

Malaria in the African highlands: past, present and future

S.W. Lindsay¹ & W.J.M. Martens²

Many of the first European settlers in Africa sought refuge from the heat and diseases of the plains by moving to the cool and salubrious highlands. Although many of the highlands were originally malaria free, there has been a progressive rise in the incidence of the disease over the last 50 years, largely as a consequence of agroforestry development, and it has been exacerbated by scarce health resources. In these areas of fringe transmission where the malaria pattern is unstable, epidemics may be precipitated by relatively subtle climatic changes. Since there is little immunity against the disease in these communities, outbreaks can be devastating, resulting in a substantial increase in morbidity and death among both children and adults. We present here the results obtained using a mathematical model designed to identify these epidemic-prone regions in the African highlands and the differences expected to occur as a result of projected global climate change. These highlands should be recognized as an area of special concern. We further recommend that a regional modelling approach should be adopted to assess the extent and severity of this problem and help improve disease surveillance and the quality of health care delivered in this unstable ecosystem.

Introduction

Altitude is one of the oldest defences against malaria. As early as the sixteenth century the Spanish recognized there was little or no malaria at high altitudes in the New World (1). The protection afforded by elevation was also described in many early textbooks on tropical medicine, including that of the pioneer James Lind (2). Even before the mechanism of malaria transmission had been elucidated, Hirsch recognized that protection against the disease was related to low temperatures and high altitudes (3). He noticed that epidemics in the highlands were always located in a valley with a small declivity or a basin-like depression in a plateau — places where water collects and malaria mosquitos breed. The salubrious effects of higher altitude were well recognized by early European settlers, and hill stations became a common feature of expatriate life in various parts of the tropics. Even today in Ethiopia many lowland farmers shelter in the highlands until the malaria season has ended (T. Ghebreyesus, personal communication, 1997). Hills and mountains have therefore been recognized as a natural shelter

against the heat and diseases of the lowlands for at least several centuries.

The current upper height limit for malaria in the African highlands is difficult to define precisely, and is likely to rise, as discussed below. In many countries this boundary was thought to occur around 2000 m; for example, in Burundi (4), Ethiopia (5, 6), Kenya (7), Morocco (8), and Rwanda (4). Malaria epidemics have occasionally been reported at higher altitudes (up to 2550 m (7)) but are rare. In other parts of Africa the upper limit is slightly lower: at around 1700–1800 m in Zaire (9) and at 1200 m in Zimbabwe (10). Generally we considered that areas higher than 1500 m (Fig. 1) have little or no malaria.

Most malaria epidemics in the African highlands are due to *Plasmodium falciparum*, the most lethal and dominant species found in the continent. While epidemics of vivax malaria have also been reported, for example, in the Atlas Mountains in the 1930s (8), they are unusual. In most highland areas, local communities have little or no immunity against malarial parasites and thus the disease affects both adults and children. This contrasts with the lowlands where immunity is high among most adults and malaria morbidity is confined largely to young children and primigravidae. As a consequence of the low immunity in highland communities, epidemics in the mountains are characterized by high morbidity and mortality among both children and adults, as illustrated by the outbreaks experienced in the Ethiopian highlands, where there were approximately 7000 deaths in 1953 (12) and 150 000 in 1958 (13). The highlands are thus areas of unstable malaria patterns primarily because of the low and fluctuating levels

¹ Reader, Department of Biological Sciences, University of Durham, South Road, Durham DH1 3LE, England and Danish Bilharziasis Laboratory, 2920 Charlottenlund, Denmark. Requests for reprints should be sent to Dr Lindsay at the former address.

² Assistant Professor, Department of Mathematics, Maastricht University, Maastricht, Netherlands

Reprint No 5820