AGRICULTURE AND NATURAL RESOURCES

Journal homepage: http://anres.kasetsart.org

Research article

Diversity of macroinvertebrates in a wetland ecosystem consisting of predominantly *Typha* spp. in Nonthaburi, Thailand

Kamalaporn Kanongdate[a,*], Watchariya Purivirojkul[b]

[a] *Faculty of Environment and Resource Studies. Mahidol University, Salaya 73170, Thaland.*
[b] *Animal Systematics and Ecologu Speciality Research Unit, Department of Zoology, Faculty of Science, Kasetsart University, Bang Khen Campus, Bangkok 10900, Thaland.*

Article Info

Article history:
Received 27 May 2019
Revised 10 February 2020
Accepted 29 February 2020
Available online 31 March 2020

Keywords:
Biodiversity,
Invertebrate,
Typha,
Wetland

Abstract

Macroinvertebrates play a vital role as a decomposer community of the food web in an ecosystem dominated by *Typha* species. This study assessed the relationship of species richness and abundance of macroinvertebrates with the density of *Typha* species that predominated in an ecosystem. Pitfall traps were set along three transects, each approximately 10 m long. On each transect, four traps each were set at respective distances of 0−1 m, 3−4 m, 6−7 m and 9−10 m (4 traps × 4 distances = 16 traps). *Typha* species along each transect were cut every 2 wk. Samples were collected within 18 wk. In total, 21 groups of taxa of macroinvertebrates were identified. The biodiversity index of the study area was low (Shannon Wiener index = 1.355) and the evenness index was also very low (J′ = 0.140). The most abundant groups were the Collembola and the Acari. The Pearson correlation coefficient (r) indicated a significant positive correlation between the density of *Typha* species and the number of macroinvertebrate groups (r = 0.239, p = 0.013) whereas Kendall's tau-b correlation (T_b) indicated a significant negative correlation between time and the number of macroinvertebrate groups (T_b = -0.428, p = 0.000). The study suggested that anthropogenic-induced alterations in the densities of *Typha* species have influenced the diversity of macroinvertebrates in this ecosystem.

Introduction

With increasing pressure on land, wetland ecosystems predominantly inhabited by the *Typha* genus, especially in inner cities, are often viewed as "wasteland". Thus, the ecological function of such fragile ecosystems as carbon sink and urban-oxygen providers (Pandey et al. 2016) and as habitat for macroinvertebrates and diverse group of organisms is often overlooked since commercial interest seems to drive the decision-making process.

Most macroinvertebrates found in such ecosystems constitute a major group of decomposers and serve as basic food for higher trophic-level animals; thus, the macroinvertebrates can influence the biodiversity of the entire system (Zozaya and Neiff, 1991). The seasonal rate of decomposition of *Typha latifolia* in a free-water surface, constructed wetland indicated that the decomposition rate in that ecosystem was quite slow (Álvares and Bécares, 2006). Thus, as a mono-species abundant, species of *Typha* are hypothesized to limit the diversity of macroinvertebrate groups, which play a vital role as decomposers to stabilize the energy flow in an ecosystem.

Tall et al. (2008) observed that the macroinvertebrates predominant in emergent vegetation were different from those in the sediment. They reported that the macroinvertebrates in areas of emergent vegetation were mostly epibenthic fauna such as crustaceans (Gammaridae, Asellidae) and molluscs (Valvatidae) and they were commonly found at fluvial sites, whereas insect larvae (Chironomidae, Caenidae) were found at tributary-plume sites. Furthermore, those

* Corresponding author.
E-mail address: kamalaporn.kan@mahidol.edu (K. Kanongdate)

https://doi.org/10.34044/j.anres.2020.54.2.05

they found predominantly in sediment were mostly the Oligochaeta and Sphaeridae. However, a decline in aquatic macroinvertebrate density and biomass has been observed in a *Typha*-invaded ecosystem by Lawrence et al. (2016) and therefore their study was a guide for the current study regarding the need to identify techniques that promote structurally diverse and biologically rich macroinvertebrates. *Typha* communities have been reported to support the most diverse populations of macroinvertebrates compared with open water (Olson et al., 1995). However, it seems most studies on the composition of macroinvertebrates focused primarily on aquatic communities (such as Lawrence et al., 2016; Solis et al., 2018; Walker et al., 2013) whereas that of a *Typha* ecosystem—which often experiences a dry period and is usually exploited for non-aquatic macroinvertebrates—has rarely been investigated. The objective of the study was to evaluate the species richness and abundance of macroinvertebrate groups and their relationship with the density of a *Typha* ecosystem.

Materials and Methods

A *Typha* ecosystem located in a suburban area in Nonthaburi province (13° 49 ′5.08″ N, 100° 21′7.95″ E), Thailand was selected for study as it had been undisturbed by anthropogenic activities for at least 10 yr. Data from Thai Meteorological Department (n.d.) indicated that the area is prone to seasonal waterlogging during the wet season (July to October) and is relatively dry during the dry season. The mean temperature was in the range 28–30°C with the highest temperatures in April (32–34°C). The average annual rainfall was in the range 1,200–1,400 mm. The period for the current study covered both the dry and wet seasons (January to July 2016). However, the study had a relatively longer dry period; consequently, all samples were collected during the dry period.

Macroinvertebrate investigation

Transect and pitfall trap setting

Three 10 m long transects (A, B, C) were established in the *Typha* ecosystem (Fig. 1). Each transect was separated from the subsequent transect at successive distances of 10 m. Four traps each were set at successive distances of 0–1 m (Q1), 3–4 m (Q2), 6–7 m (Q3) and 9–10 m (Q4) along each transect. Ethyl alcohol (70%) was used to trap the macroinvertebrates according to the conventional technique described by Larsen and Forsyth (2005). *Typha* spp. in Q1, Q2, Q3 and Q4 were cut every 2 wk over a period of 18 wk. The density of *Typha* spp. in Q1, Q2, Q3 and Q4 was determined on the same day of sampling.

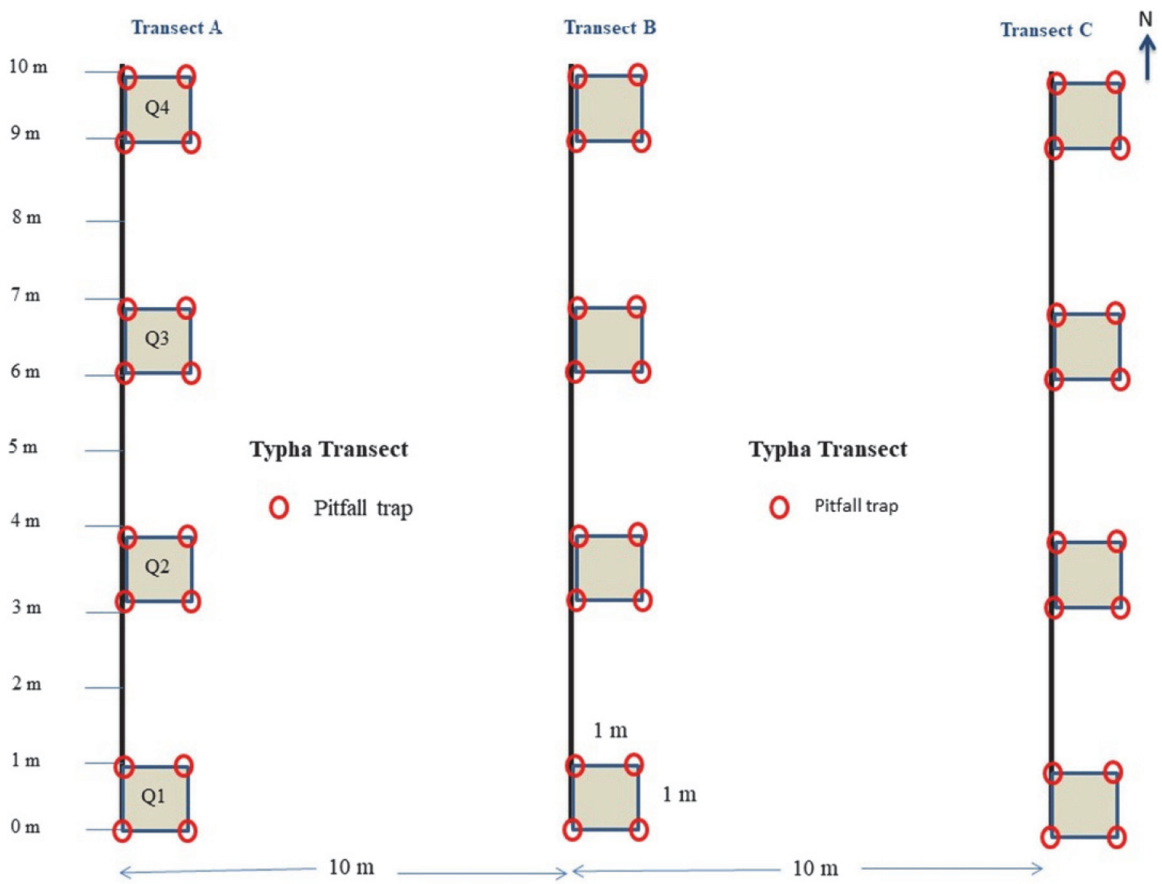

Fig. 1 Pitfall traps across transects A, B and C

Pitfall trap preparation

Bamboo sticks were placed every 1 m along each of the 10 m transects. Four bottles each with volume 1,206 cm^3 and containing ethyl alcohol (70%) were tied to the bamboo sticks at each of the sampling points (Q1, Q2, Q3, Q4) along the transect. A mesh-net was placed on top of each bottle and a roof cover was provided to prevent the entry of water from precipitation. The bottles were covered with dry leaves or grasses. In situations of heavy rains resulting in waterlogged conditions, the top of the bottle was placed so it would be above the water surface. Samples of macroinvertebrates were collected every week and transported to the laboratory where they were identified and classified to the family level.

Data Analysis

Differences in numbers of macroinvertebrate groups were analyzed along transects and among transects. An independent sample t test was used to analyze differences in the numbers of macroinvertebrate groups between Line A and Line B, Line A and Line C and Line B and Line C. Pearson's correlation coefficient (r) was used to assess for relationships between the density of *Typha* spp. and numbers of macroinvertebrate groups, Kendall's tau-b correlation was also used to assess relationships between time and numbers of macroinvertebrate groups. The normal distribution of macroinvertebrates was analyzed. The SPSS statistical package, (Statistics 21; IBM Corp.; White Plains, NY, USA) was used for all data analysis at a test significance level of $p < 0.05$. The Shannon Wiener index (H′) and the evenness index (J′) were used to express the diversity of macroinvertebrates.

Results

Macroinvertebrates

The number of macroinvertebrate groups showed a normal distribution; eight groups were observed (Fig. 2). The maximum was observed for 19 groups and the minimum was no observation for the group.

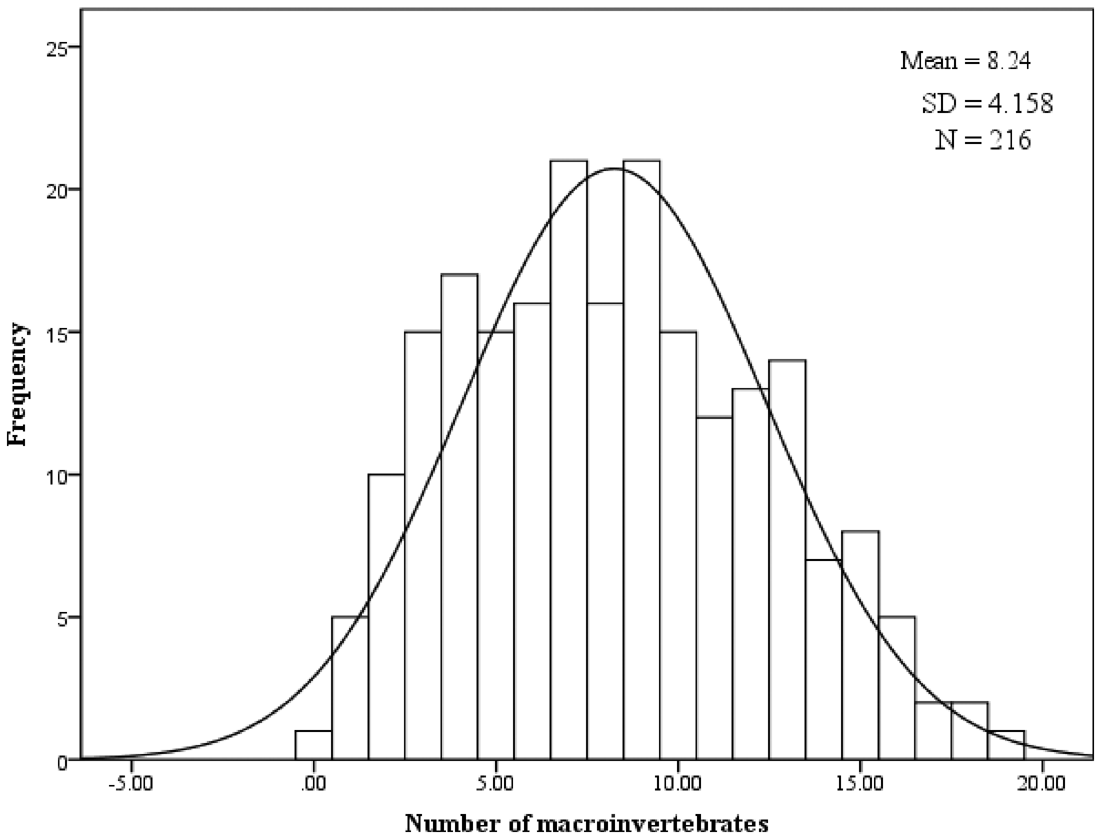

Fig. 2 Normal distribution of macroinvertebrate groups.

All the macroinvertebrates observed in the *Typha* ecosystem belonged to the Phylum Arthropoda, and the Classes Collembola (springtail), Insecta or Xesopoda and Arachnida (spider and mite). There were seven Orders in the class Insecta: the Order Coleoptera with 10 families and the Orders Orthoptera, Diptera, Dermaptera, Hymenoptera and Hemiptera (Table 1). The abundance of macroinvertebrates was from greatest to least: Collembola (1,014 individuals) > Acari (543 individuals) > Staphylinidae (279 individuals). The least abundant of macroinvertebrates were the Silphidae and Caelifera (2 individuals each). Most of the macroinvertebrates observed were predators. For example, the Acari (mites: predator) and Collembola (spring tails: prey) had the highest population richness, followed by the Formicidae and then by the Coleoptera especially the Families Carabidae and Staphylinidae. Other predators observed belonged to the Orders Hemiptera and Hymenoptera and the Suborder Brachycera.

The Shannon Wiener index of biodiversity in the study area was low (H′ = 1.355). The evenness index was also very low (J′ = 0.140). The biodiversity index of the macroinvertebrates varied across the different densities of *Typha* buds. Macroinvertebrates of *Typha* buds with density < 5, had J′ values in the range 0.099–0.337. For *Typha* buds of density between 5 and 10, J′ was in the range 0.144–0.240, whereas for *Typha* buds with a density greater than 10, J′ was in the range 0.133–0.347.

Correlation analysis with the coefficient of determination (R^2) indicated that changes in time explained 42.4% of the variance in the number of macroinvertebrate groups (R^2 = 0.424). Figs. 3A, 3B and 3C show the distribution of the number of macroinvertebrate groups in transects A, B and C observed during 18 wk. Kendall's tau-b (T_b) suggested a strong negative correlation between time and the number of macroinvertebrate (T_b = -0.428, p = 0.000; Table 2).

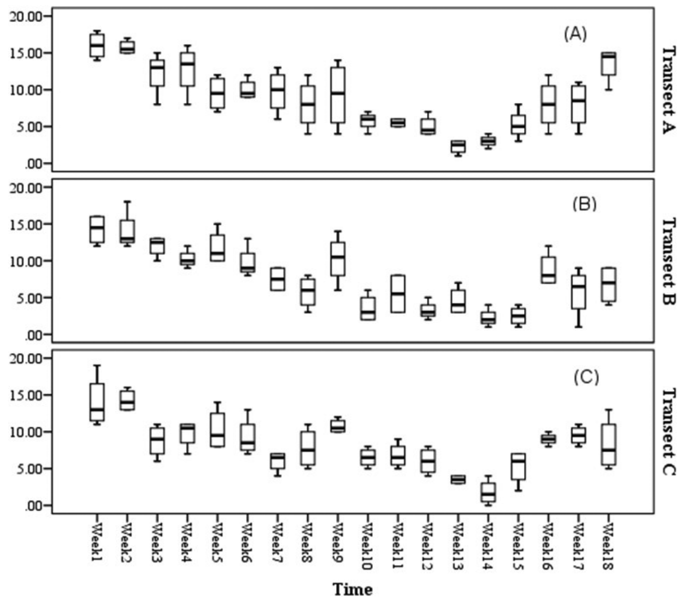

Fig. 3 Number of macroinvertebrates observed during 18 wk: (A) along transect A; (B) along transect B and (C) along transect C, where error bars show confidence interval level at 95%.

Table 2 Kendall's tau_b correlation coefficient between time and number of macroinvertebrates groups

	Time	Number of macroinvertebrates groups
Correlation coefficient	1.00	-0.428**
Significance (2-tailed)	0.000	0.000
N	216	216

** Correlation is significant at the 0.01 level (2-tailed). N = sample size

Table 1 Observed macroinvertebrates in *Typha* ecosystem

Class	Subclass	Order	Suborder	Family
Arachnida	Acari			
	Araneae			
Malacostraca		Asseln		
Insecta		Diptera	Brachycera	
			Nematocera	
		Dermaptera		
		Coleoptera		Carabidae
				Cleridae
				Coccinelidae
				Curculionidae
				Dermestidae
				Elateridae
				Geotrupidae
				Scarabaeidae
				Silphidae
				Staphylinidae
		Hymenoptera		Formicidae
		Hemiptera	Heteroptera	
		Orthoptera	Caelifera	
			Ensifera	
				Gryllidae
Collembola				

The t test indicated that the number of macroinvertebrate groups was significantly different between transects A and B (F = 2.132, $p < 0.05$; Table 3) as well as transects A and C (F = 12.128, $p < 0.05$; Table 3). However, there was no significant difference in the number of macroinvertebrate groups between transects B and C (F = 3.648, $p = 0.450$; Table 3).

Table 3 Sample t test results among transects

Transect between	F value	*p* Value
A and B	2.132	0.000
A and C	12.128	0.001
B and C	3.648	0.450

Relationship between Typha density and number of macroinvertebrate groups

The density of *Typha* spp. observed along each transect averaged 6 buds/m^2 and followed a normal distribution. The minimum and maximum observed buds were 1 and 20 buds/m^2, respectively.

Fig.4A shows the number of macroinvertebrates groups with a *Typha* bud density of less than 5. The number of macroinvertebrates groups with a density of *Typha* buds between 5 and 10 is shown in Fig. 4B, and with more than 10 buds is presented in Fig. 4C. *Typha* bud density was significant and positively correlated with the number of macroinvertebrate groups (r = 0.239, $p = 0.013$; Table 4).

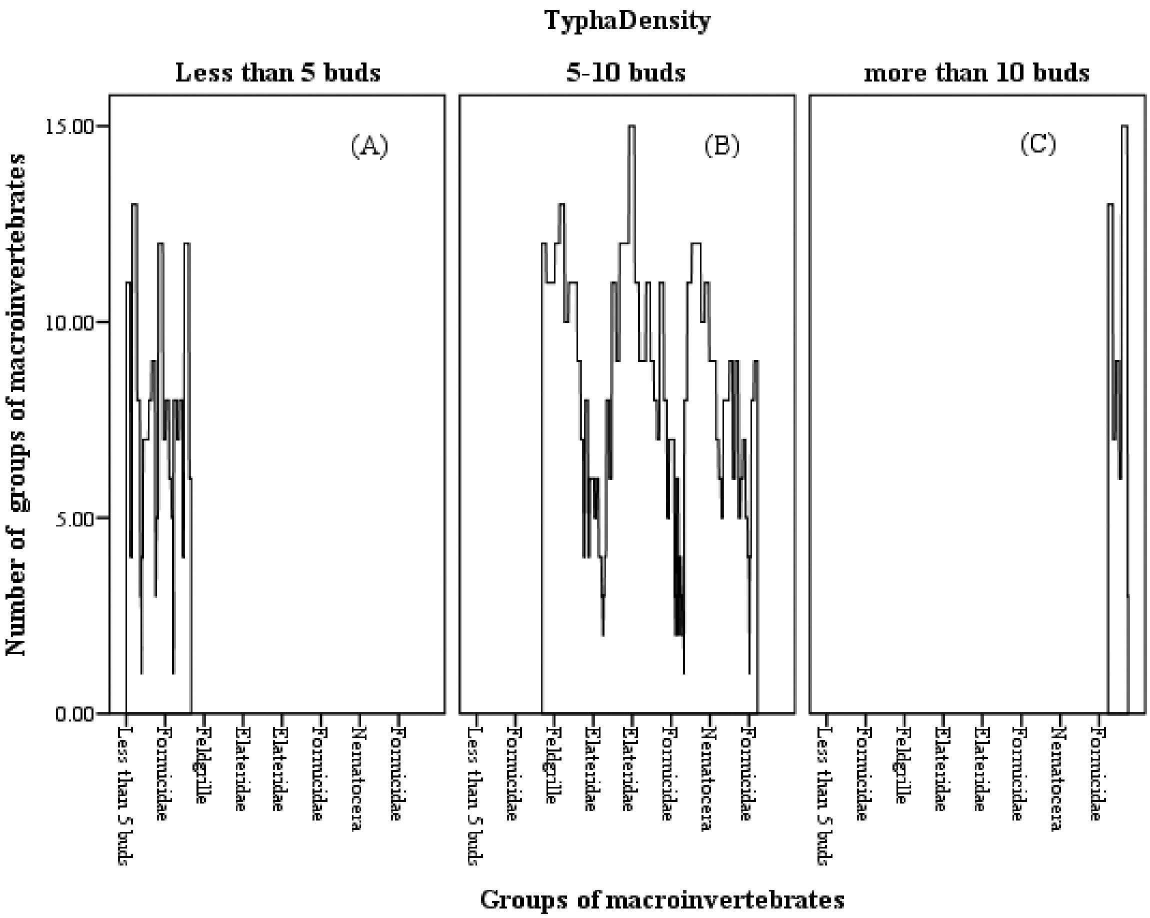

Fig. 4 Density of groups of macroinvertebrates by *Typha* with: (A) less than 5 buds; (B) between 5 and 10 buds; (C) more than 10 buds

Table 4 Pearson correlation between *Typha* spp. density and number of macroinvertebrate groups

	Typha spp. density	Number of groups of macroinvertebrates
Pearson correlation coefficient	1.00	0.239**
Significance (2-tailed)	0.013	0.013
N	108	108

** Correlation is significant at the 0.05 level (2-tailed). N = sample size

Regression analysis indicated a linear relationship between *Typha* density and the number of macroinvertebrate groups (x = 0.378y + 5.7, where x is the number of macroinvertebrate groups and y is the *Typha* density) as shown in Fig. 5A.

Discussion

The change in the number of macroinvertebrate groups was consistent with the theory of "community distribution and niche differentiation in space and time" (Krebs, 1994). Time is an important factor, which tends to determine the decline in number of macroinvertebrate groups. Even though the decline in the number of macroinvertebrate groups over time was significant, the number of macroinvertebrate groups may have likely increased after the decline. This suggested resilience of the system to restore to its initial state with time. However, the sustained disturbance through successive cutting of *Typha* spp. every 2 wk may likely have influenced the decline in the number of macroinvertebrate groups as based on restoration theory (Perrow et al., 2002), after successive disturbance, the number of macroinvertebrate groups was unable to recover and reach the initial level.

Most observed macroinvertebrates in the predominantly *Typha* ecosystem were predators which was consistent with Dvořak and Best (1982). This suggested an early successional pattern of macroinvertebrate communities after anthropogenic-induced disturbance following the cutting of the *Typha spp.* It is probable that the groups of macroinvertebrates colonizing following disturbance may have resulted from the dispersal ability of the taxa (Bilton et al., 2001). However, a shift in dominant plant species may lead to different macroinvertebrate community compositions and structures over time (CaÑedo-Argüelles and Rieradevall, 2011). This seemed to supported by the significantly higher number of macroinvertebrate groups in transect A relative to transects B and C. Since the area along transects B and C has not been directly subjected to disturbance for more than 10 yr, the dispersal of certain groups of macroinvertebrates appeared to be unaffected. This may explain the why there was no significant difference between the comparable number of groups of macroinvertebrates observed in transects B and C.

Typha management, either by cutting or other methods, should also take into account the density of the *Typha* species. Techniques for maintaining *Typha* density as well as maintaining some open spaces are likely to enhance the species richness of decomposers that can stabilize the entropy of the ecosystem through the decomposition process. However, Do and Joo (2015) suggested that to enhance biodiversity of the carabid beetle in a wetland ecosystem such as paddy fields, the frequency of agricultural activities should be limited.

Only small numbers of woodlice, ensifera and crickets were observed. These macroinvertebrates play a major role as decomposers that feed on the dead leaves and roots of *Typha* species. The small numbers of woodlice may have impacted on energy cycling in the

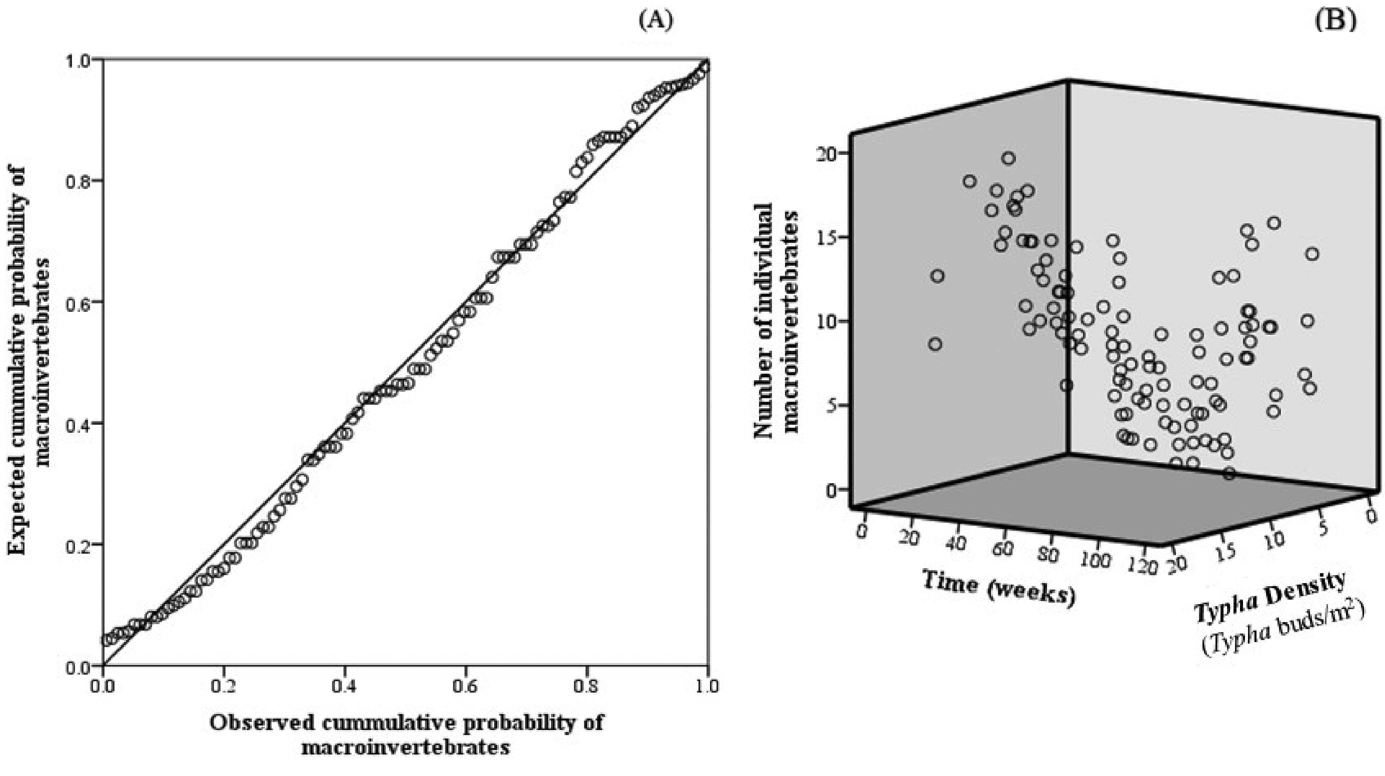

Fig. 5 Relationship between *Typha* density and macroinvertebrates: (A) linear regression between *Typha* density and number of macroinvertebrate groups; (B) number of macroinvertebrate groups over time and for different *Typha* densities

Typha ecosystem, slowing down the rate of decomposition of dead plants (George, 1969). In addition, ensifera and crickets may have influenced the numbers of predators such as reptiles, which inhabit such ecosystem and may have led to an unbalanced food web.

The study of the assemblage of macroinvertebrate groups in *Typha* ecosystem is likely to be useful for further development and for application as a bio indicator of ecosystem health. For example, the Collembola is one of several bio indicators of soil fertility due to the ecological habits of its species. They prefer to live in an environment with a relatively high moisture content, in particular under heaps of dead leaves, in rotting bark or logs and on fungi. Kunapan and Teerakup (2010) reported that slightly acid soil commonly causes infertile eggs in *Collembola xenylla*. Nevertheless, the vegetation structure may also influence the presence of certain group of macroinvertebrates (Scheffer et al., 1984). Barnes and Barnes (1955) found that the Araneae were more frequently found in the edge community of dense broom. It seems that erectus brooms-edge was the optimum habitat for spiders, irrespective of the geography, microclimate, age or history of that ecosystem. This was consistent with Duffey (1966) who concluded that habitat structure was the most important factor for spiders. This was corroborated by the findings of the current study; cutting Typha over time can initially lead to a decline in the population of spiders or at least of one uncommon species that normally can be found in temporal ponds (Nicolet et al., 2004), but the density of *Typha* in particular had a positive influence on increasing the species richness of macroinvertebrate groups.

Species richness of macroinvertebrates observed in the *Typha* ecosystem showed that there were high numbers of the Collembola and Acari. The higher density of *Typha* species had significant influence on the number of macroinvertebrate groups. The frequency of *Typha* cutting likely led to a decrease in the diversity and numbers of individual macroinvertebrates over time. The increase in the number of macroinvertebrate groups may have enhanced the decomposition rate at ground level. The results from the current study suggested that the macroinvertebrate assemblage in a *Typha* ecosystem may be influenced by anthropogenically induced disturbances. This finding may be useful in planning regarding *Typha* ecosystem management.

Ethics Statements

Animal care and all experimental procedures were approved by the Mahidol University-Institute Animal Care and Use Committee (MU-IACUC) (Approval Number: COA. No. MU-IACUC 2016/001).

Conflict of Interest

The authors declare that there are no conflicts of interest.

Acknowledgements

This research project was funded and supported by Mahidol University and the National Research Council of Thailand 2016. The authors thank the Master and Bachelor students for their assistance during field investigation and laboratory analysis and the support with facilities provided by the Faculty of Environment and Resource Studies, Mahidol University. Dr. Seth Nii-Annang assisted with proofreading an earlier version of the manuscript.

References

Álvares, J.A., Bécares, E. 2006. Seasonal decomposition of *Typha latifolia* in a free-water surface constructed wetland. Ecol. Eng. 28: 99−105.

Barnes, R.D., Barnes, B.M. 1955. The spider population of the abstract Broomsedge Community of the southeastern Piedmond. Ecology. 36: 658−666.

Bilton, D.T., Freeland, J.R., Okamura, B. 2001. Dispersal in freshwater invertebrates. Annu. Rev. Ecol. Evol. Syst. 32: 159–181.

CaÑedo-Argüelles, M., Rieradevall, M. 2011. Early succession of the macroinvertebrate community in a shallow lake: Response to changes in the habitat condition. Limnologica. 41: 363–370.

Do, Y., Joo, G.J. 2015. Response of carabid beetles to wetland creation in an intensive agricultural landscape. Ecol. Eng. 84: 47−52.

Duffey, E. 1966. Spider ecology and habitat structure. Senck. Biol. 47: 45−49.

Dvořak, J., Best, E.P.H. 1982. Macro-invertebrate communities associated with the macrophytes of Lake Vechten: Structural and functional relationships. Hydrobiologia. 95: 115−126.

George, D.R. 1969. Some aspects of the ecology of woodlice. M. Sc. Thesis, Durham University. Durham, UK. http://etheses.dur.ac.uk/10189, 18 March 2018.

Krebs, C. 1994. Ecology: The Experimental Analysis of Distribution and Abundance, 4th ed. Harper Collins. New York, NY, USA.

Kunapan, A., Teerakup, W. 2010. The influence of acid-base condition on the biology of *Benylla* sp. (Collembola; Hypogastruridae) under the laboratory study. Division of Biology, Faculty of Science, Mahidol University. The exhibition of scientific projects No. 11st (SciEx 2010) BI-P-11. Faculty of Science, Mahidol University. [in Thai].

Larsen, T.H., Forsyth, A. 2005. Trap spacing and transect design for dung beetle biodiversity studies. Biotropica. 37: 322−325.

Lawrence, B.A., Bourke, K., Lishawa, S.C., Tuchman, N.C. 2016. Typha invasion associated with reduced aquatic macroinvertebrate abundance in northern Lake Huron coastal wetlands. J. Great Lakes Res. 42: 1412−1419.

Nicolet, P., Biggs, J., Fox, G., Hodson, M.J., Reynolds, C., Whitfield, M., Williams, P. 2004 The wetland plant and macroinvertebrate assemblages of temporary ponds in England and Wales. Biol. Conserv. 120: 261−278.

Olson, E.J., Engstrom, E.S., Doeringsfeld, M.R., Bellig, R. 1995. Abundance and distribution of macroinvertebrates in relation to macrophyte communities in a Prairie Marsh, Swan Lake, Minnesota. J. Freshwater Ecol. 10: 325−335.

Pandey, V.C., Sahu, N., Behara, S.K., Singh, N. 2016. Carbon sequestration in fly ash dumps: Comparative assessment of three plant association. Ecol. Eng. 95: 198−205.

Perrow, M.R., Davy, A.J. 2002. Principles of restoration: Handbook of ecological restoration Volume 1. Cambridge University Press. Cambridge, UK.

Scheffer, M., Achterberg, A.A., Beltman, B. 1984. Distribution of macro-invertebrates in a ditch in relation to the vegetation. Freshwater Biol. 14: 367370.

Solis, M., Bonetto, C., Marrochi, N., Paracampo, A., Muyni, H. 2018. Aquatic macroinvertebrate assemblages are affected by insecticide applications on the Argentine Pampas. Ecotox. Environ. Safe. 148: 11−16.

Tall, L., Méthot, G., Armellin, A., Pinel-Alloul, B. 2008. Bioassessment of benthic macroinvertebrates in wetland habitats of Lake Saint-Pierre (St. Lawrence River). J. Great Lakes Res. 34: 599−614.

Thai Meteorological Department. n.d. The knowledge on meteorology: Seasons in Thailand. https://www.tmd.go.th/info/info.php?FileID=23, 2 November 2018. [in Thai].

Walker, P.D., Wijnhoven, S., Velde, G.V.D. 2013. Macrophyte presence and growth form influence macroinvertebrate community structure. Aquat. Bot. 104: 80−87.

Zozaya, I.B., Neiff, J.J. 1991. Decomposition and colonization by invertebrates of *Typha latifolia* L. litter in Chaco cattail swamp (Argentina). Aquat. Bot. 40: 185−193.