DOI: https://doi.org/10.53555/nnpbs.v2i11.699 **Publication URL: http://nnpub.org/index.php/PBS/article/view/699**

THE BENTHIC MACROFAUNAL COMMUNITY IN AGRICULTURAL DITCHES IN KOLE PADDY FIELDS, VEMBANAD KOLE WETLANDS, INDIA

Vineetha S*

**Department of Marine Biology, Microbiology & Biochemistry, School of Marine Sciences, Cochin University of Science and Technology, Fine Arts Avenue, Kochi-682016, Kerala*

Corresponding Author: -

Abstract: -

Paddy fields are connected by drainage ditches (channels), that are considered as drivers of biodiversity in agricultural areas. The macrobenthic community structure in agricultural ditches of Kole paddy fields, a part of the Ramsar site Vembanad kole wetlands during a complete crop season was analyzed. The macrobenthic fauna belonged to phyla Annelida, Arthropoda and Mollusca and classes Oligochaeta (60.39%), Insecta (39.31%), Mollusca (0.15%) and Hirudinae (0.15%). The class Oligochaeta was represented by Tubificidae, Naididae, Lumbriculidae; Insecta by Diptera, Coleoptera, Odonata; Mollusca by Bivalvia, Gastropoda. Composition of macrobenthos resembled to that of fresh water wetlands and paddy fields. The average number of macrobenthos was 1475±2064 ind./m^2. There was an unusually high abundance in May (5155 ind./m^2); but the environmental parameters remained usual. The abundance of good quality food or some specific, localized condition acting on a microscale which could not be recorded in the environmental analysis would have resulted in the unusual distribution of the fauna. Highest diversity (3.17) and species richness (1.95) was observed during May 2011, during the unusual abundance. Predominant functional feeding group was collector gatherers indicating the abundance of fine organic particulate matter (FPOM) in the substrate. No significant correlation emerged between macrobenthic abundance and environmental parameters.

Keywords: - *Agricultural ditches. benthic fauna. Vembanad Kole. paddy wetlands.*

INTRODUCTION

Paddy fields are the largest anthropogenic wetlands on earth. Paddy fields are connected by drainage ditches (channels) which are small, line-shaped water bodies, mostly slow-flowing or static, dug to regulate water level of surrounding agricultural areas (Verdonschot et al 2011,). Moreover, in paddy fields, due to its shallow and compartmented nature, the habitable area for aquatic organisms is less, meanwhile the agricultural ditches present a suitable habitat for aquatic organisms. Several studies have pinpointed drainage ditches as a surrogate habitat for lentic aquatic invertebrates, whose natural habitats have been affected by cultivation; and as drivers of biodiversity in agricultural areas (Watson and Ormerod, 2004; Herzon and Helenius, 2008). However, the inhabitant organisms might be at risk due to the exposure to agrochemicals as the ditches are in immediate contact with agricultural systems and due to a lesser of volume of water present in them. So, an understanding of agricultural ditch communities is essential for management and conservation aspects. Though many studies are done from various parts of the world, there is a conspicuous lacuna in the literature on the ecology of ditches from India though India stands first in the area under rice cultivation, second in rice production and has an agriculturally based economy (Balachandran, 2007)

Kole wetlands are among the water-logged, paddy cultivating areas in Kerala and were under rice cultivation for the past 200 years (Anon., 1989). They are distinguished for its high rice production, even the term Kole in Malayalam (the regional language of Kerala) means 'bumper yield of high returns in case flood does not damage the crops' (Johnkutty and Venugopal, 1993). This study analyzed the macrobenthic community structure in agricultural ditches of Kole paddy fields, a part of the Ramsar site Vembanad kole wetlands. Benthic fauna plays an important role in the ecology of aquatic ecosystems as they release dissolved nutrients by their feeding activities, excretion and burrowing into sediments and increase the rate of decomposition of particulate matter (Covich et al., 1999; Stripari and Henry, 2002). The role of benthic invertebrates as food for avian fauna also emphasizes the need for benthic study as this wetland comes under Central Asian- Indian flyway of migratory birds where water birds halt for short periods to rest and feed during their annual migrations, and these 'stepping stones' are essential for their survival (Anon, 1996; Sivaperuman and Jayson, 2000).

Materials and Methods

Study area

Maranchery Kole paddy fields (100 72'N 750 98'E) lies between Maranchery and Veliyamkodu panchayats (a village council is called panchayat) in Malappuram district and is a part of the Ponnani Kole (Fig.1). The Kole lands has an area of 13,632 ha. spreading over Thrissur and Malappuram districts of Kerala state, India; extending from northern bank of Chalakkudy river in the South to the southern bank of Bharathappuzha river in the North. The intrusion of salt water to the paddy fields is prevented by Viyyam dam situated at the downstream end of Kole lands. It is believed that Kole lands were lagoons formed by the recession of the seas centuries ago. A shallow portion of the sea along the western periphery of the main land was secluded and they were slowly silted up during rains making the lagoons shallow (Kurup and Varadachar, 1975). During summer months the farmers bunded the fields, dewatered and cultivated paddy. The main crop is Punja (Summer crop) raised between December/January and April/May. Seasonal paddy cultivation was practiced here. Monthly field sampling was done in two agricultural ditches through the paddy fields for a complete crop season *punja* from January to May 2011 for the study of macrobenthos and environmental parameters.

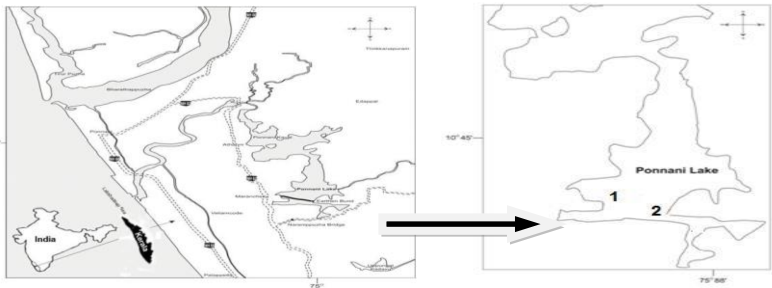

Figure:1**. Location of Agricultural ditches in Maranchery Kole paddy fields**

Sampling and Analysis

As the water body was shallow, water samples were collected using a locally fabricated shallow water sampler of 1 liter capacity. The sediment samples were collected using a Van Veen grab of size 0.45m^2. Temperature of the water and sediment samples were measured in the field using a standard degree centigrade thermometer of 0°C to 50°C range and 0.l°C accuracy. pH was measured using Systronics digital pH meter model MK VI. Dissolved oxygen was analyzed by modified Winkler method (Strickland and Parsons, 1972); organic carbon was analyzed by Walkley - Black method, then converted to organic matter by multiplying with Van Bemmelen factor of 1.742 (Jackson, 1973), available nitrogen of sediment was analyzed by Kjeldhal method (Jackson, 1973; Carter, 1993), available phosphorus was analyzed by Olsen's method (Olsen et al., 1954); particle size was analyzed by particle analyzer Sympatrec T 100 laser diffraction granulometer. Sediment samples in replicate were collected for the analysis of macrobenthos using a VanVeen grab of size 0.45m^2. The samples were washed in the field itself through a sieve of mesh size 500 μm and those that were retained in the sieve were collected and preserved in 5% formalin (McIntyre and Eleftheriou, 2005). The organisms were sorted into different taxonomic groups. Identification was done using standard keys (Yule and Sen, 2004; Morse et al., 1994). Statistical analysis was done using PRIMER 6 (Plymouth Routines in Multivariate Ecological Research, version 6) and SPSS 16 (Statistical Programme for Social Sciences, version 16).

Results and Discussions

The average depth of the channels was 1.22±0.02 m, as it was a man managed system; depth varied less between months and sampling stations. Water temperature ranged from 27.1°C in January to 33°C in May with an average of 30.37±2.67°C. A gradual increase in temperature from January to May was apparent. The average water pH was 5.84±1.23, agreeing to the previous studies from Thrissur Kole wetlands which revealed that the water was slightly acidic in nature (Tessy and Sreekumar 2008). Lowest dissolved oxygen recorded was 5.08mg/L in February and highest was 7.2mg/L in April with an average of 6.68±0.53mg/L. Oxygen levels never reached a harmful anoxic level for biota. Sediment temperature showed an average of 28.95±2.03°C. Sediment pH varied between 6.49 in May to 7.19 in March showing an average of 6.78±0.38. The sediment was found to be reduced in nature showing an average Eh of -235.03±32.33mV. The average value of moisture content and organic matter were19.05±6.34% 5.63±2.09% respectively; both implying a favorable condition for benthic life. Available nitrogen values ranged from 0.0055% in May to 0.0185% in January whereas available phosphorus ranged from 0.24 ppm in March to 0.47 ppm in February. The sediment texture in channels showed clay, silt and sand percentages as 23.65, 50.24 and 25.72 respectively.

The macrobenthic fauna in agricultural ditches belonged to phyla Annelida, Arthropoda and Mollusca and classes Oligochaeta (60.39%), Insecta (39.31%), Mollusca (0.15%) and Hirudinae (0.15%). The class Oligochaeta consisted of Tubificidae, Naididae and Lumbriculidae. The class Insecta consisted of Diptera represented by Chironomidae, Ceratopogonidae, Empedidae; Coleoptera represented by Gyrinidae and Odonata represented by Euphaeidae. Class Mollusca consisted of Bivalvia represented by Unionidae and Gastropoda represented by Bithynidae (Fig.2). The composition of benthic macrobenthos resembled to that of fresh water wetlands and paddy fields where oligochaetes, insects, gastropods are the most common benthic inhabitants (Ojha et al. 2010). Previous studies from agricultural drainage ditches of Maryland, United States showed that ditches that had properties of linear wetlands supported communities of lentic invertebrates such as Oligochaeta whereas ditches that had higher flow velocities supported communities of lotic invertebrates. The presence of leeches could be attributed to the submerged aquatic macrophytes which has been regarded as one of the important factors for their distribution (Sawyer, 1974), giving them protection, solid substrate for locomotion and deposition of cocoon (Nozley, 1932).

The average number of macrobenthos was 1475±2064 ind./m^2. The abundance was higher in January (700 ind./m^2) and March (689 ind./m^2) but an unusually high abundance was observed in May (5155 ind./m^2). The unusually high benthic abundance was observed previously by Wishner et al. (1990), the enriched sediment resulting from reduced consumption and degradation of sinking material supplying high food level, was the suggested reason. According to Brinkhurst (1972), the competition in oligochaetes is avoided by selective digestion of the bacteria with the sediment, which lead to a degree of collaboration as feces of one species of the worm becomes the preferred food for another species. This could be a probable reason for the close clumping of oligochaetes (Kumar and Bohra 1999). Brinkhurst (1972) documented that, the unusual abundance of oligochaetes especially tubificids were clear indication of excess organic matter in an environment where oxygen deficiency and high silt loads combine to kill most of the fauna. But in this study, in May, all the environmental parameters analyzed, especially oxygen, organic matter and silt content remained similar to the other samples. Though tubificids were the most abundant (61%), naidids also showed a good abundance (39%) in the particular samples. Along with oligochaetes in the benthic sample, insect larvae especially chironomids also showed an unusually high abundance comparable to that of oligochaetes.

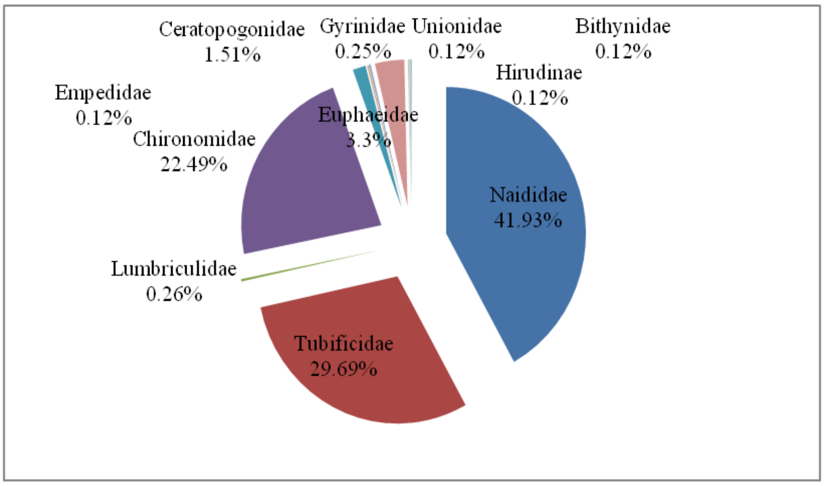

Figure 2: **Mean percentage composition of macrobenthic fauna in Agricultural ditches in Maranchery Kole paddy fields during Punja crop season 2011**

However, both Wishner et al. (1990) and Brinkhurst (1972) emphasized the significance of the abundance of food source for the unusual benthic abundance. The organic matter in the present study was higher throughout the study period, ensuring a food source for benthos. Apart from the quantity of organic matter, the nutritional quality is also important in determining benthic abundance (Neiraa 2001, Cibic et al. 2007). The abundance of good quality food would have favored the unusual benthic abundance in May 2010 or some specific, localized condition acting on a microscale which could not

be recorded in the environmental analysis would have resulted in the patchy distribution of the fauna in channels as suggested by Verdonschot et al. (2011) from his studies on agricultural ditches from Italy. Furthermore, the variation in microhabitat characteristics, resource availability, biotic interactions, and stochastic events results in the patchy the distribution of species and individuals both within and between ditches (De Meester et al., 2005; Scheffer et al., 2006).
Diversity analysis revealed that the highest species richness (1.95) and species diversity (3.17) in May, during the unusually high abundance; and species dominance (0.36) in February. The lowest species richness (1.20) and species diversity (2.28) was recorded in April and February respectively; and species dominance (0.15) in January. Different studied from ditches revealed contradictory information on diversity. Williams et al. (2004) found that intermittent ditches in southern England supported fewer species whereas Painter (1999) suggested that ditches could provide refuges for species characteristic of the formerly extensive (semi)natural lentic ecosystems and may have potential to harbor high diversity.

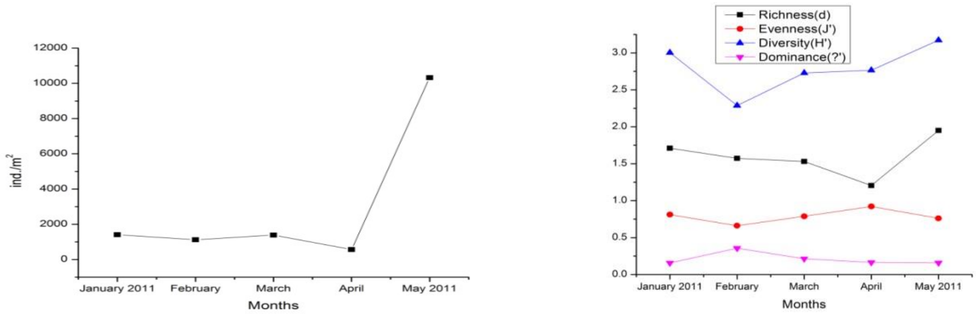

Figure 3: Monthly mean variation in numerical abundance (ind./m2) and Diversity indices of macrobenthic fauna in Agricultural ditches in Maranchery Kole paddy fields during *Punja* crop season 2011

Considering the functional feeding groups of the benthic fauna in these agricultural dicthes, the predominant feeding group was collector gatherers (94.35%) represented by Naididae, Tubificidae, Lumbriculidae, Chironomide that feed on deposited fine particulate organic material followed by predators (5.39%) represented by Ceratopogonidae, Euphidae, Gyrinidae, Empedidae, Hirudinae, that feed on other macroinvertebrate fauna by engulfing prey; scrapers (0.13%) represented by Bithynidae that feed on aufwuchs from various substratum surfaces; filter filters (0.13%) represented by Unionidae that feed on that feed by filtering particles from the passing water (Fig.5). The relative abundances of the groups reflect environmental conditions, particularly the quantity and quality of particulate organic matter inputs and periphyton growth (Cummins and Klug 1979, Wiggins and Mackay 1979). The predominance of collector gatherers here indicates the abundance of fine organic particulate matter (FPOM) in the system. A low ratio of filter-gatherers reveals that fine particulate organic matter in suspension is low compared to fine particulate organic matter in the substrate.

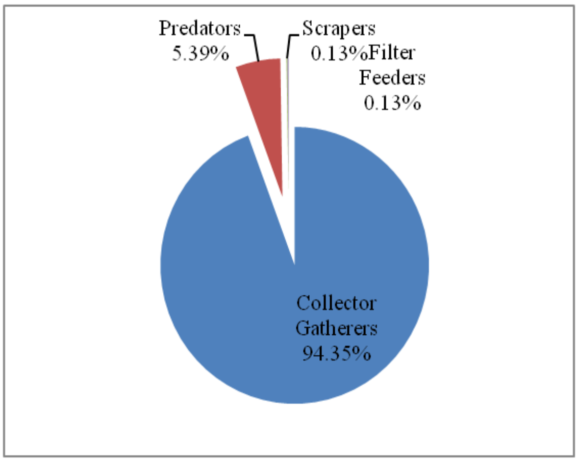

Figure 4: **Mean percentage composition of functional feeding groups of macrobenthic families in Agricultural ditches in Maranchery Kole paddy fields during *Punja* crop season 2011**

The interactions between macrobenthic abundance and environmental parameters were analyzed using correlation analysis. The results showed no significant correlation between macrobenthic abundance and environmental parameters, the maximum correlation was observed between water temperature and numerical abundance of macrobenthos (r^2=0.40, p=0.25). In a study from agricultural ditches of Maryland also the lack of a significant relationship between benthos and nutrient concentrations in either soil or water was observed; the study suggested that instead of nutrients, physical alterations to flow, area, and oxygen concentration could affect benthic distribution (Leslie et.al 2012).

There is growing interest in the concepts of eco-agriculture (McNeely and Scherr 2001) whereby agricultural systems are managed as both a food production and biodiversity conservation system. Though the focus of biological conservation slowly shifted to managed ecosystems, including agricultural systems since late 1980s (Western and Pearl, 1989), from the literature it was evident that ecological studies on agricultural ditches began in 2000s. In this regard a comparison with similar systems was difficult especially in the Indian scenario, mainly when agrochemicals usage in paddy cultivation is increasing. Hence in conservation and management perspectives, more information is essential from agricultural ditches due to its role in providing a holistic picture of the paddy field ecosystem particularly when researchers opined that, owing to its biological diversity paddy fields could even surrogate the loss of natural wetlands.

Acknowledgements
The author is thankful to the Head of the Department of Marine biology, Microbiology and Biochemistry, Cochin university of Science and Technology for providing necessary facilities. The author is thankful to University Grants Commission for the research fellowship. This study was a part of the research project funded by Kerala state Biodiversity Board, the author is thankful to them.

References

[1].Anonymous. 1989. Scheme for studying the possible changes in the ecosystem consequent on the conservation of Thannermukkam Bund, Thrissur, Kerala. Kerala Agricultural University.
[2].Anonymous. 1996. Asia-Pacific Water bird Conservation Strategy, 1996-2000. Wetlands International AsiaPacific, Kula Lumpur, Publication No.117, and International Waterfowl and Wetlands Research Bureau - Japan Committee, Tokyo.
[3].Balachandran PV. 2007. Rice scenario of Kerala and the future strategies. Proceedings of XIX Kerala Science Congress, Kannur, Kerala 22-32 pp.
[4].Brinkhurst RO. 1972. The role of studge worm in Eutrophication. U.S. EPA Washington, D.C. Ecological Research Series.
[5].Carter, M. R., Parton,W. J., Rowland, I. C., Schultz, J. E., and Steed, G. R. 1993. Simulation of soil organic carbon and nitrogen changes in cereal and pasture systems of southern Australia, Austr. J. Soil Res., 31, 481– 491,
[6].Cibic T, Acquavita A , Aleffi F , Bettoso N, Blasutto O, De Vittor C, Falconi C, Falomo J, Faresi L, Predonzani S, Tamberlich F, Fonda Umani S. 2008. Integrated approach to sediment pollution: A case study in the Gulf of Trieste. Marine Pollution Bulletin 56:1650–1667.
[7].Covinch, A.P., Palmer, M.A. and Crowl, T.A. 1999. The role of benthic invertebrate species in freshwater ecosystems. BioScience. vol. 49(2):119-127
[8].Cummins KW, Klug MJ. 1979. Feeding ecology of stream invertebrates. Annual Review of Ecology and Systematics 10:147-172.
[9].De Meester, L., Declerck, S., Stoks, R., Louette, G., Van De Meutter, F., De Bie, T., Michels, E., Brendonck, L., 2005. Ponds and pools as model systems in conser- vation biology, ecology and evolutionary biology. Aquatic Conservation: Marine and Freshwater Ecosystems 15, 715–725.
[10]. Herzon, I., and J. Helenius. 2008. Agricultural drainage ditches, their biologicalimportanceandfunctioning.
[11]. Biol. Conserv. 141: 1171-1183
[12]. Jackson M L. 1973. Soil chemical analysis, Printers- Hall India Ltd, New Delhi.
[13]. Johnkutty I, Venugopal VK. 1993. Kole wetlands of Kerala, Kerala Agricultural University, Thrissur 68PP.
[14]. Kumar A and Bohra C. 1999. Gastropods as indicators of the pollution status of some wetlands of Santhal Pargana, Bihar,India, Indian J. Env. and Ecoplan. 2 (1): 83-87.
[15]. Leslie AW, Smith RF, Ruppert DE, Bejleri K, Mcgrath JM, Needelman BA, Lamp WO.2012. Environmental Factors Structuring Benthic Macro Invertebrate Communities of Agricultural Ditches in Maryland. Environmental Entomology 41(4):802-812.
[16]. McIntyre AD, Antasious Eleftheriou. 2005. 3rd edn. Methods for the study of Marine benthos. Blackwell Scientific Publications.
[17]. McNeely JA, Scherr 2001. Common ground common future. How ecoagriculture can help feed the world and save biodiversity. Gland Switzerland: The World Conservation union (IUCN) pg 24
[18]. Morse, J. C., Yang, L. and Tian, L. 1994. Aquatic insects of China useful for monitoring water quality. Hohai University Press, Nanjing
[19]. Neira C, Sellanes J, Levin LA, Arntz WE. 2001. Meiofaunal distributions on the Peru margin: relationship to oxygen and organic matter availability. Deep-Sea Research. Pt. I: Oceanography. Research Paper 48:2453– 2472.
[20]. Nozley, A. 1932. A biological study of a temporary pond in Western Canada, Amer, Naiur, 86,235-249.
[21]. Ojha NK, Pandey MK, Yadav RN. 2010. Studies on macrobenthic community of paddy field of rural Chapra. Bioscan: Special issue 2:579-585.
[22]. Olsen S, Cole C, Watanabe F, Dean L. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular Nr 939, US Gov. Print. Office, Washington, D.C.
[23]. Painter DJ. 1999. Macroinvertebrate distributions and the conservation value of aquatic Coleoptera, Mollusca and Odonata on ditches of traditionally managed and grazing fen at Wicken Fen, UK. Journal of Applied Ecology 36:33–48.
[24]. Sawyer, R.T. 1974. Leeches (Annelida-Hirudinea) in Poll Ecol. of Fresh Inv. Ed. Hart & Fuller. Academic Press, London-New York.
[25]. Scheffer, M., Van Geest, G.J., Zimmer, K., Jeppesen, E., Sondergaard, M., Butler, M.G., Hanson, M.A., DeClerck, S., De Meester, L., 2006. Small habitat size and isolation can promote species richness: secondorder effects on biodiversity in shallow lakes and ponds. Oikos 112, 227–231.

[26]. Sivaperuman C, Jayson EA. 2000. Birds of Kole Wetlands, Thrissur, Kerala. Zoos' Print Journal 15(10):344349.
[27]. Strickland JDH, Parsons TR. 1972. A practical handbook of seawater analysis. Bull Fish Res Bd Can, 2nd Edn vol 167:310pp.
[28]. Stripari N. and Henry R., 2002. The invertebrate colonization during decomposition of Eichhornia azurea Kunth in a lateral lake in the mouth zone of Paranapanema river into Jurumirim Reservoir (Sa˜ o Paulo,
[29]. Brazil). Braz. J. Biol., 62, 293–310
[30]. Tessy PP, Sreekumar R. 2008. Assessment of phytoplankton diversity and the hydrographic parameters in Thrissur Kol welands (part of Vembanad- Kol, Ramsar site), Kerala, India. Proceedings of International Conference on Biodiversity Conservation and Management. 44-47..
[31]. Verdonschot RCM, Keizer-Vler HE, Verdonschot PFM. 2011. Biodiversity value of agricultural drainage ditches: a comparative analysis of the aquatic invertebrate fauna of ditches and small lakes Aquatic Conservation Marine Freshwater Ecosystem 21:715–727.
[32]. Watson, A. M., and S. J. Ormerod. 2004. The microdistribution of three uncommon freshwater gastropods in the drainage ditches of British graz- ing marshes. Aquatic Conservation: Marine and Freshwater Ecosystems 14:221–236.
[33]. Western D. and Pearl M.C. 1989. Conservation for the Twenty-first Century. — Oxford University Press, New York
[34]. Wiggins GB, Mackay RJ. 1979. Some relationships between systematics and trophic ecology in Nearctic aquatic insects, with special reference to Trichoptera. Ecology 59:1211-1220.
[35]. Williams P, Whitfield M, Biggs J, Bray S, Fox G, Nicolet P, Sear D. 2003. Comparative biodiversity of rivers, streams, ditches and ponds in an agricultural landscape in Southern England. Biological Conservation 115:329–341.
[36]. Wishner K, Levin L, Gowing M, Mullineaux L. 1990. Involvement of the oxygen minimum in benthic zonation on a deep sea mount. Nature 346:57-59.
[37]. Yule CM, Sen YH. 2004. Freshwater invertebrates of the Malaysian region / editors Kuala Lumpur, Malaysia : Akademi Sains Malaysia.