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IMPACT OF BIODIVERSITY ON TICK-BORNE DISEASES

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ABSTRACT

It is a well-known fact that high biodiversity is related to the health and proper functioning of environment. Recently, the attempts to search the relations between biodiversity and human health are also undertaken. A number of studies demonstrate that people living in undegraded environment are less exposed to the diseases of affluence. However, they are at a higher risk of contracting zoonoses. It is believed that the higher the number of animals, the higher is the number of ticks. Consequently, there is a serious risk of borreliosis and other tick-borne diseases. Such assumption, however, may be erroneous. A number of studies suggest a decreasing prevalence of tick-borne disease pathogens in high-biodiversity areas. In this paper, a promising hypothesis explaining this relation is discussed.

Key words: *Lyme disease, ticks, biodiversity, dilution effect*

INTRODUCTION

Castor bean tick (*Ixodes ricinus*) is a common ectoparasite of terrestrial animals. Ticks parasitize birds and reptiles. To the largest extent, they infest mammals which are decisive hosts for their survival. Small mammals, mainly rodents, are the most common hosts for ticks' larvae and nymphs. Adults feed on large mammals, especially those belonging to the family *Cervidae*. Ticks may feed on each vertebrate species. Thus, they are common parasites in humans. Ticks are considered to be dangerous as they are the vectors of many pathogens, including viruses (tick borne encephalitis), protozoa (*Babesia sp*.) and bacteria (*Borrelia burgdorferi*, *Anaplasma phagocytophilum*) (1,2,3). Ticks become infected while feeding on infected hosts. Animal whose population predominantly carries pathogens but does not present with symptoms is a natural reservoir of infection. Infection with *Borrelia burgdorferi* in human (horse or dog), however, may lead to Lyme disease. In Poland, an increasing number of Lyme disease cases is observed (4,5). Moreover, studies on the prevalence of antibodies to *B. burgdorferi* in humans suggest that this number is underestimated (6,7). Probably, it results from unspecific symptoms of disease, except for erythema chronicum migrans. However, such symptom is not always reported (8,9). An increasing role of ticks in the epidemiology of diseases is attributed to the changes in natural environment such as wetland drainage and wasteland forestation (10). It may also be affected by the phenomenon of global warming. From researches transpires that the increase of global temperature leads to the extension of geographic distribution of many tick species (11). Recently, a relation between the decrease of tick host biodiversity and the higher risk of tick-borne diseases is widely discussed (12-14). The objective of this article is to investigate this relation.

DILUTION EFFECT HYPOTHESIS

Until now, it was a common belief that the higher the number of ticks, the higher is the risk of tick-borne diseases (10). However, it should be noted that tick hosts differ from one another with regard to reservoir competence (15) with an example being *B. burgdorferi* whose list of hosts includes a number of mammals, bird and reptiles species. Rodents are the most competent reservoir of *B. burgdorferi*. The majority of rodents are infected with this bacterium (3). Large mammals such as those belonging to the family *Cervidae* and carnivores are considered to be less competent reservoirs (15) while even less competent are reptiles (16-18). It was assumed that poorly competent reservoirs can dilute the effect of competent reservoirs by ensuring alternative areas for tick infestation in which the risk of infection is lower (19,20). On a basis of this, American parasitologists of the team of Richard Ostfeld from the

Cary Institute of Ecosystem Studies developed a dilution effect hypothesis which correlates biodiversity with the prevalence of vector-borne diseases on a particular area (12-14). For dilution effect to be present in environment, four criteria are to be met: (I) vector must be a generalist which means that it has to feed on different host species, not only on selected ones; (II) hosts species must differ from one another concerning reservoir competence; (III) the most competent reservoirs must predominate in environment and feed the majority of vector population; (IV) there is no transovarial transfer of pathogens (from female to her offspring) in vector (12). All of these criteria are met in case of *Borrelia*-tick-vertebrate model. Furthermore, studies suggest the occurrence of dilution effect in natural environment (21-23). Computer modelling is also supportive in this respect. It enables to operate with the number of tick host species. It unambiguously demonstrates that the increase in the number of species in environment leads to the decrease of pathogen prevalence in ticks (19). Field works also confirmed the phenomenon of dilution effect. It is well-illustrated by the studies on tick-borne encephalitis virus. The results suggest that the decrease in the number of *Cervidae* population, which is a poorly competent reservoir, but simultaneously an important host of ticks, leads to the significant increase in the prevalence of this virus in natural environment (31). Researches on other species with the examples being *Trypanosome* and West Nile Virus which are transmitted by bugs (24) and mosquitoes, respectively (25-27) also confirmed the dilution effect hypothesis. These studies demonstrate that the higher the biodiversity, the lower the percentage of vectors are infected with pathogens.

IMPLICATIONS FOR ENVIRONMENT PROTECTION AND TICK-BORNE DISEASE PREVENTION

Studies on dilution effect refute the opinion that the higher the number of vector hosts, the higher is the risk of tick-borne diseases. Rodents such as voles, mice and rats which are the most competent *Borrelia* reservoirs occur in all, even extensively degraded environments of low biodiversity. Thus, these animals are associated with the highest risk of infection. Increasing biodiversity, resulting from the appearance of new species, which are predominantly poorly competent reservoirs (e.g. lizards, large and medium-sized mammals, birds), leads to a decreasing probability of tick infestation of rodents. Consequently, a risk of infection is reduced (Fig.1.).

Such phenomenon calls for a change of the approach to tick-borne diseases prevention. Actions undertaken with the objective to reduce the number of tick hosts seem to be inappropriate as finally the effect could be different from the one expected. A good example can be the process of fox population reduction. These animals are common tick hosts, however, they are poorly competent *Borrelia* reservoir. In fact, a few of them transmit *Borrelia* (12). Thus, they dilute the high

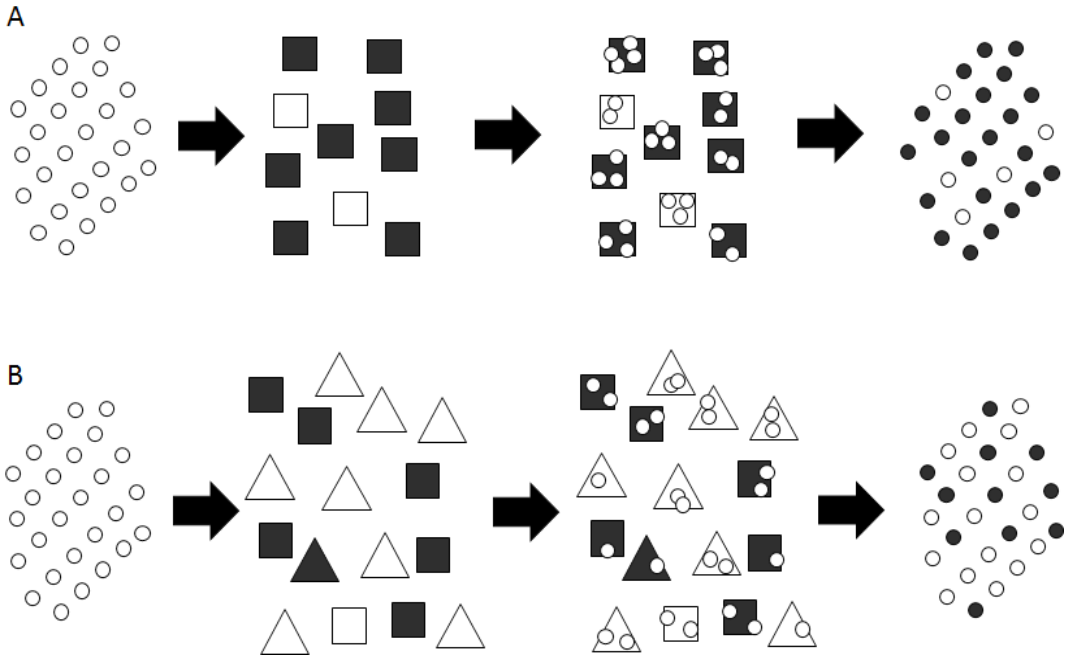

Fig. 1. Dilution effect scheme. Ticks (white dots) in low-biodiversity environment (A) have a great chance to feed on a competent reservoir host (quadrangles), which with high probability would be infected with pathogens (grey). As a consequence, the majority of ticks will become infected (grey dots). In high-biodiversity environment (B) ticks have a great chance to feed on poorly competent reservoir host (triangles). Probably, they would not become infected.

prevalence of pathogens in rodents. Furthermore, as foxes feed on rodents, they reduce the population of the most competent reservoir. Therefore, it might be possible that the increasing number of foxes has a positive effect on the epidemiology of tick-borne diseases, consequently reducing the risk of infection in humans. It should not be forgotten, however, that the presence of foxes is associated with other risks such as infection with *Echinococcus granulosus* or rabies virus. A different relation between parasite and host is observed in case of *Cervidae* population. These animals play an important role in tick life cycle as here adult ticks most frequently reproduce (28). Moreover, ticks to the largest extent feed on *Cervidae* population (28). Until now, it was thought that the reduction of *Cervidae* population contributes to the decrease of tick-borne disease risk. However, recent studies suggest a contrary relation (28). It results from the fact that ticks are rarely infected while feeding on these animals (15,29).

Another species which may contribute to borreliosis prevention are lizards. Sand lizard *Lacerta agilis* and viviparous lizard *Zootoca vivipara*, which are common in Poland, are poorly competent *Borrelia* reservoirs. Simultaneously, however, they are hosts for a number of ticks (16,30). Moreover, it is assumed that viviparous lizards may eliminate this bacterium during hibernation when their body is totally frozen. Thus, they may serve as filters where ticks may be cleared of pathogens. Further studies are required in this respect for better understanding of mechanisms in pathogen-parasite-host model. So far, the initial results are promising. They suggest that healthy and more diversified environment may improve human health.

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