Gametocytes, Sporozoites and Liver Schizonts

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SUMMARY

Plasmodium falciparum **differs from other human species of** *Plasmodium* **in the short, limited exo-erythrocytic stage in the life cycle, which is an apparent disadvantage in surviving through a prolonged non-transmission season such as occurs throughout much of tropical Africa. The mechanism of survival of the parasite from one transmission season to the next and their importance in malaria control are discussed.**

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This paper is an attempt to answer the apparently frivolous question: 'Why should *P. falciparum* malaria occur at all in regions with a prolonged dry season?'

The malaria parasites of higher primates belong to 2 subgenera of *Plasmodium* — *Plasmodium* (s.s.) and *Laverania*.[1] The latter differs morphologically from the former by the shape of its gametocytes and the distribution of pigment in infected blood cells, but more important are the differences in its life cycle, i.e. the absence of a secondary exo-erythrocytic stage and the long period, 10 - 12 days, needed for the maturation of the gametocytes.

Laverania comprises 2 species only: *P.* (*L.*) *falciparum* and *P.* (*L.*) *reichenowi*. The latter is restricted to chimpanzees, but the former is the commonest and most widespread malaria parasite of man, accounting, in tropical Africa, for about 95% of all malarial infections, and it is natural to inquire why this should be. In the savannah regions of Africa, with a main transmission season lasting not more than 5 months, and a prolonged dry season, the absence of a prolonged exo-erythrocytic cycle would seem to be a disadvantage.

Since the parasite cannot survive the dry season in the exo-erythrocytic form, and the life of the trophozoites is limited by the immune response of the host, *P. falciparum* must be capable of surviving this critical period of its existence, either in hibernating mosquitoes as a gametocyte or in the human host as a sporozoite.

Harwin and Goldsmid[2] have argued the case for survival in the sporozoite stage. They noted that in Rhodesia, although the main transmission season lasts from January to April, there is a minor peak in October which is presumed to be due to mosquitoes which have overwintered as adults. These may do so only in very small numbers, but the gametocyte rate in this small, aged population could be assumed to be high. It must be conceded, however, that while the adults of the *Anopheles gambiae* complex can be found throughout the winter in the Rhodesian lowveld, aged, overwintering adults have yet to be demonstrated at higher altitudes. This led Leeson[3] to believe that *A. gambiae* annually invaded the Rhodesian highveld from a reservoir in the lowveld. Unfortunately, his work was carried out 34 years before the recognition of *A. gambiae* as a sibling species complex, and much of the value of his work is thereby nullified. Leeson did, in fact, find *A. funestus* adults hibernating in the bed of the Mazoe River at Shamva, but his observations actually refer to *A. rivulorum*, which was then undescribed. Leeson also reported a case of malaria at Shamva in October, in which the evidence incriminating overwintering *A. funestus* was particularly strong.

What, then, of the overwintering of *Laverania* in the form of gametocytes? It is a common finding that a higher proportion of positive slides examined during the dry season shows gametocytes than do those actually taken during the transmission season (Table I). This is consistent with the relatively long period of maturation, and it seems logical that the gametocytes should be correspondingly long-lived.

TABLE I. RESULTS OF EXAMINATIONS OF ROUTINE BLOOD FILMS TAKEN IN RHODESIA BETWEEN OCTOBER 1971 AND OCTOBER 1972

Month and year		No. of films taken	Parasite rate %	Gametocyte rate %	% of positive slides showing gametocytes
October	1971	25	—	—	—
November	1971	174	—	—	—
December	1971	172	0,6	—	—
January	1972	2 038	0,6	0,1	15
February	1972	4 072	3,9	1,2	33
March	1972	3 676	2,5	0,5	19
April	1972	4 799	13,0	4,6	34
May	1972	1 460	1,0	0,5	47
June	1972	573	4,0	3,0	74
July	1972	1 078	1,9	0,6	33
August	1972	362	1,1	0,6	50
September	1972	204	—	—	—
October	1972	1 564	3,9	2,2	54

Hawking *et al.*[4] showed that the gametocytes of *Plasmodium* (s.s.) are short-lived, maturing at the peak hour of mosquito activity during the night and dying off, or at least losing their infectivity, before morning. They later tried to demonstrate the same with *P. falciparum*.[5] They confirmed (in *Aotus* monkeys) a 9 - 12-day period for the development of gametocytes from merozoites and demon-

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strated a 24-hour cycle in the ability to exflagellate. It cannot be said, however, that they demonstrated that the gametocytes, having once matured, die off rapidly as do those of *Plasmodium* (s.s.). The possibility of their living for a period of several months therefore remains.

What are the practical applications of this to malaria control? Whatever the mechanism of survival during the dry season, it is clear that *P. falciparum* malaria in Africa is mainly a disease of late summer, with a minor peak at the end of the dry season. The same probably applies (or applied) in southern Europe, where *P. falciparum* was early recognised as the parasite responsible for the aestivo-autumnal fevers, in contrast with the malaria of early spring caused by *P. vivax*. This predominance of *P. vivax* in spring would naturally mask any early increase in *P. falciparum* infections. Assuming that the October increase in the prevalence of *P. falciparum* is important, this is a season of the year at which control of transmission by means of residual insecticides is relatively easy because of low mosquito populations. With this in view, control measures in Rhodesia now involve two cycles of spraying with benzene hexachloride:* the first, beginning in October, being aimed at reducing the overwintering parasite reservoir, whether gametocyte or sporozoite, and the second at reducing actual transmission of the disease.

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* Resistance to BHC has now been demonstrated in Rhodesian *A. gambiae* species B; first by Dr G. R. Davidson of the Ross Institute, London, and later confirmed locally. This means that the use of BHC as an insecticide will have to be discontinued in favour of DDT.