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The Applicability of Core Community Ecological Theories in Periodontitis

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ABSTRACT

The field of ‘microbial ecology’ has gained much attention from the scientific community, especially in the past decade with the fastest improvements in ‘omics’ technologies. There is substantial evidence on commonalities in ‘community ‘in both ‘macro’ and ‘micro’ ecosystems. However, cross system comparisons in research arena needs much efforts ever than before. Periodontitis is a major public health threat, being the commonest ‘poly microbial’ disease across the globe. Here we suggest the possibility of applying six core community ecology theories: succession, community assembly, meta-community dynamics, multi-trophic interactions in initiation and progression of periodontitis from the normal healthy status and restoration. Now the time has come for the collaboration of microbiome researchers and applied scientists to uncover complex species interactions and make the cross-system comparisons. Findings of such research in ‘community ecology’ will shed light into precision periodontal management and optimized treatment outcomes from molecular perspectives through to public health perspectives.

Keywords; Succession, Community Assembly, Meta Community, Multitrophic Interactions, Disturbance, Restoration

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Highlights

- The is an unconditional truth in 'community dynamics' of 'macro' and 'micro' environments with commonalities in the ecological organization.
- Significant advancements in 'omics' technologies provide an extra ordinary opportunity to uncover the complex microbial ecosystems.
- Periodontitis is the commonest polymicrobial disease of humans across the globe dominated by gram negative strict anaerobes.
- Succession, community assembly, meta community, multitrophic interactions, disturbance and restoration are core community ecology theories which developed and validated to explain the complex species interactions of plant/ animal eco systems.
- Same theories can be applied to explain the main events of initiation of periodontitis from normal healthy status, it's progression and restoration by periodontal management using non - invasive methods.

The applicability of core community ecological theories in periodontitis

The community ecology studies on macro-organismal communities originated in 1920s (Clements, 1916; Gleason, 1926). Single or isolated theories had been proposed to explain the multifaceted species interactions culminating in the relative abundance and distribution of species across space and time in plant and animal communities. This arena has evolved slowly but steadily since then for more than eight decades, developing and validating multiple community ecological theories to explain possible theories of community dynamics in various macro ecosystems (Christian et al., 2015). Meanwhile, contemporary advancements in next generation sequencing technologies and 'omics methods'such as Metagenomics, Metatranscriptomics, Metaproteomics, Metametabolomics especially in the last decade,overcame the inherent limitations in conventional culture techniques and molecular techniques.This provided an extraordinary opportunity to unveil complex microbial ecosystems (Perera et al., 2016). Moreover, to understand the temporal and spatial dynamics of microbial communities, interactions between the community membersneed to be investigated. Against this back drop, multiple 'community ecology' theories have been developed and validated in plant and animal ecosystems to understand the emergent properties of communities in establishment of an environment, responses to unexpected changesand re-establishment (Costello et al., 2012; Christian et al., 2015; Haruta et al.,2016). Here we focus on six major theories in 'community ecology': succession, community assembly, meta community, multitrophic interactions, disturbance and restoration that could be applied to study the dynamics of host associated microbial communities in the oral cavity, with regards to the progression of periodontal diseases from the normal healthy status.These keystone theories are extensively used in agriculture, environmental science and bio medical science.

The oral cavity with its various micro habitats makes an exceptionally complex 'meta habitat' harboringdiverse anddynamic'meta community'which originated at theneonatal period and evolved with time subjected to temporal variations.This 'meta community' consistsof closer to 1000 bacterial species, fungi, archaea and protozoa (Perera et al., 2016). These microbes maintain an ecological equilibrium or homeostasis with the host by 'multitrophic interactions'based on cooperation and synergism as well as competition and antagonism with regard to the well- being and health (Perera et al., 2016). Nevertheless, in periodontitis a 'disturbance' or dysbiotic statebreaking the harmony of normal sub gingival micro flora might occur (Perera et al., 2016). This is caused by poor oral hygiene, smoking, diabetes, pregnancy, genetic susceptibility, poor nutrition, age and patients with HIV infections (Khan et al., 2015), which can be considered as ecological stress factorsfacilitating the 'community assembly'or enrichment of Gram negative, anaerobic periodonto pathogens in the sub gingival biofilm (Ai et al., 2017). Hence, periodontal diseases are initiated and continue to advanceby dysbiotic but metabolically compatible microbial consortia at or below the gingival margin.Virulent attributes of these microbes are termed as 'poly microbial synergy' involve concerted action, which could progress the disease condition via chronic inflammation. This may deteriorate loss ofthe alveolar bonearound the teethand subsequent loss ofteeth, if untreated (Lamont and Hajishengallis, 2015). Furthermore, 'mal odor' produce by 'inflammophilic' community enriched by Gram negative anaerobes, which nourishes through inflammatory tissue breakdown-derived nutrients could be considered as the most devastating 'social issue' in untreated chronic periodontitis.

Succession follows when primary colonizers of a habitat facilitate the success of secondary colonizers (Connell and Slatyer, 1977). A transition from facultative anaerobes to strict anaerobes is evident in the progression of periodontitis (Teles et al., 2013). Successionof bacterial species in supragingival plaque samples within hours (Li et al., 2004), to days (Teles et al., 2012; Uzel., 2011) and months (Haffajee et al., 2008) of undisturbed plaque accumulation has been investigated. The adhesion mechanisms demonstrated the specificity in the attachment sites for early colonizers or pioneers from saliva - the yellowcomplex facultative anaerobes such as *Streptococcus intermedius*, *Streptococcus oralis*and*Streptococcus mitis*increasing in numbers and proportions within hours of after plaque removal (Li et al., 2004). Then, putative strict anaerobic periodontal pathogens including purple complex member –*Veillonella parvula* and green complex member-*Capnocytopha gagingivalis* as well as theorange complex member-*Fusobacteriumnucleatum*enriched as successors during 7-days of supra gingivalbiofilm regrowth (Teles et al., 2013). Human intervention studies have demonstrated that therestoration of dysbioticmicrobiome in gingivitis to its former healthy status can be easily achieved by means of antiseptic mouth wash. Furthermore, control of acute periodontal infections such as acute necrotizing ulcerative gingivitis and acute necrotizing ulcerative periodontitis is obtained by treating with an antibiotic regimen consisting ofamoxicillin and metronidazole for7 days(Teles et al., 2013).

In this correspondence interpretation of existing environmental microbiology hypothesis is done by suggesting the possibility of application of core 'community ecology' theories in initiation and progression of periodontitis.This ground breaking field of research needs the collaboration of microbiome researchers and applied scientistsinvolved in community ecology studies touncovercomplex species interactions and makethe cross-systemcomparisons.

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