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The Use of Head Capsule Deformities in Chironomid Larvae (Diptera: Chironomidae) To Assess Environmental Pollution In Rice Fields Of Hooghly District, West Bengal, India

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ABSTRACT

The incidence of deformities in the head capsule of Chironomid larvae are considered as indicators of environmental pollution such as heavy metals, pesticides, but as well by organic contaminants. Deformities of *Chironomus sp.* (Diptera: Chironomidae) larvae have been proposed as a bioindicator of sediment quality and environmental stress. Larvae of *Chironomus* sp. were collected from rice fields located at Rishra, Serampore and Khanakul (District-Hooghly, West Bengal, India). Significant differences were observed in deformities between three sites. The agronomic practices revealed an overuse of pesticides in the rice field for better productivity. Samples obtained from Rishra exhibited high incidence of deformity compared with Serampore and Khanakul. Rishra was polluted area and various types of industrial effluents discharge into the rice field periodically. Beside industrial effluents the farmer uses large amount of pesticide in the rice field. Laboratory experiments demonstrated a correlation between field concentration of pesticide and occurrence of deformed larvae. The occurrence of higher frequencies of deformities in Rishra indicated that the frequency of deformities was apparent with increase of environmental pollutants.

Key words: *Chironomus* sp., Deformity, Pollution, Rice field.

1.0 INTRODUCTION

Rice fields are a unique man-made environment supporting a rather wide diversity of aquatic organisms which is closely related to environmental changes of rice agro-ecosystems [1]. Species of chironomidae have been recorded in rice fields throughout the world including India, Australia, and the USA [2]. Routine agricultural practices, such as ploughing, draining, fertilizing, and pesticide applications and wet and dry climate cycles influence diversity of inhabiting aquatic communities. Generally, rice fields undergo a wide variation of water parameters, such as temperature, pH, dissolved oxygen, conductivity, nitrate, and phosphate concentrations. Rice agroecosystems are very dynamic and are of particular environmental concern because they exhibit a high capacity to accumulate and deliver pollutants. The application of pesticides in rice fields may alter aquatic orgamismal community structure, trophic cascade and also contaminate adjacent water bodies ultimately affecting the aquatic environments [3].

The chironomid larvae are considered as model organisms for bioassays because they spend most of their developmental occasion in sediments surface where they remain exposed to different toxicants; also, they are somewhat easy to culture and have a short life cycle. These criteria create them appropriate organisms for ecotoxicological monitoring [4, 5, 6].

Morphological deformities in chironomid larvae represent more traditional and useful criteria for biological assessment of water quality. The relationship between morphological deformities and occurrence of heavy metals and pesticides within their habitat sediments was highly significant [7]. The high incidence of deformity in mouthparts of chironomid larvae occurring in the River Damodar flowing through the industrial region of West Bengal have been recorded [8]. Such deformities could provide a useful tool for assessing aquatic pollution, specifically relating to industrial wastes and agricultural runoff [9, 4, 10, 11, 5, 12, 13, 14, 6]. The application of chironomid deformities as bioindicators of pollution stress has been reviewed and revealed primarily for bioassessment purposes [12]. High levels of deformity (42.4%) were recorded from the Hrazdan River in central Armenia [15]. The larvae when exposed to stress or pollution they exhibit mouthparts deformities, especially in the mentum. These hypotheses based on field observation and are reflection of the environmental pollution due to heavy metal, pesticides and other xenobiotics [16, 5, 17]. The metals induce morphological deformities in *Chironomus* spp. and also observed that concentration of metals, particularly Ni and Mn, were highly correlated with larval deformities [6]. The incidence of head capsule deformities in *Chironomus* spp. larvae were observed in this study. The number and severity of chironomid larval head capsule deformities have been shown to be correlated with high levels of Zn and Cu in the sediments [4, 10, 13]. The objective of the present study was to investigate the use of chironomid mouthparts deformities to assess environment pollution in rice fields of Hooghly District.

2.0 MATERIALS AND METHODS

The study was conducted at three locations in Hooghly District, West Bengal, India (Fig. 1): (A) Khanakul is mainly an agricultural area. (B) Serampore is a pre-colonial town on the right bank of the River Hooghly while (C) Rishra is an industrial town having polluted area with various types of periodically discharged industrial effluents into surrounding rice fields in addition to usage of large amount of pesticides in the rice fields.

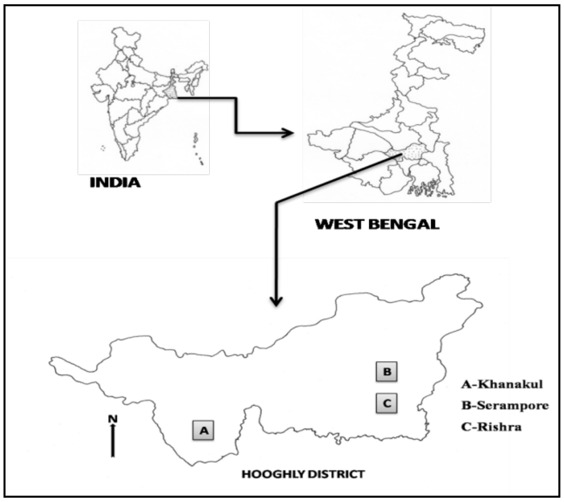

Fig.1. Map showing location of the three field sampling sites.

The samples were randomly collected from the three predetermined sites from July 2009 to September 2012. Adult chironomids were collected by sweep net around the sampling sites. Larvae were collected from mud bottom (10 cm) in the rice fields with mud scrapers and a scoop sampler [18, 13]. Each sample was transferred to a plastic bucket and then washed with water and passed through a sieve (300-µm pore). On each sampling occasion, field-collected immature chironomids were brought to the laboratory for sorting in containers filled with aerated water [19].

The physico-chemical parameters were measured at each sampling site in the rice fields on monthly basis during 2009 and 2012 [20, 18]. Water and soil parameters were analyzed by Geological Survey of India (GSI), Saltlake, Kolkata.

Chironomid larvae, pupae, pupal exuviae and adults were preserved and stored in 70–90% ethyl alcohol. The phenol–balsam technique [21] was mainly adopted in preparation of microslides of material for study. In case of larvae, the head capsule removed from the body was treated with a warm 10% KOH solution, washed in distilled water and transferred into 70% alcohol and then to alcoholic phenol. The head capsules were placed ventrodorsally on the slide, whereas the body was oriented horizontally with its dorsal side up.

The immature midge stages and adult chironomids were identified [22] and deformities of chironomid larvae were evaluated [4, 10].

3.0 RESULTS AND DISCUSSION

Data concerning measured physico-chemical parameters in the field during July, 2009 – September, 2012, are presented in Table1. These parameters varied between the three field sampling sites. For example, the mean water temperature was 1 - 2°C higher at Rishra compared to the Khanakul and Serampore sites. The mean value of water pH at the three sites ranged from 6.9 -7.7 pH units. The BOD was higher at Rishra compared to the other two sites. The water temperature and pH were higher in highly contaminated site compared to relatively less contaminated site [3]. All the parameters are comparatively higher in Rishra sampling site. This indicates that Rishra site was more polluted than the other two sites.

Table. 1. Physico-chemical characteristics (mean ± SD) at three sampling field sites during 2009-2012.

PARAMETERS	KHANAKUL			SERAMPORE			RISHRA		
	Jul	Aug	Sept	Jul	Aug	Sept	Jul	Aug	Sept
Water Parameters									
Temp.(°C)	24.7±0.82	24.5±0.71	23.6±0.84	26.5±1.08	25.9±0.88	25.1±0.99	26.3±0.95	25.3±0.82	24.9±0.74
pH	6.9±0.16	7.3± 0.24	7.5± 0.12	7.4± 0.36	7.3± 0.25	7.5± 0.13	6.9± 0.30	7.5± 0.42	7.7± 0.33
DO (mg/l)	7.7± 0.33	7.9± 0.13	8.1± 0.21	7.3± 0.24	7.5± 0.13	7.4± 0.36	6.6± 0.37	7.6± 0.33	7.4± 0.18

BOD (mg/l)	4.5± 0.33	4.0± 0.18	4.0± 0.20	5.8± 0.32	4.0± 0.23	3.9± 0.23	5.0± 0.19	4.0± 0.20	4.4± 0.32
SO_4^{-2} (ppm)	0.93±0.25	1.06±0.41	1.05±0.36	7.12±1.02	7.76±0.86	7.43±0.43	17.91±3.13	18.47±2.90	18.03±2.62
NO_3^- (ppm)	0.16±0.05	0.10±0.08	0.11±0.08	0.30±0.05	0.29±0.05	0.28±0.06	0.38±0.07	0.34±0.06	0.35±0.09
Mg^{++} (ppm)	14.60±1.42	14.55±1.32	14.45±1.71	16.80±1.76	16.63±1.88	16.30±2.45	11.18±2.89	11.43±3.07	11.20±3.71
Na^+ (ppm)	1.76±0.53	1.77±0.55	1.92±0.70	6.41±0.93	6.32±0.80	6.55±0.63	21.11±0.75	21.19±0.72	21.16±0.73
K^+ (ppm)	0.56±0.39	0.62±0.42	0.70±0.66	3.82±0.87	3.80±0.81	3.62±1.20	10.82±1.88	10.84±2.26	10.52±2.04
Po_4^{-3} (ppm)	0.08±0.07	0.11±0.08	0.09±0.09	0.27±0.05	0.30±0.07	0.25±0.12	0.80±0.13	0.92±0.21	0.95±0.27
Sio_2 (ppm)	1.57±0.58	1.63±0.55	1.32±0.47	2.22±0.97	2.36±0.84	2.13±1.06	12.32±1.56	12.56±1.50	12.26±1.71
TDS (ppm)	83.25±14.22	82.75±12.66	85.25±12.39	278.00±18.74	280.25±18.08	282.00±15.21	689.00±18.01	692.00±7.44	694.00±10.23
Soil Parameters									
Cu (ppm)	33.00±3.37	32.50±4.80	33.50±3.51	38.00±4.32	38.25±3.86	38.50±1.00	64.00±4.55	63.00±8.29	63.75±1.50
Zn (ppm)	76.25±4.19	76.75±2.99	78.50±3.32	85.75±3.09	84.75±3.10	85.75±3.40	217.50±4.12	217.25±2.50	217.75±3.40
Pb (ppm)	29.50±2.08	29.00±2.16	29.00±1.41	40.25±1.70	40.00±2.70	38.50±3.00	79.00±2.58	79.50±2.38	78.50±2.08

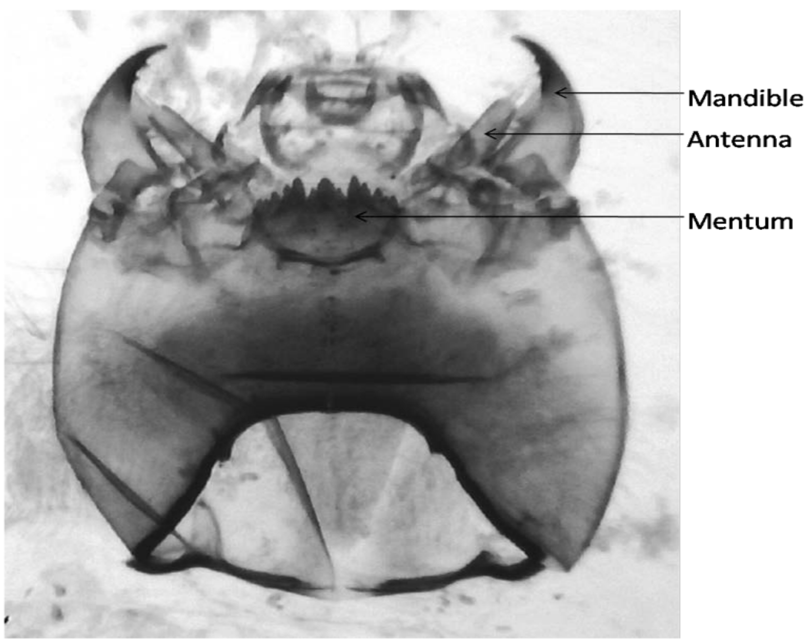

Fig.2. Head capsule of Chironomid larvae showing mouthparts.

Head capsules of chironomid larvae consists of mentum, mandible and antenna (Fig. 2). In normal cases antenna 5-segmented (Fig. 3), basal segment with a ring organ at its ½; blade not longer than flagellum; accessory blade about 0.5 as long as 2^{nd} flagellomere; lauterborn organ present. Mandible with 1 apical and 3 inner teeth, dorsal tooth pale, seta subdentalis simple with a few subapical toothlets and a row of radial arranged basal grooves, seta interna with 3–4 main plumose branches, 2–3 seta interna, pecten mandibularis usually developed. Mentum with a trifid median tooth, 2 smaller, outer toothlets may be almost fused with central part or quite separate and 6 pairs of lateral teeth, first 2 mostly very closely approximated, fourth sometimes smaller than two neighouring ones Deformities in the head capsules (mentum, mandibles, and antennae) of larval *Chironomus* spp. have been described by several workers[4, 10, 11, 6, 17, 8, 16, 23]. The morphological deformity of various chironomid genera occur when they are exposed to contaminants [7, 9]. Chironomids are present in a wide variety of aquatic habitats and environmental conditions [24] and thus they have been used as bio-monitoring agents of aquatic pollution.

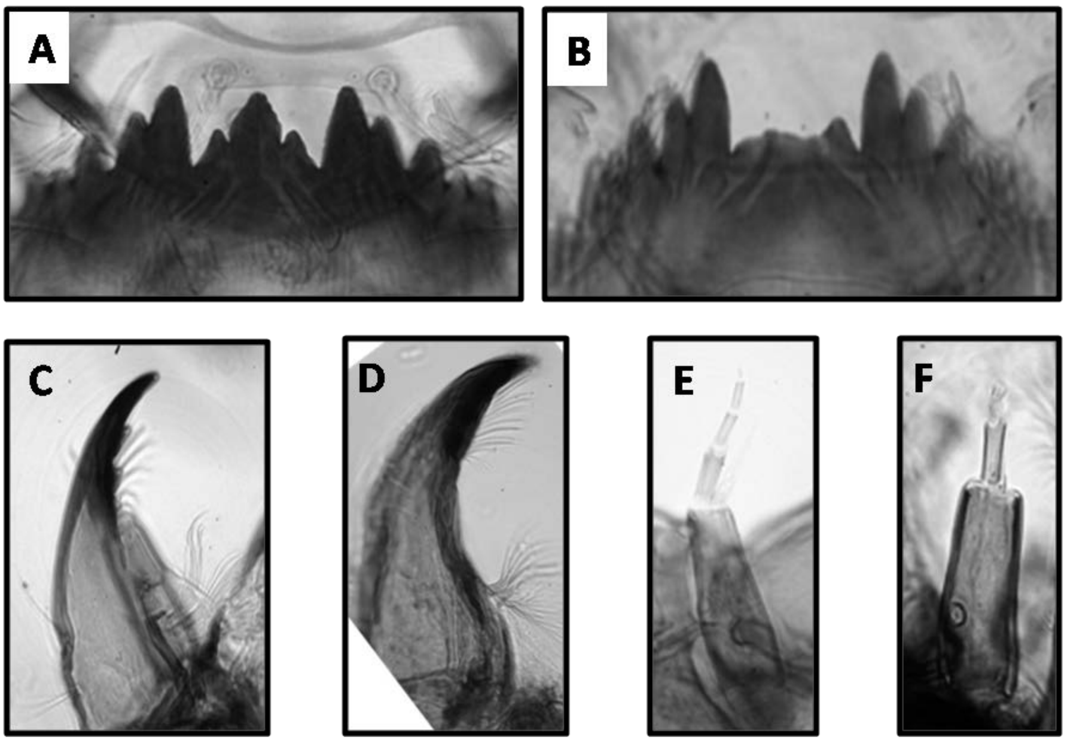

Fig.3. A-normal mentum, B-deformed mentum, C-normal mandible, D-deformed mandible, E-normal antenna, F-deformed antenna.

Mentum deformity was the most frequent than the other deformity of which median teeth deformities were the most frequent compare to mediolateral and lateral teeth [6]. Deformities in mentum range from the loss of inner lateral or median teeth to massive disorganization and loss of symmetry [4]. In the present study 3680 *Chironomus* sp. larvae were collected out of which 26.6% were deformed larvae; among deformed larvae mentum deformity 49.8%, mandible deformity 19.6% and antennal deformity 30.6% existed. The results of the present study also revealed that (Fig. 4) out of total deformities at all sites, the highest occurred at the Rishra rice field (55.1%) followed by Serampore site (26.5%), and then the Khanakul site (18.4%). Previously it was also reported up to 17% deformities among chironomid larvae in polluted environments [9]. This indicates that larvae of *Chironomus* sp. normally respond to pollution. In this study, the incidence of deformity was highest in the larvae collected from Rishra, the most polluted site also influenced by effluents discharged from the surrounding industrial outfits.

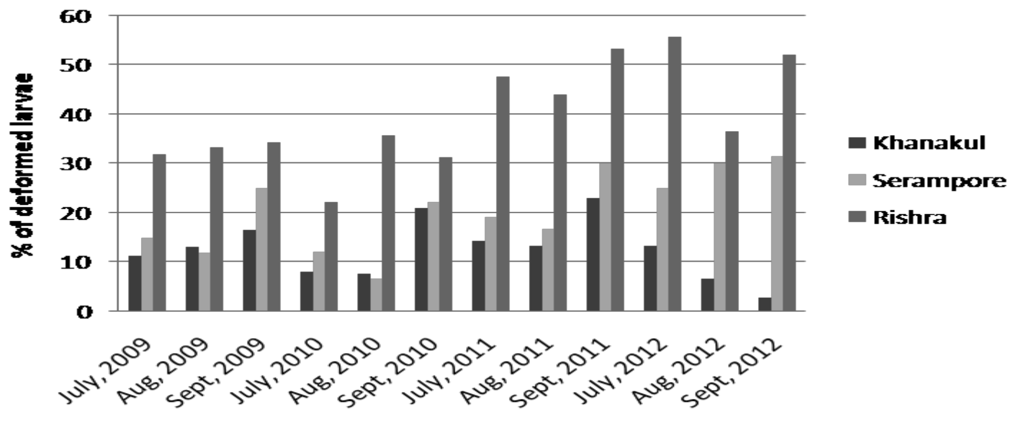

Fig.4. Percentage of deformity incidence in *Chironomus* sp. larvae (July 2009 to September 2012) from three sampling sites.

4.0 CONCLUSION

The basic interest of pollution in the society is envisaged on its effect on living beings, hence assessment of pollution with the help of biological organisms poses problem. This study revealed the impact of pesticides and industrial contaminants in terms of deformities of various structures of head capsule of *Chironomus* spp. larvae inhabiting the rice fields of Hooghly, West Bengal. The incidence of deformities in larval mentum in the rice field of industrial region was relatively higher compared to non-industrialized agricultural areas. Such deformities could also serve as an early warning useful tool in assessment of pollutants prevalent in rice field environments that receive anthropogenic, agricultural, and industrial discharges. Therefore, more attention should be made to sediment characteristics in agricultural fields with special emphasis on industrial region. Greater concern also should be shown for natural abnormalities when chironomid mouthpart deformities are used as an index of environmental degradation.

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