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PARAMETERS AFFECTING MACROINVERTEBRATES DISTRIBUTION IN FRESHWATER

Aquatic macroinvertebrates are an important part of the food chain, especially for fish. Many feed on algae and bacteria, which are on the lower end of the food chain. Some shred and eat leaves and other organic matter that enters the water. Because of their abundance and position in the aquatic food chain, benthos plays a critical role in the natural flow of energy and nutrients. As benthos die, they decay, leaving behind nutrients that are reused by aquatic plants and other animals in the food chain (Internet 1).

Unlike fish, benthos cannot move around as much, so they are less able to escape the effects of sediment and other pollutants that diminish water quality. Therefore, benthos can give reliable information on stream and lake water quality. Their long life cycles allow studies conducted by aquatic ecologists to determine any decline in environmental quality. Macro invertebrates constitute a heterogeneous assemblage of animal phyla and consequently it is probable that some members will respond to whatever stresses are placed upon them (Hellowell, 1986).

Biomonitoring is the use of the biological responses to assess changes in environment. Therefore, macroinvertebrates are most frequently used as indicator species. Cairns & Pratt (1993) conclude that biological surveillance of communities, with special emphasis on characterising taxonomic richness and composition, is perhaps the most sensitive tool now available for quickly and accurately detecting alterations in aquatic ecosystems.

Conca and Wright (1992) states that ideally ecologists and managers should understand the processes which lead to the observed patterns of community structure in unstressed flowing-water systems and that this would provide a firm foundation from which to investigate the processes taking place when environmental stresses lead to community change, both structural and functional.

Many parameters will determine the distribution pattern of macroinvertebrates in freshwaters. Numerous studies and publications have been produced to determine which are the most relevant factors affecting this distribution.

Hynes (1960, 1970) has listed abiotic factors that predominately seem to affect macroinvertebrate population, they are, in order of importance of impact:

- Current speed: many invertebrates have an inherent need for current either because they rely on it for feeding purposes or because their respiratory requirement demands it.
- Temperature: intimately related to latitude, altitude, seasons, and relative distance from the source.
- Substratum: certain species are confined to fairly well defined types of substratum.
- Level of oxygen: main factor in polluted waters.
- Salinity, acidity, hardness, and general water chemistry.

Those parameters are also defined of prime importance for D. H. Mills (1972), who stated that the chief environmental factors affecting distribution of aquatic animals in streams are:

- The chemical nature of the water, this may affect the distribution of aquatic organisms in a number of ways. The concentration of dissolved oxygen is important. Oxygen is not very soluble in water and its solubility depends on the temperature. The calcium content of water is also important for species such as the freshwater shrimp, many snails and mussels, which are abundant in hard water.
- The physical nature of the water, water movement, and temperature. The surface velocity of water has been shown to have an effect on caddis larvae and it was found that the number of Trichoptera larvae along a current gradient became progressively less numerous with increasing distance from a source.

Temperature has been implicated as a mechanism influencing spatial and temporal isolation (Ward 1992), and as one of several primary factors influencing life history patterns of aquatic insects (Sweeney 1984). In earlier researches, Grenier (1949), Zahar (1951) showed that population of Simuliidae differs in genera to their occurrence in altitude, thus in temperature. Various aspects of water chemistry, e.g., acidity, dissolved oxygen; water hardness, etc. (Bell 1971; Pennak 1978; Fryer 1980; Faith and Norris 1989; Schell and Kerekes 1989; Foster 1991) also influence the distribution of freshwater taxa, although ascertaining the effects of selected chemical factors can be difficult (Ward 1992).

More recently, ecologists have emphasized their study on one or two particular parameters that will define the distribution of organisms.

Current velocity is often regarded as the most important factor. According to Allen (1995) current velocity is the most important factor affecting fluvial macroinvertebrates: “ Biologists have long believed that water as a medium, and current as a force, strongly determine ecological distributions and shape anatomical

and behavioural adaptations". Its importance has even led to the establishment of different criteria for classifying flow environment (Davis and Barmuda, 1989). In another study, Newlon and Rabe (1977) stated that the two most important factors affecting macroinvertebrates are substrate and suspended sediment. They found that there are four to five physical and chemical factors that have significant influence over biomass and diversity of macroinvertebrates. These factors include substrate, suspended sediment, gradient, water temperature, and stream order and width. Minshall (1984) supports these findings and provides a literature review of insect-substratum relationships. Peeters et al (2000) have defined in their study that current velocity and substratum are the two main physical factors affecting distribution of lotic macroinvertebrates. Earlier researches tend to demonstrate that substratum/organism relationship was not well understood due to a lack of research on that subject (Hynes, 1970). Other parameters have to be taken into account when studying factors affecting macroinvertebrates, Graca et al. in a recent study report (2002) demonstrated the importance of scale in studying the impact of different parameters such as substrate type, particle size, current velocity, depth, organic content and habitat heterogeneity on spatial richness. They concluded that at a small scale invertebrate and taxa richness was dependent on detritus accumulation and hydraulic constraints, and a large scale, taxa richness was dependent of climatic and geomorphologic factors.

All these studies have been focused on abiotic factors (i.e. physical and chemical parameters) influencing macroinvertebrates. It is important to also include biotic factors. Biotic factors are more difficult to measure, as they are mainly interaction between organisms. These interactions include predation, competition (intraspecific or interspecific), and parasitism. Numerous potential effects of vertebrate predators on aquatic macroinvertebrates have been described, such as salamander predation on macroinvertebrates (Taylor et al. 1988). However, other studies showed that salamander/macroinvertebrate predation relationship is not well determined (Taylor et al. 1988; Petranks 1989). Other predator such as fish can affect and alter development (Diehl 1992), species composition (Healey 1984), and species abundance (Macan 1977; Healey 1984) of benthic macroinvertebrate communities. The attenuation and elimination of specific taxa (e.g., *Chaoborus*) has also been reported (Stenson, 1978). Predation interaction have been studied by Murdoch and Bence (1987) who concluded that predators were sources of instability in freshwater environments, while Thorp (1986) proposed that predators contributed directly and indirectly to community regulation and population stability.

Relevant literature shows that when investigating the different parameters affecting distribution of macroinvertebrates in order to differentiate the most relevant ones, it is important to take into account that macroinvertebrate ecology is complex, and that interactions with their environment are numerous. All of these interactions will have an effect to a certain extent, upon their distribution.

REFERENCES

- Bell, H.L. 1971. Effect of low pH on the survival and emergence of aquatic insects. *Water Research* 5, 313-319.
- Cairns, J. and J.R. Pratt 1993. A history of biological monitoring using benthic macroinvertebrates. Pages 10-27, In: D. M. Rosenberg and V.R. Resh (eds.) *Freshwater Biomonitoring And Benthic Macroinvertebrates*, Chapman & Hall, N.Y.
- Conca, J. L. and Wright, J. 1992. Diffusion and Flow in Gravel, Soil, and Whole Rock. *Applied Hydrogeology*, Hanover.
- Faith, D.P. and R.H. Norris 1989. Correlation of environmental variables with patterns of distribution and abundance of common and rare freshwater macroinvertebrates. *Bio. Conserv.* 50, 77-98.
- Foster, G.N. 1991. Aquatic beetle population changes associated with recreating a trout fishery by limiting a lake catchment. *Arch. Hydrobiol.* 122(3), 313-322.
- Fryer, G. 1980. Acidity and species diversity in freshwater crustacean faunas. *Freshwater Bio.* 10, 41-45.
- M.A.S. Graça¹, R. Cortes², P. Pinto³, C.N. Coimbra¹, M.J. Carvalho¹, and S. Oliveira². 2002. Factors affecting spatial richness of macroinvertebrate taxa in streams. Departamento de Zoologia, Universidade de Coimbra, 3004-517 Coimbra, Portugal, ²Departamento Florestal, Universidade de Tras-os-Montes e Alto Douro, Portugal.
- Healey, M. 1984. Fish predation on aquatic insects. (in V.H. Resh and D.M. Rosenberg, eds., *The Ecology of Aquatic Insects.*) 255-288.1955:127-131.
- Hellawell, J. M. 1986. Biological indicators of freshwater pollution and environmental management. Elsevier Applied Science.
- Hynes H. B. N.
1960. *The Biology of polluted waters*. Liverpool University Press.
1970. *The Ecology of running waters*. Liverpool University Press
- Grenier, P. 1949. Contributio a l'etude biologique des Simuliidae de France. *Physiologia comp. Oecol.*
- Macan, T.T. 1977. The influence of predation on the composition of freshwater animal communities. *Bio. Rev.* 52, 45-70.
- Mills, D. H. 1972. *An Introduction to freshwater ecology*. Cox & Wyman Ltd.
- Murdoch, W.W. and J. Bence. 1987. General predators and unstable prey populations. (in W.C. Kerfoot and A. Sih, eds., *Predation: Direct and Indirect Impacts on Aquatic Communities*, Univ. Press of New England, Hanover and London.) 17-30.

- Newlon, T.A. and Rabe, F.W. 1977. Comparison of macroinvertebrate samplers and the relationship of environmental factors to biomass and diversity variability in a small watershed. Research Technical Completion Report, project A-049-IDA; Idaho Water Resources Research Institute, University of Idaho, Moscow.
- Pennak, R.W. 1978. Fresh-water Invertebrates of the United States (Second Edition). John Wiley and Sons, New York. 803 pp.
- E. T. H. M. Peeters, S. Batten, J. A. J. Beijer, and J. J. P. Gardeniers. 2000. The combined effects of current velocity and substratum particle size on the performance of *Gammarus pulex*, an experimental approach. Aquatic Ecology and Water Quality Management Group, Environmental Sciences, Wageningen University, The Netherlands.
- Petranka, J.W. 1989. Density-dependent growth and survival of larval Ambystoma. evidence from whole-pond manipulations. *Ecology* 70(6), 1752-1767.
- Schell, V.A. and J.J. Kerekes. 1989. Distribution, abundance, and biomass of benthic macroinvertebrates relative to pH and nutrients in eight lakes of Nova Scotia, Canada. *Water, Air, and Soil Pollution* 46, 359-374.
- Sweeney, B.W. 1984. Factors influencing life history patterns of aquatic insects (in V.H. Resh and D.M. Rosenberg, eds., *The Ecology of Aquatic Insects*.) 56-100.
- Taylor, B.E., R.A. Estes, J.H.K. Pechmann, and R.D. Semlitsch. 1988. Trophic relations in a temporary pond: larval salamanders and their macroinvertebrate prey. *Can. J. Zool.* 66, 2191-2198.
- Stenson, J.A.E. 1978. Differential predation by fish on two species of *Chaoborus* (Diptera, Chaoboridae). *Qikos* 31: 98-101.
- Diehl, S. 1992. Fish predation and benthic community structure: the role of omnivory and habitat complexity. *Ecology* 73, 1646-1661.
- Thorp, J.H. 1986. Two distinct roles of predators in freshwater assemblages. *Qikos* 47, 75-82.
- Ward, J.V. 1992. *Aquatic Insect Ecology: 1. Biology and Habitat*. John Wiley and Sons, New York. 438 pp
- Zahar, A. R. 1951. The ecology and distribution of black flies (Simuliidae) in South East Scotland. *Animal Ecology*.