The Biology of Crayfish Plague Pathogen Aphanomyces astaci: Current Answers to Most Frequent Questions

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The Biology of Crayfish Plague Pathogen Aphanomyces astaci

Current Answers to Most Frequent

Questions

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Introduction

Fungal and fungal-like pathogens are responsible for some of the most severe diseases occurring in wildlife. During the last decades, natural populations of endangered animal species have experienced an increasing number of fungal infections. Some of the pathogens responsible for these diseases are associated with the first documented extinction events in various species caused by infection and resulting in increasing rates of biodiversity loss (Fisher et al. 2012). Probably, one of the most notorious cases is the so-called 'crayfish plague' caused by the fungal-like organism Aphanomyces astaci Schikora (Oomycetes). This pathogen is considered among the one hundred world's worst invasive species (http://www.issg.org), and has destroyed the majority of the native populations of freshwater crayfish in Europe (Unestam 1972, Edgerton et al.

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2004, Diéguez-Uribeondo et al. 2006). The rapid and devastating effects of crayfish plague, and the loss of dense native populations, have consequently resulted in a number of generalizations and myths of this disease throughout Europe.

Over time crayfish plague has become one of the best-known invertebrate diseases due to recent advances in developmental biology, cell biology, genomics, molecular taxonomy and phylogeny. Additionally, the development of molecular tools

for identification of A. astaci is providing a better understanding of the biology and molecular genetics of the crayfish plague pathogen. There is still a substantial lack of understanding of the disease and the biology of the pathogen by the general public, but also by people involved in the management of freshwater ecosystems. This can lead to difficulties when trying to implement conservation action plans. Thus, the aim of this chapter is to provide information on the main general questions on crayfish plague by reviewing the current state of the art of this disease. Through these questions, we intend to present an update of the current knowledge, recent developments, and new innovative technologies on the crayfish plague. Furthermore, we will provide recommendations on how this information can be applied to successful conservation and management programs.

What is Crayfish Plague?

Crayfish plague is an infectious disease that affects freshwater crayfish and is caused by the zoospore producing species A. astaci (Oomycetes). Crayfish plague is one of the most devastating diseases ever reported in animals. It has literally 'wiped out' the majority of the native populations of freshwater crayfish in Europe, where it has spread rapidly throughout the continent (Fig. 9.1) (Unestam 1972, Alderman 1996, Edgerton et al. 2004). Because of this dramatic population decline, the European native species of crayfish are listed in the Red List of Threatened Species of the IUCN (Füreder et al. 2010): as 'Endangered' Austropotamobius pallipes (Lereboullet), as 'Vulnerable' Astacus astacus (L.), as 'Data Deficient' Astacus pachypus Rathke and Austropotamobius torrentium (Schrank), and as 'Least Concern' Astacus leptodactylus Eschscholtz.

This rapid decline is due to the fact that European native species of crayfish are extremely susceptible to the crayfish plague pathogen. This pathogen grows fast in the cuticle of susceptible crayfish, and spreads through other tissues causing death of the host in sometimes as little as six days after exposure to zoospores (Unestam 1972, Alderman and Polglase 1986, Makkonen et al. 2012) (Fig. 9.2). As a consequence, the populations of the highly susceptible species can suffer mass mortalities that tend to affect 100% of the individuals, and not the rest of fauna and flora (Diéguez-Uribeondo et al. 2006). Moreover, other crayfish species are also susceptible to this disease, and globally, this pathogen is currently threatening more than 300 native species in Asia, Madagascar, Australasia and South America (Taylor 2002).

Fig. 9.1. Spread of crayfish plague in Europe. The dot-line indicates a possible way of introduction of this disease from North American. Black-circles indicate places where high mortalities of crayfish were diagnosed or resembled cray fish plague in early spread of the disease. Black lines indicate possible ways of spread of the initial wave of the disease. Gray circles show some of the first introductions of the alien crayfish plague carriers, Pacifastacus leniusculus and Procambarus clarkii , respectively, that generated new crayfish plague outbreaks.

When did Crayfi sh Plague First Occur?

The first crayfish mass mortality events where no other aquatic species were affected and resembling crayfish plague were reported in 1859 in Lombardy, Italy (Ninni 1865, Seligo 1895), and from there, it seems to have spread to other regions of Italy (Alderman 1996) (Fig. 9.1). A second focus of crayfish plague started in France on the Plateau de Langres in 1874, and was followed by a series of outbreaks in other regions of France, e.g., Aisne, Aube, Haute, and Alsace. The outbreaks seemed to have spread to Germany in 1877, Austria in 1879, Belgium and Luxemburg in 1880, Slovenia in 1880–90, Switzerland in 1881, Prussia in 1883, Latvia in 1886, Russia in 1892, Estonia in 1894, Finland in 1900, Sweden in 1907 and Lithuania 1920 (Alderman 1996) (Fig. 9.1). A more recent summary of all countries affected was summarised by Oidtmann (2009).

The causative agent of the disease was not identified until 1903 by Schikora and was not isolated until 1930's (Nybelin 1934). Since then, crayfish plague has been striking the native freshwater crayfish population in Europe until today. It is not known how this pathogen was brought into Europe, but there are records showing that introductions of freshwater species from America were particularly intense in the 19th century. The first report of an introduction of a North American crayfish species is dated in 1890, when 90 specimens of the spiny cheek crayfish, Orconectes limosus (Rafinesque), were imported to Europe and successfully released into a pond in Barnówko, Poland

Fig. 9.2. The crayfish plague pathogen Aphanomyces astaci: (a) a specimen of the susceptible species white-clawed crayfish, Austropotamobius pallipes, dying on crayfish plague; (b) colonization of the cuticle by hyphae of A. astaci. The cuticle has a melanized spot at the site of penetration as a result of the response of immune system of the crayfish; (c) characteristic rounded hyphal tips of A. astaci growing within the cuticle; (d) melanized hyphae of A. astaci growing within the cuticle of the North American crayfish species Pacifastacus leniusculus. Scale bar = 20 μm.

(McDonald 1983, Filipová et al. 2011). Other introductions during this period are also reported in 1895 in France but with no success (Kossakowski 1966). The spiny cheek crayfish was found to be a chronic carrier of this disease in 1984 (Vey et al. 1983), and later confirmed by Oidtmann et al. (2006), and others (Kozubíková et al. 2011). This crayfish species became widely spread throughout Central and Northern Europe by man, and acts as chronic source of the pathogen (Grandjean et al. 2014). Thus, imports of this crayfish species seem to have been one of the first, if not the original, sources of introduction of crayfish plague into Europe.

Huang et al. (1994) showed that new waves of crayfish plague outbreaks in Sweden coincided with new large-scale set of introductions of other North American crayfish species, i.e., the signal crayfish Pacifastacus leniusculus (Dana), in 1964–1969 (Bohman et al. 2006). Furthermore, Diéguez-Uribeondo et al. (1997a) and Diéguez-Uribeondo and Söderhäll (1999) showed the connection between the introductions of signal crayfish and the red swamp crayfish Procambarus clarkii (Girard) in 1973–1974 with the declines

of native crayfish in Spain. Norway was affected in 1971 (Taugbøl et al. 1993), Spain in 1975–1978 (Diéguez-Uribeondo et al. 1997b), England in 1981 (Alderman 1993), Greece in 1982 (Alderman 1997), Turkey in 1984 (Alderman 1997) and Ireland in 1986 (Matthews and Reynolds 1992). In England and Greece, the outbreaks have been shown to be related to introductions of the signal crayfish (Alderman et al. 1990, Alderman

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