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A Comparative Analysis on the Effects of Temperature and Humidity on Selective Species of Chironomid Midges from West Bengal, India

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ABSTRACT

Seasonal abundance of chironomid midges, *Dicrotendipes pelochloris* Kieffer (1912), *Clinotanypus novempunctatus* Kieffer (1910), *Tanypus olesaetheri* Ashe and O'Connor (2009) and *Polypedilum nudiceps* Chaudhuri *et al*. (1981) were studied with correlation of the abundance of the biting midges with respect to temperature and relative humidity in two plateau sites of Chottanagpur (Matha and Susunia). Comparative analyses on the effects of the two parameters were also performed. Environmental parameter, humidity was found to have profound effect on the populations of the midges than temperature.

Keywords Seasonal abundance, Temperature, Humidity, Chironomidae, Chironominae.

INTRODUCTION

Forests cover approximately 30% of India's landmass (Kumari *et al.* 2019). They are vital to maintaining the life on earth. Studies on the ecology of sylvatic chironomid midges are scarce. Their habitats range from tree liter to tree holes. Chironomid species assemblage depends on the interaction of various biotic and abiotic factors in a particular locality (Armitage *et al.* 1995). Temperature and humidity are two important ecological factors that affect any insect community in an area (Jordan and Tomberlin 2017). A little change in these factors can have profound impact on the species population inhabiting there (Pureswaran *et al.* 2018). Few aspects of the seasonal changes of temperature and humidity can be predicted. However, unlikely extreme changes in the temperature that occur only for a few days cannot be predicted. These changes in general have a more adverse effect on the ecosystem (Krüger *et al.* 2021). Emergence of adults depends on a wide range of factors including temperature and humidity (Khaliq *et al.* 2014). Humidity is also an important factor in the development of midges. Very low humidity may lead to desiccation of the midges.

Chironomids or non-biting midges belong to a diverse group of nematocerous Diptera having 11 subfamilies. Among them the subfamilies Chironominae and Tanypodinae are diverse groups and well studied. Till date, Chironominae comprises of 225 species belonging to 42 genera while 149 tanypod species under 22 genera are so far recorded from the Oriental region (Hazra *et al.* 2016, Mondal *et al.* 2020).

Very few works (Chatterjee *et al.* 2018) have

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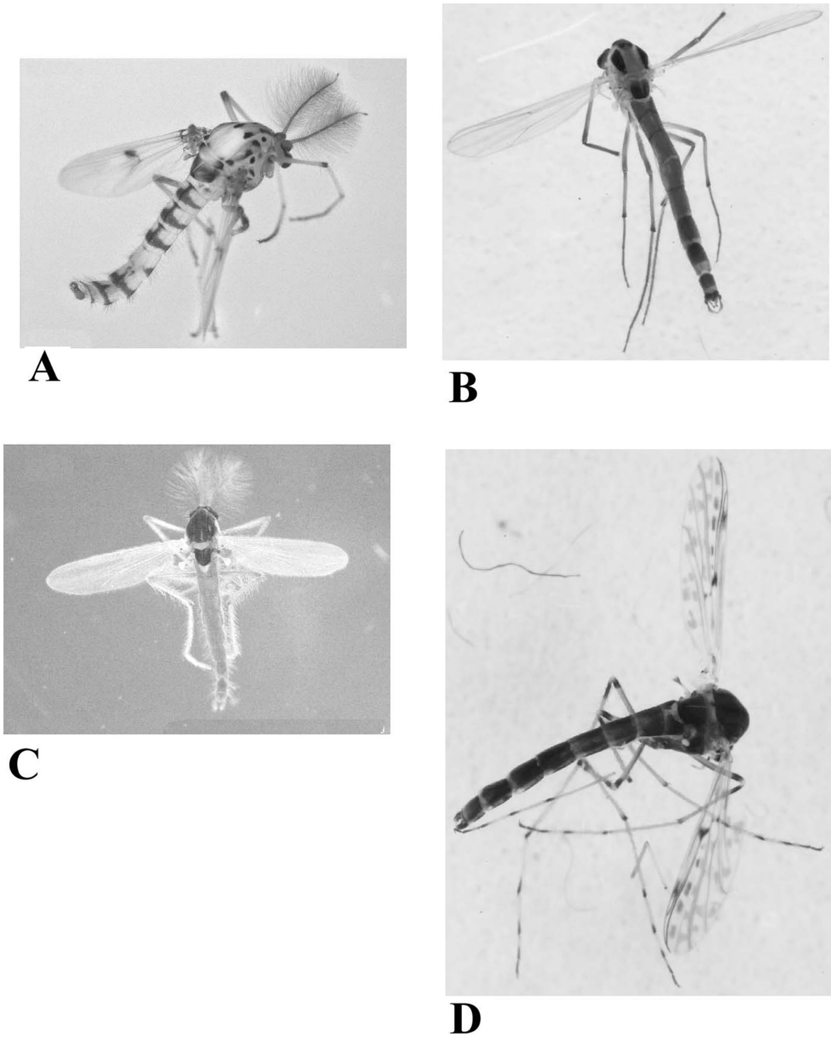

Fig. 1. Habitus dorsalis of selected midge species: A *Clinotanypus novempunctatus*, B *Dicrotendipes pelochloris*, C *Polypedilum nudiceps*, D *Tanypus olesaetheri.*

been done on the ecology of nematocerous dipterans from India. In this study an attempt has been made to find out the influence of temperature and humidity on the population size of four selected midge species under different genera (Fig. 1).

MATERIALS AND METHODS

Selection of sampling sites : Two sites : Matha (23.11, 86.06) and Susunia (23.67, 87.02) were selected. Matha (Figs. 2B– C) is a dense forested area with deciduous vegetation. There are small streams inside the forests. Logging is done on a limited scale. Susunia (Figs. 2D–E), a part of the Eastern Ghats, is one of the highest points in southern West Bengal. Vegetation here is predominantly dry deciduous type. Except a small spring there are no waterbodies nearby. The collections sites were selected in such a manner so that the physiography and overall landuse was similar between the two places. Availability of

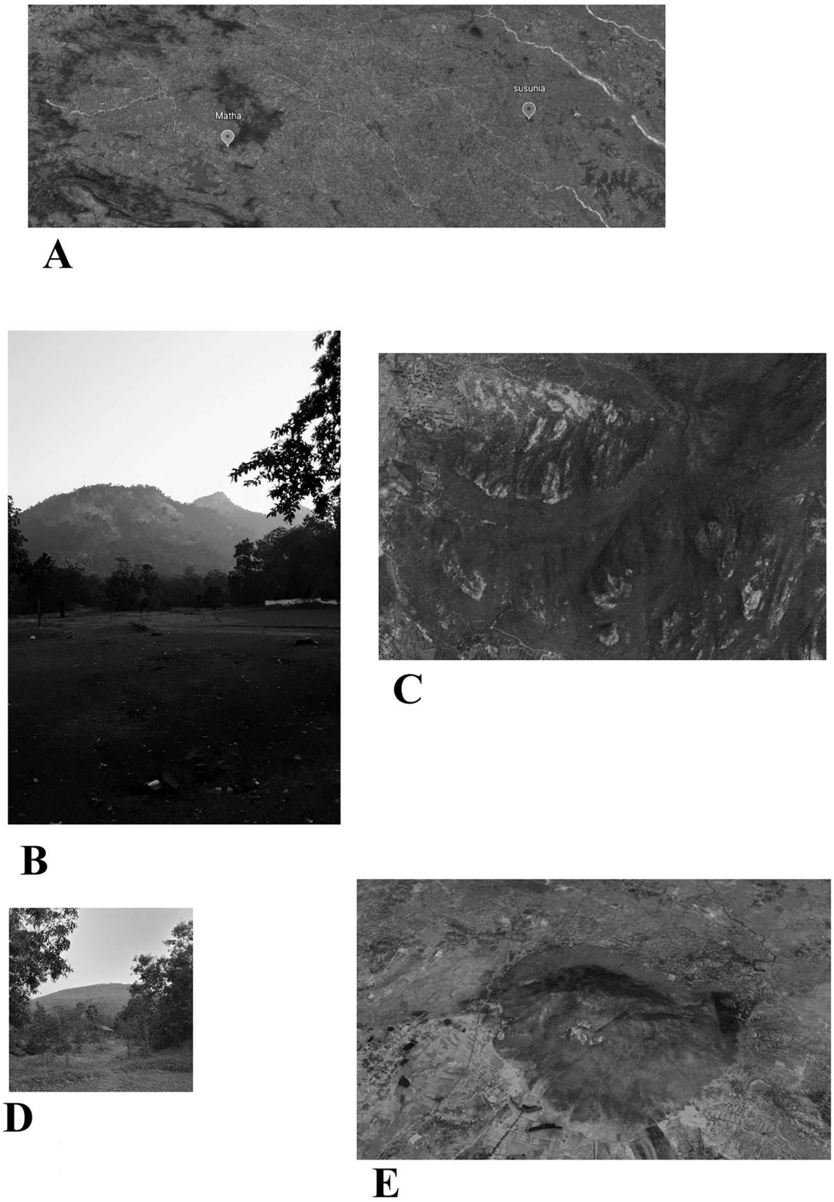

Fig. 2. Satellite and photographic images of collection sites. A: location of Susunia and Matha, B: Matha (collection site), C: Matha (Satellite image), D: Susunia (Collection site), E: Susunia (Satellite image).

hassle free transport and easy access to terrain are also important factors the collection of specimens throughout the study period.

Adult midge collection and identification : The study was conducted out for 12 months from April 2019 to March 2020. For this study only adult midges were considered. The midges were collected with the help of open light traps. Traps were set up from dusk to dawn for three consecutive days. Forested areas with minimal human interference were selected for the study. The midges were sorted and preserved

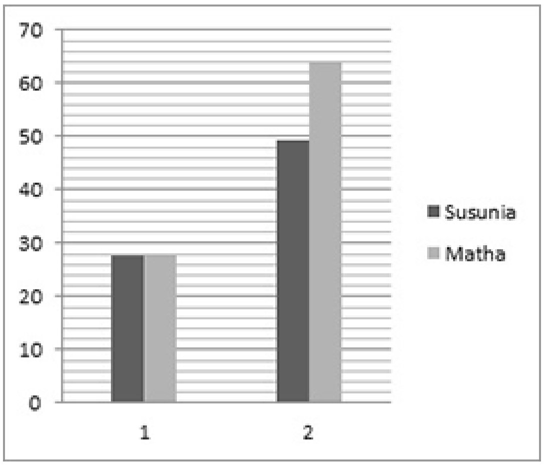

Fig. 3. Graphical representation of temperature and humidity between Matha and Susunia.

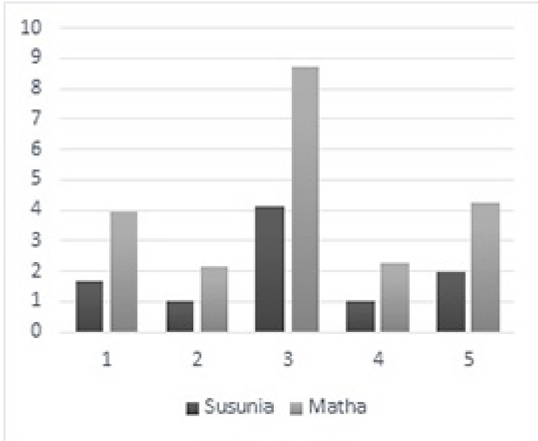

Fig. 4. Graphical representation showing population sizes of four species in the collection sites (1. *Polypedilum nudiceps*, 2. *Dicrotendipes pelochloris,* 3. *Tanypus olesaetheri*, 4. *Clinotanypus novempunctatus*, 5. Total.

in 70% ethanol. Specimens were mounted using Phenol Balsam following Wirth and Marston 1968. Identification was done upto species level using keys (Mukherjee *et al.* 2020, Roback 1971).

Record of temperature and humidity : Temperature and humidity were measured using weather station. Temperatures are recorded in Celsius (°C). Relative humidity being a ratio has no unit involved.

Statistical analysis : The data obtained were analyzed using Microsoft Excel and PAST (Hammer *et*

Table 1. ANOVA analysis showing difference in temperature and humidity between collection sites.

	Summary	Temperature	Humidity	Total		
Susunia	–	–	–			
Count	36	36	72			
Sum	998	1770	2768			
Average	27.72222	49.16667	38.44444			
Variance	63.52063	231.6857	262.1095			
Matha	–	–	–			
Count	36	36	72			
Sum	995	2308	3303			
Average	27.63889	64.11111	45.875			
Variance	51.49444	205.3016	463.8292			
Total	–	–	–			
Count	72	72				
Sum	1993	4078				
Average	27.68056	56.63889				
Variance	56.69933	272.0368				
Anova						
Source of variation	SS	Df	MS	F	P-value	F crit
Sample	1987.674	1	1987.674	14.40337	0.000219	3.908741
Columns	30189.06	1	30189.06	218.7604	2.12E-30	3.908741
Interaction	2032.507	1	2032.507	14.72825	0.000187	3.908741
Within	19320.08	140	138.0006	0		

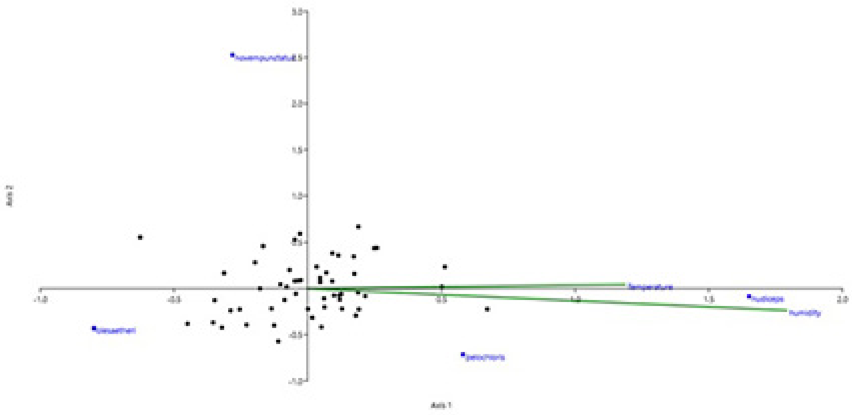

Fig. 5. CCA plot to find out the effect of temperature and humidity on insect populations.

al. 2001). The correlation between temperature and humidity was measured using SPSS (IBM 2016).

RESULTS

A total of 895 individuals were obtained during the study. The temperature ranged from 41 to 16 °C, relative humidity ranged from 71 to 26% at Susunia. In Matha temperature ranged from 41 to 15°C and humidity had a range between 91 and 49%. ANOVA analysis showed that there was no significant difference in the temperature between the two places.

Table 2. ANOVA analysis comparing the populations of four species in Matha and Susunia.

Summary	*Polypedilum nudiceps*	*Dicroten-dipes pelochloris*	*Tanypus olesaetheri*	*Clinotanypus novem-punctatus*	Total	
Susunia	–	–	–	–	–	
Count	36	36	36	36	144	
Sum	61	37	149	37	284	
Average	1.694444	1.027778	4.138889	1.027778	1.972222	
Variance	1.989683	1.113492	6.465873	1.113492	4.264957	
Matha	–	–	–	–	–	
Count	36	36	36	36	144	
Sum	143	77	314	81	615	
Average	3.972222	2.138889	8.722222	2.25	4.270833	
Variance	8.656349	4.40873	28.66349	3.278571	18.19886	
Total	–	–	–	–	–	
	Count	72	72	72	72	
Sum	204	114	463	118		
Average	2.833333	1.583333	6.430556	1.638889		
Variance	6.56338	3.035211	22.643	2.543818		
ANOVA						
Source of variation	SS	df	MS	F	P-value	F crit
Sample	380.4201	1	380.4201	54.64856	1.67E-12	3.874884
Columns	1122.983	3	374.3275	53.77334	1.77E-27	2.636845
Interaction	140.2049	3	46.73495	6.713625	0.000217	2.636845
Within	1949.139	280	6.96121			
Total	3592.747	287	–	–	–	–

Table 3. Eigenvalues of humidity and temperature with the four species.

Axis	Eigenvalue	%
Humidity	0.006397	99.74
Temperature	1.70E-05	0.2647
	Humidity	Temperature
P. nudiceps	1.65084	-0.08437
D. pelochloris	0.580237	-0.71457
T. olesaetheri	-0.79873	-0.43086
C. novempunctatus	-0.28057	2.52678

Table 4. Correlation between temperature and the four species.

	Temperature	Humidity
Temperature	1	
Humidity	-0.04402	1
P. nudiceps	0.256763	0.893566
D. pelochloris	0.207136	0.860716
T. olesaetheri	0.26184	0.887616
C. novempuctatus	0.269197	0.773392

However, the difference in humidity was significant among them (Table 1, Fig. 3).

Number of specimens of *P. nudiceps* obtained in Susunia and Matha was significantly different. There were more individuals in Matha than in Susunia. Similarly, *D. pelochloris*, *C. novempunctatus* and *T. olesaetheri* were also found in higher number in Matha than in Susunia (Table 2, Fig. 4).

A CCA plot (Fig. 5) revealed that the within the recorded ranges population of *P. nudiceps* did not show significant correlation with temperature or humidity. *Dicrotendipes* pelochloris population showed positive correlation with temperature while a negative correlation with humidity was obtained. Both the correlations were found to be significant with their Eigenvalue being higher than 0.05. *Tanypus olesaetheri* showed significant negative correlation with both temperature and humidity. *Clinotanypus novempunctatus* showed a positive correlation temperature.

Humidity, however, was negatively correlated with the population size of *C. novempunctatus*. The correlations were significant even in this species population. Population density of *Polypedilum nudiceps* were not found to be significantly correlated with temperature and humidity. The Eigenvalues of the four species with temperature and humidity are represented in Table 3.

Z-values showing the correlation between the parameter and the four species are given in Table 4. The population size of the species was also significantly different in various seasons. As expected, the populations in general were larger during the monsoon season with a crash in the population recorded during the post monsoon seasons (Table 5).

DISCUSSION

Most members of chironomid midges prefer environments with high humidity for their development. According to Armitrage *et al*. (1995) the humid conditions appeared more conducive for completion of their life cycle. Optimum relative humidity rather than air temperature seems essential for growth of the larval midges. Compared to the monsoon season, a smaller number of midges were encountered during high temperature of the pre-monsoon season. The moderate temperature of the monsoon might be conducive for development and multiplication. From our analyses we found that both temperature and humidity have an important influence on the populations of midge species investigated. However, we found that populations of these four species were more affected by humidity than temperature. Two tanypod species showed significant negative correlation with humidity. The effect of humidity on these two tanypod species was more detrimental compared to the two chironomine species. The tanypod larvae live in soft sediments of ponds that are more prone to lose moisture. The development of the midges ceased during high temperature and low humidity due to desiccation of the habitat resulting arrest of the development. This explains the negative correlation of *Clinotanypus and Tanypus* population with humidity.

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Table 5. ANOVA showing the difference among the population in pre, post and monsoon seasons.

Anova: Two-factor with replication

Summary	*P. nudiceps*	*D. pelochloris*	*T. olesaetheri*	*C. novempuctatus*	Total	
Monsoon						
Count	2	2	2	2	8	
Sum	127	67	244	55	493	
Average	63.5	33.5	122	27.5	61.625	
Variance	1404.5	480.5	4232	364.5	2527.125	
Post Monsoon						
Count	2	2	2	2	8	
Sum	23	17	82	25	147	
Average	11.5	8.5	41	12.5	18.375	
Variance	40.5	0.5	242	40.5	243.6964	
Pre-Monsoon						
Count	2	2	2	2	8	
Sum	54	30	137	38	259	
Average	27	15	68.5	19	32.375	
Variance	200	32	1300.5	32	741.9821	
Total						
Count	6	6	6	6		
Sum	204	114	463	118		
Average	34	19	77.16667	19.66667		
Variance	899.2	237.2	2512.167	132.6667		
ANOVA						
Source of variation	SS	df	MS	F	P-value	F crit
Sample	7792.333	2	3896.167	5.586236	0.019286	3.885294
Columns	13475.79	3	4491.931	6.440429	0.007596	3.490295
Interaction	2744.333	6	457.3889	NO	0.686178	2.99612
Within	8369.5	12	697.4583			
Total	32381.96	23				

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