1. Alarm bells ringing: more of the same, and new and novel diseases and pests

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Abstract

Global change has increased the interest of politicians and the public alike to seek ways and means to preserve the planet and mitigate a looming human health catastrophe. Europe has experienced, during recent years, the introduction of vector-borne diseases from tropical regions, notably Africa. Although it has been argued that climate change is the key responsible factor for more northerly distributions of vectors, their competence to transmit pathogens, and observed invasions, other drivers, notably travel and trade, and insecticide resistance have also facilitated these processes. Examples are given of recent vector-borne disease outbreaks (Chikungunya in Italy and Bluetongue virus in The Netherlands). It is concluded that increased occurrence of vector-borne diseases in endemic regions and more frequent 'contact' with Europe will lead to an increasing number of invasions and disease outbreaks in the foreseeable future.

Keywords: Europe, pest, vector-borne disease, climate change, transport, travel, insecticide resistance

Introduction

Never before in the history of mankind has the impact of globalisation and industrialisation been more felt and debated than at the start of the third millennium. Not only have the consequences of our changing planet featured more prominently on the agenda of scientists and politicians during recent years, also the broader public has been exposed and involved more intensively, not in the least due to Al Gore's 'An inconvenient truth' (Gore 2006). The world has witnessed the sudden outbreak of severe acute respiratory syndrome (SARS) in 2003, as well as its rapid decline, with alarm and disbelief (Elston 2005, Yu and Sung 2004). Suddenly, a new disease, potentially fatal to humans, had emerged seemingly from nowhere, and for reasons that were not well understood. Around the same time, outbreaks of Ebola virus in Africa were reported with increasing frequency, without a clear explanation for the rise in incidence of this highly fatal disease (Legrand *et al.* 2007, Walsh *et al.* 2005). Since 2005 the world is in the grip of avian influenza, caused by the influenza viral strain H5N1, which not only affects birds, but can jump to humans where it causes extraordinarily high fatalities in patients (Elston 2005, Peiris *et al.* 2007).

The realisation and acceptance that global change, and more particularly so climate change (Figure 1), are very likely the result of human activities have led to rising concern over how this will affect human health (WHO 1996, McMichael 2001, IPCC 2007). The already observed and likely to increase phenomena related to climate change are multifold and entail, besides global warming, more extreme weather conditions. Warmer winters, increased precipitation, and warm spells/heat waves are likely not only to affect humans (Kovats *et al.* 2005, Campbell-Lendrum and Woodruff 2006) but entire ecosystems and organisms that occupy these. Rising temperatures will have the highest impact on the biology of poikilothermic species (i.e. species for which body temperature varies with the temperature of its surroundings), which includes all arthropods that feature in this volume. Arctic regions and deserts are hostile regions for most arthropods, whereas these

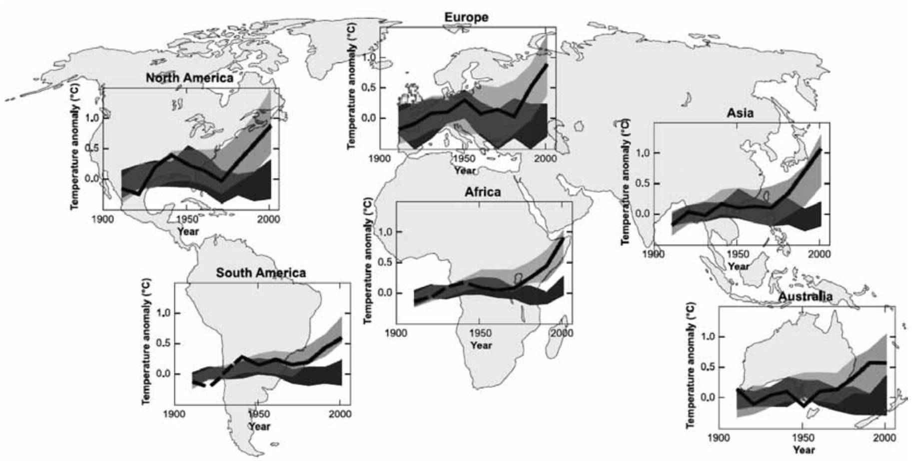

Figure 1. Changes in the observed (black line) and modeled temperature anomalies (5 and 95% confidence limits for the period 1906-2005. Light grey: confidence limits incorporating 14 climate models that include anthropogenic change. Dark grey: confidence limits of 5 models excluding human-induced change (IPCC 2007).

organisms thrive in regions where temperatures are tropical but rainfall tempers the impact of heat. The worlds biodiversity hotspots are located in tropical regions, where insect life in particular is abundant and characterised by high diversity (Orme *et al.* 2005). In general, arthropods respond to increased temperatures by expanding their distribution range to occupy new suitable habitats, by displaying altered physiological processes that include higher reproductive rates, by having an increased longevity and higher food consumption, and through benefiting the transmission of pathogens because of reduced extrinsic incubation periods. All of these factors are therefore likely to increase the abundance and spatio-temporal distribution of arthropods that cause nuisance to humans and livestock as well as those that transmit disease (Githeko *et al.* 2000, Khasnis and Nettleman 2005). Consequently, we may expect a geographical redistribution of vector-borne diseases and pests depending on the response of these organisms to the changing environmental conditions (Patz and Kovats 2002, Patz and Olson 2006, Rogers and Randolph 2006).

It has been argued that the focus on global warming as the sole cause for increased problems with arthropod-borne diseases is (at least partially) misleading as other anthropogenic and environmental changes also contribute to the observed phenomena (Molyneux 2003, Sutherst 2004, Zell 2004, Takken *et al.* 2005a, Sumilo *et al.* 2007). In the case of malaria, for example, well-documented land use changes such as hydrological, urbanisation, mining, agricultural, and forest-related impacts (exploitation activities, road construction, deforestation and population movements) are having significant impact on the global burden of this disease. In the case of many settings, for instance the Amazon region of Brazil, all these factors interplay (Takken *et al.* 2005b) and continue to aggravate the situation (Arruda *et al.* 2007, WHO 2005).

The above example relates to a tropical disease, but similar problems are being faced within the confines of the European continent. Unlike most people inhabiting developing countries, who have adapted both from a socio-economic and health perspective to the ever-present burden of arthropod-borne infectious disease, Europeans have become used to the absence of such threats, progressively so since the 1960s. The gradual decline of diseases like malaria, largely attributed to improved health care and application of the residual insecticide dichloro-diphenyl-trichloroethane (DDT) for vector control (e.g. Snowden 2006, Bruce-Chwatt and De Zulueta 1980), resulted in 'Anophelism without malaria', when potential vectors persisted in the environment, but the parasite reservoir was eradicated (Jetten and Takken 1994). Most Europeans now consider malaria a disease of the tropics and merely a risk associated with travel to endemic regions. Yet, in south-eastern Europe (Turkey) a contrasting situation is unfolding, whereby agricultural expansion through irrigation schemes, coupled with a migrant labour force, is causing grave concern and indeed more frequent malaria epidemics (Ejov 2001). With increasing frequency, these developments spark discussions about the possible return of malaria to much of southern and even northern Europe. Although the risk of focal autochthonous transmission is not zero, historic endemicity levels will not recur given the likely and adequate responses of public health authorities to such possible events (see Chapters 2 and 3).

From models to outbreaks

Much different is the situation regarding arboviral diseases such as the West Nile, Usutu, dengue and Chikungunya viruses. Mosquito-borne, these diseases originate from the African continent and have become established in the northern hemisphere. Of key importance here is the fact that these viruses have non-human hosts, in which the virus can amplify, and through which they can conquer a lot of territory over a short period of time (e.g. through bird migration). West Nile virus reached New York in 1999 (Briese *et al.* 1999) and moved across the USA to reach California, following hundreds of fatal and thousands of seriously ill patients, a mere five years later. The massive impact of this disease introduction in a naïve host population (Komar 2003) has recently been attributed to genetic changes affecting its virulence (Brault *et al.* 2007). Likewise, the Usutu virus reached Central Europe, possibly through a migratory bird returning from Africa, and has since sparked an outbreak in bird populations in Austria (Weissenböck *et al.* 2002). It has spread to neighbouring countries since, causing local outbreaks in Budapest, Zürich and northern Italy (see Chapter 9).

The current availability of powerful computing tools and remote sensing technology has led to numerous attempts to predict the distribution of vectors and disease in response to change, from country, to regional, to global levels (Martens and McMichael 2003). Biological or empirical models that incorporate measured relationships between vector and/or pathogen development, or are based on correlations between spatio-temporal distributions in relation to environmental variables (statistical models) have sought to define the likelihood for establishment of vectors and the stability of the host-pathogen-vector system once in place (Campbell-Lendrum and Woodruff 2006, Kiszewski *et al.* 2004). The basic reproductive rate, R_0, integrates several important variables, and is indicative for the absence (if <1) or presence (if >1) of potential spread of disease (Anderson and May 1992).

Regarding Chikungunya virus, recent calculations of this latter parameter yielded values of close to 1 for southern Europe in the case of transmission by the Asian tiger mosquito *Aedes albopictus* (Skuse). The establishment of this competent vector in southern Europe (mainly in Italy), following its global spread facilitated by the used-tyre trade (Reiter 1998) coupled with the return of virus-infected human hosts from various Indian Ocean islands in 2005/6, where a massive epidemic of this disease raged at that time (Pialoux *et al.* 2007), caused concern for an outbreak in Europe (Fusco *et al.* 2006). As recent as August 2007 this indeed happened when the first outbreak of this tropical virus was recorded in two small towns near Ravenna, in the Emilia Romagna province, on the Adriatic coast. Believed to be introduced by an infected traveller returning from India, the local tiger mosquito population vectored the disease effectively to some 150 inhabitants of the Ravenna region (Enserink 2007, see also Chapters 10 and 14 for more details). This event clearly demonstrates that the likelihood of vector-borne disease establishment can be predicted accurately and may indeed happen.

Invasion through travel and trade

The aforementioned case of Chikungunya introduction in north-eastern Italy demonstrates the importance of another driver for change in vector-borne disease occurrence, namely travel and trade. Since the 1950s, air transportation has seen a growth of nearly 9% per year, and shipping traffic has grown nearly 30% in that time (Upham *et al.* 2003, Zachcial and Heideloff 2003). Africa alone has seen an increase in tourist travelers from 6.7 to nearly 17 million within a decade (1990-2000) (Franco-Parades and Santos-Preciado 2006). Not only has the number of travelers returning to Europe with infectious pathogens increased (Jelinek 2000), also vectors have been shown capable of hitchhiking on long-haul flights (Tatem *et al.* 2006a) or in shipping containers (Tatem *et al.* 2006b). A striking example entails the introduction and possible establishment of *Ae. albopictus* in The Netherlands in 2005 through container shipments of Lucky Bamboo (*Dracaena sanderiana*) arriving from southern China (Scholte *et al.* 2007, see also Chapter 14).

The devastating outcome of the introduction of bluetongue virus in The Netherlands in August 2006 provides yet another example of how trade and travel can introduce a vector-borne disease in areas far from where it is endemic. In September 2007, a year after its introduction, Dutch farmers were suffering the loss of some 3000 sheep per week (see Chapters 6 and 7).

More of the same…

Two interesting examples of human and livestock pests feature in this book because of another major driving force: insecticide resistance. Head lice have long played a negligible role until resistance to commonly used products surfaced and led to increased prevalence and sometimes epidemics in the late 1990s (Hill 2006, see also Chapter 17). A similar problem has been reported regarding the resurgence of the sheep scab mite in the UK, which again appears to be closely linked to the loss of insecticidal efficacy of widely used veterinary pesticides (see Chapter 13). The story is not different for bed bugs that can now be found in five star hotels in major European cities (see Chapter 15).

And new and novel…

Throughout this volume it surfaces that Europe can no longer be considered without risk of introduction of vector-borne disease. Since the start of this millennium many introductions have taken place, and most recently this included an African virus, transmitted by an Asian mosquito species, in Europe. Of the various drivers of change discussed, climate change, travel and trade, and insecticide resistance are predominantly reported to have caused more of the same, or new and novel. The presence of Lyme borreliosis and Tick-borne encephalitis in Europe is not new, but certainly considered to be increasing. In the Netherlands alone, cases have tripled since 1994 (estimated at nearly seventeen thousand in 2006) (Hofhuis *et al.* 2006). Although the changing distribution and overwintering of ticks in larger numbers and different life stages has been attributed to climate change (Lindgren and Jaenson 2006), this again appears to be only part of the cause for increased prevalence of tick-borne disease (Sumilo *et al.* 2007). Changes in human behaviour, and in particular increased outdoor activity, are considered additional drivers (see Chapters 11 and 12).

Worldwide a large number of diseases are transmitted by arthropods. Increased prevalence in regions where these are endemic, coupled with increased interaction with Europe are making their introduction and possible establishment ever more likely. This volume details, for a number of arthropods and vector-borne diseases, the factors that underpin invasion success and elaborates on how these can be mitigated. Alarm bells, though, are ringing.

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