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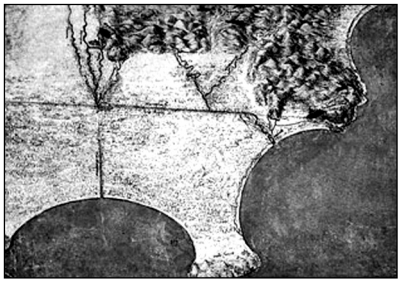
Public Health History Corner



The Agro Pontino, climate change and malaria

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Introduction

Recently in Italy a case of malaria was reported (November 2009). The patient was an Italian man of 44 years of age who had not travelled out of the country. The man apparently contracted malaria during a 2 weeks stay in August 2009 in a former malaria endemic area, the "Agro Pontino" (60-100 km South of Rome). Although confirmation of the *Plasmodium* species and the results of the epidemiological investigation undertaken by the Ministry of Health are still not available, the case seems unlikely to be linked with accidental contact of the patient with imported vectors or contaminated blood. This case raised concern over the possible recrudescence of malaria in Italy, especially in light of current and future climate change. Given the importance of the topic, this article will provide a brief review of the history of malaria in the Agro Pontino and the recent discussions that have appeared in scientific journals concerning the link between malaria and climate change.

Current statistics of Malaria in Italy

Malaria was eradicated in Italy after the Second World War following a large eradication campaign. The vectors that were targeted were *Anopheles labranchie, A. superpictus and A. sacharovi* and the World Health Organization declared the country free of malaria in 1970. Since 1970 most of the cases that have occurred in Italy have been imported, few are autochthonous (because of vectors that have arrived with airplanes, shipped luggage and containers) or because of accidental infections (blood transfusions or organ transplants). When the mode of transmission of autochthonous cases is not certain, the case is classified as "cryptic". The latest statistics available on malaria in Italy [1] refers to the period 2002-2006 (2006 included). In these 5 years, 3354 cases were reported, 99.9% of which were imported. Only 4 cases were linked to autochthonous malaria (1 cryptic case and the other 3 linked to blood transfusions or organ transplant). *Plasmodium falciparum* was responsible of 84.6% of the cases, *P. vivax* 7.7%, *P. ovale* 6.0% and *P. malariae* 1.5%, while the remaining 3.0% was found to be of mixed origin. In total 16 people died during 2002-2006, with a lethality among non Italian patients of 0.6% and among Italian patients 1.5%. Before 2002, only 1 case of a woman infected with *Plasmodium vivax* linked to indigenous *A. labranchie* was reported. This occurred in 1997 in coastal Maremma which is approximately 120 km North of Rome [2].

The history of malaria in Agro Pontino

Nearly 40 years after the WHO declared Italy free from malaria-risk, a probable new autochthonous case of malaria was announced from a geographical area that symbolizes the liberation of Italy from malaria, the plain Agro Pontino. This is the land where man has fought for several centuries to reclaim the swamps and make habitable the vast Pontine Territory. This article will provide a synopsis of the numerous projects that have been undertaken in an attempt to recover the land during the past centuries.

The name Agro Pontino identifies a territory, once known as the "Pontine Marshes", without a clearly defined physical boundary that is surrounded East by the Ausoni and Lepine mountains, West by the Tyrrhenian Sea and delimited Southward by the promontory of Circeo and Northward by the city of Rome.

The first historical information comes from the "Written History" by Dionysius of Halicarnassus (first century BC) who described the area as "an expanse of permanently marshy land". The first project that aimed to bring the Pontine Marshes back to life dates back to Caesar, as reported by both Plutarch and Cicero. Actually Cicero, who was one of Caesar's enemies, considered this idea almost a mockery of the dictator. The original plan of Julius Caesar was to turn the Gulf of Terracina into a major port, supported by a very long channel that extended from Rome to the sea across the entire Pontine plain, in order to drain water from the marshy lands. This ingenious design would have allowed for the achievement of two objectives: the draining of the marshes and secondly, the consequent gain of a vast area of land for public and private construction. However, the project never came to fruition. Later another famous emperor, Nero, also tried to reclaim the land but his project was soon interrupted by enormous difficulties encountered during construction.

A couple of centuries later, the Barbarian Prince Theodoric (regnant 493 ÷ 520) was successful in draining the swamps as described in numerous reports, the most prominent of which are those by Cassiodorus and Procopius. Unfortunately, we know from subsequent events and evidence that in the high Middle Ages the land previously recovered had once again been reclaimed by the water. As a result, after the fall of the Roman Empire, the Agro Pontino inhabitants were increasing afflicted by malaria.

Under Charlemagne (around 800) , the "Pontine Marshes" passed into the hands of the Roman pontiffs.

In 1514 Leo X, anxious to link his name to a great public work, was interested in recovering the vast Pontine area just on the outskirts of Rome. He was a son of Lorenzo de 'Medici, called the Magnificent, and had the same taste for beauty as his father. However, it was not just the pursuit of fame that made him motivated, but also the population explosion and the need for food. To overcome the scarcity of economic resources of his pontifical state, the Pope gave to his brother Giuliano, "motu proprio" (7 July 1514), the lands of the Pontine Marshes hoping that he would be able to liberate them from the waters. Giuliano, was a close friend of Leonardo da Vinci, the famous scientist, and appointed him the task. The first result of this effort was certainly remarkable because large portions of territory were quickly returned to agriculture. However, the untimely death of Giuliano in 1516 and disagreements with local residents stopped the progress of the work.

Seventy years afterwards another Pope, Sixtus V, tried another reclamation plan. The result was the recovery of 4,600 hectares of highly fertile land, and flourishing agriculture. Sixtus V was so enthusiastic that, during the same year, he personally decided to inspect the results. The trip, however, marked the destiny of Sixtus V as he contracted a disease (possibly malaria) during the visit, which a year later led to his death.

Several other Popes manifested through the subsequent century the desire to undertake interesting rehabilitation projects, which nevertheless remained only

on paper and were never realised. At that time, the Pontine area was like a huge pond approximately 50 kilometres wide and 15 kilometres long, as described by Johann Caspar Goethe during his travels in Italy in 1740. The reclamation of the Pontine Marshes seemed, therefore, a "cursed" enterprise.

A real breakthrough occurred under the pontificate of Pius VI (1775-1799) when 30,000 hectares of lands were wrested from malaria. It was only the beginning: after the unification of Italy the new Italian Parliament appointed a commission in 1870 to study the problem. Even the national hero Giuseppe Garibaldi, presented its own proposal in 1875. The final proposal was adopted in 1878. After the first world war, 1915-18, soldiers returning home claimed the land that they had been promised as a reward. At this time there is a change in the objectives of the policy concerning the draining of the Agro Pontino marshes. The drainage of Agro Pontino becomes a way to get social and political consensus by offering to the dispossessed peasants the task of draining the land that will in turn become their new homes and offer stable agricultural work.

In those years, the evidence that malaria was a disease that could be defeated with the care offered by medical science heightened the demand for the draining and subsequent colonisation of the Agro Pontino. The 11th of June 1925 is considered to be the D-Day of the land reclamation and marks the commencement of the "Battle for Wheat". The Head of Government Benito Mussolini declared: "....The battle of the swamp means liberating the health of millions of Italians from the lethal dangers of malaria and misery". In 1929 Mussolini appointed a specific secretariat devoted to land reclamation projects, which speed up the drainage. On the 29th of August 1931, the Government delivered the first 18,000 hectares of land to the farmers, while the Italian Red Cross is undertook a coordinated program of malaria eradication from the area. Two reclamation consortia (Piscinara and Pontino) developed 800 km of trunk-roads and 500 km of farm and municipal roads, 2400 bridges to cross the 500 km of drains and 250 km of irrigation canals. Over 3500 farms were set up during that period. Thus begins the marked and significant progressive reduction of the incidence of malaria. It was the dawn of a new age for the Agro Pontino.

Climate change and malaria

The notion that the future world will be warmer and sicker [3] because of the projected change in rainfall and temperature, favouring the emergence and persistence of many infectious microorganisms, is generating a lot of attention in scientific and popular journals. Vector borne diseases (VBD) are particularly sensitive to change in ecological conditions (including temperature, moisture and rainfall regimes) that constrain arthropod vector life cycles and are often used to illustrate future scenarios of threats for human health. Among VBDs, speculations on the potential impact of climate change on human health often focuses on malaria and its vectors [4] due to its importance in terms of global burden of disease. The latest global quantification of malaria burden from the World Health Organisation [5] estimated 247 million episodes of malaria in 2006, with a wide uncertainty interval (5th–95th centiles) from 189 million to 327 million cases. Most of the cases (86%, or 212 million) were in Africa. There were an estimated 881,000 (610000–1212000) malaria deaths in 2006, of which 91% (801000, range 520000–1126000) were in Africa and 85% of which were of children under 5 years of age.

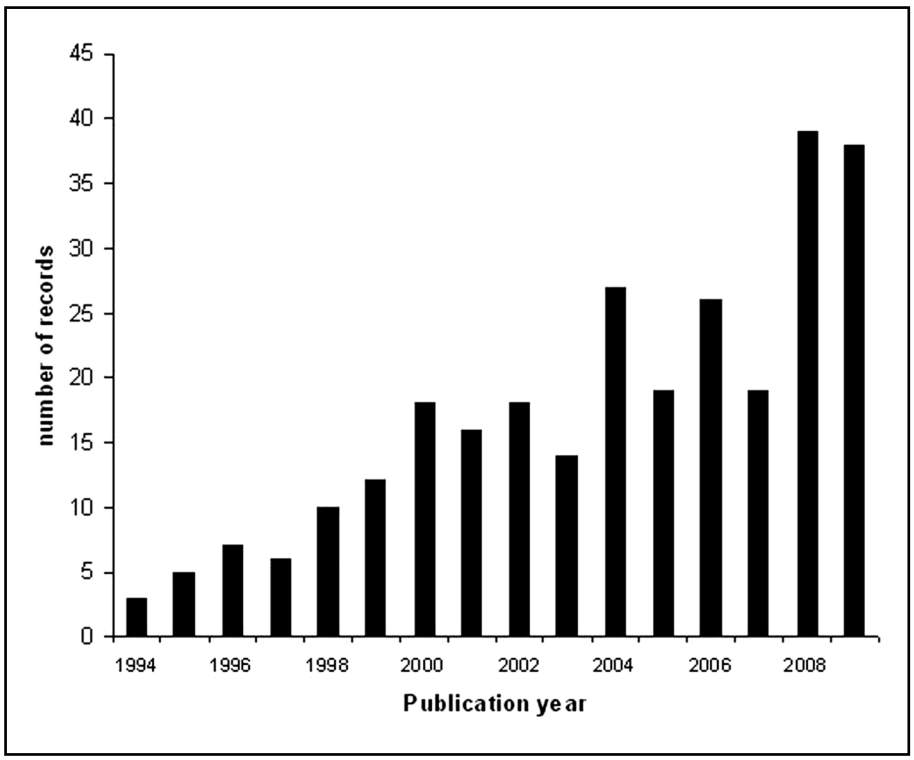
Because the incubation period of malaria parasites within the mosquito is temperature sensitive [6], more and more studies have focused on the likely impact of climate change on the burden of malaria. At the time of writing (December 2009) we undertook a search of the ISI Web of Science database using the string "malaria AND climate change" as the topic. We retrieved 279 records consisting of scientific papers published from 1992 onwards. The

number of papers published has continuously increased through time (figure 1), roughly doubling in number in the last two years. This demonstrates the increased interest of the scientific community in this area.

Several early papers contributed to the view that malaria (as well as some other VBDs) will spread towards northern latitudes and regions at higher altitude following the rise in temperatures. Clear examples of this are the maps that show a proportional increase in the risk of malaria towards northern latitudes [7]. However, most of those GIS maps were based on predictions of simple models that often overlooked socioeconomic, environmental and behavioural factors that are themselves tightly interconnected with the response of vectors to climatic variables [8]. Lafferty in a recent review [9] compared the time series of (increasing) temperature with the time series of the (decreasing) area of the earth where malaria is prevalent and offered clear evidence that socio-economic and land use changes and malaria control measures are indeed causing the shrinkage (and not the expansion) of malaria endemic areas toward the tropics. Therefore, ecological and socio-economical factors seem to offset the effect of increasing temperature. For this reason Lafferty article and related commentaries [9] have highlighted the need for more attention to be paid to the study of ecological systems when examining the link between climate change and infectious diseases.

The results of interactions between hosts, pathogens, the environment and socioeconomic factors are complex by definition and highly non linear. On a regional scale, predictive models of future malaria spread should account for the number of viable habitats to sustain the vector life cycle and the behaviour and socioeconomics of the human population inhabiting the area. For example, the general reduction of suitable habitats in Southern Europe through the drainage of stagnant waters, the adoption of modern farming and cattle rearing methods, the urbanization of the landscape and the obvious evolution of medical care systems, render the reestablishment of malaria as highly unlikely even if temperature and rainfall patterns become more favourable to *Anopheles*

Figure.1 Number of scientific papers published per year (from 1994 onwards) retrieved from ISI web of Science with the keywords malaria and climate change



populations. Modeling attempts using current environmental and health care conditions corroborate this conclusion. For British counties Kuhn et al. [10] concluded that, even if future scenario may suggest an increased malaria transmission rate, the actual risk for population will be negligible, unless malaria treatment becomes ineffective (e.g. drug resistance).

In regions where prevalence is still high (some part of Central America, Northern part of South America, tropical and sub tropical Asia, sub Saharan Africa), factors other than climate change can be the cause of the high transmission rate. Reiter [11] summarized the main factors causing the high malaria prevalence in the tropics as following: poverty (reduced access to health systems, malnutrition and other debilitating diseases such as HIV), high birth rates and densely populated urban areas (increased attack rate), increased density of suitable habitats for Anopheles through deforestation and irrigation of large portions of land, increase movement of populations who are either migrating in search of work or displaced due to war (arrival of non immune people in areas of high transmission), as well as insecticide and drug resistance [11].

Conclusions and outlook

An "evidence based assessment" of the effect of climate change on human health should include, not only a punctual epidemiology of infectious diseases (e.g. the observed patterns), but also a deeper understanding of the environmental forces (including socioeconomics and behavioural factors) driving disease transmission. The complexity of this endeavour is exacerbated by the lack of high quality datasets. Process based models which include spatially explicit environmental and socio-economical determinants are demanding in terms of data. At the European level, the European Centre for Disease Prevention and Control has recently recognized the need to develop an infrastructure (named the European Environment and Epidemiology Network) that will serve as repository for climatic and other environmental data and infectious disease surveillance, coming from various sources [12]. Given the obvious difficulties, it remains to be seen if and how this infrastructure can be replicated, at least partially, in less developed areas of the world. In general terms a concerted effort among climatologists, ecologists and epidemiologists might provide spatially explicit tools to support prioritisation within health agencies.

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