INFLUENCE OF PHYSICO-CHEMICAL VARIABLES ON ABUNDANCE OF CHIRONOMIDAE (DIPTERA) IN TROPICAL RICE AGROECOSYSTEM

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ABSTRACT

Influence of selected physico-chemical factors such as water level, rice plant height, temperature, pH, conductivity, dissolved oxygen, total organic matter, total suspended solids, phosphate and nitrate-nitrogen on larval population of Chironomidae (Diptera) were studied in a rice field. These variables showed a wide range of variation over two seasons of rice cultivation studied. Water level, rice plant height, conductivity, phosphate and nitrate–nitrogen contents of the water weakly influenced the abundance of chironomid larvae in this rice field at P=0.05. However, other variables did not affect the larval population.

KEYWORDS: Chironomidae, rice agroecosystem, physico-chemical variables, abundance

1. INTRODUCTION

In South East Asia rice fields cover over 70 million hectare [1]. The rice fields have been recognized as an important source for producing cheap protein, such as fish and crab [2] and form an important component in the economic life of the rural people [3]. Generally, rice fields show a wide range of water parameters such as temperature, pH, dissolved oxygen, conductivity, nitrate and phosphate [1]. The rice field is a unique man-made environment with high diversity of aquatic organisms. The abundance of insect community in rice field follows the changes of physical and chemical parameters in this ecosystem [4]. Chironomidae (Diptera) is one of the most dominant insect families in the rice fields [5]. It is a species rich family with circa 15000 species have been recorded world wide [6]. Chironomid larvae have been recorded in rice fields throughout the world [7]. Similar to other aquatic organisms in rice agroecosystem, chironomids are subjected to changes in physico-chemical conditions such as temperature, dissolved oxygen, pH, conductivity, water levels and inputs of nutrients [1].

2. MATERIALS AND METHODS

2.1 Description of Study Area

This study was conducted at the Bukit Merah Rice Research Station, in Permatang Pauh, Seberang Perai, Pulau Pinang. The station is located in Bukit Merah, about 20 km from Butterworth. The rice cultivation activities at this station is under the supervision of Malaysian Agricultural Research and Development Institute of Bumbung Lima, Seberang Perai.

2.2 Measurement of Environmental Variables

The water layer closer to the sediment was easily measured *in situ* for their pH, electrical conductivity (EC), temperature and dissolved oxygen (DO). Water samples were collected from the field and kept in a cool Coleman® chest during transportation to the laboratory. In the laboratory, the samples were Solids (TSS), Nitrate, and Phosphate. The total organic matter

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2.3 Sampling of Chironomid Larvae

Larval sampling was carried out fortnightly during two rice growing seasons from July 2004 to July 2005. Chironomid larvae were sampled using a long handle aquatic net with a 15 X 15 cm frame and 30 cm long net.

3. RESULTS AND DISCUSSION

Five species belonging to two subfamilies of Chironomidae were identified. *Chironomus kiiensis*, *Polypedilum trigonus* and *Tanytarsus formosanus* (subfamily Chironominae), *Clinotanypus* sp and *Tanypus*
punctipennis (subfamily Tanypodinae).

Generally, selected physico-chemical variables of the rice field showed a wide range of variation (Table 1). Except for the total organic matter and total suspended solids, all variables were significantly different at all sampling occasions (Kruskal-Wallis $P \leq 0.05$). The pH however, showed s maller ranges with a mean of 6.27 rendering the field a slightly acidic environment.

The effect of environmental variables on the abundance of Chironomidae was analysed using the nonparametric Kendall's tau-b correlation. Water level, rice plant height, ion conductivity, phosphate and nitrate-nitrogen contents of the water weakly influenced the abundance of the larvae in this rice field at P=0.05 (Table 2). Other variables did not affect the larval population. The water level and plant height were the main factors determining the presence and abundance of larvae respectively in the rice field (Figure 1)

Table 1 Mean and ranges of water parameters, rice plant height and total organic matter in the sediment of rice field plots at Bukit Merah Agricultural Experimental Station, Seberang Perai measured biweekly from July 2004 to July 2005. SE = Standard Error.

Parameter	Mean ± SE	Range
Water Level (*cm*)	12.47 ± 1.372	1.5 – 35
Plant Height (*cm*)	49.98 ± 5.933	0 – 130
pH	6.274 ± 0.07	5.15 – 7.7
Conductivity (μScm^{-1})	90.13 ± 7.639	15 – 250
Dissolved Oxygen ($mg\ l^{-1}$)	2.71± 0.257	1.06 – 6.87
Temperature ($^{\circ}C$)	29.23 ± 0.316	23 – 34
Total Organic Matter (%)	5.64 ± 0.184	3.03 – 8.77
Total Suspended Solids ($gm\ l^{-1}$)	0.0048 ± 0.00033	0.0005 – 0.011
Phosphate ($mg\ l^{-1}$)	0.45 ± 0.058	0.02 – 1.83
Nitrate-Nitrogen ($mg\ l^{-1}$)	0.63 ± 0 .095	0.044 – 2.713

Table 2 Values of correlation coefficient (r) between selected environmental variables and density of chironomids larvae sampled from the rice field plots at Bukit Merah Agricultural Experimental Station, Seberang Perai (July 2004 to July 2005).

Variable	Unit	*r*	Significance
Water Level	cm	-0.197	**
Plant Height	cm	-0.157	**
pH		-0.005	NS
Conductivity	μScm^{-1}	0.108	**
Dissolved Oxygen	$mg\ l^{-1}$	0.034	NS
Temperature	$^{\circ}C$	0.016	NS
Total Organic Matter	%	0.061	NS
Total Suspended Solids	$gm\ L^{-1}$	-0.024	NS
Phosphate	$mg\ L^{-1}$	0.066	*
Nitrate-Nitrogen	$mg\ L^{-1}$	0.071	*

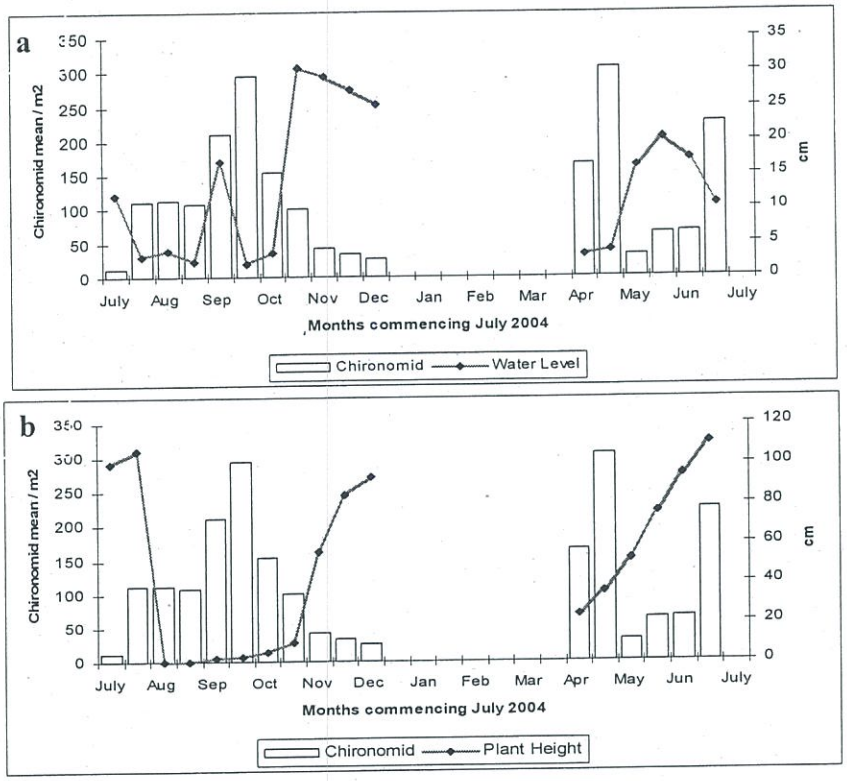

Figure 1 Abundance of chironomid larvae in relation to **a**: Water Level and **b**: Height of Rice Plant, in the rice field plots at Bukit Merah Agricultural Experimental Station, Seberang Perai.

The mean temperature was 29.23 °C and it ranged between 23 and 34 °C. [2] reported that the water temperature in the tropics varies from as low as 24 ° C in the morning or during cloudy or rainy days to 40 °C on hot sunny days. The temperature of rice field water is affected directly by the height of the rice plants. However, the mean of dissolved oxygen increases in the rice field due to photosynthesis by algal populations. In the present study, the dissolved oxygen was quite low with mean 2.71 mgL^{-1}.

Generally, the pH values in paddy fields differ according to the rice phase during cultivation period [8]. In this study, the mean of the pH showed that the rice field was slightly acidic and it was similar to what have been reported in other Malaysian rice fields [3], [2] and [4]. The pH is influenced by the metabolic activity of the flora particularly photosynthesis, also the lower levels of pH were probably due to the presence of substantial amounts of organic matter, with associated CO_2 production and nitrogen mineralization [9]. However, the value of reported conductivity was lower compared to those reported in a Malaysian rice field in the study of [3] but it was higher compared to those in the study of [4]. These differences of conductivity values referred to the inflow of water, nutrients cycling within the rice fields and fertilization [1]. The concentration of nitrate-nitrogen in this field was high with a mean 0.63 mg L^{-1}. [2] reported a lower content of nitrate in the rice field studied (0.27 mg l^{-1}). Generally the difference referred to the amount and frequency of fertilizations [9], agricultural activities and activity of the nitrification bacteria [10].

Although the rice field was routinely fertilized, the mean value of total suspended solids in this rice field was lower than that of the Kelang River in the study of [10]. However, fertilization as well as decomposition of macrophytes could have contributed to the high value of total organic matter of this rice field.

Water was the most important factor determining the existence of chironomid larvae in the rice field. The density of the larvae in this rice field was very much influenced by the availability of water [5]. In this study, the amount of water in the field (water level) was found to be negatively correlated with the larval population density. At higher water level, the amount of organic matters, cations and nutrient is much diluted making them less available to the larvae [11]. In contrast, dissolved oxygen is not important for the chironomid larvae because of the presence of hemoglobin pigments in their bodies. Some species of Chironomidae show high level of tolerance to oxygen depletion and are capable of maintaining metabolic activity in anoxia [12] and [6].

Besides dissolved oxygen, Chironomidae is also tolerant to living in acidic environment. [13] reported that chironomids have a good ability to survive and reproduce in polluted water with critical levels of low pH. The pH of the water in this rice field ranged between 5.15 and 7.7, well within tolerance range for this insect.

4. CONCLUSION

The environmental variables showed a wide range of variation following the cultivation activities such as ploughing, draining, fertilizing and pesticides application. The fluctuation of chrionomid larval population in this rice field was related to the changes in levels of physico-chemical variables in the field. The Chironomidae is very common in many rice fields in Malaysia [14] and [15]. Its role and function in the ecology of rice fields are still not fully understood and need further investigation. This study contributes information on the distribution and factors influencing chironomid population in the rice field.

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