interestingly highest evenness (0.845) was noticed in winter season.

Canonical correspondence Analysis was established using four water quality parameters of temperature, dissolved oxygen, conductivity, and salinity (Fig. 4).

The first axis explains 60.2% (0.520 eigenvalue) and second axis 39.79% (0.344 eigenvalue) among species and environmental data. Overall environmental parameter has influenced the planktonic community structure where TDS showed meagre influence (Fig. 5).

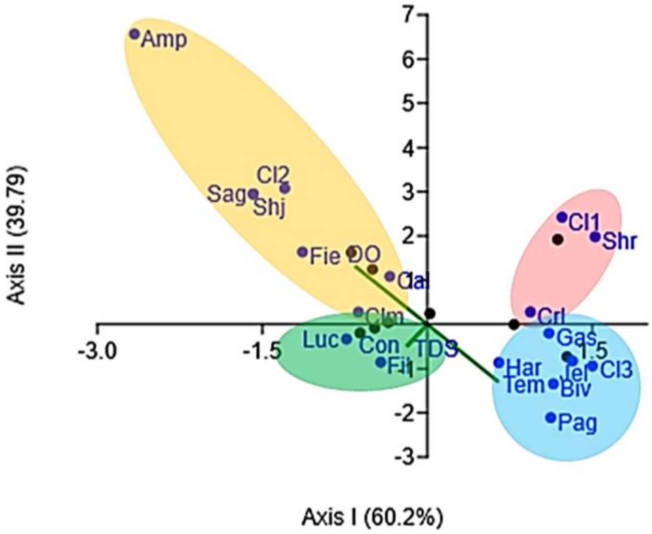

Figure 5. Canonical Correspondence Analysis CCA was established using 4 environmental variables (temperature, dissolved oxygen, total dissolved substances and conductivity) and details of eigenvalue of the axis I 0.520 and axis II 0.344.

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Discussion

Seasonal data on the diversity and assemblage structure of zooplanktons inhabiting Indus River Estuary (IRE) is gathered to fill knowledge gaps and describe their interaction with habitat characteristics. Moreover, well pronounced seasonality is obvious in zooplankton community in certain seasons. The holoplankton such as *Lucifer* and Calanoid Copepods dominated the zooplankton assemblage in terms of species diversity and abundance. Analysis of CCA reveals that salinity and turbidity are the triggers of diversity and abundance of zooplankton in IRE. Although identification of zooplankton groups at species level was not possible. However, current data makes basic information available about the zooplankton present in the IRE. This study demonstrates variation of zooplankton and their link with habitat characteristics. Despite their small size zooplankton contribute for highly productive systems through food-web structure[7]. Among zooplankton this study reveals that Decapoda is widely distributed in estuarine environment.

Significant seasonal variations such as peak appeared in March-April and this could be because of flood season in the river. Upwelling and down welling processes occasionally fertilize oceans due to hydrographic agitations here may explain the significant growth of the plankton populations. The more abundant zooplankton during that season can be related to the favorable climate or physicochemical parameter.

Nevertheless, the zooplankton peak in March-April may also related to a prevalent event within the Indus River estuary – the period of vertical mixing when the nutrient-rich, cold and complex waters reach at the surface near estuarine mouth. It is interpretable that lowest diversity was observed in NEM and the reason could be the lowest amount of food availability (phytoplankton) as physicochemical parameters do not favor phytoplankton growth. The higher peaks in *Lucifer* spp. abundance seem to be related to the autotrophic food potentially accessible. The diversity metrics were comparable and multiple indices used appropriately. Such pattern was seen in earlier studies[7, 8] support the idea that functional diversity is moderately a consideration of taxonomic diversity[9,10]. Recently multiple diversity indices were adopted to determine Phytoplanktons and their role in muddy habitat of Indus River Estuarine[11].

Canonical correspondence analysis using environmental variables demonstrated four groups are determinant shows that half of the zooplankton population reacts positively in estuarine ecosystem and survive whereas thirteen species on the left side (See CCA plot) negatively react with period changed of environmental parameters. It is pertinent to mention here that environmental factors can be the indicators that bring effects on biological communities. Hence it is quite complex interaction that exists between hydrography and planktonic community distribution. Critical suggestions for future studies may include examining the long-term trends of these groups and understanding the ecological significance of their abundance and distribution in the study area.

Conclusion

The findings of the study could serve as a baseline data for future investigations on the zooplanktons in that is essential to monitor the changes in the abundance and distribution over time, as they play a crucial role in the food web dynamics and nutrient flow in aquatic ecosystems. The complexity in taxonomic identification highlights the need for advanced molecular tools and species-level identification for accurate and precise data analysis. The study has also shed light on the importance of considering multiple factors such as hydrographical and physicochemical parameters and their impact on the distribution and abundance of tiny organisms in the IRE.

Author's Declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images that are not ours have been included with the necessary permission for re-publication, which is attached to the manuscript.
- The author has signed an animal welfare statement.
- Ethical Clearance: The project was approved by the local ethical committee in University of Karachi.

Author's Contribution Statement

MM identified species and drafted the manuscript, SKP designed study and finally shaped the article, and FHSZ helped in editing and improved the quality of the manuscript.

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بنية وتركيب العوالق الحيوانية في مصب نهر الأندوس، السند، باكستان

مشيادة المعراج[1]، شير خان بانوار[1] و فاطمة حياة شاهين زافا[2]

[1]مركز التميز في علم الأحياء البحرية ، جامعة كراتشي- 75270 ، السند ، باكستان.
[2]قسم علم الحيوان ، الجامعة الأوردو الفيدرالية للفنون والعلوم والتكنولوجيا ، كراتشي، باكستان.

الخلاصة

تعد هذه الدراسة المحاولة الاولى لفحص كثرة وبنية العوالق الحيوانية في نظام بيئي فريد وهو مصب نهر الأندوس. لقد تم التعرف على30,656 فرداً وقد ضمن ست مجاميع رئيسية. ولفهما بشكل أفضل فقد قسمت الى ثمانية عشر مجموعة من العوالق. لقد شكل52.21% .Lucifer spp وكانت أكثر المجاميع وفرة، وحدثت ذروتها في اذار، بينما كانت هلبية الفكوك من اندر المجاميع وجوداً خلال مدة الدراسة كلها. ويظهر دليل التنوع اتجاهاً مختلفاً. وقد لوحظ ان أعلى قيم السيادة (0.776) كانت في الربيع (اذار). وقد دلت نتائج تحليل التناسب القانوني (CCA) اختلافات بين المحورين الاوليين تراوحت بين 60.2% و39.79%، واشارت النتائج ان عكارة الماء هي العامل الرئيس الذي ينظم وفرة وتوزيع العوالق الحيوانية، بينما كانت المواد الصلبة الذائبة الكلية في ادنى قيمها المؤثرة أعتماداً على تحليل التناسب القانوني (CCA).

الكلمات المفتاحية: تحليل التناسب القانوني، تنوع مختلطة التغذية، مصب نهر الأندوس، مستوى التغذية، العوالق الحيوانية.