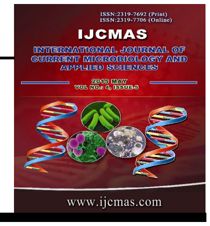

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Original Research Article

Altitudinal Variations in Diversity and Taxonomic Distinctness of Microalgae in Chalakudi River, flowing through the Biodiversity Hotspot, Western Ghats, India

K.M. Mohamed Nasser[1*] and S. Sureshkumar[2]

[1]P.G Department of Botany, MES Asmabi College, P.Vemballur, 680671 Kerala, India
[2]PG Department and Research Centre of Aquaculture and Fishery Microbiology, MES Ponnani College, Ponnani, 679 586, Kerala, India

**Corresponding author*

A B S T R A C T

The variation in the diversity and taxonomic distinctness of freshwater microalgae with respect to season and altitude has been studied in Chalakkudy River flowing through the biodiversity hot spot area of Western Ghats. 241 species of microalgae belong to 5 different classes viz., Chlorophyceae, Desmidiaceae, Bacillariophyceae, Euglenophyceae and Cyanophyceae were identified from the study area. A decreasing trend in Shannon diversity index was recorded with increase in altitude irrespective of seasons with higher value in low altitude area (6.6) and lower values in High altitude area (2.5). Maximum abundance of microalgae was observed in the post monsoon season and minimum during monsoon season. The values of both average taxonomic distinctness (AvTD; Δ+) and variation in taxonomic diversity (VarTD; □+) were analyzed to assess their variation from mean values using funnel plots. Simulation tests on Δ+ and□+ values using ellipses show that at low altitude area during monsoon both Δ+ and □+ fall outside the 95% confidence ellipse. High VarTD at high altitude area shows low diversity and low AvTD, which may be due to the higher occurrence of oligotrophic indicator species and low occurrence of other groups and in Low altitude area high AvTD and low VarTD may be due to occurrence of large number of groups (family, order etc.) and most of the groups are represented by different number of species.

Keywords

Microalgae, diversity, taxonomic distinctness, Western Ghats, Chalakkudy River

Introduction

Microalgae are integral part of aquatic ecosystem as primary producers, which transfer energy from abiotic components to different trophic levels. Documentation of the patterns in biodiversity of primary producers might be important due to its innate relationship with ecosystem function (Tilman, 2000). Conserving biodiversity through the protection of species richness is often an implicit or explicit goal of many management and conservation strategies (Gotelli and Colwell, 2001). In aquatic ecosystem the species diversity of organism is related to season, nutrients and climatic factors (Tolimieri, 2007). Therefore, the relationship between biodiversity and habitat features is important for the understanding of biogeography which in turn helpful in designing conservation strategies and designating conservation areas.

Biodiversity is however a complex concept and is much more intricate than just the total number of species in a given area (Purvis and Hector, 2000). Taxonomic distinctness presents diversity as the relatedness of the species within a sample based on the distance between species in a classification tree (Clark and Warwick, 2001). Average taxonomic distinctness (AvTD; Δ+) is the mean of all species to species distances through the tree for all pairs of species within a sample and represents the taxonomic breadth of sample. The variation in taxonomic distinctness (VarTD; □+) is the variation in branch length among all pairs of species and is a measure of the irregularities and divergences in the distribution of branch length in a sample. Both indices are based on presence or absence of data and unlike many biodiversity measures neither is affected by the number of species or the sampling effort (Clark and Warwick, 1998).

In aquatic environment the taxonomic distinctness has been used as tool to examine environmental degradation like the effect of pollution (Guo *et al.* 2001) and other anthropogenic drivers (Wildsmith *et al.*, 2009). Trends in taxonomic distinctness with season and habitat have been examined for marine microalgae (Vaheeda 2008). Bevilaqua *et al.* (2009) used the taxonomic distinctness indices for assessing the patterns of biodiversity Sea weeds in Adraitic Sea in Italy. Mounillota *et al.* (2005) studied the taxonomic distinctness to discriminate the coastal lagoon environments based on microalgal communities. However, the studies on the microalgal taxonomic diversity in the Western Ghats region are least attempted. Here we describe quantitatively how species diversity, AvTD and VarTD vary with season and altitude for microalgae on a river flowing through high rated biodiversity hotspots of southern Western Ghats, India.

Materials and Methods

Water samples were collected from streams of Chalakudy river basin during 2009-2012. Collections were made seasonally for 2 years fixing a total of 10 stations at high, medium and low altitudes. All the samples were collected in quadruplicate. Microalgae were enumerated and identified using standard keys (Venkataraman, 1939; Desikachary, 1959; Agarkar *et al.* 1979; Prescott 1982; Sarode and Kamat 1984; Anand, 1989).

The study area (Fig. 1) lies between $10^{o}13'$ to $10^{o}55'$ N and $76^{o}25'$ to $76^{o}77'$ E-in the Anamalai landscape unit of southern Western Ghats immediate south of Palakkad gap. The Chalakkudy River originates from the north western part of Anamalai Hills and flow westward to reach the Lakshadweep Sea near Kodungallur in the west. Anamalai is marked as one among the three very hot spots of biodiversity in the entire Western Ghats.

Data analysis

Species and individual count of the microalgae in each sample were tabulated separately. Shannon diversity Index (H□), AvTD and VarTD were worked out for each stations using Primer 6.1.14 software. ANOVA was employed to test the differences between various diversity indices among the stations with respect to season and altitude. A reference list from species to class was made for the 241 microalgae collected from the region. This list combined with the data matrix was used to calculate the values of AvTD and VarTD. The results of ANOVA showed that there is no significant ($P>0.05$) variation in diversity indices among the stations categorized under high, medium and low altitude and showed significant ($P<0.05$) variation between the stations of various altitudes. Further comparison of diversity indices between the seasons showed that there is significant ($P<0.05$) variation between the post-monsoon, pre-monsoon and monsoon seasons and there is no significant ($P>0.05$) variation between same season in first and second year of study. Therefore the entire data is pooled as high, medium and low altitude with respect to post-monsoon, pre-monsoon and monsoon seasons.

The values of H□, Δ+ and□+ were again worked out for each region and seasons two-way ANOVA was employed to test the differences in the indices among the regions and seasons. To test the departure from the expectations of taxonomic distinctness values, we generated 95% confidence funnel following Warwick and Clark (1998). The values of the Δ+ and □+ of nine samples plotted against the corresponding values of number of species.

Using the same simulations underlying the construction of funnels, a scatter plot was developed by plotting Δ+ against □+ and also developed 50 and 75% confidence contour ellipse (Clark and Warwick, 2001). This bivariate approach was used to test departure from expectation of Δ+and □+ values on the whole assemblage characterizing each area. All the analysis was done using the Primer 6.1.14 package (Clark and Warwick, 2001).

Result and Discussion

241 species of microalgae belong to 5 classes viz., Chlorophyceae, Desmidiaceae, Bacillariophyceae, Euglenophyceae and Cyanophyceae were identified from the study area. 68 species of Chlorophytons under 39 genera, 71 desmids under 11 genera, 72 diatoms under 27 genera, 11 Euglenoids under 4 genera and 20 Blue-green algae 11 genera were recorded during the present study.

Tas and Gonulol (2007) identified 104 species of microalgae from a shallow river in Turkey, 46% belongs to Chlorophyceae, 23% Bacillariophyceae, 16% belongs to Cyanophyceae and 11% belogs to Euglenophyceae. Hulyal and Kaliwal (2009) investigated microalgal diversity from Almatti Canal of Karnataka and reported 81 species of microalgae with the dominance of Bacillariophyceae (31%) followed by Chlorophyceae (8%) Cyanophyceae (4%), desmids (27%) and 30% Dinophyceae. Krishnan (2010) reported 46 microalgae from a tropical high altitude lake in Western Ghats, Mullapperiyar which comprises 60% diatoms, 30% desmids and 10% blue green algae. Similar observations were made during the present investigation with the dominance of diatoms from the high altitude area followed by desmids.

During the post-monsoon season at low altitude area maximum microalgal diversity and abundance were observed followed by pre-monsoon. Lowest microalgal abundance was recorded during monsoon season in the high altitude area (Fig. 2). Angsupanich and Rakkheaw (1997) reported a peak of microalgal production during post monsoon period and were lowest in the rainy period in Thale River in Thailand.

Wondie *et al.* (2007) observed highest microalgal production rates in post rainy season due to high nutrient availability and light conditions from a high altitude river Tana, Etiopia. Abundance of microalgae observed in the post monsoon season can attributed to the higher nutrient availability in the area after the monsoon rains.

The result of ANOVA showed that there is significant variation ($P<0.05$) in species diversity of microalgae with respect to altitude and season (Table 1). Though average taxonomic distinctness showed significant variation ($P<0.05$) with respect to season and altitude, the combination of the two brings in no significant variation ($P>0.05$) in the average taxonomic distinctness.

The Shannon diversity index ranged from 2.56 to 4.62 during the study period. During post-monsoon season higher diversity of periphytic microalgae was observed throughout the Chalakkudy River basin with Shannon index varying from 4.62 to 3.89. Though a lower diversity was observed generally during pre-monsoon when compared to post-monsoon, a higher diversity (4.19) was observed in downstream during pre-monsoon. Least diversity was observed during monsoon season (3.32 to 2.56) (Fig. 2). Low mean diversity of periphytic microalgae was recorded in the upstream regions in all seasons and higher diversity was observed in the downstream region. AvTD($\Delta+$) is a measure of biodiversity based on taxonomic distance from species, i.e., describes how closely related species constitute the assemblage.. Lower values denote the assemblage of closely related species and value increases with increasing occurrence of diverse groups. Higher values of $\Delta+$ in the low altitude area and lower values in high altitude area were observed irrespective of season. However, higher values for $\Delta+$ were recorded during the pre- monsoon season in all the three different altitudes (Fig. 3).

The VarTD (□+) emphasizes how similar the upper taxonomic levels (e.g. orders, classes) are within samples. Higher values of □+ shows the dominance of few species in the samples, whereas, lower values denote even distribution of all the species in the assemblages. □+ was recorded to be maximum in the high altitude and minimum in the low altitude area. Monsoon season at high altitude zone have the highest □+ value whereas the lowest value was observed during the monsoon at low altitude (Fig. 4).

Shannon-Wiener diversity index is a suitable indicator for water quality. Hendley (1977) used Shannon-Wiener diversity index as pollution index of micro algal communities especially diatoms and put forward the following scale "0–1: high pollution, 1–2 moderate, 2–3 small scale and 3–4 incipient pollution". The values of the diversity index of present investigation from all regions vary between 4.62 and 2.56. All the water quality parameters recorded from the Chalakkudy river basin did not cross the normal values prescribed by the pollution control board. Hence it is perceived that the regions studied were not under pollution stress.

AvTD ($\Delta+$) is a measure of biodiversity based on taxonomic distance species, i.e. describes how closely related species constitute the assemblage. Lower values denote the assemblage of closely related species and value increases with increasing occurrence of diverse groups. Higher values of $\Delta+$ in the downstream area and lower values in upstream area were observed during the present irrespective of season. However, higher values for $\Delta+$ were recorded during the pre-monsoon season in all the three different altitudes. This point towards the inference that, taxonomic diversity was higher in downstream region and one can expect lower diversity in upstream regions. Higher microalgal diversity or larger number of individuals belonging to different higher taxa was present during pre-monson season (Costello *et al.*, 2004). The loss of families in the different classes of microalgae in the upstream region due to environmental stress could be responsible for the significant decrease of the average taxonomic distinctness. McCann (2000) is of the view that the stability of an ecosystem depends on the ability of the community to contain species or functional groups that are capable of withstanding different response. At the same time as the taxonomic diversity is related to trophic diversity, the observed reduction in AvTd during post-monsoon and monsoon seasons at upstream and during monsoon at midstream can be explained as loss of functionality of microalgal assemblage in these areas due to environmental stress Higher average taxonomic distinctness (Δ+) values recorded from the downstream regions irrespective of the seasons and during post monsoon season from all the regions suggest the availability of large ecological niches with low environmental stress, allowing the establishment of populations with a high taxonomic diversity and varied biological requirements.

The VarTD (□+) emphasizes how similar the upper taxonomic levels (e.g. orders, classes) are within samples. Higher values of □+ shows the predominance of few species in the samples, whereas, lower values denote even distribution of all the species in the assemblages. According to Mouillotta *et al.* (2005) variation in Taxonomic distinctness is more related to the environmental variability. High VarTD (low taxonomic evenness) values indicate the presence of a phylogenetically closely related species. □+ was recorded to be maximum in the upstream and minimum in the downstream area. Monsoon season at upstream region recorded the highest □+ value whereas the lowest value was observed during the monsoon at downstream region. In upstream area the total microalgae were represented from two major classes viz., Chlorophyceae and Bacillariophyceae under 7 orders and 16 families, while in the downstream area the same is represented with 4 classes viz., Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae under 14 order and 28 families. The absence of indicative classes like Cyanophyceae and Euglenophyceae in the upstream area and its occurrence in downstream area clearly give the idea of uneven distribution of species belonging to the higher taxa in the samples. Upstream regions during post-monsoon and monsoon seasons occupied above the expected value indicate the unevenness in the distribution of the higher taxonomic group. The funnel plots for □+ reveals that during all the seasons in midstream, during post-monsoon in downstream regions and during pre-monsoon in downstream and upstream regions lie with in the mean □+ line suggesting an overall increase in complexity based on number of species widely dispersed in the higher taxa. High diversity observed in downstream region with high AvTD and low VarTD shows the presence of larger number of individuals belong to many taxonomic groups which are more or less evenly present in the samples. At upstream area, though the diverse groups were present, most of them belong to similar class and orders as was observed from high VarTD recorded from the area during in all the seasons. Bevilacqua *et al.* (2009) observed low VarTD in the assemblages of epiphytic hydroids due to the higher proportion of algal thallus. Comparison of Δ+ and □ + values using ellipses showed that, the periphytic algal community of the downstream region during monsoon season fell outside the 95% confidence ellipse even though upstream region during monsoon season fell within the ellipse. The presence filamentous Chlorophyceae in the downstream region make it unique during monsoon season than the other regions.

With respect to classical diversity indices, the greater potential of taxonomic distinctness indices in detecting environmental impact is, however, less clear. Some habitats or areas may have naturally lower values of taxonomic distinctness than others, but unless they are perturbed in some way so that their Δ+ values should fall within expectations (Warwick and Clark, 1998). The Δ+ values during post-monsoon in upstream region showed departure from expectations. This may be the reflection of lack of evenness in the species composition due to the ability of microalgae in the area to tolerate extreme environmental stress prevailing in upstream habitat. Lower temperature in the hill areas also reduces profound growth of algae. Vaheeda (2008) reported that the taxonomic distinctness of microalgae in the back waters of Kodungallur was departed from the expected 95% confidence level of stations that is extremely affected by environmental stress due to coir retting. The variation in taxonomic distinctness emphasizes how similar the upper taxonomic levels are within samples. In the present study the value of for VarTD during the post-monsoon in the upstream region is deviated from the expected level of distinctness. Water movements and fluctuation in physic-chemical parameters significantly affects the composition of microalgae in the upstream areas.

Pollution and other human intervention brings in algal proliferation in terms of diversity in the low altitude area and brings eutrophic condition while in high altitude low number of species that comprises more oligotrophic indicative group provide the information of oligotrophic water suitable for human consumption. This study help to detect and monitor changes in bio diversity in space and time in different parts of Western Ghats, yet there has been little consideration of which attributes of biodiversity quantifiable and ecologically relevant.

Table.1 Mean square and significance levels for two way ANOVA of variables recorded at three different altitudes of Chalakkudy River for three seasons during 2009-2011

	Season	Altitude	Season X altitude
Factor type	Fixed	Random	
Degree of Freedom	2	2	4
Diversity	51.20**	111.90***	94.5***
Δ+	219.9*	235.12*	11.88 ns
□+	12443.8 ns	121364*	17653.4***

Fig.1 Map showing the study area

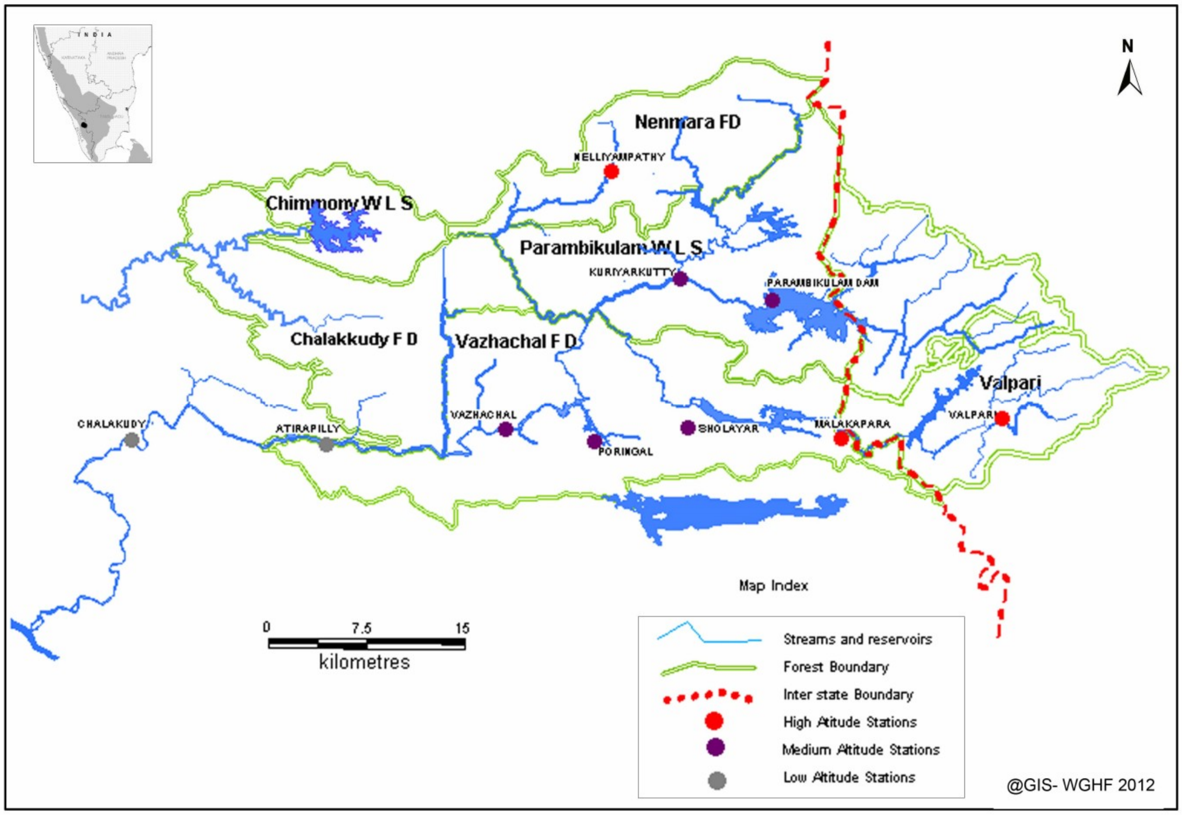


Fig.2 Shannon diversity index of microalgae collected from different altitudes during three different seasons in Chalakkudy River flowing through Western Ghats

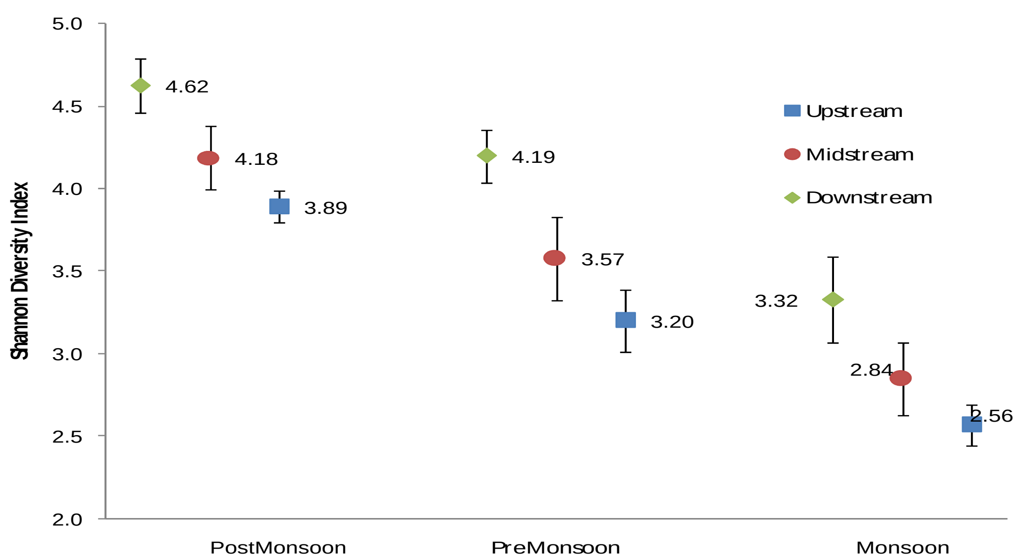


Fig.3 Average taxonomic distinctness of microalgae from different areas of Western Ghats during three different seasons

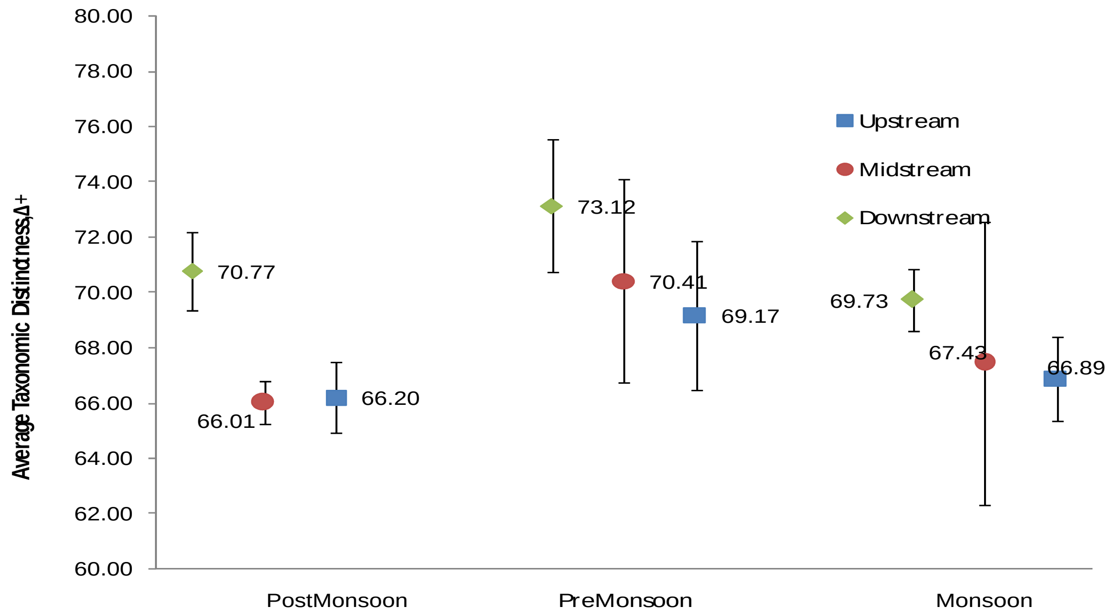


Fig.4 Variation in taxonomic distinctness of microalgae from different areas of Western Ghats during three different seasons

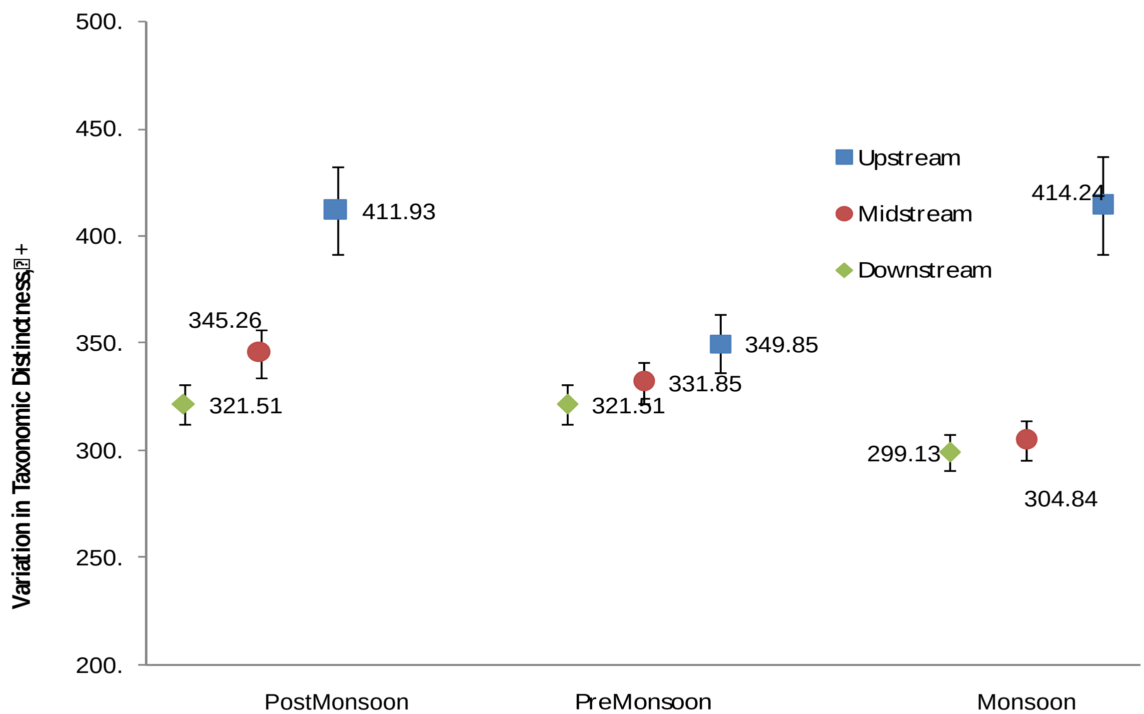


Fig.5 Average taxonomic distinctness (A) and Variation in taxonomic distinctness (B) of microalgae in three regions of Western Ghats in different seasons

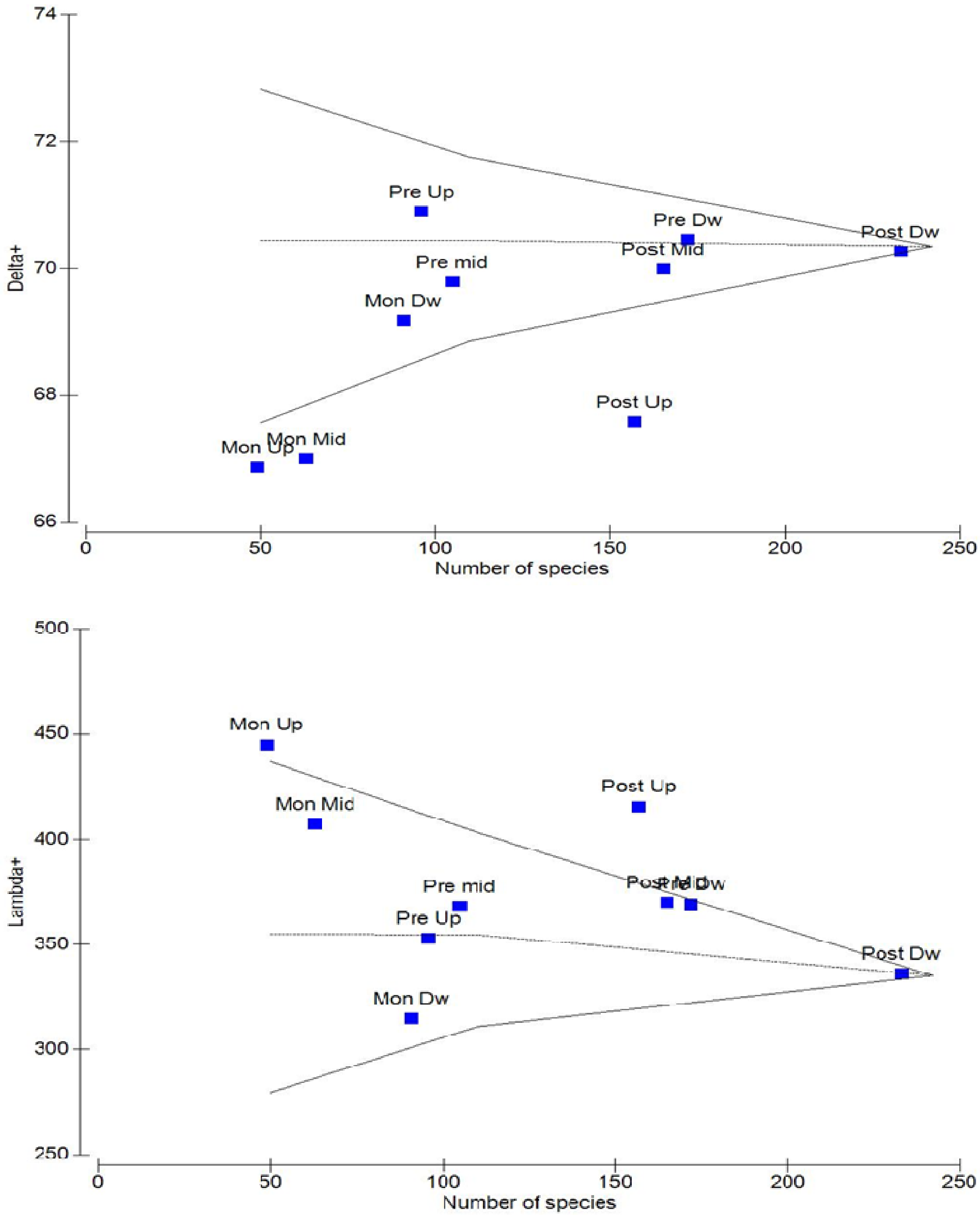
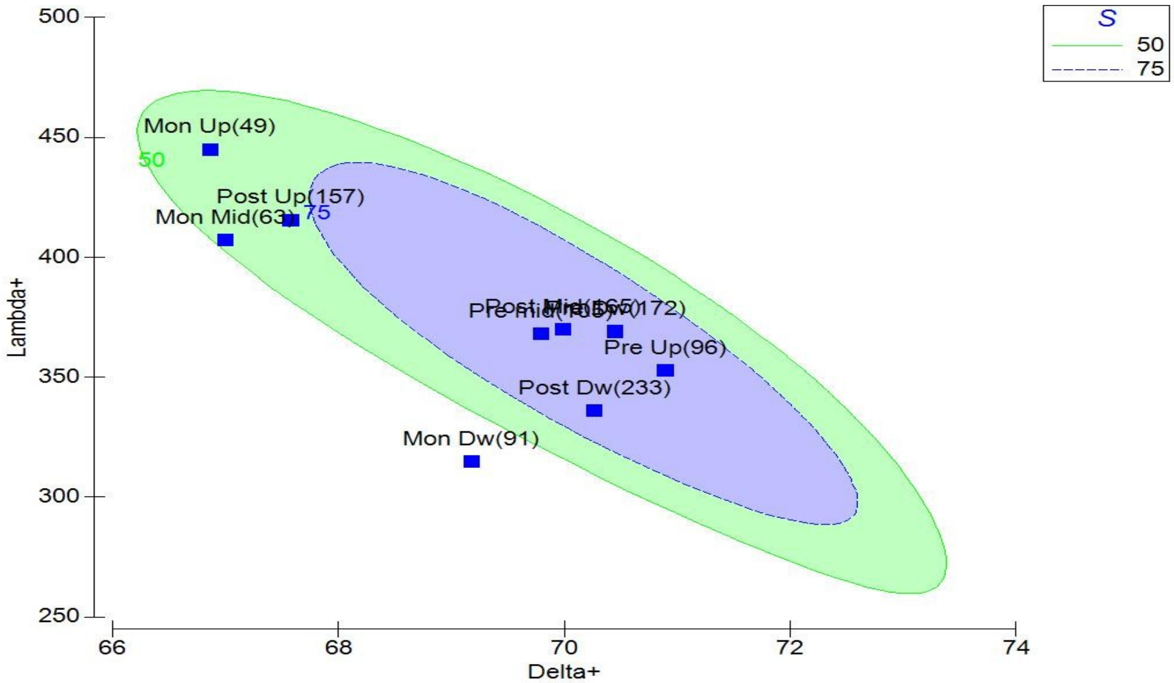


Fig.6 Average taxonomic distinctness of three regons in three seasons plotted against correspoinding values of variation in taxonomic distinctness



References

Agarkar, D.S., Agarker, M.S., Dikshit, R. 1979. Desmids from Bandhavgarh, Madhya Pradesh, India. *Hydrobiologia,* 65(3): 213–223.

Anand, N. 1989. A hand book of green algae. Bishen Singh Mahendrapal Singh Publishers, Dehradun.

Angsupanich, S., Rakkheaw, S. 1997. Seasonal variation of phytoplankton community in Thale Sap Songkhla, a lagoon Lake in Southern Thailand. *Neth. J. Aquat. Ecol.*, 30(4): 297–307.

Bevilacqua, S., Fraschetti, S., Terilizzi, Boero, F. 2009. The use of taxonomic distinctness indices in assessing patterns of biodiversity in modular organisms. *Mar. Ecol.,* 30: 151–163.

Clarke K.R., Warwick R.M. 1998. A taxonomic distinctness index and its statistical properties. *J. Appl. Ecol.,* 35: 523–531.

Clarke, K.R., Warwick, R.M. 2001. A further biodiversity index applicable to species lists: Variation in taxonomic distinctness. *Mar. Ecol. Prog. Series,* 184: 21–29.

Costello, M.J., Pohle, G., Martin, A. 2004. Evaluating biodiversity in marine environmental assessments. Research and Development Monograph Series 2001, Canadian Environmental Assessment Agency, Ottawa.

Desikachary, T.V. 1959. Cyanophyta-ICAR Monograph on algae. ICAR, NewDelhi, India.

Gotelli, N.J., Colwell, R.K. 2001. Quantifing bio diversity: procedures and pitfalls in the measurement and comparison of species richnss. *Ecol. Lett.,* 4: 379–391.

Guo, Y., Somerfield, P.J., Warwick, R.M., Zhang, Z. 2001. Large scale patterns in the community structure and biodiversity of freeliving nematodes in the Bohai Sea, China. *J. Mar. Biol. Assoc. U.K.,* 81: 755–763.

Hendley, N.I. 1977. The species diversity index of some inshore diatom communities and its use in assessing the degree of pollution insult on parts of North coast of Camwall. In: Crammer, J (Ed), 4th symposium on recent and fossil marine diatoms, Pp. 353–378.

Hulyal, S.B., Kaliwal, B.B. 2009. Dynamics of Phytoplankton in relation to physcico-chemical factors of Almatti reservoir. *Environ. Monit. Assess.,* 153: 45–59.

McCann, K.S. 2000. The diversity – stability debate. *Nature,* 405: 228–233.

Mouillotta, D., Gallarda, S., Aliaumea, C., Verlaqueb, M., Belsherc, T., Troussellierа, M., Chia, T.D. 2005. Ability of taxonomic diversity indices to discriminate coastal lagoon environments based on macrophyte communities. *Ecol. Indicators,* 5(1): 1–17.

Prescott, G.W. 1982. Algae of western Great Lakes Area, with an illustrated key to the genera of Desmids and fresh water Diatoms. Koengutein Otto Koeltz.

Purvis, A., Hector, A. 2000. Getting the measure of bio diversity. *Nature,* 405: 212–219.

Renaud, P.E., Webb, T.J., Bjorgesaeter, A., Karakkassia, I., Kedra, M., *et al.* 2009. Continental-scale patterns in benthic invertebrate diversity: insights from the MacroBen data base. *Mar. Ecol. Prog. Series,* 382: 239–252.

Sarode, P.T., Kamat, N.D. 1984. Fresh water Diatoms of Maharashtra. Sai Kripa Prakashan, Aurangabad

Tas, B., Gonulol, A. 2007. An ecologic and Taxonomic study on phytoplankton of a shollow Lake, Turkey. *J. Environ. Biol.,* 28(2): 439–445.

Tilman, D. 2000. Causes, consequences and ethics of bio diversity. *Nature,* 405: 2008–2011.

Tolimieri, N. 2007. Patterns in species richness, species density and evenness in ground fish assemblages on the continental slope of the U S Pacefic coast. *Environ. Biol. Fishes,* 78: 242–256.

Vaheeda, K.K. 2008. Ecological studies on the brakish waters of Kodungallur area, Kerala, India. Ph.D thesis, Mahatma Gandhi University, Kerala.

Venkataraman, G. 1939. A systematic account of some south Indian diatoms. *Proc. Indian Acad. Sci.,* 10(6): 293–368.

Warwick, RM., Clarke, K.R. 1998. Taxonomic distinctness and environmental assessment. *J. Appl. Ecol.,* 35: 532–543.

Wildsmith, M.D., Rose, T.H., Potter, I.C., Warwick, R.M., Clark, *et al.* 2009. Changes in the benthic microinvertibrate fauna of a large microtidal estuary following extreme modifications aimed at reducing eutrophication. *Mar. Pollut. Bull.,* 58: 1250–1262.

Wondie, A., Mengsitu, M., Vijverberg, J., Dejan, E. 2007. Seasonal variation in primary production in a large high laltitude tropical lake (Lake Tana, Ethiopia): effects of nutrient availability and water transparency. *Aquat. Ecol.,* 41: 195–207.