Genes & Diseases (2017) 4, 154–158

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://ees.elsevier.com/gendis/default.asp

REVIEW ARTICLE

Life history tradeoffs of pathogens and the treatment principle of antibiogenesis

Rui-An Wang

Department of Pathology, Shenzhen Hospital, Southern Medical University, Shenzhen 518100, China

Received 20 March 2017; accepted 13 July 2017
Available online 20 July 2017

KEYWORDS
Antibiogenesis;
Bacterium;
Fecundity;
Infectious disease;
Life history tradeoffs;
Lifespan;
Pathogen;
Virus

Abstract There are no eternal individual lives so life continues by relaying with reproduction. Consequently, lifespan and fecundity are two essential genetic traits of life. The life history tradeoffs theory holds that there is an inverse relationship between lifespan and fecundity. This paper proposes two new concepts, i.e., "lifespan of pathogens" and treatment of infections by "antibiogenesis". The lifespan of pathogens is the time limitation of those tiny lives just as other large creatures. Notably, the lifespan of bacterium is the time interval from the cell division by which it is produced to next division by then its life ends and transforms to two new lives, or dies. Antibiogenesis means inhibiting generation of new lives. By the principle of life history tradeoffs, the lifespan of pathogens determines the speed of their proliferations and consequently the modality of infection. The treatment principle of antibiogenesis requires the duration of treatment to be determined by the lifespan of infected pathogens. The life history tradeoffs theory and the two concepts are helpful to understanding the pathobiology and shaping the clinical aspects of infectious diseases.

Significance of the paper

For the first time the paper answers the following questions. 1) Are bacteria immortal? How are their lifespans defined? 2) Why is the latent period of hepatitis A, SARS, plague infections very short and why are there no chronic infections of these pathogens? 3) Why does the treatment of tuberculosis and leprosy take a long time? 4) Why, in the case of hepatitis B, does immunotolerance not result in rampant proliferation of the virus? The tradeoff between the lifespan and fecundity is the law of conservation in biology. If a species has a long lifespan with high fecundity, the biological system would not exist; similarly, if it has a short lifespan with low fecundity, the species would not exist.

E-mail address: ruian79@yahoo.com.
Peer review under responsibility of Chongqing Medical University.

http://dx.doi.org/10.1016/j.gendis.2017.07.004

Introduction

It is well-known that no eternal individual life exists in the biosphere. However, life continues by relaying from generation to generation with reproduction. Thus lifespan, the time limitation of an individual life, and fecundity, the efficiency with which an individual life can multiply or propagate, are the two essential genetic traits of life. The life history tradeoffs evolution theory holds that there is an inverse relationship between the two.[1] Figuratively, the relationship between the lifespan and fecundity is just like the diagram of Taiji (Fig. 1). Lives with long lifespan have a lower fecundity, and vice versa.[12] The tradeoffs between lifespan and fecundity are universal in the biosphere, ranging from microorganisms to plants and to animal kingdom, including humans.[2–6] While the mechanisms of the tradeoffs are still an enigma,[7] it is critically important to maintain the diversity and balance of the biosphere for the existence of species. The tradeoffs not only exist between species[8] but also are important adaptation mechanism for a given species. It has been shown that when lifespan extended in model animals, the fecundity inevitably weakened. Sir2 in yeast was shown to be a balancer between the longevity of parent cells and the number of progenies produced by a parent cell.[3] The life history tradeoffs in viruses and cancer cells have also been noticed in recent years.[9–11]

The tradeoffs between lifespan and fecundity are the key to the balance of biosphere. They are like two variants in an equation. If both of them decrease, i.e., short lifespan with lower fecundity, this life cannot exist. Conversely, if both of them increase, i.e., an organism with long lifespan and robust fecundity, such as the fictitious creature of the Darwinian demon, this life will dominate the ecosystem and the whole system will collapse immediately.

Microorganisms and parasites are highly important in medicine. Except for some worms, the pathogens are generally tiny lives. Interestingly, although we have a better knowledge of how long a specific type of worm lives, we rarely think about the lifespan of bacteria and viruses. Nonetheless, the lifespan of these pathogens is critical for understanding their biological properties and the diseases they cause.

Figure 1 Interrelationship between lifespan and fecundity is depicted by the Taiji diagram. The fecundity increases as the lifespan shorten. Reversely, when the lifespan prolongs, the fecundity decreases.

The lifespan of bacteria

Lifespan of bacteria is from one division to next division or death

Bacterium is a special type of life generally deemed to be immortal, because they reproduce by division. When a cell divides, it is hard to know where and when the life will end. If they keep on dividing, the life seems to be limitless. Based on the same principle, tumor biologists deem that cancer cells are immortal. However, there is no eternal individual life in the philosophical sense. The trick is when a cell divides, its original life no longer exists, and instead it is transformed into two new lives. So the lifespan of a bacterium or any cell which reproduces by division is from one division to next division or death. The immortality of the bacteria and cancer cells is just a mirage without metaphysical reasoning.

Why is *M. tuberculosis* so difficult to grow and *M. leprae* never grown on a plate?

Defining the lifespan of bacteria not only settles a contradiction but also is critically important for understanding the biology of bacteria and many other related issues in medicine. For example, *M. tuberculosis* is a slowly growing bacterium. Professors of microbiology often describe *M. tuberculosis* as "lazy" (reluctant to grow), "hard" (nutritiously more demanding) and "tough" (their infections are difficult to treat) in class teaching. Yet there is no logical and metaphysical explanation to all these phenomena. A more difficult bacterium is *M. leprae*. It has never been successively grown in the lab ever since it was discovered about one and a half centuries ago.

With the concept of bacterial lifespan, we understand that since the *M. tuberculosis* has a longer lifespan than most of common bacteria such as *E. coli*, they inevitably grow slower. The generation time of *E. coli* is about 18–20 min and the generation time of *M. tuberculosis* is around 18 h *in vitro*. The generation time is considered as surrogate average lifespan of the bacterium under specific conditions. No one knows the generation time of *M. leprae* since it has never been successfully grown *in vitro*. The explanation is that *M. leprae* has such a long lifespan that a colony will not show up for months, or even years.[12]

The lifespan of pathogens determines the infection type they cause

As lifespan holds an inverse relationship with fecundity, pathogenic bacteria with short lifespans proliferate very fast and tend to cause acute infections in a short latent period (Fig. 2, curve A). In contrast, those pathogenic bacteria with long lifespans proliferate very slowly and cannot generate large amounts of pathogens in a short time so they usually cannot cause acute infections (Fig. 2, curve C). The latent period of diseases caused by long living pathogens is also very long. In addition, when antibiotics are applied, the short living bacteria soon die out so that acute infections get cured in a short time (Fig. 3). However,