

DISTRIBUTION AND ABUNDANCE OF LARVAL CHIRONOMIDAE (DIPTERA) IN A RICE AGROECOSYSTEM IN PENANG, MALAYSIA

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With 1 Figure and 3 Tables

ABSTRACT: The distribution and abundance of chironomid larvae were investigated in Bukit Merah Agricultural Experimental Research Station, Penang, Malaysia. The mean density of chironomid larvae during the period of the study was 120.95 larvae m⁻². *Chironomus kiinesis* was the most abundant species while four other species - *Polypedilum trigonus*, *Tanytarsus formosanus*, *Tanytus punctipennis* and *Clinotanypus* sp. - were found in low numbers although they occurred during all rice wet phases. Generally, water level, rice plant height, conductivity and nitrate-nitrogen significantly ($P < 0.01$) though weakly influenced the larval abundance in this rice field. Other measured variables did not significantly affect larval populations.

RESUMO: A distribuição e abundância das larvas de quironomídeos foi analisada na Estação de Investigação Agrícola de Bukit Merah, Penang na Malásia. A densidade populacional média larvar foi de 120.95 larvas m⁻² tendo-se registado uma variação significativa entre épocas e locais de amostragem. A densidade máxima foi 294.39 m⁻² para a primeira época e de 306.37 m⁻² para a segunda. Amostragens bissemanais realizadas em campos de arroz em duas épocas distintas do crescimento vegetativo (2004/2005) revelaram a *Chironomus kiinesis* como a espécie mais abundante enquanto que as espécies *Polypedilum trigonus*, *Tanytarsus formosanus*, *Tanytus punctipennis* e *Clinotanypus* apresentaram um reduzido número de indivíduos embora estivessem presentes ao longo de toda a fase húmida da cultura do arroz.

Keywords: chironomids, physico-chemical parameters, rice agroecosystem.

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INTRODUCTION

Chironomidae inhabit rice fields throughout the world (STEVENS, 1995, STEVENS *et al.*, 2000). Members of *Chironomus*, *Cricotopus*, *Paralauterborniella* and *Tanytarsus* are particularly common in such systems (BERG, 1995). In Malaysia, rice is the third most important agricultural crop, covering almost 209,300 ha, primarily on peninsular Malaysia (KARIM *et al.*, 2004). These systems support a diverse insect fauna, an important food source for fish (ALI & AHMAD, 1988; CHE SALMAH & ABU HASSAN, 2002). Aquatic insect populations in rice fields closely follow changes in rice plant growth and season, in particular water availability (CHE SALMAH *et al.* 2000).

Chironomid populations in rice agroecosystems are subject to changes in physico-chemical conditions and input of nutrients (LIM, 1990). Chironomid abundance patterns are also influenced by the available larval food, particularly the deposition of organic matter and detritus on the bottom (GALDEAN *et al.*, 2000). Enrichment from addition of fertilizers can also indirectly affect chironomid productivity (ALI, 1989).

In Malaysia, very little is known on the ecology of rice field chironomid populations despite their abundance and the influence of agricultural practices and chemical applications. This study investigates the influences of chemical and physical environmental changes on the spatial and temporal distributions of larval chironomids in an experimental rice agroecosystem.

MATERIALS AND METHODS

The Bukit Merah Agricultural Experimental Research Station (BMAES; 5.417° N., 100.417° E) in Permatang Pauh, Seberang Perai, Pulau Pinang, Malaysia, is managed by the Agriculture Centre of Bukit Merah, Seberang Perai, under the supervision of Malaysian Agricultural Research and Development Institute. Two easily accessible plots measuring 1.52 ha each were selected for the study.

Quantitative collections of chironomid larvae were made fortnightly over two inundated rice growing seasons (July 2004 and July 2005; including a drought period after the first crop cycle) by dragging a randomly placed handnet (300 µm mesh, 15 x 15 cm metal frame) over approximately one metre of the bottom sediments between rice hills. In the laboratory, samples were sieved (300 µm mesh) and retained midge larvae sorted and preserved in 80% ethanol for identification and counting. Permanent slide mounts were prepared for identification to genus or species using appropriate keys (KIKUCHI *et al.* 1985; HASEGAWA & SASA 1987; MORSE *et al.*, 1994; MERRITT & CUMMINS, 1996; EPLER 2001; CRANSTON, 2004).

Conductivity, pH, daytime water temperature, dissolved oxygen (DO), total suspended solids and phosphate and nitrate concentrations were measured with electronic probes *in situ* at the mud-water interface at three randomly selected sampling sites. Water

depth and rice plant height were measured at each site and water samples were collected for laboratorial determination of total organic matter content (TOM) of the substratum, total suspended solids (TSS), nitrate and phosphate of the water (YSI 9100 photometer test kit).

RESULTS

Larvae belonging to the subfamilies Chironominae and Tanypodinae were collected on all sampling occasions. *Chironomus kiiensis* Tokunaga, *Polypedilum trigonus* Townes, and *Tanytarsus formosanus* Kieffer were identified from the former subfamily and *Clinotanypus* sp. and *Tanypus punctipennis* Meigen from the latter (Table 1).

TABLE 1. Composition of chironomid taxa collected from an experimental rice field at BMAES.

Taxa	Season 1			Season 2		
	Mean	Range	%	Mean	Range	%
<i>Chironomus kiiensis</i>	43.91	2.57 - 121.28	40.8	85.17	9.78 - 148.99	59.3
<i>Polypedilum trigonus</i>	3.23	0 - 17.33	3.0	10.45	1.11 - 50.02	7.3
<i>Tanytarsus formosanus</i>	27.98	0 - 143.74	26.0	25.64	2 - 118.72	17.9
<i>Clinotanypus</i> sp	15.00	0.26 - 82.37	13.9	6.93	0.22 - 82.37	4.8
<i>Tanypus punctipennis</i>	17.49	0 - 117.81	16.3	15.34	2.89 - 36.24	10.7
Total	107.61	11.81 - 294.4	100.0	143.53	31.79 - 306.4	100.0

TABLE 2. Mean values and range of selected parameters measured in the experimental rice field at BMAES.

Parameter	Mean \pm SE	Range
Water Level (cm)	13.99 \pm 0.486	1.5 – 35
Plant Height (cm)	51.69 \pm 1.893	0 – 130
pH (unit)	6.271 \pm 0.021	5.15 – 7.7
Conductivity (μ Scm ⁻¹)	84.06 \pm 2.283	15 – 250
Dissolved Oxygen (mgL ⁻¹)	2.87 \pm 0.073	1.06 – 6.87
Temperature (°C)	29.21 \pm 0.010	23 – 34
Total Organic Matter (%)	5.68 \pm 0.062	3.03 – 8.77
Total Suspended Solids (mg L ⁻¹)	0.0048 \pm 0.00011	0.0005 – 0.011
Phosphate (mg L ⁻¹)	0.43 \pm 0.020	0.02 – 1.83
Nitrate-Nitrogen (mg L ⁻¹)	0.57 \pm 0.030	0.044 – 2.713

Measured parameters were highly variable (Table 2). *Chironomus kiiensis*, *P. trigonus*, and *T. formosanus* (Table 3) were all strongly positively or negatively correlated with water depth. *Tanytus punctipennis* and *T. formosanus* were negatively correlated with plant height but positively correlated with water pH. *Chironomus kiiensis*, *P. trigonus* and *Clinotanytus* sp. showed strong but different associations with conductivity. All species showed either a significant positive or negative association with dissolved oxygen levels. *Tanytarsus formosanus* was positively correlated with water temperature, but *Clinotanytus* sp. negatively correlated. Total suspended solids did not influence larval abundance. Larval densities of *C. kiiensis* and *P. trigonus* were positively correlated with Phosphate-P concentration but *Clinotanytus* sp. exhibited an inverse relationship with this parameter. Concentration of nitrate negatively impacted *Clinotanytus* sp. larvae, whereas *T. formosanus*, showed a strong positive correlation ($P < 0.01$) (Table 3).

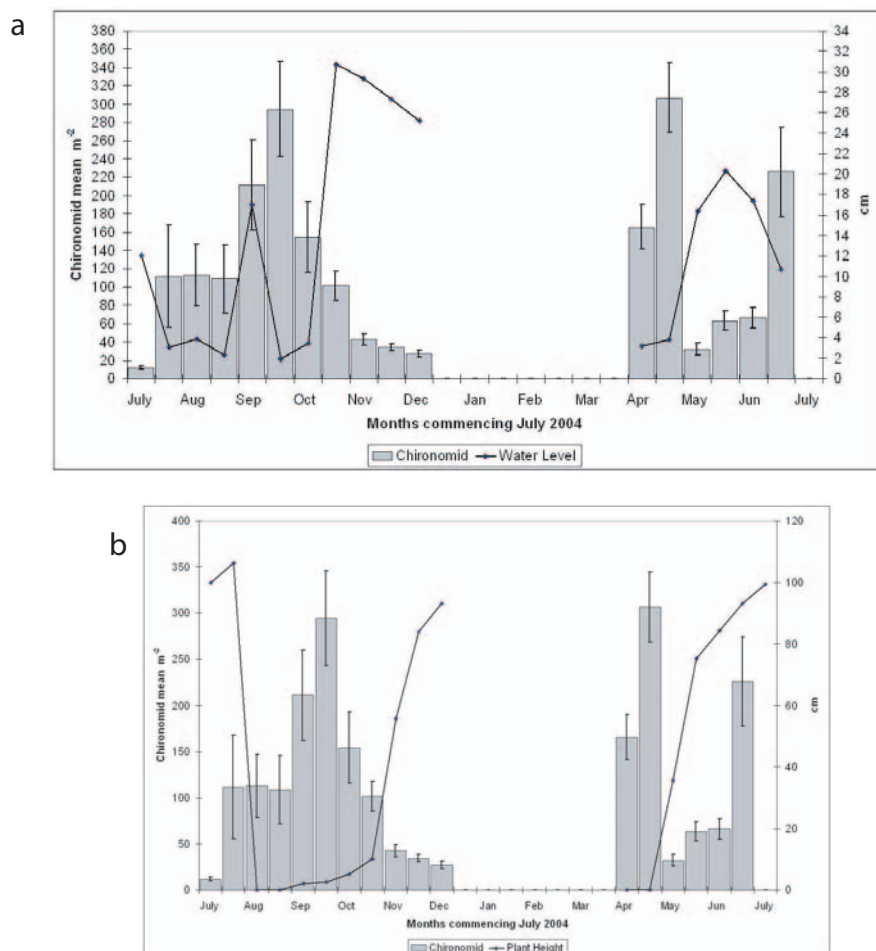


Fig. 1. Chironomid larval abundance in relation to a: Water Level, b: Height of Rice Plant in the rice field plots at BMAES.

TABLE 3. Non-parametric correlation analysis (Kendall's tau-b) between environmental variables and species densities of chironomid in the rice field plots (significant correlations only).

	Water Level	Plant Height	pH	Conductivity	Dissolved Oxygen	Temperature	Total Organic Matter	Total Suspended Solids	Phosphate	Nitrate-Nitrogen
<i>Chironomus kiiensis</i>	-0.223**	-0.020	-0.021	0.162**	-0.145**	0.039	-0.056	0.022	0.139**	0.044
<i>Polypedilum trigonus</i>	-0.145**	-0.01	-0.072	0.173**	-0.140**	-0.013	-0.053	-0.021	0.087*	-0.022
<i>Tanytarsus formosanus</i>	-0.139**	-0.212**	0.112**	-0.022	0.209**	0.112**	0.104**	-0.005	0.020	0.124**
<i>Clinotanypus</i> sp.	0.185**	-0.045	0.012	-0.157**	0.091*	-0.169**	0.096**	0.024	-0.137**	-0.135**
<i>Tanypus punctipennis</i>	-0.014	-0.087*	0.129**	0.015	0.205**	0.065	0.086*	-0.056	0.007	0.043

*significant at 0.05 ; ** significant at 0.01

DISCUSSION

Chironomidae are common insects during the wet phase of the rice growing season. Abundance levels were low compared to other rice field studies (STEVENS, 1995; CHE SALMAH, 1996; STEVENS *et al.*, 2000; STEVENS *et al.*, 2006). Two to three generations of Chironomidae occurred, as expected in tropics where insects tend to be multivoltine (CHE SALMAH *et al.*, 1999). Chironomid abundance peaked when rice plants were young and small (Fig. 1b), since shading by larger plants slows weed decomposition (BAMBARADENIYA & AMERASINGHE, 2003) or reduces the amount of detritus available (CHE SALMAH & ABU HASSAN, 2002). Similar to CHE SALMAH & ABU HASSAN (2002), lowest chironomid density occurred in tiller and pre-harvest phase.

Irrigation patterns affect fluctuations in water depth, water chemistry and soil fertility. This in turn affects rice plant growth, physicochemical properties of water and the rice-field biota which use physiological or behavioural adaptations (BAMBARADENIYA & AMERASINGHE, 2003) to survive and recover from sudden environmental change (low dissolved oxygen levels, low pH). Larval chironomid density in rice fields is largely determined by water availability (CHE SALMAH & ABU HASSAN, 2002). We found a negative relationship between water level and larval population density (Fig. 1a) since rising water levels dilute the amount of available organic matter and nutrients (REAL *et al.*, 2000; ALI *et al.*, 2002; WALKER *et al.*, 2003). Dissolved oxygen is not important for some larvae since they contain haemoglobin (CRANSTON, 1995) to maintain metabolic activity during anoxia. Similar to ALI (1989) and ALI *et al.* (2003) we found a positive relationship between chironomid abundance and nutrients.

In conclusion, further qualitative and quantitative sampling will allow a clearer picture of temporal trends in chironomid communities and the physicochemical parameters in rice fields.

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