J. mar. biol. Ass. India, 1994, **36** (1 & 2) : 226-235

DISTRIBUTION AND ABUNDANCE OF TWO TABANID INSECTS (DIPTERA : TABANIDAE) IN THE HOOGHLY ESTUARY, SAGAR ISLAND, INDIA

S. RAY AND A. CHOUDHURY

Department of Marine Science, Calcutta University, 35 B. C. Road, Calcutta 700 019, India

ABSTRACT

Abundance and seasonal fluctuations of two larvae of tabanid insects *viz. Atylotus agrestis* and *Tabanus striatus* in the mud and sandflats of Hooghly Estuary were studied in relation to some important environmental parameters at three stations in and around Sagar Island during July 1982 to June 1984. *A. agrestis* was abundant throughout the year, maximum during postmonsoon and minimum during premonsoon, whereas *T. striatus* was almost absent during premonsoon and maximum recorded in monsoon. Results of ANOVA indicate that almost all ecological parameters were varied significantly over months, stations and years, but the populations of these two species varied significantly only over months. Soil temperature, soil moisture, salinity, dissolved oxygen, pH, organic carbon and available phosphorus appear to be the major factors controlling their distribution in the intertidal habitat as evident from correlation coefficient analyses. Multiple regression analyses show that the combined effects of all parameters on both the species were positively significant at all the stations.

INTRODUCTION

FEWER species of tabanidae are more or less 'marine' members which inhabit and are restricted to the coastal areas and they develop in the soil of salt marshes, brackishwater pools and even in tidal over wash areas (Axtell, 1976).

The role of insects, including tabanids, in the marsh ecosystem is poorly understood (Daiber, 1974). Investigations carried out so far have been concentrated on the collections of adult insects only. The role of tabanid larvae in the salt marshes can only be speculated upon.

The immature stages of *Atylotus agrestis* and *Tabanus striatus* are distributed throughout the coastal region of Sagar Island (Ray and Choudhury, 1987). The present investigation intends to document the occurrence, abundance and distribution of these tabanid insects in relation to some important environmental parameters.

The authors are greatly indebted to Susama Devichoudhurani, Marine Biological Research Institute, Sagar Island, Sundarbans for all field and laboratory facilities. One of the authors (SR) is very much thankful to Dept. of Environment for financial assistance during the tenure of the work. Thanks are also due to Dr. M. Dutta of Zoological Survey of India for identifying the specimens.

MATERIALS AND METHODS

Study area

Sagar Island the largest delta of Sundarbans, situated nearly 85 km south of Calcutta (21° 31'N to 21°53'N and 88°02'E to 88°15'E) is surrounded by large bodies of water, River Hooghly in the north and the northwestern side and River Mooriganga in the eastern side. The southern part of the island faces the open sea, Bay of Bengal (Fig. 1).

Three stations in and around Sagar Island were selected for the present investigation (Fig. 1), Beguakhali Creek (station I) in southwestern part, Sagar Creek (station II) and supralittoral zone of Dhablat area facing Bay of Bengal (station III) in southeastern part.

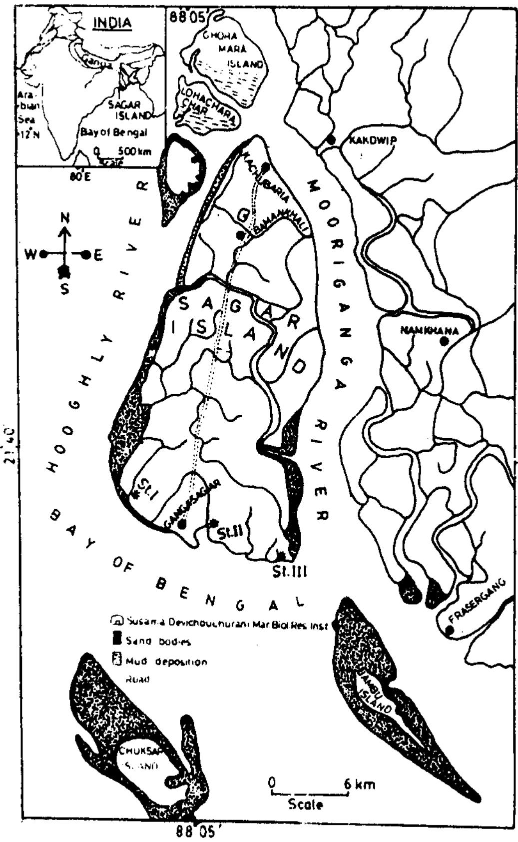

Fig. 1. Sagar Island showing field stations.

Seasons

Seasons are pronounced in this estuarine system, each with four months duration. The premonsoon (March to June) is the dry season with occasionally higher temperature. The monsoon (southwest) season (July to October) is accompanied by heavy rainfall and the postmonsoon (November to February) comprised partly the winter season, comparatively with lower temperature and lesser precipitation.

TABLE 1. *Analysis of variance for ecological parameters over months, years and stations. Calculation was based on monthly samples (n = 24). In case of rainfall d.f. for error and total are 11 and 23 respectively.*

Source of variation	d.f.	Soil temperature		Soil Moisture		Rainfall		Salinity		Dissolved oxygen		pH		Organic carbon		Available phosphorus	
		M.S	F	M.S.	F	M.S.	F.	M.S.	F.	M.S.	F	M.S.	F.	M.S.	F.	M.S.	F.
Months (M)	11	126.60	844**	81.26	239**	82.15	8.17**	418.57	152.76**	3.29	19.35**	0.12	12**	0.24	40	7.8	52**
Years (Y)	1	7.03	46.86**	0.14	0.41	0.06	0.006	1.18	0.43	0.06	0.35	0	0	0.05	8.3*	1.70	11.33**
Stations (S)	2	1.02	6.8**	10.85	31.91**	—	—	20.57	7.51**	0.31	1.82	0.005	0.5	0.005	0.83	0.44	2.93
Interaction (M × Y)	11	2.39	15.93**	3.95	11.62**	—	—	7.78	2.84	0.59	3.47**	0.04	4**	0.01	1.67	0.16	1.07
Interaction (M × S)	22	0.18	1.2	1.08	3.18**	—	—	2.97	1.08	0.20	1.18	0	0.6	0.002	0.33	0.75	5.0**
Interaction (Y × S)	2	0.04	0.27	0.64	1.88	—	—	4.45	1.62	0.12	0.71	0	0.5	0.005	0.83	0.33	2.2
Error	22	0.15		0.34		9.43		2.74		0.17		0.01		0.006		0.15	
Total	71	20.22		13.97		43.80		68.54		0.73		0.03		0.04		1.45	

* Significant at 5% level
** Significant at 1% level

Sampling procedure

The larval and pupal populations were sampled from July 1982 to June 1984 from the soil at fortnightly interval from three stations

Simultaneously with the larvae and pupae sampling, various environmental parameters *viz.* air temperature, soil temperature, soil moisture, rainfall, salinity, dissolved oxygen and pH of

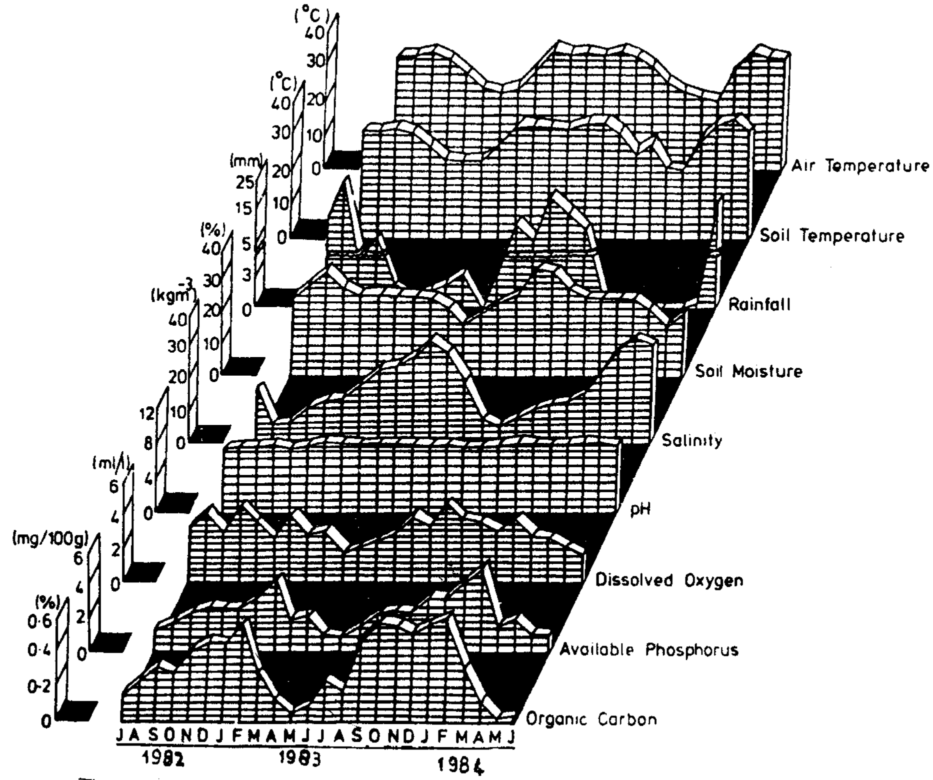

Fig. 2. Monthly fluctuation of different ecological parameters at station I.

during neap tide period in morning 0930 to 1130 hrs. Samples were removed from the sites at consistent position along transects traversing the beach. There were four transects on each site, each consisting of five samples, the transects were one metre apart and the samples were also one metre apart, so that a representative rectangle of the site was under observation. Each soil sample consisted of 25 cm^2 cut neatly to a depth of 9 cm by corer. Larvae and pupae were recovered from the soil by standardised magnesium sulphate floatation technique (Davies and Linley, 1966). Pupae were counted immediately, larvae were washed, then placed in 70% alcohol, whence they were later removed for counting.

interstitial water, organic carbon, available phosphorus, percentage of sand, silt and clay of the soil were also recorded.

Analysis procedure

To find out the variation of different environmental factors and species populations over months, years and stations three way classifications of analysis of variance were computed. Correlation coefficients were done to know the relationship between different environmental parameters and species population. Combined effect of eight environmental parameters (soil temperature, soil moisture, rainfall, salinity, dissolved oxygen, pH, organic carbon and available phosphorus) on these species was ascertained by multiple regression analysis. (this part of the exercise has been computerised following FORTRAN programme) (Snedecor and Cochran, 1967).

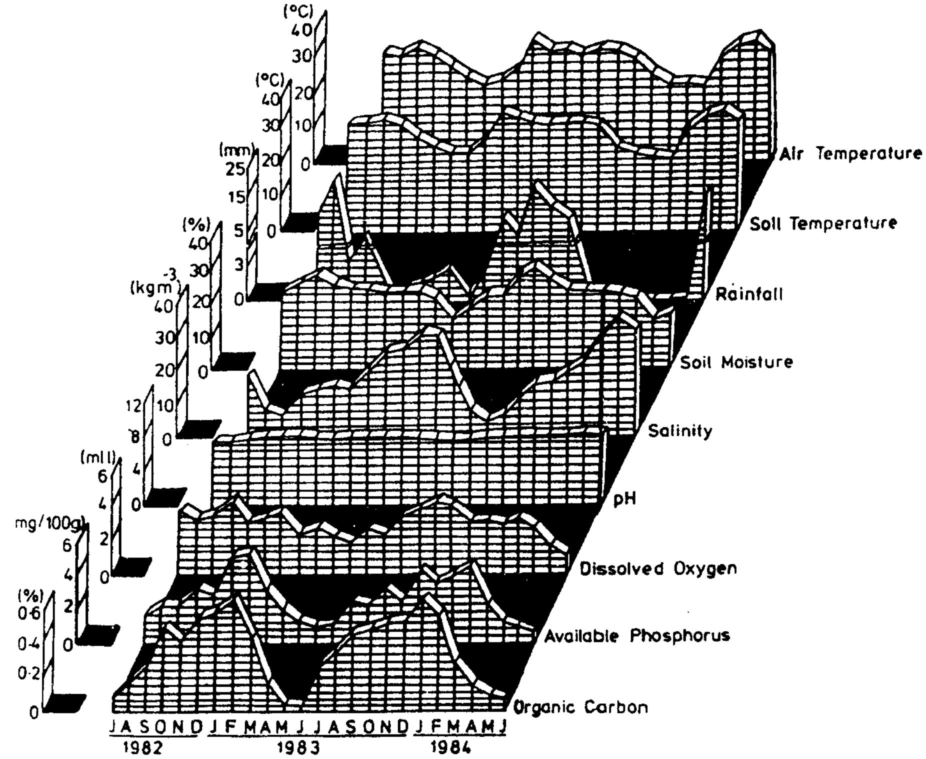

Fig. 3. Monthly fluctuation of different ecological parameters at station II.

Results

Environmental parameters

Rapid and distinct seasonal change of different environmental parameters is the striking feature of the deltaic estuary. A marked variation of all parameters during different months was noticed at all the stations (Fig. 2 to 5). Increase in air and soil temperature was noticed in premonsoon period and decreased during postmonsoon. A bimodal temperature oscillation was a distinguished feature. Soil moisture was observed maximum in monsoon and minimum in premonsoon at all the stations. Salinity increased to maximum during premonsoon months, which is inversely proportional to the rate of precipitation. The variation in concentration of dissolved oxygen was not conspicuous as in salinity. The maximum value was recorded during monsoon and minimum in premonsoon. pH remained almost constant with minor fluctuation range throughout the year except during monsoon. The pattern of change in the nutrients (organic carbon and available phosphorus) content of the soil at all the stations was very distinct. Every year the nutrients increased to maximum during postmonsoon and decreased during premonsoon. Textural condition of the soil remained almost constant throughout the year with minor fluctuations. At station I, sand was the major constituent of the soil followed by silt and clay. Texture of station II was composed mainly by silt and followed by sand and clay, but in station III it was composed of sand and silt; clay percentage was minimum.

Statistical analysis

Results of ANOVA show that all environmental parameters were always significantly varies over months and some of them also significantly varied over years and

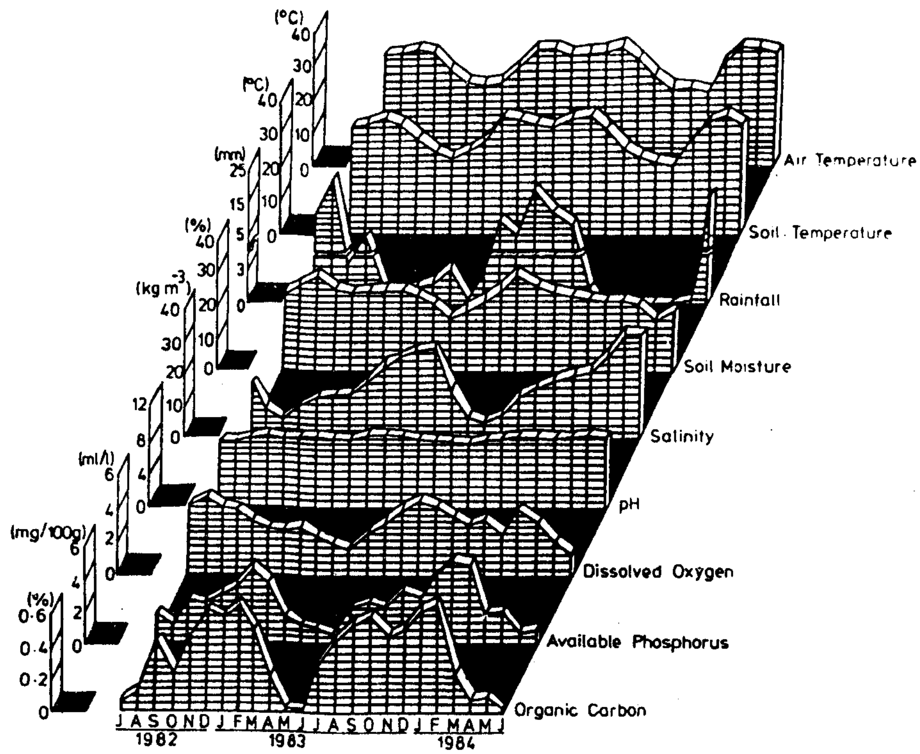

Fig. 4. Monthly fluctuation of different ecological parameters at station III.

Larval and pupal distribution

Tabanids in the collected field samples were represented only by two species *A. agrestis* and *T. striatus*, the former being abundant throughout the seasons. The sporadic occurrence of *T. striatus* during the months of less salinity (July to January) was recorded (Fig. 6). Maximum density of *A. agrestis* population was documented during the postmonsoon months, but during premonsoon period the population was either absent or very scarce. Maximum occurrence of *T. striatus* population was encountered during monsoon period.

stations (Table 1). The results of this test also show that the populations of these two species were varied significantly only over months (Table 2). Correlation coefficient analyses among ecological parameters and between ecological parameters and these two species show both positive and negative relation at all the stations (Table 3 and 4). Combined effects of all ecological parameters on these species were always significant at all the stations. These effects at all the stations are explained by the following equation.

TABLE 2. *Analysis of variance for* A. agrestis *and* T. striatus *over months, years and stations. Calculation was on monthly samples (n = 24)*

Source of variation	d.f.	*A. agrestis*		*T. striatus*	
		M.S.	F	M.S.	F
Months (M)	11	94.40	55.20**	88.20	56.18**
Years (Y)	1	3.84	2.25	1.38	0.88
Stations (S)	2	1.95	1.44	0.01	0.01
Interaction (M x Y)	11	4.45	2.60	3.39	2.16
Interaction (M x S)	22	3.35	1.96	1.69	1.08
Interaction (S x Y)	2	0.73	0.43	0.68	0.43
Error	22	1.71		1.57	
Total	71	17.01		15.24	

** Significant at 1% level.

TABLE 3. *Correlation coefficient among the ecological parameters at all the stations. Calculation was based on monthly samples (n = 24).*

	Soil moisture	Rainfall	Salinity	Dissolved Oxygen	pH	Organic Carbon	Available phosphorus
Station I							
Soil temperature	-0.134	0.486*	0.242	-0.280	-0.086	0.783**	-0.811**
Soil moisture		0.210	-0.913**	0.206**	-0.691**	0.660**	0.367
Rainfall			-0.255	0.210	-0.461*	-0.349**	-0.413*
Salinity				-0.290**	0.722**	-0.645**	-0.413*
Dissolved oxygen					-0.526**	0.564**	0.410-*
pH						-0.228	0.027
Organic carbon							0.842*
Station II							
Soil temperature	-0.225	0.431*	0.229	-0.189	-0.051	-0.810**	-0.824**
Soil moisture		0.077	-0.879**	0.806**	-0.609**	0.576**	0.518**
Rainfall			-0.258	0.090	-0.412-*	-0.373	-0.341
Salinity				-0.784**	0.649**	-0.567**	0. 565**
Dissolved oxygen					-0.456*	0.485*	0.552**
pH						-0.144	-0.070
Organic carbon							0.885**
Station III							
Soil temperature	-0.175	0.493*	0.113	0.048	-0.251	-0.734**	-0.851**
Soil moisture		0.184	-0.989**	0.787**	-0.683**	0.576**	0.430**
Rainfall			-0.253	0.238	-0.621**	-0.363	-0.413
Salinity				-0.812**	0.706**	-0.545**	-0.425**
Dissolved oxygen					-0.654**	0.231	0.222
pH						-0.142	0.073
Organic carbon							0.841**

* Significant at 5% level ** Significant at 1% level

A. agrestis

(Station I) $\hat{Y} = -91.39 - 0.69X_1 + 0.98X_2 - 0.10X_3 - 0.03X_4 - 0.29X_5 + 12.26X_6 - 7.74X_7 - 0.21X_8$

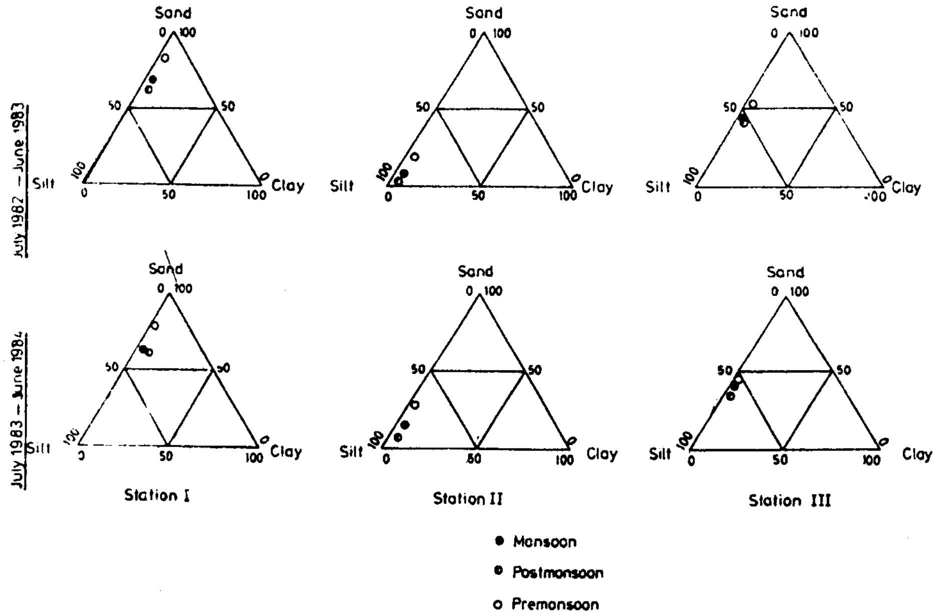

Fig. 5. Percentage of sand, silt and clay during different seasons at station I, II and III.

(Station II) $\hat{Y} = -16.04 - 1.10X_1 + 0.18X_2 - 0.18X_3 - 0.33X_4 - 0.24X_5 - 7.67X_6 - 1.59X_7 - 2.17X_8$

(Station III) $\hat{Y} = -75.37 - 0.08X_1 + 1.11X_2 - 0.05X_3 - 0.05X_4 - 0.82X_5 + 6.42X_6 - 2.59X_7 + 1.68X_8$

T. striatus

(Station I) $\hat{Y} = 23.12 + 0.82X_1 - 1.32X_2 + 0.08X_3 - 0.06X_4 + 0.55X_5 - 1.20X_6 + 29.9X_7 - 1.22X_8$

(Station II) $\hat{Y} = 0.21 + 0.01X_1 - 0.17X_2 - 0.05X_3 - 0.65X_4 - 0.20X_5 + 2.98X_6 - 5.93X_7 - 0.84X_8$

(Station III) $\hat{Y} = 54.85 + 0.07X_1 - 0.39X_2 - 0.02X_3 - 0.51X_4 + 0.48X_5 + 2.98X_6 - 0.47X_7 + 0.17X_8$

where, $\hat{Y}$ = population, X_1 = soil temperature, X_2 = soil moisture, X_3 = rainfall, X_4 = salinity, X_5 = dissolved oxygen, X_6 = pH, X_7 = organic carbon and X_8 = available phosphorus.

Discussion

The mangrove salt marshes of the deltaic Sundarbans at the land-sea interface in the mouth of Hooghly Estuary contain a number of unstable habitats. The general pattern of the drainage creeks experiencing tides twice in 24 hrs is more or less stable, but the detailed topography of creek margins is continually changing and eroded creek banks are a familiar feature of salt marshes of Sundarbans, supporting a variety of salt addicted vegetation. The instability of edge region is of fundamental importance, since it is to such region that a number of soil living species are largely confined (Foster and Treherne, 1976). The organisms inhabiting that region can be expected to react and adapt physical, chemical and biological changes of the environment. Of all the factors, salinity perhaps is the most variable component of the ecosystem which really experts perceptable impact on the behaviour of the littoral community. Monsoon flows exert profound influences on every aspect of estuarine condition. Considering the importance of the effects of monsoon in the system, Hooghly Estuary may be called as a 'tropical monsoon estuary'! Rapid fall of salinity, consequent on heavy precipitation and surface drainage interferes with the distribution of marine forms, but during premonsoon just opposite environment prevails in this system and high salinity interferes with the distribution of freshwater forms. Only euryhaline and

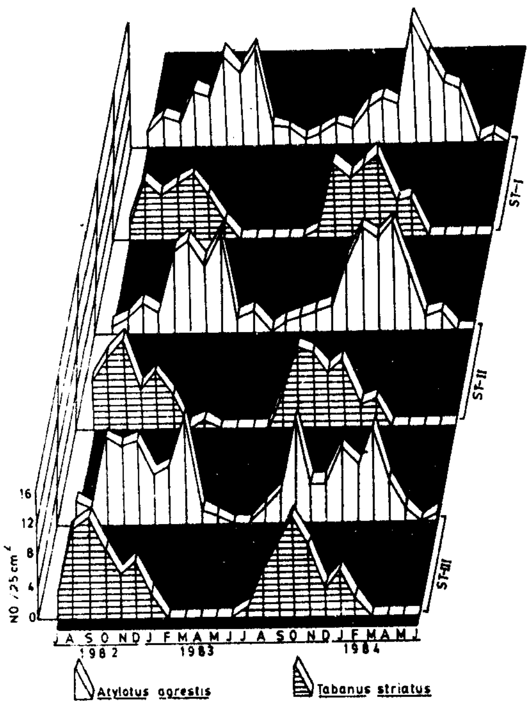

Fig. 6. Monthly fluctuation of two tabanid insects at different stations.

oligohaline species can tolerate these extreme range of saline environment. Many salt marsh insects exhibit a wide range of tolerance to environmental salinity (Clements, 1963; Macan, 1974).

From the available data it appears that *T. striatus* was completely absent during high saline condition (premonsoon period) and *A. agrestis* was less encountered during that period proves the former species is not able to withstand the high saline condition, but to a

TABLE 4. *Correlation coefficient of* A. agrestis *and* T. striatus *with all ecological parameters. In case of sand, silt and clay the calculation was based on seasonal data (n = 6), but in other cases it was based on monthly samples (n = 24)*

	Soil temperature	Soil moisture	Rainfall	Salinity	Dissolved oxygen	pH	Organic carbon	Available phosphorus	Sand	Silt	Clay
Station I											
A. agrestis	-0.687**	0.475*	-0.397*	-0.450*	0.383	0.025	0.794**	0.704**	-0.824*	0.812*	0.836*
T. striatus	-0.033	0.728**	0.325	-0.853**	0.712**	-0.632**	0.437*	0.178	-0.851*	0.840*	0.833*
Station II											
A. agrestis	-0.898**	0.484*	-0.454*	-0.457*	0.385	-0.026	0.851**	0.801**	-0.789*	0.787*	0.459
T. striatus	0.154	0.685**	0.435*	-0.849**	0.609**	-0.601**	0.170	0.183	-0.518	0.522	0.065
Station III											
A. agrestis	-0.599**	0.630**	-0.322	-0.521**	0.351	-0.040	0.726**	0.783**	-0.661	0.494	0.666
T. striatus	0.036	0.718**	0.313	-0.799**	0.724**	-0.685**	0.345	0.243	-0.085	0.185	-0.112

* Significant at 5% level ** Significant at 1% level

certain extent, the later species is able to tolerate that stressful situation. Significant negative correlation coefficient results between salinity and these two species also supports the same view.

The change in the population densities of *T. striatus* seems to be directly associated with dissolved oxygen and inversely associated with pH as evident from correlation coefficient analyses.

TABLE 5. *ANOVA values of the interaction of individual species with different ecological parameters. Eight ecological parameters were taken, calculation was based on monthly samples (n = 24)*

Source of variation			*A. agrestis*		*T. striatus*	
		d.f.	M.S.	F	M.S.	F
Station I	$\Sigma\hat{y}^2$	8	38.42	5.56	39.11	13.30**
	Σd^2	15	6.91		2.94	
	Σy^2	23	17.87		15.52	
Station II	$\Sigma\hat{y}^2$	8	48.21	104.80	40.33	14.99**
	Σd^2	15	0.46		2.69	
	Σy^2	23	16.78		15.78	
Station III	$\Sigma\hat{y}^2$	8	34.24	11.30	43.82	8.44**
	Σd^2	15	3.03		5.19	
	Σy^2	23	14.94		20.43	

** Significant at 1% level

Importance of temperature as a factor, like salinity for animal distribution in a particular area of niche is also emphasized by the ecologists. The most obvious impact of temperature on animal distribution so far as brackishwater zone is concerned, is the exclusion of species in areas with unsuitable temperature condition (Kinne, 1963). Highly negative correlation coefficient analyses between *A. agrestis* and temperature show one factor is inversely associated with each other.

Soil moisture is also an important environmental factor for several benthic insects (Painter, 1926; Linley, 1968). Positive correlation coefficients between soil moisture and these two species indicate that the moisure may be a causative factor exerting impact on the distribution and abundance of these species in the intertidal habitat.

Organic nutrients (organic carbon and available phosphorus) are present in maximum amount in the littoral zones of the tropical estuary (Heald and Odum, 1970; Cameron, 1972), which help to grow different types of algae in these areas, provide a novel food source for several benthic insects (Chapman, 1960). The distribution and abundance of many dipteran larvae in this environment are regulated by the available organic nutrients that help directly or indirectly to grow the algal population (Teal, 1962). Significant positive correlation coefficient results between *A. agrestis* and soil nutrients (organic carbon and available phosphorus) indicate that the abundance of this species is directly associated with each other.

Salt marsh soils are extremely varied in structure and composition *i.e.* sand, silt and clay proportion (Ranwell, 1972). The structure and composition of the soil is an important decisive factor for many benthic dipterans, some species are well adapted in all types of textural conditions, but some favours either sandy or silty natures only (Majori *et al.,* 1971; Kline, 1974). The occurrence and distribution of these two species at all the stations could be explained by their ability to adapt in different textural conditions of the soil.

REFERENCES

AXTELL, R. C. 1976. Coastal Horse Flies and Deer Flies (Diptera : Tabanidae). *In* : L. Cheng [Ed.] *Marine Insects.* North Holland Public. Co., Amsterdam and Oxford, pp. 415-455.

CAMERON, G. N. 1972. Analysis of insect trophic diversity in two salt marsh communities. *Ecology,* **53** : 58-73.

CHAPMANN, V. J. 1960. The Plant Ecology of Scott Head Island. *In* : J. A. Steers [Ed.] *Scott Head Island.* W. Heffer and Sons Ltd., Cambridge, pp. 85-163.

CLEMENTS, A. N. 1963. *The Physiology of Mosquitoes.* Pergamon Press, Oxford.

DAIBUR, F. C. 1974. *Ecology of Halophytes.* Academic Press, New York and London.

DAVIES J. B. AND J. R. LINLEY 1966. A standardized floatation method for separating *Leptoconops* (Diptera : Certaopogonidae) and other larvae from sand samples. *Mos. News,* **26** : 440.

FOSTER, F. H. AND J. E. TREHERNE 1976. Insects of Marine Salt Marshes : Problems and Adaptation. *In* : L. Cheng [Ed.] *Marine Insects.* North Holland Publc. Co., Amsterdam and Oxford, pp. 5-42.

HEALD, E. J. AND W. E. ODUM 1970. The contribution of mangrove swamps to Florida Fisheries. *Proc. Gulf and Carib. Fish Inst.,* **22** : 130-135.

KINNE, O. 1963. The effect of temperature and salinity on marine and brackish water animals. *Oceanogr. Mar. Biol. Rev.,* **1** : 301-340.

KLINE, D. L. 1974. Coastal *Culicoides* of North Carolina : Species composition, seasonal incidence and distribution within salt marsh habitats. *Ph.D. Thesis, N. Carolina State University, pp. 1-161.*

LINLEY, J. R. 1968. Studies on larval biology of *Leptoconops becquaerti* (Kieff). (Diptera : Ceratopogonidae). *Bull. Entomol. Res.,* **58** : 1-24.

MACAN, T. T. 1974. *Freshwater Ecology.* Longmans, London.

MAJORI, G., F. BERNERDINI, S. BETTINI, E. FINIZIO AND G. PIERDOMINICI 1971. Richerche sui Ceratopogonidi nel Grossetano : Nota V - Caratteristiche geologiche dei focolai di *Leptoconops* spp. *Riv. Parassitol.,* **32** : 277-291.

PAINTER, R. H. 1926. The biology of immature stages and control of the sandflies (biting ceratopogonidae) at Puetro Castilla, Hondurus. *Rep. Un. Fruit Co. Med. Dep. N.Y.,* pp. 245-262.

RANWELL, D. S. 1972. *Ecology of Salt Marshes and Sand Dunes.* Chapman and Hall, London.

RAY, S. AND A. CHOUDHURY 1987. Contribution to the study of littoral dipterans I. On a collection of family of ceratopogonidae, chironomidae, psychodiae and tabanidae from Sagar Island, India. *Rec. Zool. Surv. Ind.,* **83** : 1-4.

SNEDECOR, G. W. AND W. G. COCHRAN 1967. *Statistical Methods.* The Iowa State Univesity Press, U.S.A.

TEAL, J. M. 1962. Energy flow in the salt marsh ecosystem of Georgia. *Ecology,* 43 : 614-624.