MedCrave
Step into the World of Research
Journal of Microbiology & Experimentation

Mini Review

Open Access
CrossMark

Microbial diversity: genetic diversity vs functional diversity

Abstract

The microbial ecology focuses on the study of natural microbial community dynamics and managed system. The microbial diversity is a determining factor in the dynamics and function of ecological communities. This review aims to relate genetic and functional diversity which are two vital components of the microbial communities with the purpose of relating these concepts with the ecosystem. The microbial diversity may be interpreted in three levels: species number (taxonomic), within species (genetic) and ecological community (functional). The structure of microbial communities imprints functional characteristics of the ecosystem as the occurrence of certain ecosystem processes depend on their functional structure. Therefore, the presence of functional genes (diversidad genetica) in a microorganism enables its association with the ecosystem. The metabolic information and the detection of functional genes in the communities allow identifying functional groups, to explore the functional structure of the microbial communities. Functional diversity can be used to monitor successions and effect of perturbations. Research in this aspect will lead us to answer the critical level of diversity necessary to maintain the sustainability and functionality of the ecosystem in the face of disturbances.

Keywords: microbial communities, diversity, functional groups, microorganisms, ecosystem processes

Volume 6 Issue 1 - 2018

Zamora Figueroa Alejandra Carolina
Instituto de Zoología y Ecología Tropical, Universidad Central de Venezuela, Venezuela

Correspondence: Zamora–Figueroa AC, Centro de Ecología Aplicada, Instituto de Zoología y Ecología Tropical, Universidad Central de Venezuela, Av. Los Ilustres, Sector Valle Abajo, Los Chaguaramos, Caracas, Venezuela, Tel +58 2126051416; Fax +58 2126051204; Email alejandra.zamora@gmail.com

Received: December 18, 2017 | **Published:** February 08, 2018

Introduction

Diversity is the main descriptor of community structure and is a determining factor in the dynamics and function of ecological communities.[1] However, the latter implicitly differs based on the different types of organisms and their relative abundance within the community which is considered to be significant.[2] Research in microbial ecology focuses on the study of microbial community dynamics usually, as well as managed systems. It is a difficult task, under circumstances where they are found in different proportions in nature, and are adapted to different environmental conditions such as temperature, pH, and extreme pressures, as well as the ability to use any type of organic or inorganic substance as substrate for their metabolism. This versatility in microorganisms provided the scope for answering the reasons for changes in community throughout biotic and abiotic gradients, such as productivity, area, latitude and heterogeneity of resources.[3] how these microbial communities function in nature.[4] and how disturbances (e.g. addition of a pollutant, floods or drought) modify the structure of the community. It has been hypothesized that functioning and sustainability depend on maintaining a specific level of biodiversity. In order to substantiate this statement, the present review addresses two important components of microbial communities, genetic and functional diversity, with the purpose of relating these concepts with ecosystem functioning.

Microbial diversity

Traditionally, microbial community analysis has been based on culture techniques using a variety of culture media designed to maximize the recovery of different microbial species.[5] However, culture–dependent techniques are currently not being used often since it has been proven that most microorganisms cannot be grown in vitro.[6,7] possibly due to the limitations in providing specific growth conditions in culture media.[8] However, culture–dependent studies indicate that representatives of some bacterial divisions are sophisticated and can acclimatize to a variety of environments, whereas others appear restricted to certain habitats.[9] Contemporary studies on the diversity of prokaryotes often employ methods based on the analysis of nucleic sequences of 16S rRNA genes, which detects and quantifies the phylotypes that are difficult to culture.

These microbiological–analysis techniques have provided substantial information about the presence of different microbial communities in a variety of ecological niches. In order to address studies in microbial ecology, it is necessary to comprehend the genomic changes in the microorganism through time, as well as their response to environmental conditions.[10] Based o this, the microbial diversity may be interpreted in three levels: species number (taxonomic), within species (genetic) and ecological community (functional).[11,12] The first level is the total numbers of species present (richness), and in microorganisms this determination represents a limitation.[10] This is due to the fact that microorganisms do not reproduce sexually and therefore the term, microbial species, refers to a taxonomic unit with a particular phylogenetic relationship like 97% identity of 16S rRNA.[13] The second level refers to the total number of genes present in the microorganisms that make up a community (metagenome) and it is expressed in the physiological activity of the microorganisms within the ecosystem. This aspect is reflected in the third level of diversity known as the group of metabolic activities that influence ecosystem functioning.[10,11]

Microbial functional groups

In a microbial community, many different organisms will perform the same process and probably be found in the same niches.[14] The concept of functional groups refers to a group of microorganisms that show similar responses or effects to an ecosystem process.[15] Each functional group consists of a variable number of species defined by their use of available resources in a similar manner. Occasionally, it is characterized by having a direct effect on a specific ecosystem process.[10] Microorganisms mediate key steps in biogeochemical cycles through production of particular enzymes that are coded by functional genes. The presence of a functional gene in a genome determines the membership of a microorganism within a functional group engaged in a particular ecosystem process, and the delimitation of functional groups using functional genes requires knowledge of the biological requirements of that process.[16] On the other hand, identification of ecosystem functional groups and the relevant species is vital to estimate their relative value including their presence, abundance and expression of particular genes in which the molecular mechanisms regulate ecosystem dynamics. This reveals the complexity of some apparently simple processes, which actually require the activity of a variety of functional groups.[10,16]

Relationship between ecosystem function and diversity

Microbial communities play key roles in maintaining multiple ecosystem and offers services (multi functionality), including nutrient cycling, primary production, litter decomposition, and climate regulation.[17] In other words, the structure of microbial communities imprints functional characteristics of the ecosystem since the occurrence of certain ecosystem processes depend on their functional structure; for example, organic matter decomposition depends on the microorganisms involved and their interactions. Likewise, well–organized communities that contain a certain level of diversity are stable.[18] The ability of an ecosystem to resist extreme perturbations or stress conditions partly relies on the diversity within the system.[2] If some kind of stress is introduced to this community, the stability may collapse and the diversity will change. Diversity can therefore be used to monitor successions and effect of perturbations. This approach refers to the concept of ecological resilience and validates the species richness associated to the functional diversity within the ecosystem which is directly proportional.

On the other hand, Griffits et al.[19] pronounced that greater species diversity within functional groups in the ecosystem make it more resistant to disturbance and this equilibrium is apparently related to species richness within functional groups. It has been recognized, that species within a functional group are not identical and differ in their requirements, resistance to stress, growth rate and other properties related to their competitive ability. Therefore, it is established that there may be redundant species within functional groups that may disappear during a disturbance without affecting the ecosystem. It is a fact that functional genes that carry out the same roles in disparate taxa are frequently related, falling into one same family of enzymes. This arises when functional genes are ancient evolutionary developments or have been the subject of horizontal gene transfer.[16] Then, these aspects attempt to relay the functionality of the ecosystem in relation to the maintenance of a specific level of diversity.

Conclusion

The study of microbial diversity is important as it determines the distribution of microorganisms in the environment and enhances the knowledge of the functional role of diversity. In addition, functional diversity serves as an expression of genetic diversity and allows emphasizing species synergism and can be an indicator of spatial and temporal changes. Research in this aspect will answer the critical level of diversity necessary to maintain the sustainability and functionality of the ecosystem in the face of disturbances.

Acknowledgments

I am very thankful to Maria Lopez from Editorial Office of MedCrave Group for the invitation to prepare this review.

Conflicts of interest

None.

References

1. Loreau M From Populations to Ecosystems: Theoretical Foundations for a New Ecological Synthesis. Princeton University Press, New Jersey, USA. 2010. 320 p.
2. Fakruddin M, Mannan K. Methods for analyzing diversity of microbial communities in Natural Environments. *Ceylon Journal of Cience*. (Bio Sci) 2013;42(1):19–33.
3. Hughes JB, Hellmann JJ, Ricketts TH, et al. Counting the uncountable: statistical approaches to estimating microbial diversity. *Appl Environ Microbiol*. 2001;67(10):4399–4406.
4. Torsvik V, Øvreås L. Microbial diversity and function in soil: from genes to ecosystems. *Current Opinion in Microbiology*. 2002;5(3):240–245.
5. Hill GT, Mitkowski NA, Aldrich–Wolfe L, et al. Methods for assessing the composition and diversity of soil microbial communities. *Applied Soil Ecology*. 2000;15(1):25–36.
6. Rappe MS, Giovannoni SJ. The uncultured microbial majority. *Annu Rev Microbiol.* 2003;57:369–394.
7. Ritz K. The plate debate: cultivable communities have no utility in contemporary environmental microbial ecology. *FEMS Microbiol Ecol.* 2007:60(3):358–362.
8. Trevors J. Bacterial biodiversity in soil with an emphasis on chemicallycontaminated soils. *Water Air Soil Pollution*. 1998;101(1–4):45–67.
9. Reysenbach AL, Giver LJ, Wickham GS, et al. Differential amplification of rRNA genes by polymerase chain reaction. *Appl Environ Microbiol*. 1992;58(10):3417–3418.
10. Zamora AC, Malaver N, Ramos J. Análisis Funcional de Microorganismos: un estimador de diversidad y estructura comunitaria. *Acta Biológica Venezuelica*. 2012;32(1):57–86.
11. Zak J, Willing M, Moorhead D, et al. Functional diversity of microbial communities: A quantitative approach. *Soil Biology and Biochemistry*. 1994;26(9):1101–1108.
12. Harpole W. Neutral theory of species diversity. *Nature Education Knowledge*. 2010;3(10):60.
13. Haegeman B, Hamelin J, Moriarty J, et al. Robust estimation of microbial diversity in theory and in practice. *ISME J*. 2013;7:1092–1101.
14. Zhao L, Ma T, Gao M, et al.. Characterization of microbial diversity and community in wáter flooding oil reservoirs in China. *World J Microbiol Biotechnol*. 2012;28(10):3039–3052.
15. Gitay H, Noble IR. What are functional types and how should we seek them? In: Smith TM, et al. (Eds.), Plant functional types. Their relavance to ecosystem properties and global change. Cambridge Univ Press, England, UK. 1997. 369 p.
16. Zak D, Blackwood CB, Waldrop MP. A molecular dawn for biogeochemistry. *Trends Ecol Evolut.* 2006:21(6):288–295.
17. Bardgett RD, van der Putten WH Belowground biodiversity and ecosystem functioning. Nature 2014;515(7528):505–511.
18. Yannarell AC, Triplett EW. Geographic and environmental sources of variation in lake bacterial community composition. *Appl Environ Microbiol*. 2005;71(1):227–239.
19. Griffiths B, Ritz K, Wheatley R. Relationship between Functional Diversity and Genetic Diversity in Complex Microbial Communities. In: Insam H & Rangger A (Eds.), Microbial Communities. Functional vs. Structural Approach. Springer, New York, USA. 1997. 263 p