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On the Population Dynamics of Larvae of *Chironomus* sp. (Chironomidae, Diptera, Insecta) in Relation to Water Quality and Soil Texture of Ganga River (between Buxar and Ballia)

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The paper deals with the seasonal variation in the population of the larvae of *Chironomus* sp. in Ganga river, in relation to soil texture and bottom layer water quality in the stretch between Buxar and Ballia. In the present investigation, the larval population showed maximum numerical count spread over winter to early summer with more of less bimodal pattern at both the centres. Late months of summer and the entire monsoon season were not conducive for colonisation as the river was highly polluted and water current was aggressive owing to inundation. Among the abiotic factors examined, the seasonal abundance of *Chironomus* larvae in the river was influenced greatly by water current, homogeneous silt content, total alkalinity and water temperature while other variables appeared to play a secondary role. Karl Pearson's correlation coefficients and multiple regression analyses were conducted to see the relationship and effects of different abiotic variables on the population of *Chironomus* larvae. Overall, Buxar centre showed higher abundance (8263 U/m^2) in comparison to Ballia (534 U/m^2) during the period of study.

Key Words : Ganga river, water quality, Soil texture, Larvae of *Chironomus* sp.

Introduction

Studies on the larvae of *Chironomus* sp. are of fundamental importance as they contribute a major percentage of benthic fauna of aquatic ecosystems (Bhowmic 1968, Singh & Srivastava 1989, Oswood 1989) and play a very significant role as food for bottom dwelling fishes and other macro-invertebrates of economic value. Distribution and Colonisation of *Chironomids* are influenced

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by a wide range of physical and environmental variables (Armitage et al. 1995). While Naiman et al. (1987), Oswood (1989), Statzner et al. (1988), Hildrew et al. (1991) and Rundle et al. (1993) studied various aspects of bottom fauna in diverse variety of ecosystems, McLohan (1970) has focussed the adaptability of *Chironomus* larvae to the different environmental conditions.

Studies on bottom fauna in Indian watersheds are mainly concerned with the whole benthic communities (Bhowmic 1968, Verma & Dalela 1975, Sehgal 1977, Jhingaran 1985, Rao et al. 1985 and 1987, Kumar 1987, Singh & Srivastava 1989, Augustine & Diwan 1991 and Sinha et al. 1993) rather than specific studies related to any animal.

Publications related to quantitative variation in depterian forms of Ganga river, particularly of *Chironomus* larvae are very scarce. This study is an attempt to interpret the influence of different abiotic environmental variables on numerical abundance and distribution of this benthic form, in relation to pollution load and soil texture of the river between Buxar and Ballia. However, in the present study, the species level identification of larvae was not done; but the total colonisation of 4th instar larvae of *Chironomus* sp., present in the river, was assessed and taken as a pooled data in relation to abiotic environmental variables.

Study Area

The Ganga river between Buxar and Ballia (35 kms downstream from the former) borders the state of Bihar and Uttar pradesh. A sandy belt covering an areas of about 5 kms^2 bisects the river current a little stretch downstream from Buxar and harbours annual shrubs of xerophytic nature. Because of several small sandy belts, many narrow water strips are formed. All these sandy belts are partly or wholly inundated during monsoon. The river receives its another tributary river Tons a few kilometers upstream from Ballia. A streamlet locally called Katehar nala, connects the well known Suraha lake with the river adjacent to Ballia. The streamlet fills up or drains out the lake depending upon the relative water level of the river and lake (figure 1).

Materials and Methods

Monthly collection of samples of bottom layer water, soil and *Chironomus* larvae was done from two fixed stations in mid stream of the river in front of Buxar and Ballia (a stretch of 35 kms downstream from Buxar). A detailed account on the methods for the analysis of water and numerical estimation of larvac of *Chironomus* sp. has been presented by the authors in earlier communications (Singh & Srivastava 1988 and 1989); taxonomic identification of the larvae was performed according to Pennak (1978). Soil texture in terms of relative amount of sand, silt and clay was estimated following International Pipette Method (Piper 1950).

Statistical Analysis

In order to establish the relationship of the larval population of *Chironomus* sp. with the abiotic variables of water, data were subjected to Karl Pearson's correlation coefficient; but the magnitude of influence exerted by soil texture was determined by log-linear multiple regression analysis. Multiple regression analysis, with the explanatory variables of water quality was avoided as to escape the results from the expected problems ought to be created by multicollinearity among the abiotic variables; since most of them are

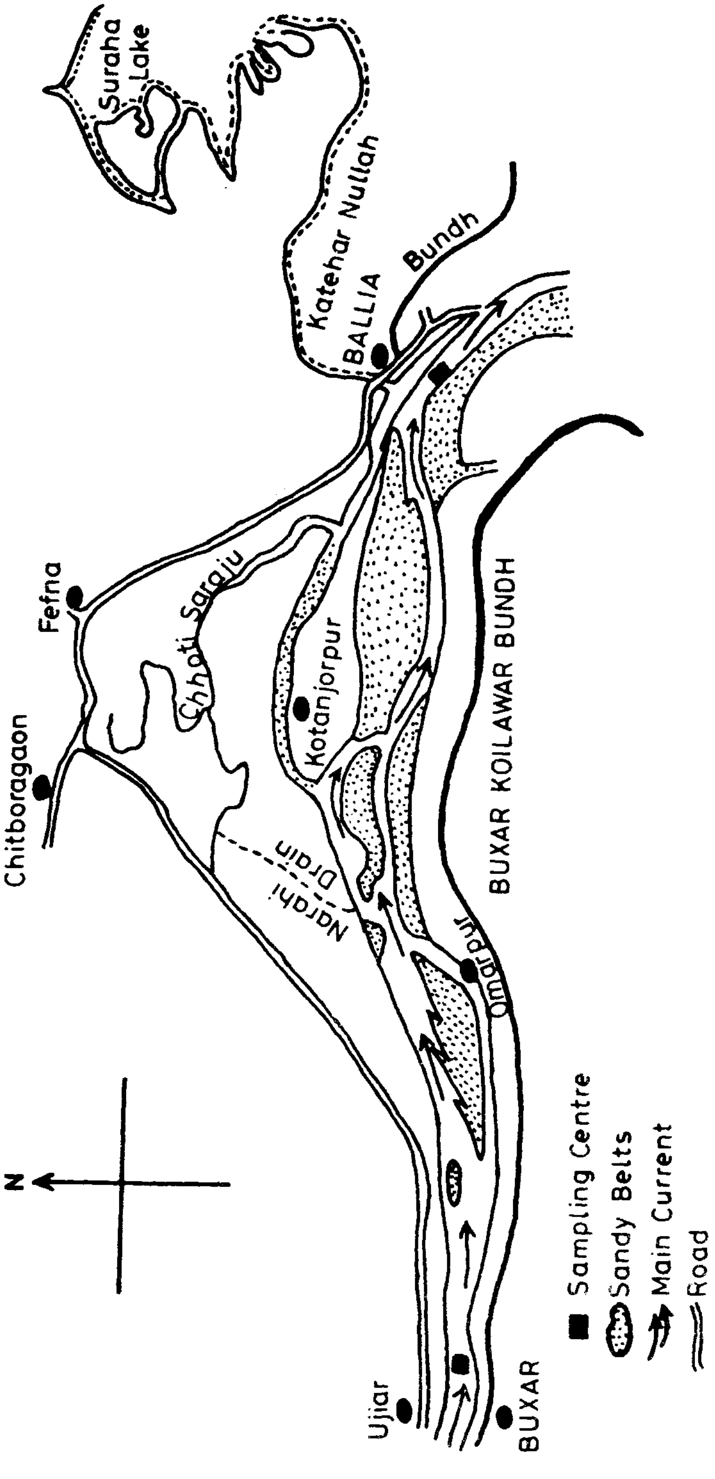

Figure 1 The stury area

significantly correlated to one another (table 6). Student's 't' test was applied to test the level of significance of correlation coefficients (r) and egression coefficients (b).

Results

Water

Seasonal variations in water quality of bottom layer water of the river at the Buxar and Ballia centre are depicted in table 1, figure 2. Variations in water of both the centres were not conspicuous except that the water current was much higher at Ballia centre than at Buxar (observed by site witness) where water flow was slow during most part of the year. Further, during monsoon, owing to inundation and flood, water current became swift at both the centres.

Soil Texture

Relative percentage of sand, silt and clay is given in table 2, figure 3. Soil of the Ganga river at both the centres was observed to be sandy throughout the year; but, however, percentage of sand was recorded maximum during monsoon season in comparison to summer and winter. Overall, Ballia centre experienced consistently high quantity of sand throughout the year (C.V. = 1.3216%, 0.9988% and 2.3605% for winter, summer and monsoon respectively) in comparison to Buxar where prevalence of sand was less and exhibited inconsistency (C. V. = 14. 1497%, 5.6332% and 7.4074% for winter, summer and monsoon respectively; table 2).

Chironomus Larvae

Population dynamics of larvae of *Chironomus* sp. exhibited more or less similar trend at both the centres with slight variation and showed a bimodal pattern of distribution. At Buxar centre it attained its first peak in the month of March. Thereafter, a declining trend in the numerical count was witnessed till the onset of monsoon season when the population was very thin leading to nil in the month of October. The second pulse was recorded in December. Corresponding values at Ballia centre were recorded in March and January. Unlike Buxar, the population was zero during two consecutive months (September and October) of the monsoon season at Ballia centre (table 3).

The year round observation revealed that winter and early summer season (December - March) facilitated significant colonisation of this dipteran form at both the stations; while the population was low during late summer and whole monsoon. Overall, it was noticed that Buxar centre shared higher numerical value (8263 U/m^2) of *Chironomus* larvae than to Ballia (534 U/m^2) (table 3, figures 2 and 3).

Discussion

Year round observations at the sampling sites of Ganga river revealed that water current at Ballia centre was high throughout the year, which became more swift during monsoon season (Singh & Srivastava 1989 and 1991 and Srivastava & Singh 1995) and this was perhaps responsible for the greater sand component of the bottom soil at the centre. Buxar centre exhibited sluggish flow in contrast to Ballia all along the year except during monsoon; this caused sedimentation and relatively higher silt and clay contents (table 2). This is in conformity with the findings observed by Jhingaran (1985), Oyenken (1988) and Singh & Srivastava (1989) in different lotic ecosystems and estuaries. Though both the study sites were sandy, water current of the river regulated

Table 1 *Seasonal variation in Physico-Chemical characters of the bottom layer water of Ganga river (between Buxar and Ballia); X ± S D. Value given in parenthesis is co-efficient of variation (C V %)*

Parameters	BUXAR			BALLIA		
	Summer (Mar. - June)	Monsoon (Jul. - Oct.)	Winter (Nov. - Feb)	Summer (Mar. - June)	Monsoon (Jul. - Oct.)	Winter (Nov. - Feb)
Water	29.6	29.625	21.075	29.2	29.5	22.65
Temperature	± 3.0886	± 0.8958	± 1.7289	± 1.7833	± 1. 2415	± 3.8940
(°C)	(10.4345)	(3.0238)	(8.2036)	(6.1072)	(4.2085)	(17.1912)
*p*H	7.85	7.275	7.7	7.70	7.32	7.72
	± 0.3697	± 0.15	± 0.1154	± 0.3464	± 0.05	± 0.2986
	(4.7096)	(2.0619)	(1.4987)	(4.4987)	(0.6831)	(3.8679)
Dissolved	9.05	6.275	10.7	8.0	6.35	10.25
Oxygen (mg/l)	± 2.1436	± 0.6702	± 1.4652	± 1.4071	± 0.2381	± 1.1818
	(23.741)	(10.6804)	(13.6935)	15.8101)	(3.7496)	(11.5298)
Total	196.75	116.25	194.475	196.1	108.125	193.2125
Alkalinity (mg/l)	± 41.1754	± 21.4651	± 17.654	± 40.7002	± 12.1338	± 18.6858
	(20.9278)	(18.4646)	(9.0778)	(20.7548)	(11.2220)	(9.6711)
Chloride (mg/l)	31.025	9.15	18.775	29.725	9.025	29.725
	± 2.4784	± 9.9256	± 8.4005	± 1.8482	± 10.0047	± 1.8482
	(7.9884)	(108.4765)	(44.7430)	(6.2177)	(110.8554)	(6.2177)
COD (mg/l)	10.725	16.1	6.30	8.225	13.95	5.9
	± 2.4757	± 0.8406	± 1.2909	± 1.0813	± 1.4526	± 1.8992
	(23.0835)	(5.2211)	(20.4905)	(13.1465)	(10.4129)	(32.1898)
BOD (mg/l)	5.90	7.525	3.075	4.25	6.1	2.775
	± 0.9486	± 1.2996	± 0.6652	± 0.6455	± 0.8679	± 0.7632
	(16.0779)	(17.2704)	(21.6325)	(15.18823)	(14.2279)	(27.5027)
SO_4^{--}(mg/l)	50.8325	109.25	49.635	47.3975	75.1	51.182
	± 10.9230	± 21.4725	± 14.269	± 3.9789	± 31.4065	± 8.9239
	(21.4882)	(19.6545)	(28.7479)	(8.3779)	(41.8196)	(17.4354)
Total Solids	1462.5	4000.0	482.5	1412.5	3950.0	470.0
(mg/l)	± 852.5754	±31.6228	± 59.0903	± 724.862	± 54.4671	± 103.6028
	(58.3159)	(7.9057)	(12.2467)	(51.3177)	(13.7891)	(22.0429)

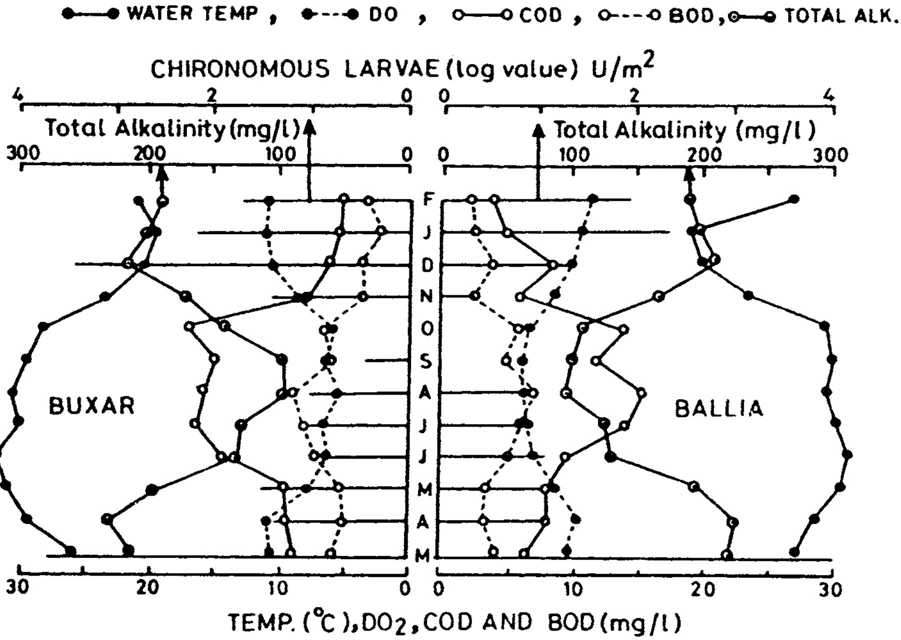

Figure 2 Monthly variation in *Chironomus larvae* population in relation to water quality (bottom layer) at Buxa and Ballia Centre of Ganga river

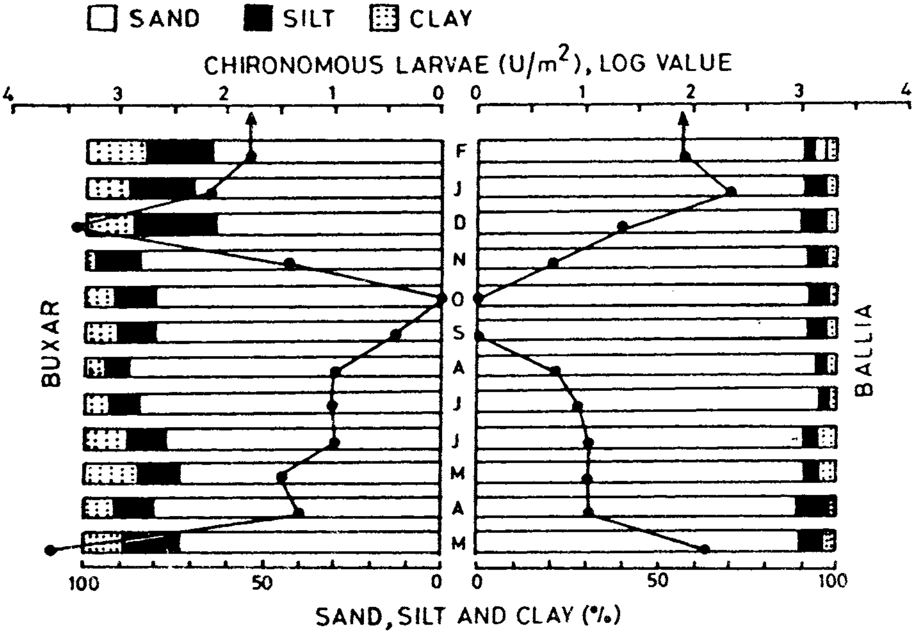

Figure 3 Monthly variation in *Chironomus larvae* population (U/m^2) in relation with sand silt and clay(%) of Centre of Ganga river bed at Buxar and Ballia

Table 2 *Seasonal variation in sand, silt and clay percentage at Buxar and Ballia. (X ± S.D.). Value given in parenthesis is coefficient of variation (C.V. %)*

Seasons	BUXAR			BALLIA		
	Sand %	Silt %	Clay %	Sand %	Silt %	Clay %
Summer	78.10 ± 4.40	12.9 ± 2.90	12.10 ± 3.40	90.1 ± 0.9	5.8 ± 2.7	4.0 ± 1.8
(Mar.-June)	(5.6338)	(22.4806)	(28.0991)	(0.9988)	(46.5517)	(45.000)
Monsoon	81.0 ± 6.0	11.1 ± 4.80	8.2 ± 1.5	93.2 ± 2.2	5.0 ± 2.0	2.3 ± 0.7
(Jul.- Oct.)	(7.4074)	(43.2432)	(18.2927)	(2.3605)	(40.0)	(30.4347)
Winter	73.5 ± 10.4	17.8 ± 5.1	10.4 ± 7.1	90.8 ± 1.2	6.3 ± 0.7	3.1 ± 0.8
(Nov.-Feb.)	(14.1497)	(28.6517)	(68.2692)	(1.3216)	(11.1111)	(25.8065)

Table 3 *Monthly prevalence of* ***Chironomus*** *larvae (Unit/m^2) in Ganga river (between Buxar and Ballia) Value given in parenthesis is percentage of respective months*

	Mar.	April	May	June	July	August	September	Oct.	November	December	January	February	Total
Buxar	5125	28.0	43.0	11	12	10	3.0	-	29	2832	105	65	8263
	(62.02)	(0.339)	(0.5204)	(0.1331)	(0.1453)	(0.1210)	(0.363)		(0.351)	(34.274)	(1.271)	(0.787)	
Ballia	136	12	10	12	9.0	6.0	-	-	6.0	23.0	228	92.0	534
	(25.468)	(2.247)	(1.8726)	(2.247)	(1.6854)	(1.1236)	-	-	(1.1236)	(4.307)	(42.697)	(17.23)	

Table 4 *Regression Equation for Chironomus larvae (Y) with sand (X_1'), silt (X_2') and Clay (X_3') contents. Values given in parenthesis = Sb*

	Equation	R	R2
BUXAR	$Y = 0.1472 - 0.5371^{***} X_1' + 1.2973^{*} X_2' + 1.1623^{**} X_3'$ (0.1782) (0.2712) (0.3053)	0.8652	0.7486
BALLIA	$Y = 0.2384 - 0.5247^{**} X_1' + 2.0122^{*} X_2' + 1.6259^{**} X_3'$ (0.12009) (0.3014) (0.4663)	0.9009	0.8177

* = $p < 0.01$, ** = $p < 0.05$, *** = $p < 0.1$

the relative textural conditions.

While Sehgal (1977) and Oyenken (1988) concluded that the seasonal variation in the population of benthic organisms in lotic eçosystem depends upon the complex interplay of various environmental factors; Naiman et al. (1987), Statzner et al. (1988), Hildrew et al. (1991) and Rundle et al. (1993) considered stream order and flow as important factors for the colonisation of benthic invertebrates. In the present study, at Buxar centre, laminar water current of the river possibly favoured the settlement of *Chironomus* larvae and enhanced its population density in contrast to Ballia where fast river current could create sufficient surge to dislodge them causing scanty population (Jhingaran 1985, Kumar 1987, Singh & Srivastava 1989 and Augustine & Diwan 1991).

Numerical count of *Chironomus* larvae was much influenced by silt and clay contents in favour of its colonisation at both the centres; whereas, sand depleted the population significantly and was unsuitable for the productivity of the larvae. Moreover, regression equations (table 4) for Buxar and Ballia explained the variation exerted by sand, silt and clay, in the population of this dipteran form by 74.86% (R^2 = 0.7486) and 81.17% (R^2 0.8117) respectively.

Further, high numerical count of this benthic form at Buxar may be attributed to the relatively high silt and clay contents at the centre. Jhingaran (1985), Singh and Srivastava (1989) and Augustine and Diwan (1991) have also reported that sluggish water flow and homogeneous silt content are conducive for the productivity of this insect.

Various factors of water quality are collectively responsible for the distribution and density of the *Chironomus* larval population (Armitage et al. 1995). In the present investigation, the population of *Chironomus* larvae was recorded to be high during winter to early months of summer season and exhibited significant positive correlation with

Table 5 *Correlation coefficients for* ***Chironomous*** *larvae population with bottom layer water quality variables for Buxar and Ballia*

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
BUXAR	***	***	*	**	****			****	****
	(–)0.5698	0.6110	0.7156	0.6952	0.5368	(–)0.6558	(–)0.4250	(–)0.5301	(–)0.5273
	(0.3247)	(0.3733)	(0.5121)	(0.4833)	(0.2882)	(0.4301)	(0.1806)	(0.2896)	(0.2780)
BALLIA	****	**	*	*	*	***		***	
	(–)0.5223	0.6903	0.7773	0.7351	07052	(–)0.7464	(–)0.6009	(–)0.4263	(–)0.6139
	(0.2728)	(0.4765)	(0.6042)	(0.5351)	(0.4973)	(0.5571)	(0.3611)	(0.1817)	(0.3769)

X_1 = Water temperature, X_2 = pH, X_3 = Dissolved oxygen, X_4 = Total alkalinity, X_5 = Chlorides, X_6 = COD, X_7 = BOD, X_8 = SO_4^{--} and X_9 = Total solids; Values given in parenthesis = r^2.
* = $p < 0.01$, ** = $p < 0.02$, *** = $p < 0.05$, **** = $p < 0.1$

Table 6 *Correlation coefficient matrix of abiotic variables of bottom layer water quality of Buxar and Ballia centres of Ganga river*

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
					BUXAR				
			**	****		*	*	****	
X_1	1	(–)0.3423	(–)0.7408	(–)0.5282	(–)0.1326	0.8703	0.8857	0.5358	0.5044
			*	*	***	***		*	**
X_2	(–) 0.2294	1	0.8047	0.8978	0.6722	(–)0.6468	(–)0.4961	(–)0.8181	(–)0.7098
	****	*		*	****	*	**	*	**
X_3	(–) 0.5912	0.8353	1	0.8754	0.5904	(–)0.8972	(–)7935	(–)0.8769	(–)0.7933
	****	**	*		***	**	****	*	*
X_4	(–) 0.5993	0.7637	0.2998	1	0.6939	(–)0.7557	(–)0.6314	(–)0.8689	(–)0.8462
			****	**				**	**
X_5	(–) 0.1294	0.5003	0.6386	0.7766	1	(–)0.4721	(–)0.2709	(–)0.7168	(–).7407
	****	*	*	**			*	*	**
X_6	0.5341	(–)0.8073	(–)0.8894	(–)0.7674	(–)0.5166	1	0.9214	0.8109	0.7065
	****	**	*	**		*		**	***
X_7	0.5841	(–)0.7519	(–)0.8479	(–)0.7041	(–)0.3849	•0.9656	1	0.7736	0.6574
		****	*	*	**	**	***		****
X_8	0.4476	(–)0.6129	(–)0.8154	(–)0.8819	(–)0.7802	0.7475	0.6581	1	0.5812
		****	*	*	**	**	**		
X_9	0.5099	(–)0.5984	(–)0.8275	(–)0.8593	(–)0.7741	0.7666	0.7506	0.5276	1
					BALLIA				

X_1 = Water temperature, X_2 = pH, X_3 = Dissolved oxygen, X_4 = Total alkalinity,

X_5 = Chloride, X_6 = COD, X_7 = BOD, X_8 = SO_4^-, X_9 = Total solids.

* = $p < 0.001$, ** = $p < 0.01$, *** = $p < 0.02$, **** = $p < 0.05$

*p*H, dissolved oxygen, total alkalinity and chlorides of the bottom layer water of the river at both the stations (table 5). This is in partial accordance with Bhowmic (1968) and Sinha et al. (1993) who inferred the peak values of *Chironomus* larvae from January-March; and many other investigators (Needham & Usinger 1956 and Kumar 1987), who concluded total alkalinity as being prime factor for the numerical abundance of benthic organisms.

Rao et al. (1985 and 1987), Verma and Dalela (1975) and Augustine and Diwan (1991) reported indicator value of *Chironomus* larvae and adaptability to organic pollution, but in the present study, however, COD, BOD, total solids and temperature of bottom layer water exhibited significant negative relationship with *Chironomus* larval population (table 5, figure 3). This was occurred possibly because of very fast water current during the period of high values of pollution indicating variables; and the aggressive flow of the river coupled with sandy soil caused exaggerated depletion of the population at both the centres. Further, the larval population represented during these period was whatever left behind rolling away by the aggressive water current of the river.

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