

SEASONAL VARIATION IN DIVERSITY OF HORSE FLIES (DIPTERA: TABANIDAE) FROM THE PART OF CENTRAL HIMALAYA

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ABSTRACT: Tabanid flies are one of the major group of dipteran pests specially in cattle animals and other livestock. Their vector capabilities and expertise in transferring disease causing pathogens are wide known during noxious bite. Despite their economic importance, they are among the less studied families of Diptera. Main focus were levied on their taxonomic studies. Objective of the present study is to analyse their α -diversity pattern on the seasonal scale in part of the Central Himalayan landscape. The present study revealed that ecological indices reached its peak value during monsoon except species richness (reached peak in pre-monsoon) and species dominance (reached peak in post monsoon). Thereby it can be concluded that diversity and even distribution may be positively correlated with average precipitation in monsoon. It was further observed from altitudinal transect that, highest Shannon weaver's diversity indices of tabanid species were recorded at an altitudinal range between 1001-1500 m in post monsoon, whereas highest Shannon weaver's diversity indices of tabanid fauna were observed at an altitudinal range between 1501-2000 m in monsoon and pre-monsoon. Present result might suggest that tabanids prefer to migrate downwards whenever average temperature fall in higher altitudes of hill region in post monsoon.

KEYWORDS: α diversity analysis, seasonal variation, horse flies, Central Himalaya.

INTRODUCTION

Diversity can be defined as the number of different items and their relative frequency. Biological diversity refers to the patchiness among living organisms from all sources and the ecological complexes of which they belong to this includes diversity within species, between species and of ecosystems⁷. Biodiversity is not only a crucial component of our life support system but also serves as the resource for meeting human requirements. For biological diversity, these items are organized at many levels, ranging from

complete ecosystems to the chemical structures that are the molecular basis of heredity. Thus the term encompasses different ecosystems, species, genes and their relative abundance⁴. One characteristic attribute to multi-species populations is diversity, also probably one of the most misused and incorrectly calculated attributes. Diversity takes into account how individuals are distributed amongst those species, i.e., the species frequency distribution. In fact, it turns out that nearly all quantitative measures of diversity are some combination of two components,

species richness and evenness, where evenness describes how equally individuals are distributed amongst the species.

Diptera is probably one of the most suitable groups for most quantitative comparisons between insect faunas to be valid, for the many reasons elaborated by Ahmed¹, especially their abundance, species richness, response to host and climate, their ease of sampling using host as bait, in many cases using canopy and sticky traps and relatively advanced taxonomy. Although Diptera especially vector groups have several economic implications in our society, is less studied and much attention is needed to work on medico-veterinary important groups of flies.

Worldwide information about Tabanidae is biased toward taxonomical research, which has been the main source of diversity data for this group of flies. The economic importance of horse and deer flies results from the vicious and persistent biting habits of the females of most species.

The Himalaya (Central Himalaya) is one of the potentially rich and recognized biodiversity zones of India, found in state of West Bengal. Not only that, northern part of the state also represents important part of biological hotspot and indo-burmese region.

Besides that, no comprehensive ecological studies conducted before this

study designed. There lies the importance to investigate and find out entire scenario of their diversity and relative abundance pattern in different season across the hilly region of West Bengal.

MATERIALS AND METHODS

α -diversity analysis:

Structural associations i.e. percentage abundance were also calculated and analysed from the pooled data and finally enumerating Tabanidae diversity with the help of several biodiversity indices. These include Shannon-weaver index, Species richness index, Evenness index and dominance diversity index.

Shannon-weaver index⁶:

Shannon-weaver index (H') = $-\sum (ni/N) \cdot \ln (ni/N)$

Where (ni/N) is proportion of individuals found in calculated sample and $\ln (ni/N)$ is natural logarithm of proportion of individuals of each species.

Species richness index³:

This index can simply be presented as no. of species present in a community.

Richness = $(S-1) / \ln N$

Where S= total no. of species found and $\ln N$ is sum of all individuals of all the species present there.

Evenness index⁵:

It is the mean distribution of individuals among the species. Evenness is expressed by considering how close a

set of observed species abundances are to those from aggregation of species having maximum possible diversity for a given N and S.

Evenness index (e) = $H' / \ln S$

Where H' is Shannon-weaver index and $\ln S$ is natural logarithm value of no. of species present.

Dominance-diversity index²:

Dominance indices are weighted toward abundance of commonest species. It is result of division of total no. of individuals of most common species (N_{max}) and sum of all the individuals of all the species present in that site.

Dominance index (D) = N_{max}/N

And finally dominance was determined by dividing the obtained value by 1 $DBP = 1/D$.

RESULTS AND DISCUSSION

Biological diversity can be measured in different ways. The two population attributes have been considered for present study are species richness and evenness. Besides that Shannon weaver's diversity and Burger – Parker's species dominance indices are also used for the current study. The type of diversity used here is alpha-diversity which represent the diversity of species within different study sites or habitats in the said areas. Due to diversified habitat restricted preference of cattle animals as host across different geo-climatic zones of West Bengal, these diversity indices are measured in above said districts

representing particular zones of West Bengal to get the whole scenario. First of all these indices values are compared within particular geo-climatic zones to find out intra-zonal variation seasonally and then among other geo-climatic zones to get the seasonal pattern of inter-zonal variation.

The above table 1 from which 4 graphical presentations have been produced. Fig. 1 clearly depicts that diversity index of species of Tabanidae in 5 study sites of Darjeeling district, representing hilly region of West Bengal in 3 seasons, according to Shannon-Weaver's indices are as follows – Site A (2.9426) > Site B (2.6997) > Site D (2.6374) > Site C (2.6347) > Site E (2.5173) in pre-monsoon. In Monsoon the scenario is as follows – Site A (3.028) > Site D (2.915) > Site E (2.8866) > Site B (2.7384) > Site C (2.7376). Whereas in Post-monsoon indices are as follows – Site A (2.7934) > Site B (2.6116) > Site C (2.4376) > Site D (2.3942) > Site E (2.2894). On consideration of species of Tabanidae recorded from 5 study sites of Darjeeling district, it has been observed that highest Shannon – Weaver's diversity index were recorded from study site A in all season in comparison to lowest diversity index which were varied seasonally from site E to site C to site E again in pre-monsoon, monsoon and post monsoon respectively.

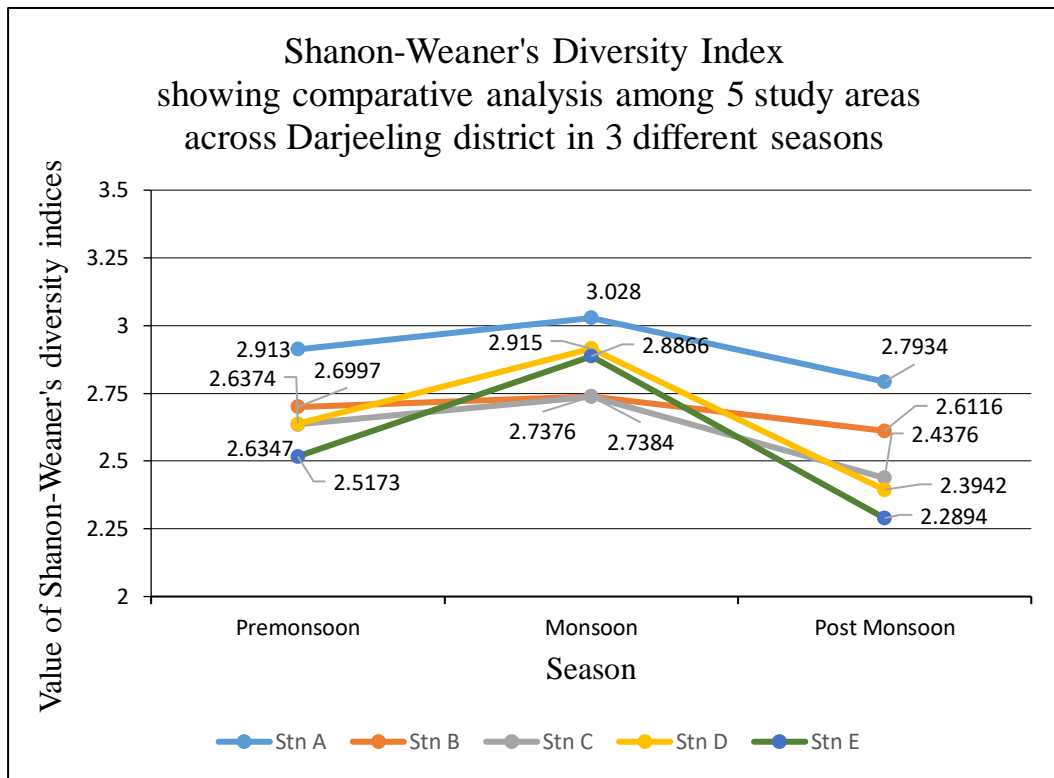


Fig 1. Comparative analysis of Shannon-Weaver's diversity indices among 5 study sites across Darjeeling district in 3 different seasons.

Table 1. Comparing 4 diversity indices of tabanid species seasonally in 5 study sites of Darjeeling district, representing hill region of West Bengal

Geo-climatic Zone	District							
			Premonsoon		Monsoon		Post Monsoon	
Hill Region	Darjeeling	Stn A	Shannon diversity	2.9426	Shannon diversity	3.028	Shannon diversity	2.7934
		Stn B	Shannon diversity	2.6997	Shannon diversity	2.7384	Shannon diversity	2.6116
		Stn C	Shannon diversity	2.6347	Shannon diversity	2.7376	Shannon diversity	2.4376
		Stn D	Shannon diversity	2.6374	Shannon diversity	2.915	Shannon diversity	2.3942
		Stn E	Shannon diversity	2.5173	Shannon diversity	2.8866	Shannon diversity	2.2894
			Pre-monsoon		Monsoon		Post Monsoon	
Hill Region	Darjeeling	Stn A	Species richness	4.29	Species richness	3.9851	Species richness	3.7245
		Stn B	Species richness	3.6988	Species richness	3.4497	Species richness	3.2716
		Stn C	Species richness	3.2737	Species richness	3.2885	Species richness	3.223
		Stn D	Species richness	2.9108	Species richness	3.6732	Species richness	2.8642
		Stn E	Species richness	2.6542	Species richness	3.7538	Species richness	2.7839
			Pre-monsoon		Monsoon		Post Monsoon	
Hill Region	Darjeeling	Stn A	Species evenness	0.9259	Species evenness	0.9528	Species evenness	0.9665
		Stn B	Species evenness	0.8867	Species evenness	0.9141	Species evenness	0.942
		Stn C	Species evenness	0.9115	Species evenness	0.9138	Species evenness	0.9001
		Stn D	Species evenness	0.9513	Species evenness	0.943	Species evenness	0.9334
		Stn E	Species evenness	0.9539	Species evenness	0.9481	Species evenness	0.9213
			Pre-monsoon		Monsoon		Post Monsoon	
Hill Region	Darjeeling	Stn A	Species dominance	0.1831	Species dominance	0.1215	Species dominance	0.1354
		Stn B	Species dominance	0.2601	Species dominance	0.215	Species dominance	0.1515
		Stn C	Species dominance	0.2333	Species dominance	0.1827	Species dominance	0.1765
		Stn D	Species dominance	0.1908	Species dominance	0.1579	Species dominance	0.197
		Stn E	Species dominance	0.1418	Species dominance	0.131	Species dominance	0.2115

Fig. 2 clearly depicts that richness index of species of Tabanidae in 5 study sites of Darjeeling district, representing hilly region of West Bengal in 3 seasons, according to Margalef's indices are as follows – Site A (4.29) > Site B (3.6988) > Site C (3.2737) > Site D (2.9108) > Site E (2.6542) in pre-monsoon. In Monsoon the scenario is as follows – Site A (3.9851) > Site E (3.7538) > Site D (3.6732) > Site B (3.4497) > Site C (3.2885). Whereas in Post-monsoon indices are as follows – Site A (3.7245) > Site B (3.2716) > Site C (3.223) > Site D (2.8642) > Site E (2.7839). On consideration of species of Tabanidae recorded from 5 study sites of Darjeeling district, it has been observed that highest Margalef's species richness index were recorded from study site A in all season in comparison to lowest species richness index which were varied seasonally from site E to site C to site E again in pre-monsoon, monsoon and post monsoon respectively.

Fig. 3 clearly depicts that evenness index of species of Tabanidae in 5 study sites of Darjeeling district, representing hilly region of West Bengal in 3 seasons, according to Pielou's indices are as follows – Site E (0.9539) > Site D (0.9513) > Site A (0.9259) > Site C (0.9115) > Site B (0.8867) in pre-monsoon. In Monsoon the scenario is as follows – Site A (0.9528) > Site E

(0.9481) > Site D (0.943) > Site B (0.9141) > Site C (0.9138). Whereas in Post-monsoon indices are as follows – Site A (0.9665) > Site B (0.942) > Site D (0.9334) > Site E (0.9213) > Site C (0.9001). On consideration of species of Tabanidae recorded from 5 study sites of Darjeeling district, it has been observed that highest Pielou's species evenness index were recorded from study site E in pre-monsoon and in site A in other seasons in comparison to lowest species evenness index which were varied seasonally from site B to site C in pre-monsoon and other 2 seasons respectively.

Fig. 4 clearly depicts that dominance index of species of Tabanidae in 5 study sites of Darjeeling district, representing hilly region of West Bengal in 3 seasons, according to Burger-Parker's indices are as follows – Site B (0.2601) > Site C (0.2333) > Site D (0.1908) > Site A (0.1831) > Site E (0.1418) in pre-monsoon. In Monsoon the scenario is as follows – Site B (0.215) > Site C (0.1827) > Site D (0.1579) > Site E (0.131) > Site A (0.1215). Whereas in Post-monsoon indices are as follows – Site E (0.2115) > Site D (0.197) > Site C (0.1765) > Site B (0.1515) > Site A (0.1354). On consideration of species of Tabanidae recorded from 5 study sites of Darjeeling district, it has been observed that highest Burger-Parker's species dominance index were recorded

from study site B in pre-monsoon and monsoon and in site E in post monsoon in comparison to lowest species dominance index which were varied

seasonally from site E to site A in pre-monsoon and other 2 seasons respectively.

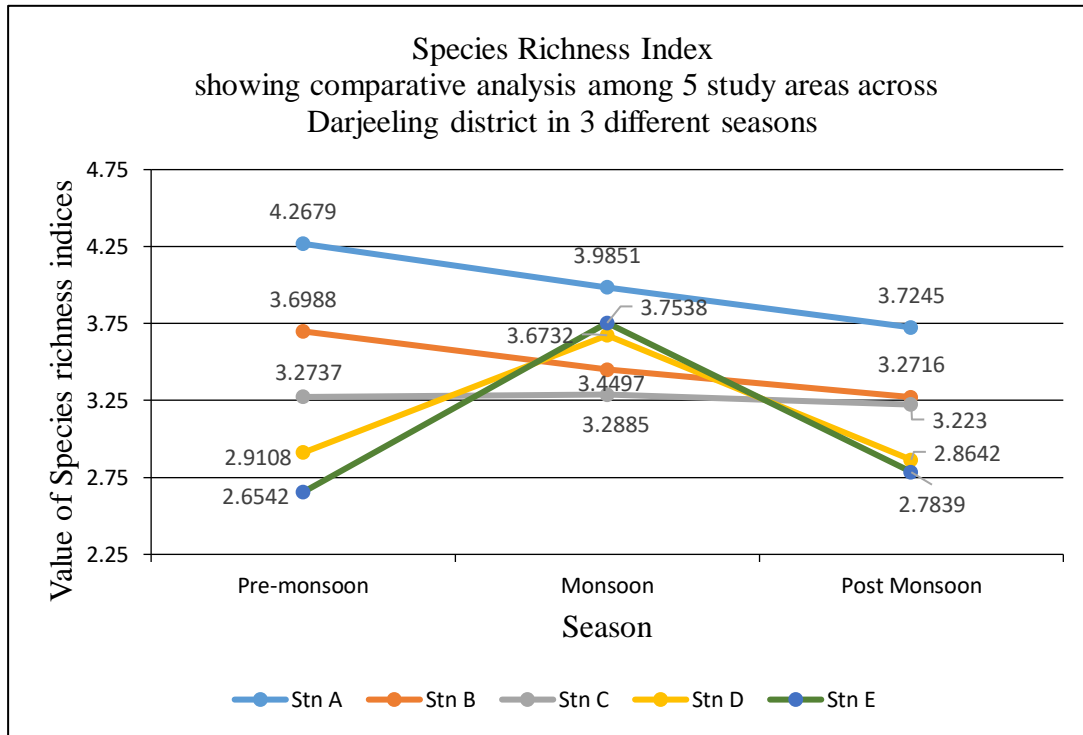


Fig 2. Comparative analysis of Species richness indices among 5 study sites across Darjeeling district in 3 different seasons.

Fig. 5 clearly depicts that 4 diversity indices of species of Tabanidae in Darjeeling district, representing hill region of West Bengal in 3 seasons. Avg. shannon diversity indices are as follows – monsoon (2.8611) > pre-monsoon (2.68) > post monsoon (2.5052). Avg. species richness indices are as follows – monsoon (3.6301) >

pre-monsoon (3.3611) > post monsoon (3.1734). Avg. species evenness indices are as follows – monsoon (0.9344) > post monsoon (0.9327) > pre-monsoon (0.924). Avg. species dominance indices are as follows – pre-monsoon (0.2018) > post monsoon (0.1744) > monsoon (0.1616).

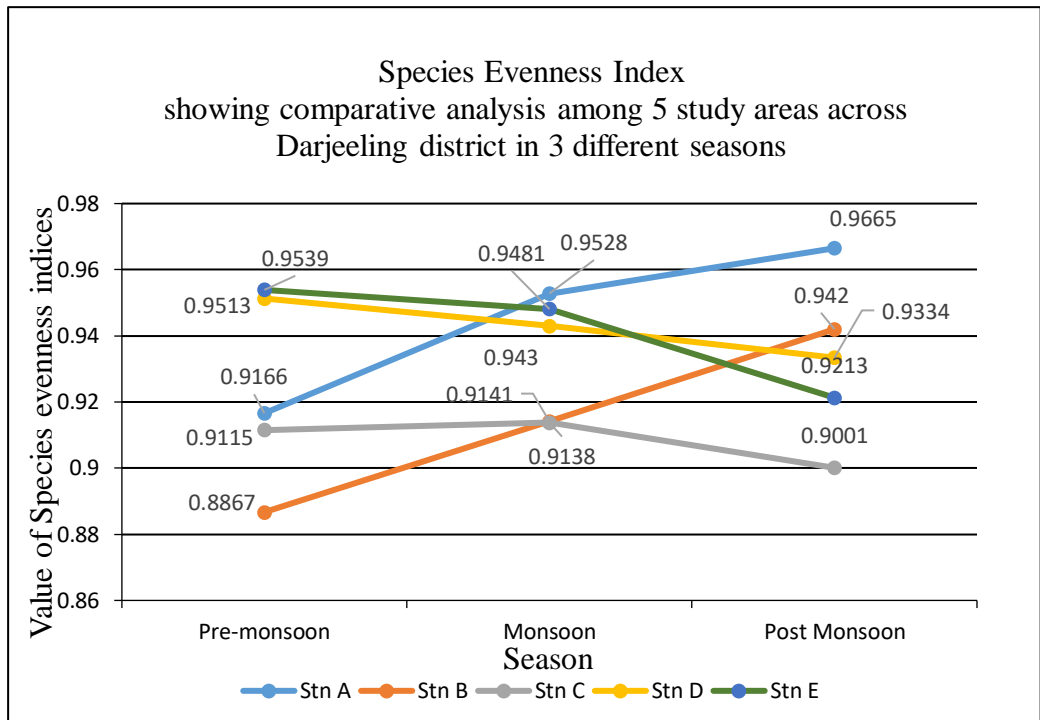


Fig 3. Comparative analysis of Species evenness indices among 5 study sites across Darjeeling district in 3 different seasons.

On consideration of species of Tabanidae recorded from study sites of Darjeeling district, it has been observed that avg. Shannon diversity indices, avg. species richness indices, and avg.

species evenness indices were recorded maximum in monsoon in comparison to avg. species dominance indices which were recorded maximum in pre-monsoon.

Table 2. Comparing 4 diversity indices of tabanid species seasonally in Darjeeling district, representing hill region of West Bengal

Geo-climatic Zone	District		Pre-monsoon	Monsoon	Post Monsoon
Hill Region	Darjeeling	Avg. Shanon Diversity	2.68	2.8611	2.5052
		Avg. Species richness	3.3611	3.6301	3.1734
		Avg. Species evenness	0.924	0.9344	0.9327
		Avg. Species dominance	0.2018	0.1616	0.1744

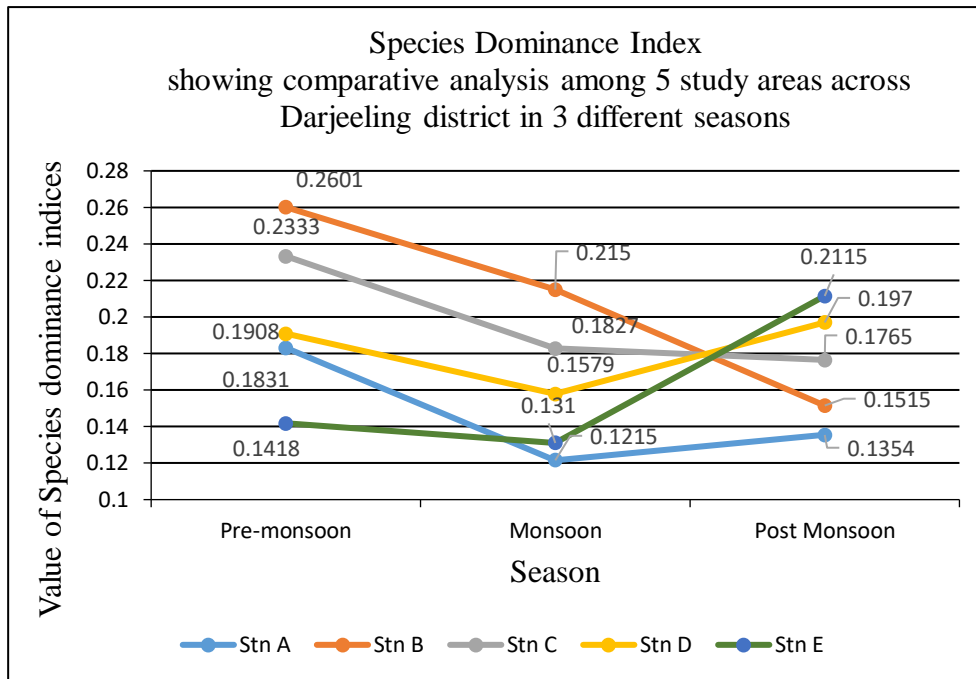


Fig 4. Comparative analysis of Species dominance indices among 5 study sites across Darjeeling district in 3 different seasons.

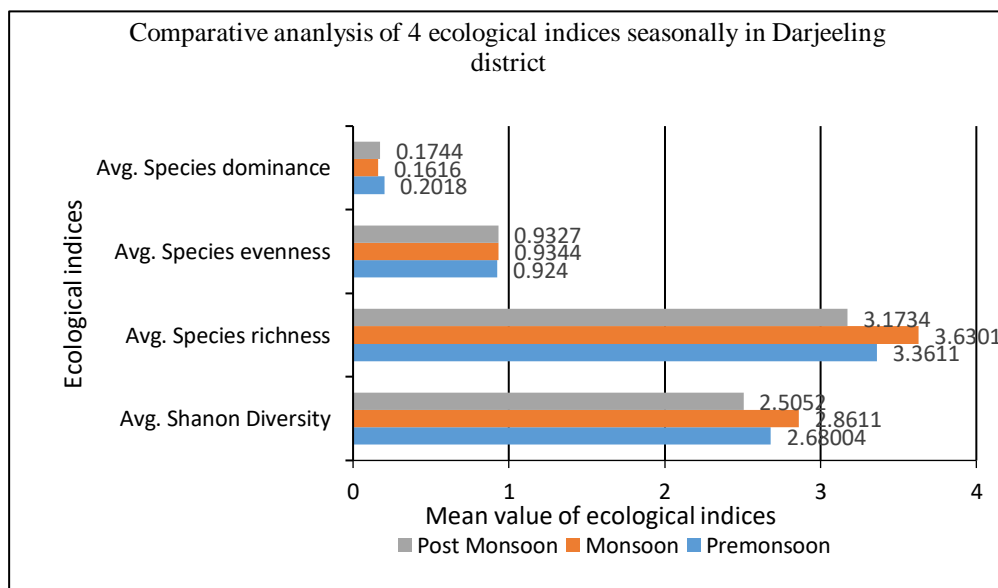


Fig 5. Comparative analysis of 4 ecological indices in 3 different season in Darjeeling district.

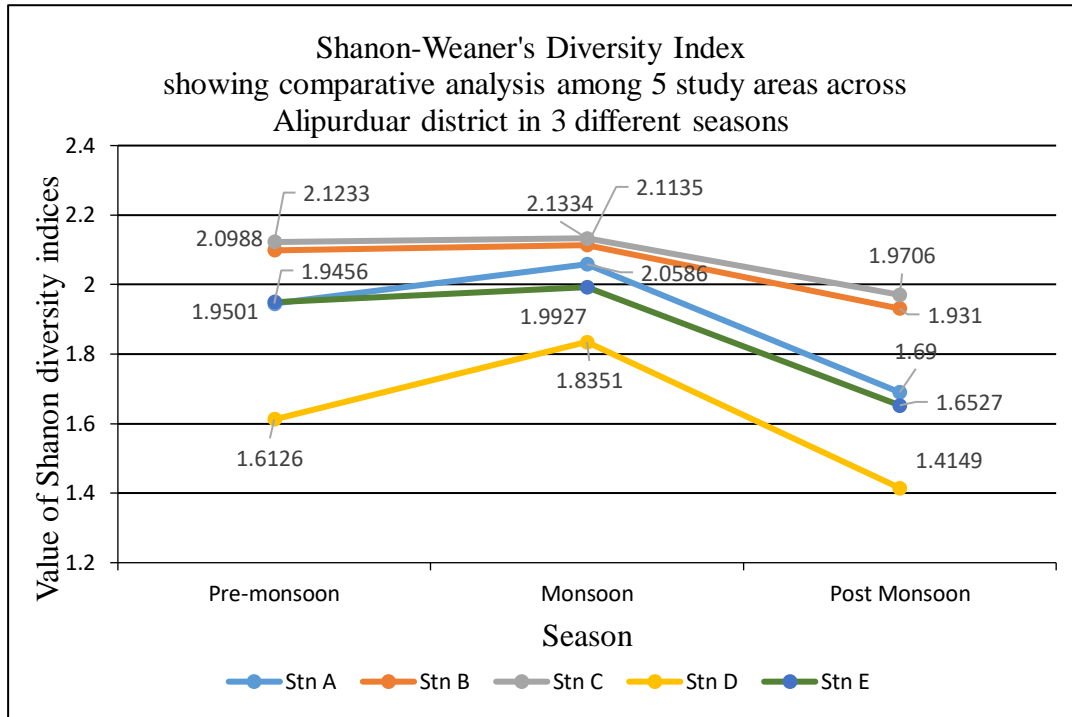


Fig 6. Comparative analysis of Shanon-Weaver's diversity indices among 5 study sites across Alipurduar district in 3 different seasons.

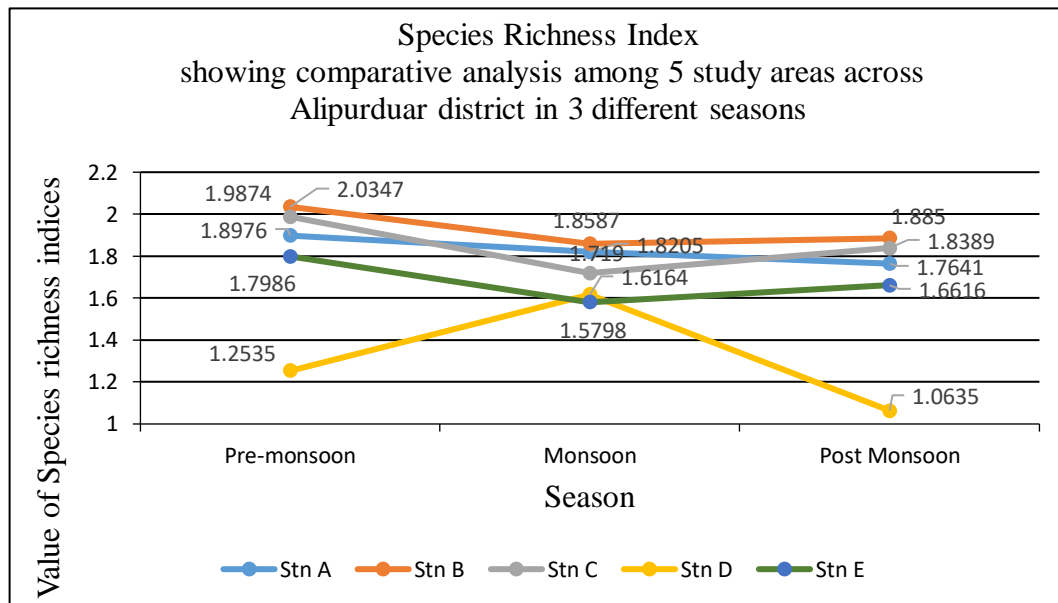


Fig 7. Comparative analysis of Species richness indices among 5 study sites across Alipurduar district in 3 different seasons.

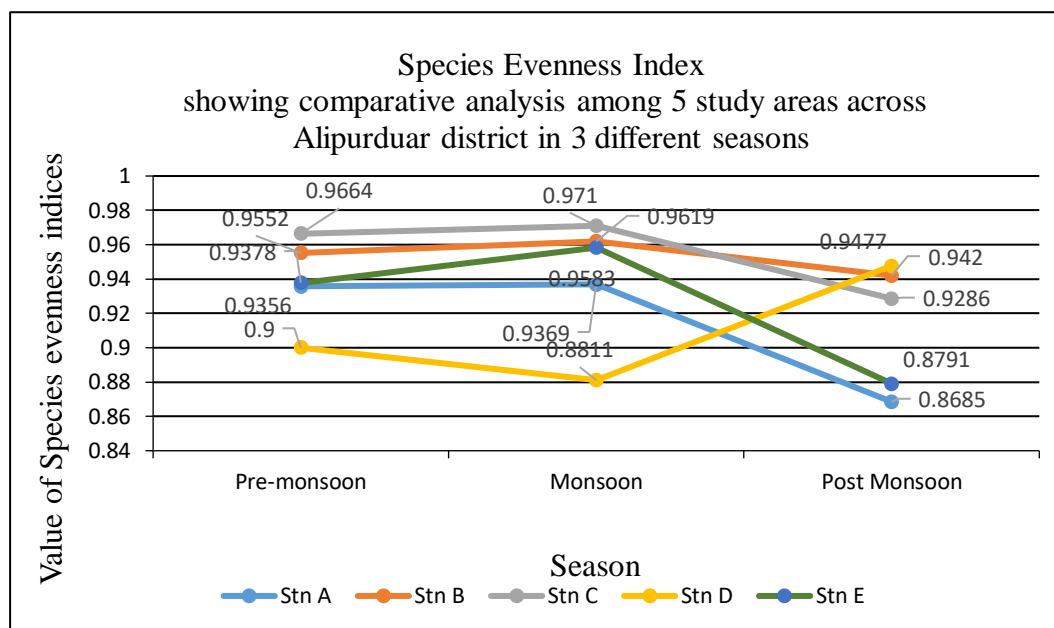


Fig 8. Comparative analysis of Species evenness indices among 5 study sites across Alipurduar district in 3 different seasons.

Table 3. Comparing 4 diversity indices of tabanid species seasonally in 5 study sites of Alipurduar district, representing hill region of West Bengal

Geo-climatic Zone	District							
			Pre-monsoon		Monsoon		Post Monsoon	
Hill Region	Alipurduar	Stn A	Shannon diversity	1.9456	Shannon diversity	2.0586	Shannon diversity	1.69
		Stn B	Shannon diversity	2.0988	Shannon diversity	2.1135	Shannon diversity	1.931
		Stn C	Shannon diversity	2.1233	Shannon diversity	2.1334	Shannon diversity	1.9706
		Stn D	Shannon diversity	1.6126	Shannon diversity	1.8351	Shannon diversity	1.4149
		Stn E	Shannon diversity	1.9501	Shannon diversity	1.9927	Shannon diversity	1.6527
			Pre-monsoon		Monsoon		Post Monsoon	
Hill Region	Alipurduar	Stn A	Species richness	1.8976	Species richness	1.8205	Species richness	3.7245
		Stn B	Species richness	2.0347	Species richness	3.4497	Species richness	3.2716
		Stn C	Species richness	1.9874	Species richness	3.2885	Species richness	3.223

		Stn D	Species richness	1.2535	Species richness	3.6732	Species richness	2.8642
		Stn E	Species richness	1.7986	Species richness	3.7538	Species richness	2.7839
			Pre-monsoon		Monsoon		Post Monsoon	
Hill Region	Alipurduar	Stn A	Species evenness	0.9259	Species evenness	0.9528	Species evenness	0.9665
		Stn B	Species evenness	0.8867	Species evenness	0.9141	Species evenness	0.942
		Stn C	Species evenness	0.9115	Species evenness	0.9138	Species evenness	0.9001
		Stn D	Species evenness	0.9513	Species evenness	0.943	Species evenness	0.9334
		Stn E	Species evenness	0.9539	Species evenness	0.9481	Species evenness	0.9213
			Pre-monsoon		Monsoon		Post Monsoon	
Hill Region	Alipurduar	Stn A	Species dominance	0.1831	Species dominance	0.1215	Species dominance	0.1354
		Stn B	Species dominance	0.2601	Species dominance	0.215	Species dominance	0.1515
		Stn C	Species dominance	0.2333	Species dominance	0.1827	Species dominance	0.1765
		Stn D	Species dominance	0.1908	Species dominance	0.1579	Species dominance	0.197
		Stn E	Species dominance	0.1418	Species dominance	0.131	Species dominance	0.2115

Table 4. Comparing 4 diversity indices of tabanid species seasonally in Alipur district, representing hill region of West Bengal

Geo-climatic Zone	District		Pre-monsoon	Monsoon	Post Monsoon
Hill Region	Alipurduar	Avg. Shanon Diversity	1.9461	2.0267	1.7318
		Avg. Species richness	1.7944	1.7189	1.6426
		Avg. Species evenness	0.939	0.9418	0.9132
		Avg. Species dominance	0.2668	0.2775	0.329

Table 5. Comparing 4 diversity indices of tabanid species seasonally in hill region of West Bengal

Geo-climatic Zone		Pre-monsoon	Monsoon	Post Monsoon
Hill Region	Avg. Shanon Diversity	2.3131	2.4439	2.1185
	Avg. Species richness	2.5778	2.6745	2.408
	Avg. Species evenness	0.9315	0.9381	0.923
	Avg. Species dominance	0.2343	0.21955	0.2517

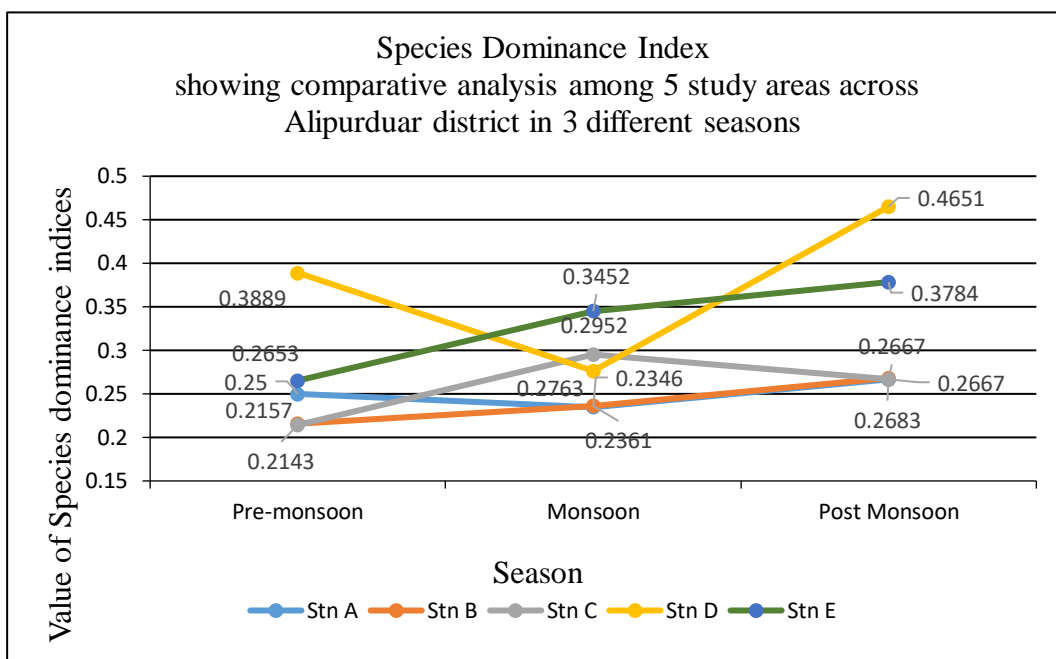


Fig 9. Comparative analysis of Species dominance indices among 5 study sites across Alipurduar district in 3 different seasons.

The above table 3 from which 4 graphical presentations have been produced. Fig. 6 clearly depicts that diversity index of species of Tabanidae in 5 study sites of Alipurduar district, representing hilly region of West Bengal in 3 seasons, according to Shannon-Weaver's indices are as follows – Site C (2.1233) > Site B (2.0988) > Site E (1.9501) > Site A (1.9456) > Site D (1.6126) in pre-monsoon. In Monsoon the scenario is as follows – Site C (2.1334) > Site B (2.1135) > Site A (2.0586) > Site E (1.9927) > Site D (1.8351). Whereas in Post-monsoon indices are as follows – Site C (1.9706)

> Site B (1.931) > Site A (1.69) > Site E (1.6527) > Site D (1.4149). On consideration of species of Tabanidae recorded from 5 study sites of Alipurduar district, it has been observed that highest Shannon – Weaver's diversity index were recorded from study site C in all season in comparison to lowest diversity index from site D in all season.

Fig. 7 clearly depicts that richness index of species of Tabanidae in 5 study sites of Alipurduar district, representing hilly region of West Bengal in 3 seasons, according to Margalef's indices are as follows – Site B (2.0347) > Site C

(1.9874) > Site A (1.8976) > Site E (1.7986) > Site D (1.2535) in pre-monsoon. In Monsoon the scenario is as follows – Site B (1.8587) > Site A (1.8205) > Site C (1.719) > Site D (1.6164) > Site E (1.5798). Whereas in Post-monsoon indices are as follows – Site B (1.885) > Site C (1.8389) > Site A (1.7641) > Site E (1.6616) > Site D (1.0635). On consideration of species of Tabanidae recorded from 5 study sites of Alipurduar district, it has been observed that highest Margalef's species richness index were recorded from study site B in all season in comparison to lowest species richness index which were varied seasonally from site D to site E to site D again in pre-monsoon, monsoon and post monsoon respectively.

Fig. 8 clearly depicts that evenness index of species of Tabanidae in 5 study sites of Alipurduar district, representing hilly region of West Bengal in 3 seasons, according to Pielou's indices are as follows – Site C (0.9664) > Site B (0.9552) > Site E (0.9378) > Site A (0.9356) > Site D (0.9) in pre-monsoon. In Monsoon the scenario is as follows – Site C (0.971) > Site B (0.9619) > Site E (0.9583) > Site A (0.9369) > Site D (0.8811). Whereas in Post-monsoon indices are as follows – Site D (0.9477) > Site B (0.942) > Site C (0.9286) > Site E (0.8791) > Site A (0.8685). On consideration of species of Tabanidae

recorded from 5 study sites of Alipurduar district, it has been observed that highest Pelou's species evenness index were recorded from study site C in pre-monsoon, monsoon and in site D in post monsoon in comparison to lowest species evenness index which were varied seasonally from site D in pre-monsoon, monsoon to site A in post monsoon respectively.

Fig. 9 clearly depicts that dominance index of species of Tabanidae in 5 study sites of Alipurduar district, representing hilly region of West Bengal in 3 seasons, according to Burger-Parker's indices are as follows – Site D (0.3889) > Site E (0.2653) > Site A (0.25) > Site B (0.2157) > Site C (0.2143) in pre-monsoon. In Monsoon the scenario is as follows – Site E (0.3452) > Site C (0.2952) > Site D (0.2763) > Site B (0.2361) > Site A (0.2346). Whereas in Post-monsoon indices are as follows – Site D (0.4651) > Site E (0.3784) > Site B (0.2683) > Site A (0.2667) = Site C (0.2667). On consideration of species of Tabanidae recorded from 5 study sites of Alipurduar district, it has been observed that highest Burger-Parker's species dominance index were recorded from study site D in pre-monsoon and post monsoon and in site E in monsoon in comparison to lowest species dominance index which were varied seasonally from site C to site A in pre-

monsoon, monsoon and jointly in site A and site C in post monsoon.

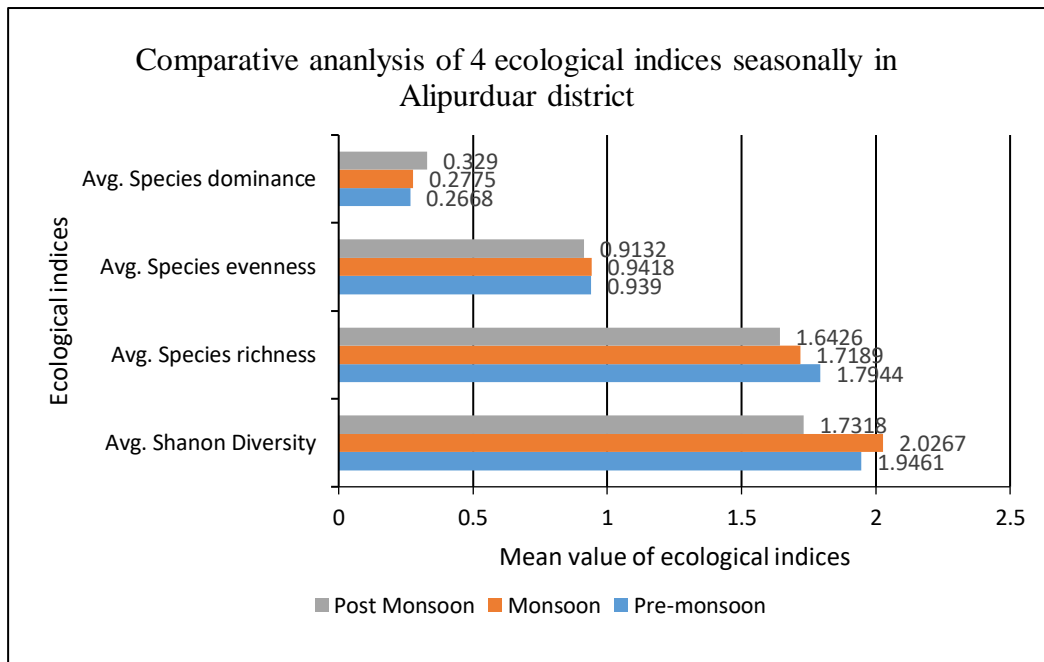


Fig.10. Comparative analysis of 4 ecological indices in 3 different season in Alipurduar district.

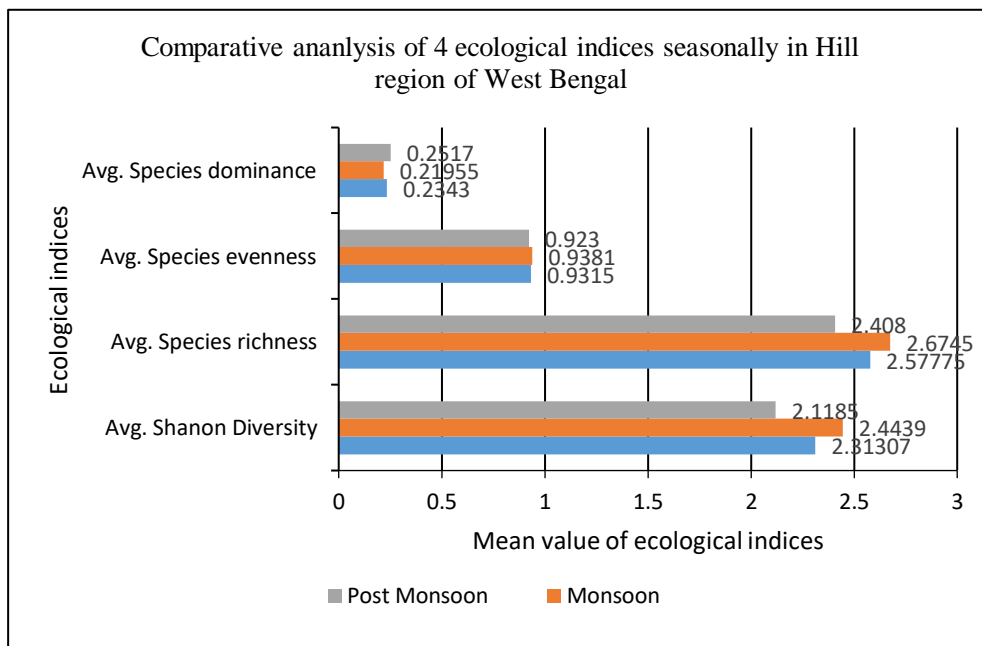


Fig.11. Comparative analysis of 4 ecological indices in Hill region.

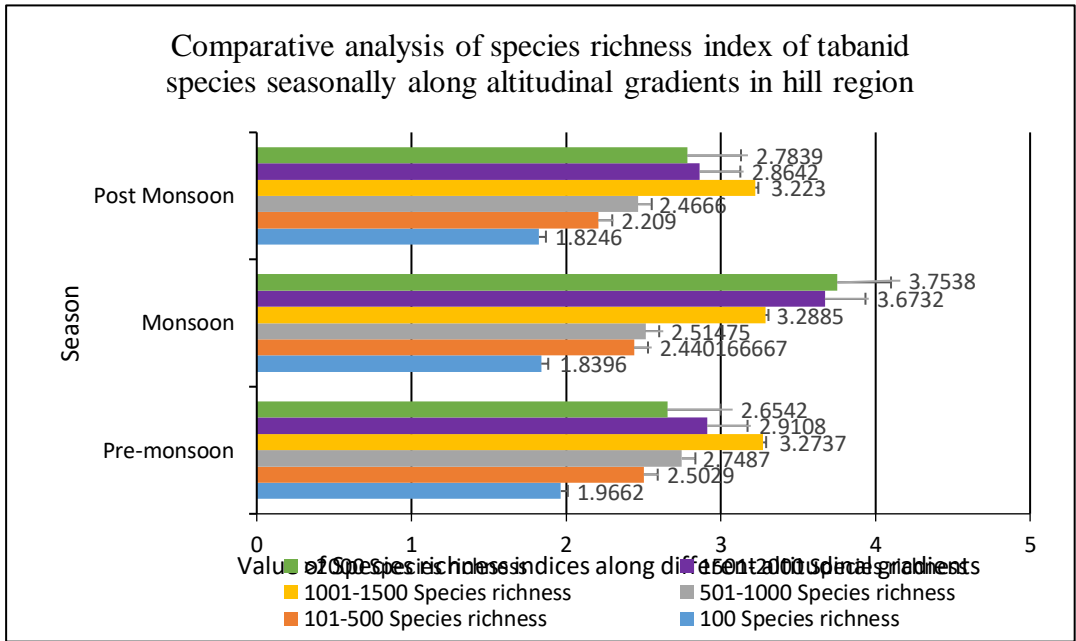


Fig 12. Comparative analysis of Shannon Weaver's diversity indices along altitudinal gradients of hill region of West Bengal in 3 different seasons.

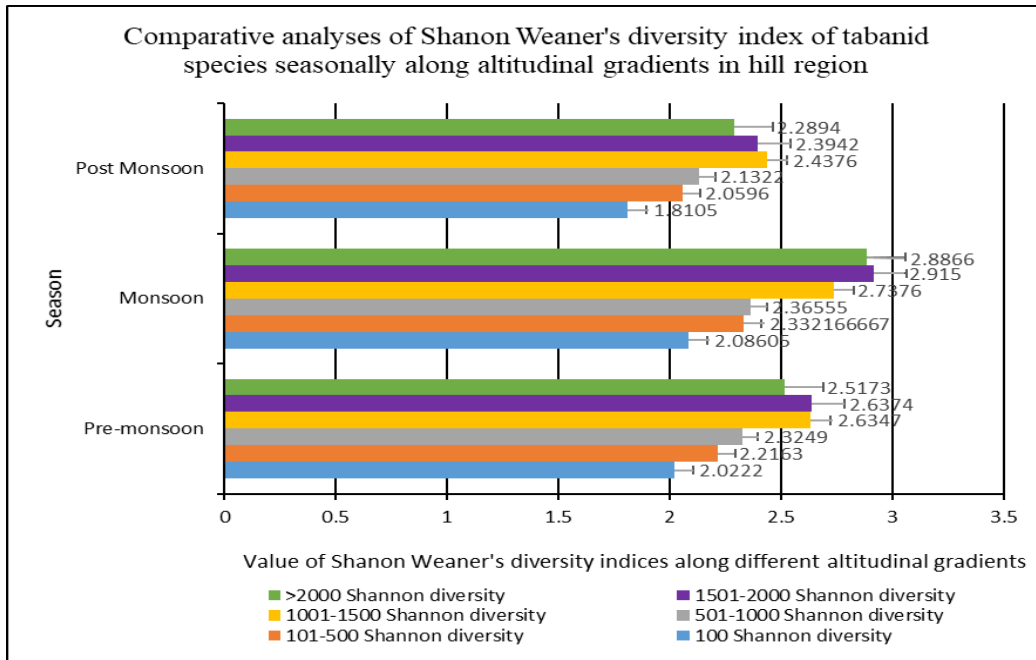


Fig 13. Comparative analysis of Species richness indices along altitudinal gradients of hill region of West Bengal in 3 different seasons.

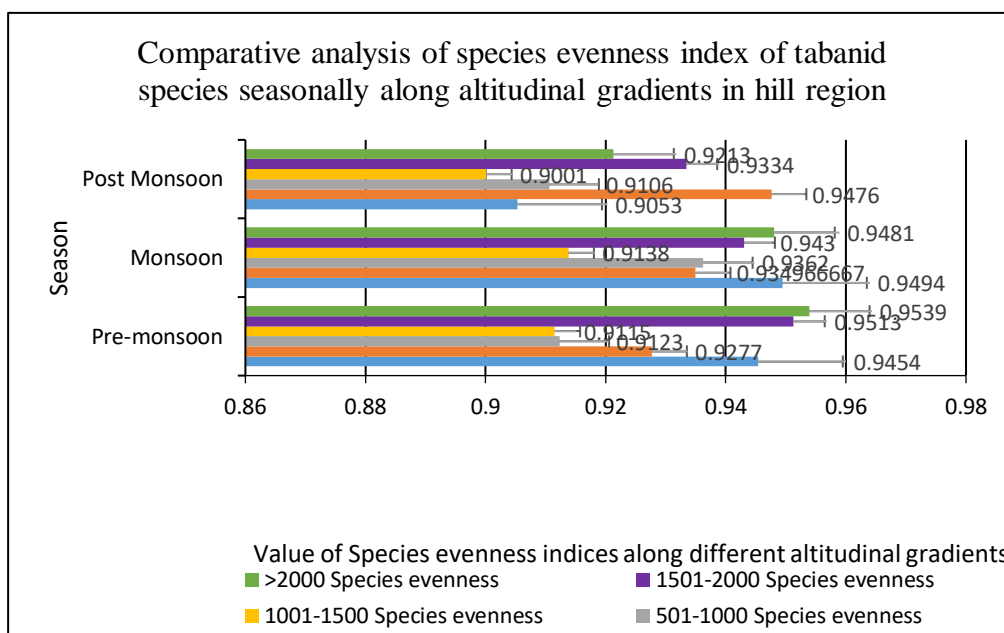


Fig 14. Comparative analysis of Species evenness indices along altitudinal gradients of hill region of West Bengal in 3 different seasons.

Fig. 10 clearly depicts that 4 diversity indices of species of Tabanidae in Alipurduar district, representing hill region of West Bengal in 3 seasons. Avg. Shannon diversity indices are as follows – monsoon (2.0267) > pre-monsoon (1.9461) > post monsoon (1.7318). Avg. species richness indices are as follows – pre-monsoon (1.7944) > monsoon (1.7189) > post monsoon (1.6426). Avg. species evenness indices are as follows – monsoon (0.9418) > pre-monsoon (0.939) > post monsoon (0.923). Avg. species dominance indices are as follows – post monsoon (0.329) > monsoon (0.2775) > pre-monsoon (0.2668). On consideration of species of Tabanidae recorded from study sites of

Alipurduar district, it has been observed that avg. Shannon diversity indices and avg. species evenness indices were recorded maximum in monsoon in comparison to avg. species richness indices and avg. species dominance indices which were recorded maximum in pre-monsoon and post monsoon respectively.

Fig. 11 clearly depicts that 4 diversity indices of species of Tabanidae in hill region of West Bengal in 3 seasons. Avg. Shannon diversity indices are as follows – monsoon (2.4439) > pre-monsoon (2.3131) > post monsoon (2.1185). Avg. species richness indices are as follows – monsoon (2.6745) > pre-monsoon (2.5778) > post monsoon

(2.408). Avg. species evenness indices are as follows – monsoon (0.9381) > pre-monsoon (0.9315) > post monsoon (0.9132). Avg. species dominance indices are as follows – post monsoon (0.2517) > pre-monsoon (0.2343) > monsoon (0.21955). On consideration of species of Tabanidae recorded from study sites of hill region, it has been observed that avg. Shannon diversity indices, avg. species richness indices and avg. species evenness indices were recorded maximum in monsoon in comparison to avg. species dominance indices which were recorded maximum in post monsoon.

The study showed that (Fig. 12) highest Shannon weaver's diversity indices of tabanid species were observed at an altitudinal range between 1001-1500 m in post monsoon, whereas highest Shannon weaver's diversity indices of tabanid fauna were observed at an altitudinal range between 1501-2000 m in monsoon and post monsoon.

The study showed that (Fig. 13) highest species richness indices of tabanid fauna were observed at an altitudinal range between 1001-1500 m in pre-monsoon and post monsoon, whereas highest species richness indices of Tabanidae were observed at an altitudinal range between above 2000 m in monsoon.

The study showed that (Fig. 14) highest species evenness indices of tabanid fauna were observed at an altitudinal

range above 2000 m in pre-monsoon, <100 m in monsoon, and between 101-500 m in post monsoon respectively.

The study showed that (Fig. 15) highest species dominance indices of tabanid fauna were observed at an altitudinal range between 501-1000 m in pre-monsoon and monsoon, whereas highest species dominance indices of Tabanidae were observed at an altitudinal range between 101-500 m in post monsoon.

Present study has reviewed the family Tabanidae from hill region of West Bengal considering its species diversity (diversity indices, abundance, richness and evenness). Moreover, it is also notable that all ecological indices reaches its peak value during monsoon except species richness (reaches peak in pre-monsoon) and species dominance (reaches peak in post monsoon). Thereby it can be concluded that diversity and even distribution may be positively correlated with avg. precipitation which is also maximum accordingly in monsoon in all regions of West Bengal. Furthermore, it can be said that maximum number of species or species richness may be positively correlated with avg. temperature which is also maximum during pre-monsoon. Finally species dominance index may be negatively correlated with avg. temperature which is minimum in post monsoon. Further when all the ecological indices in different altitudinal

gradients of hill region are considered, highest Shannon weaver's diversity indices of tabanid species were recorded at an altitudinal range between 1001-1500 m in post monsoon, whereas highest Shannon weaver's diversity indices of tabanid fauna were observed at an altitudinal range between 1501-2000 m in monsoon and post monsoon. This is may be due to the fact that during post monsoon when avg. temperature decreases tabanids prefer to migrate downwards where avg. temperature fall less than higher altitudes of hill region. When looking towards species richness trends are found to be somewhat different from previous one. Highest species richness indices of tabanid fauna were observed at an altitudinal range between 1001-1500 m in pre-monsoon and post monsoon, whereas highest species richness indices of Tabanidae were observed at an altitudinal range between above 2000 m in monsoon. This is may be due to the fact that species richness and avg. rainfall or precipitation in turn may be positively correlated with the elevation, therefore species richness expands to the higher altitudes of hill region during monsoon. Looking at the evenness scenario, highest species evenness indices of tabanid fauna were

observed at an altitudinal range above 2000 m in pre-monsoon, <100 m in monsoon, and between 101-500 m in post monsoon respectively. This may be implied that evenness somewhat may not be correlated with either altitudinal gradients or temperature or rainfall pattern, i.e., species evenness may be achieved peak irrespective of density independent factors viz. avg. temperature, avg. precipitation and altitudinal gradients. Finally coming into the last ecological index i.e., species dominance, highest species dominance indices of tabanid fauna were recorded at an altitudinal range between 501-1000 m in pre-monsoon and monsoon, whereas highest species dominance indices of Tabanidae were observed at an altitudinal range between 101-500 m in post monsoon. It can be said that species dominance may also be negatively correlated with altitudinal gradients of hill region. At the same time when avg. temperature drops in higher altitudes in post monsoon, tabanids prefer downward migration from higher to lower altitudes, thereby accelerating competition in lower altitudes resulting in shifting of peak dominance in lower altitudes of hill region during post monsoon.

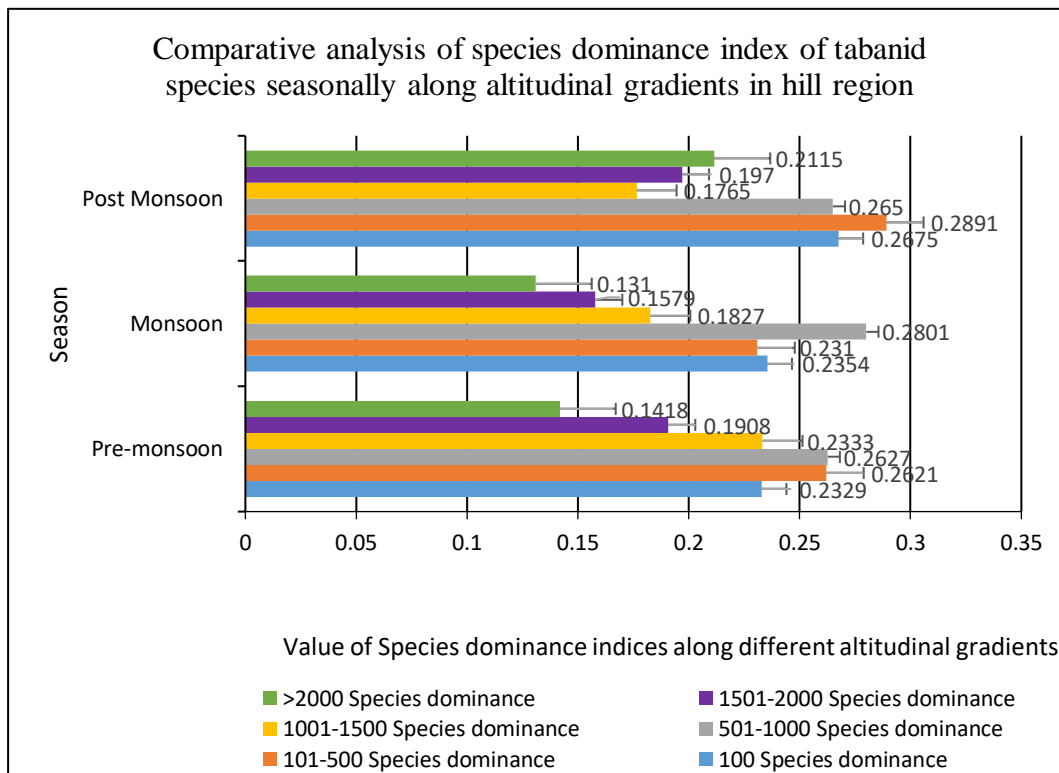


Fig. 15. Comparative analysis of Species dominance indices along altitudinal gradients of hill region of West Bengal in 3 different seasons.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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