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REVIEW

Does alteration in biodiversity really affect disease outcome? – A debate is brewing

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Abstract How changes in biodiversity alter the transmission of infectious diseases is presently under debate. Epidemiologists and ecologists have put a lot of effort to understand the mechanism behind biodiversity–disease relationship. Two important mechanisms, i.e. dilution and amplification theories have in some manner made it clear that biodiversity and disease outcome have an intimate relationship. The dilution effect theory seems to answer some overarching questions, but paucity of information about many disease systems is a real obstacle for its acceptance. Also, there is hardly any agreement on host population threshold and critical community size vis-à-vis wild life diseases. We suggest a multidimensional approach whereby the same disease system needs to be studied in different ecological zones and then the effect of biodiversity on disease outcome needs to be ascertained. Nonetheless, caution is to be taken while jumping to any conclusion as biodiversity–disease relationship is a multifactorial process.

Contents

Abbreviations: CEM, Classical Epidemiological Model; DEH, dilution effect; MNV, Murine Norovirus.

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1. Introduction

It has been a topic of keen interest for ecologists and epidemiologists to understand alterations in the biodiversity and how they bear on the disease occurrence. The Classical Epidemiological Model (CEM) explained the relationship between host abundance and infection occurrence, but it did not describe the interaction between biodiversity and disease outcomes. In recent years, researchers have taken up this important aspect primarily because a shift in biodiversity has an intimate relationship with the transmission of disease. Perusal of the literature shows both positive and negative correlations between biodiversity and disease outbreak, though it is early to speculate which phenomenon explains this relationship in a more balanced way.

It is also evident from the recent studies on some disease systems that biodiversity does not have any influence on the outcome of a disease. Stalkeld et al. (2013), based on his meta-analysis data on zoonotic diseases concluded that disease risk is more of a local trait mainly depending on the composition of reservoir hosts and vectors. However, such studies cannot be validated for other disease systems. Also, zoonotic pathogens have different transmission patterns (i.e. it is multi-species phenomenon; see Salkeld et al., 2013) which operate under specific conditions.

Knowing the ambiguous nature of the biodiversity–disease relationship, here we critically review recent theories which have been proposed by different epidemiologists, especially in the last decade. We further look at how these theories are different from the Classical Epidemiological Model and provide suggestions for a better understanding of this relationship.

2. How is biodiversity related to disease occurrence?

Alterations in biological diversity have the potency to affect the disease occurrence both in plants and animals (Keesing et al., 2010). It has been suggested that biodiversity plays a dual role in the propagation of disease; it can on the one hand become a safe haven for novel pathogens, but at the same time helps to reduce the disease risk (Keesing et al., 2010). However, more evidence favors the mechanism in which biodiversity loss actually can increase the transmission rate (Keesing et al., 2010). Keesing et al. (2010) further stated that a reduction in biodiversity can reduce disease transmission if the lost species is a host of the infectious organisms. The paucity of empirical data does not allow us to confirm the above mentioned mechanism.

There is an intimate relationship between host competence (the ability to maintain and transmit infections) and species richness. Johnson et al. (2013) found that biodiversity decreases the disease outcome through an alteration in host competence. It has been predicted that there is a strong association between species richness, community competence and the individual characters of host species (Johnson et al., 2013). The importance of 'Community Competence' with reference to the biodiversity loss and outbreak of disease risk was also supported by Keesing et al. (2010). These studies indicated that the loss of biodiversity can affect the disease risk by altering the abundance, behavior and condition of the host or vector (Keesing et al., 2010). Moreover, they recognized that multiple mechanisms could also occur in different disease systems.

It is also important that ecologists need to understand the causes which are responsible for low and high host competence. As ecologists expect that the disease pattern may change due to global warming (Zargar, 2011), it is also essential to understand host competence under different ecological conditions. It is pertinent to understand the possible outcomes of the impact of increased host diversity on the infection pattern at different latitudes.

3. 'Dilution effect' hypothesis vs 'amplification effect' hypothesis

Biodiversity–disease relationships have been studied in a variety of ways by using different hypotheses. The most important hypothesis which has been mostly discussed and debated is the 'dilution effect' hypothesis. The 'dilution effect' hypothesis (DEH) stresses the fact that increased diversity will actually decrease the disease transmission (Fig. 1). DEH is supported by various studies (LoGiudice et al., 2003; Keesing et al., 2006). The Lyme and West Nile Virus diseases show an indirect relationship with the biodiversity. It has been opined that the expression of the Lyme disease is reduced when the diversity of hosts for ticks increases (LoGiudice et al., 2003). Similarly, higher avian biodiversity has been suggested to

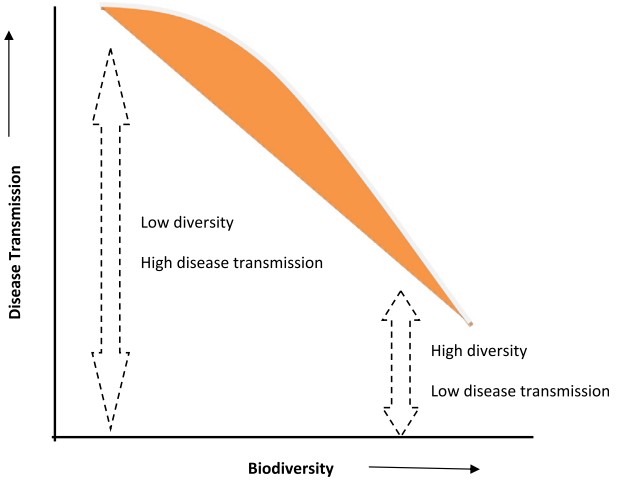

Figure 1 Diagrammatic representation of 'dilution effect' theory (based on LoGiudice et al., 2003 and Keesing et al., 2006).