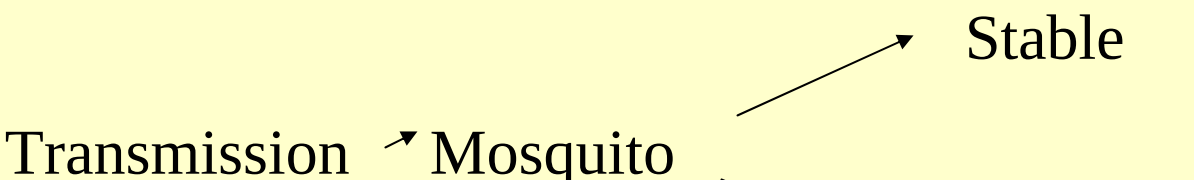
Malaria Epidemiology

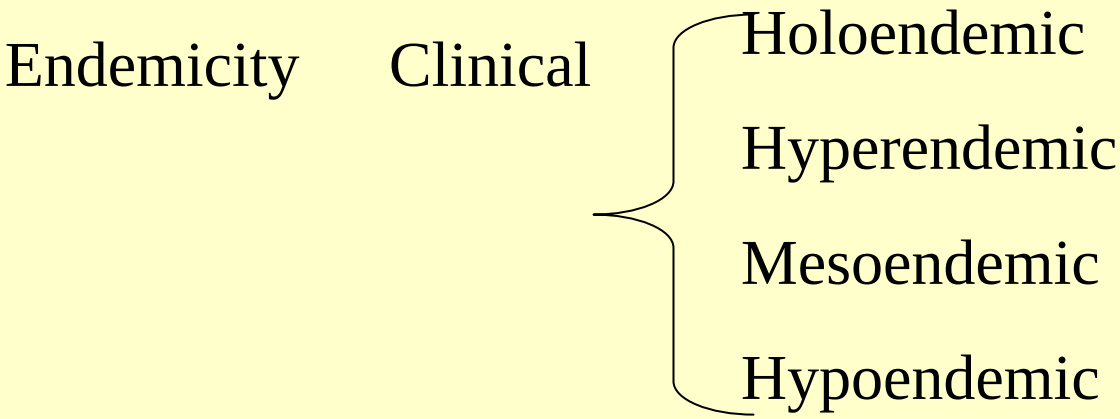
Clive Shiff, PhD

Course Objectives

- To appreciate the diversity of malaria as a disease
- To understand the factors affecting these patterns, both vectoral and human
- To assess and determine local patterns of transmission
- To interpret local indices of transmission

Malaria Epidemiology





Vectors are the KEY determinants of transmission

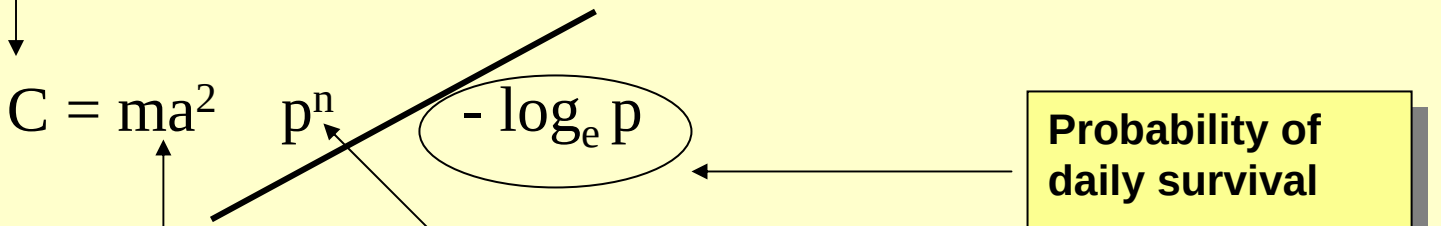
Factors Affecting Transmission

Distribution and Abundance of the mosquito vector:

- Temperature and extent of water for larval breeding
- Seasonal Fluctuation of Mosquito Populations
- Vectoral Capacity of the common vector species
- Duration of Conditions Suitable for Mosquito Survival

Vectoral capacity

Vectoral Capacity



Probability of daily survival

M= relative density of females/ a=probability mosquito will take a human blood meal that day

Proportion of mosquitoes surviving incubation period

Key factor is the probability of vector mosquito survival for at least 10 days

Entomological Inoculation Rate

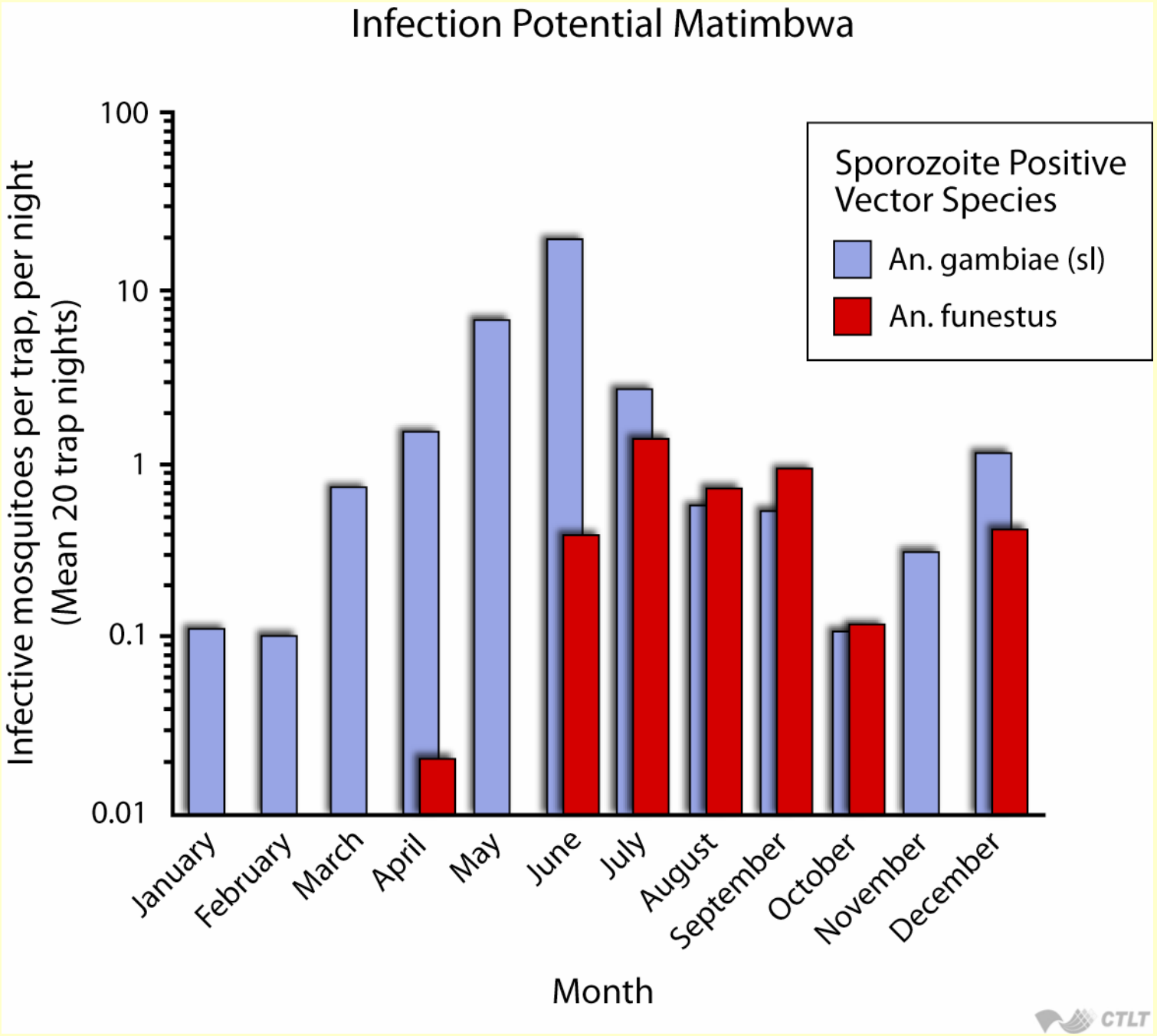
- Number of infective bites per person per unit time
- Vector density in relation to humans (m)
- Average number of persons bitten by a mosquito in one day (a)
- Proportion of vectors *infective* (s)
- EIR = *mas*

Measurement of EIR

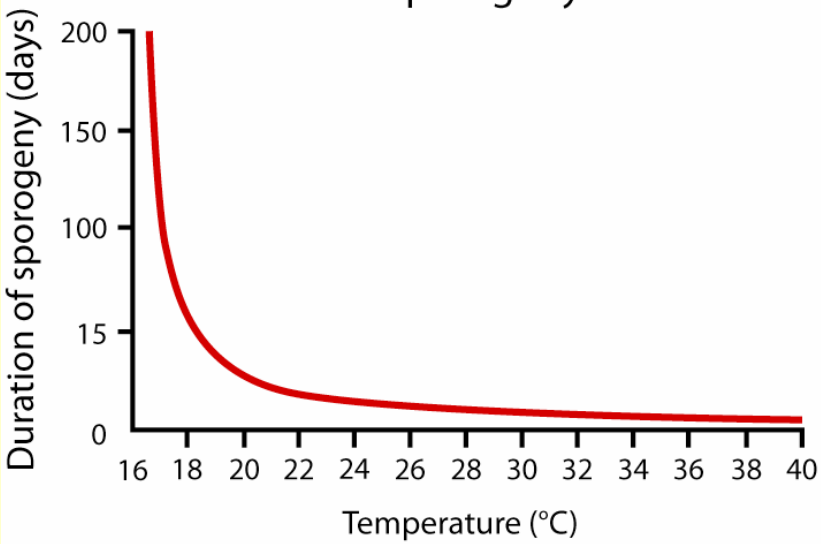
Use of light trap or similar device:

Check sample of mosquitoes for sporozoites

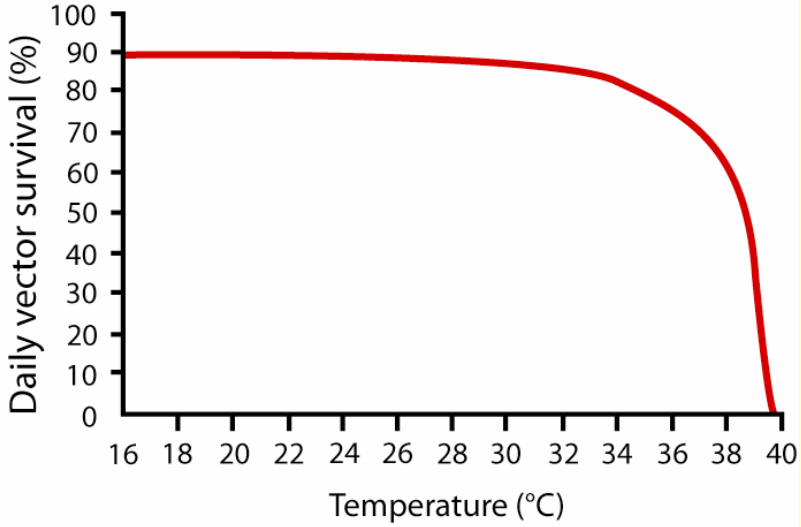
Estimate EIR/ infectious bites /person exposed


Infection Potential Matimbwa
Infective mosquitoes per trap, per night
(Mean 20 trap nights)
100
10
1
0.1
0.01
Sporozoite Positive
Vector Species
An. gambiae (sl)
An. funestus
January
February
March
April
May
June
July
August
September
October
November
December
Month
CTLT

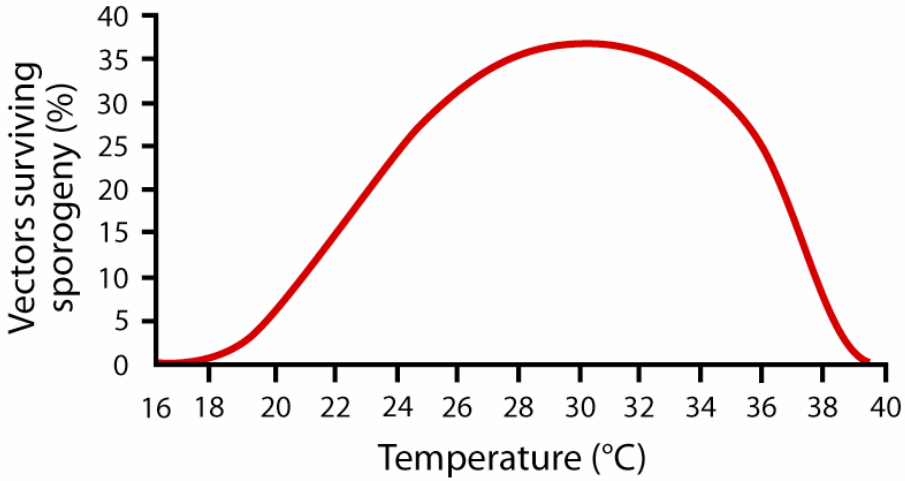
Effect of Temperature on Duration of Sporogony



Relationship Between Temperature and Daily Mosquito Survival

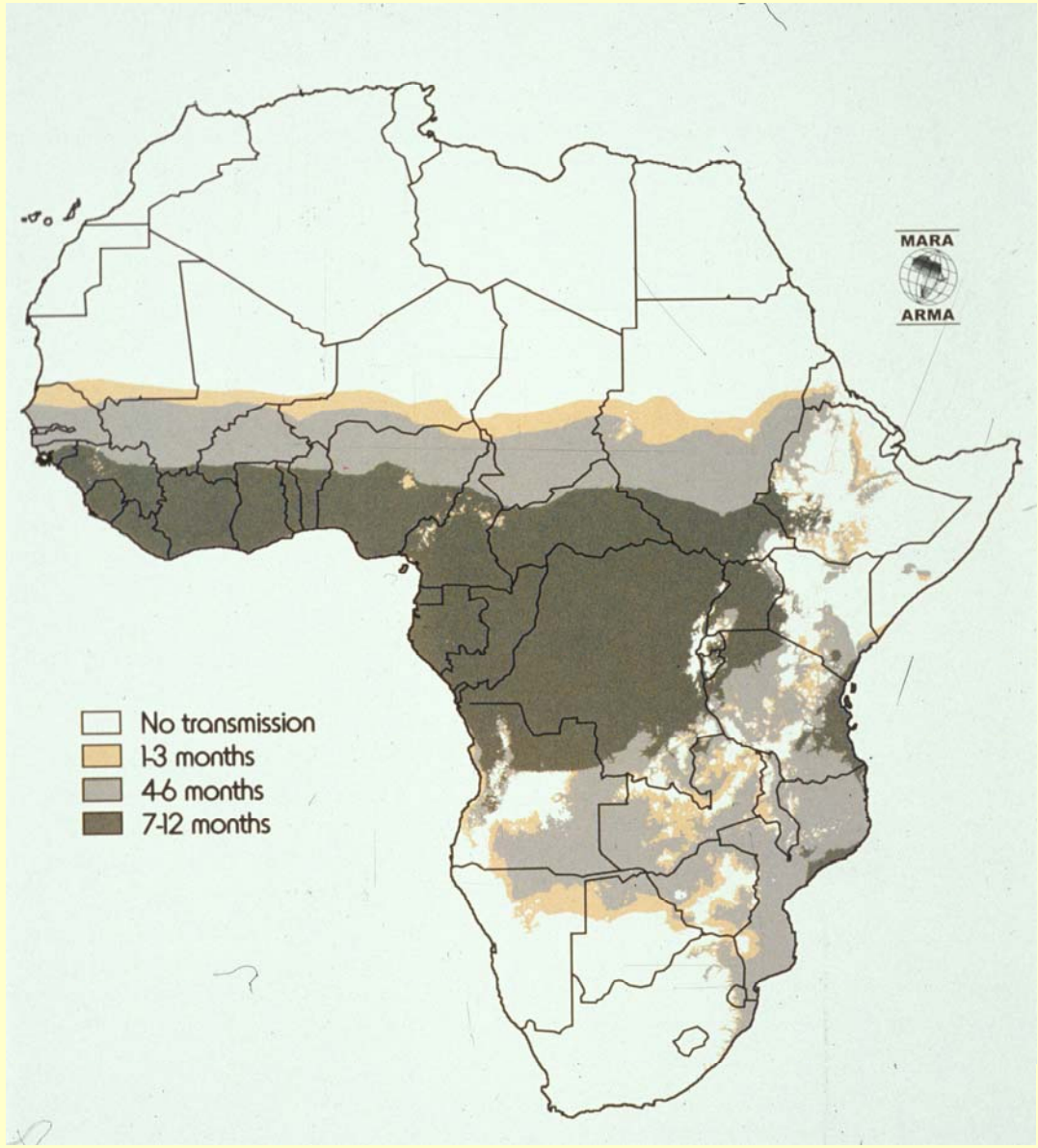


Proportion of Mosquitoes Surviving Sporogony

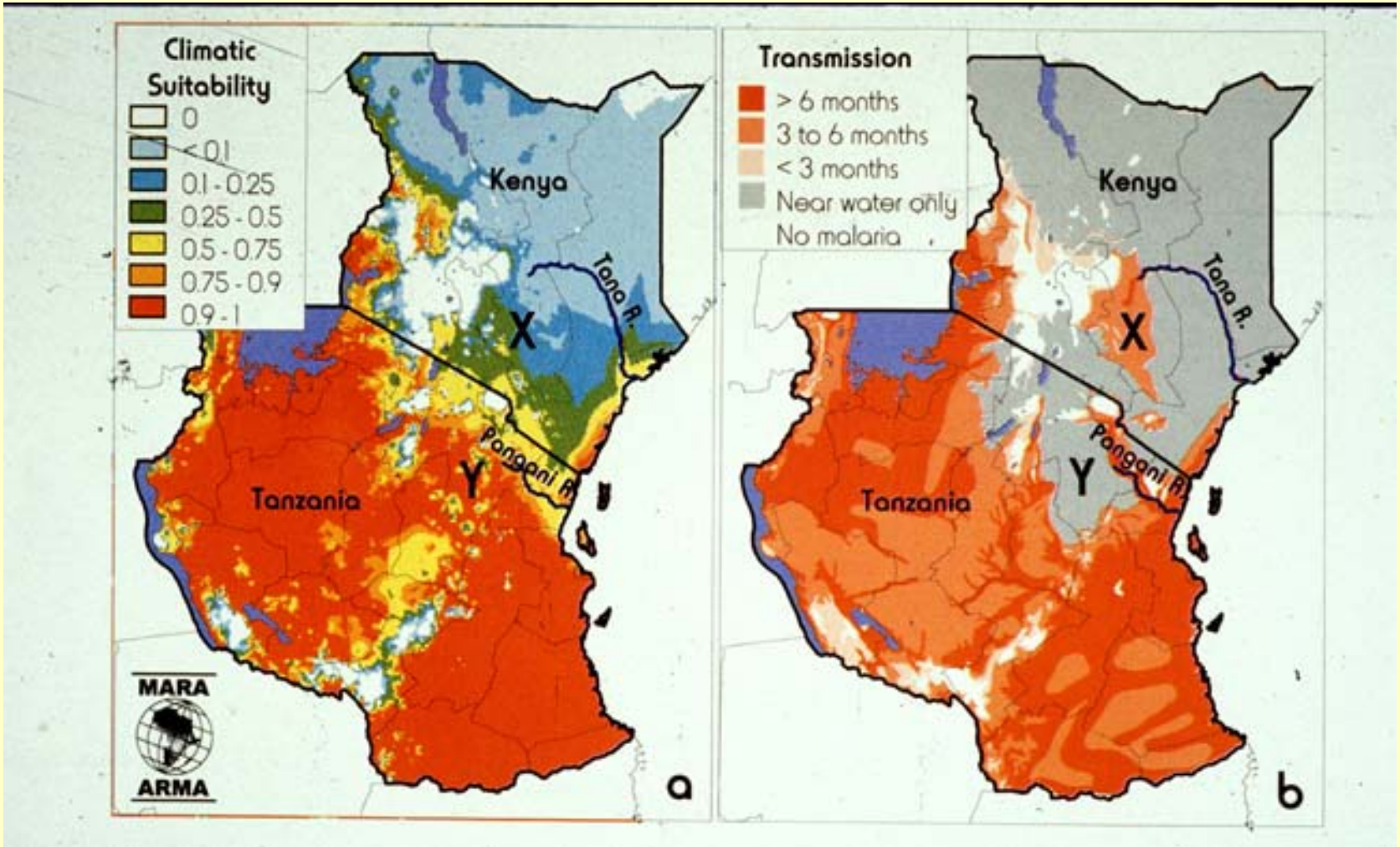


Transmission

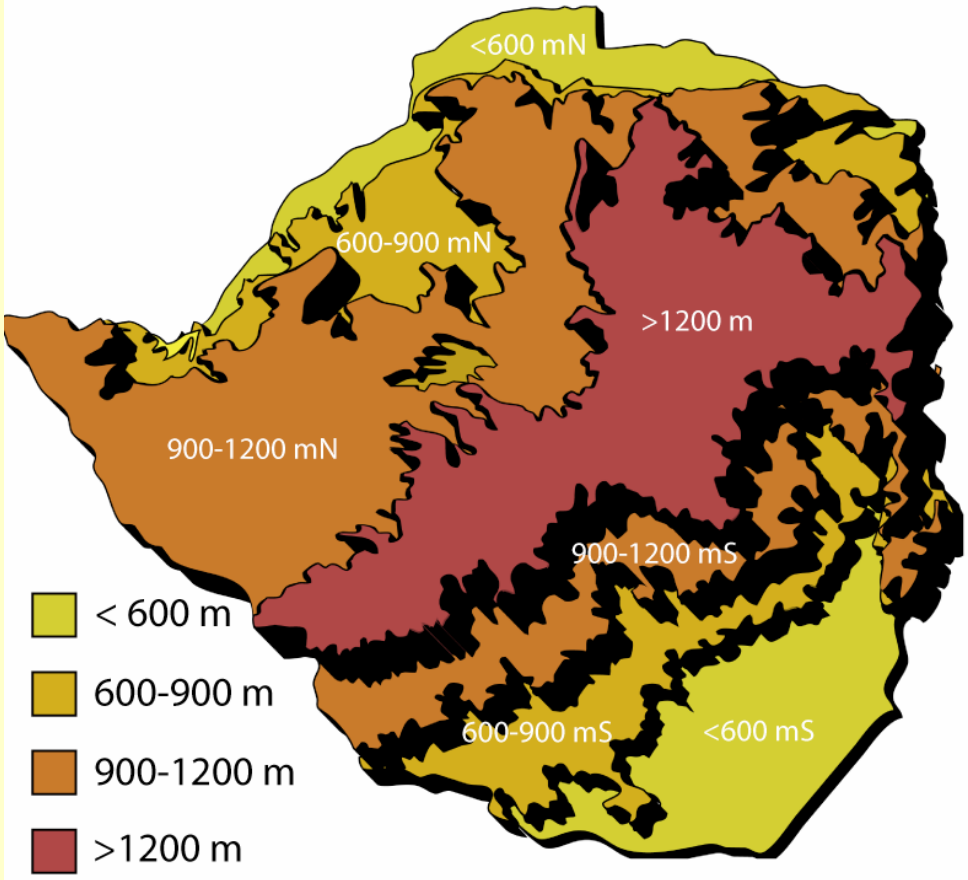
Using the survival data derived from the temperature and duration of sporogony one can assess, in continental Africa the annual period during which transmission is likely.

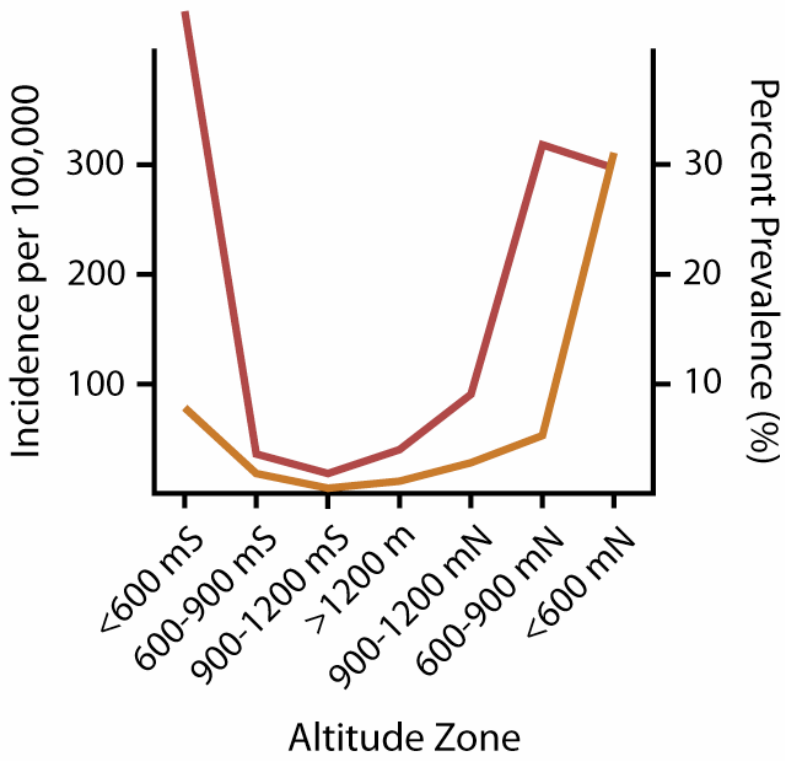


Comparison of the model with Kenyan and Tanzanian malaria maps: (a) the climatic suitability model; (b) historical malaria maps of malaria risk in Kenya (Nelson, 1959) and Tanzania (Wilson, 1956).



Map of Zimbabwe Showing Elevation and Average Annual Prevalence of Malaria by Altitude Zone, (1969-1981 and 1972-1981, Respectively)





Adapted by CTLT from Taylor & Mutambu, *Trans. Royal Soc. Trop. Med. & Hyg.*, 1986; 80: 12-19

Collections Made Inside Houses

Houses selected with eye to mosquito habitat

Number of persons sleeping at night recorded

Untreated mosquito nets provided

Alternative EIR Measurements

- Indoor resting collections (these require blood meal identification) e.g *ma x* s.
- Window traps: these collect exiting mosquitoes, usually blood fed and ready to lay eggs.
- Mosquito landing catches.

Malaria Endemicity

- Holoendemic: transmission occurs all year long
- Hyperendemic: intense, but with periods of no transmission during dry season.
- Mesoendemic: regular seasonal transmission
- Hypoendemic: very intermittent transmission.

Measuring Endemicity

- **Spleen rate**: number of palpable enlarged spleens per 100 individuals ***of similar ages***
- **Parasite Rate**: Number of persons with parasitaemia per 100 individuals ***of similar ages***
- ***?*** Measurement of parasitaemia…what does it mean epidemiologically?

Photo: Clive Shiff

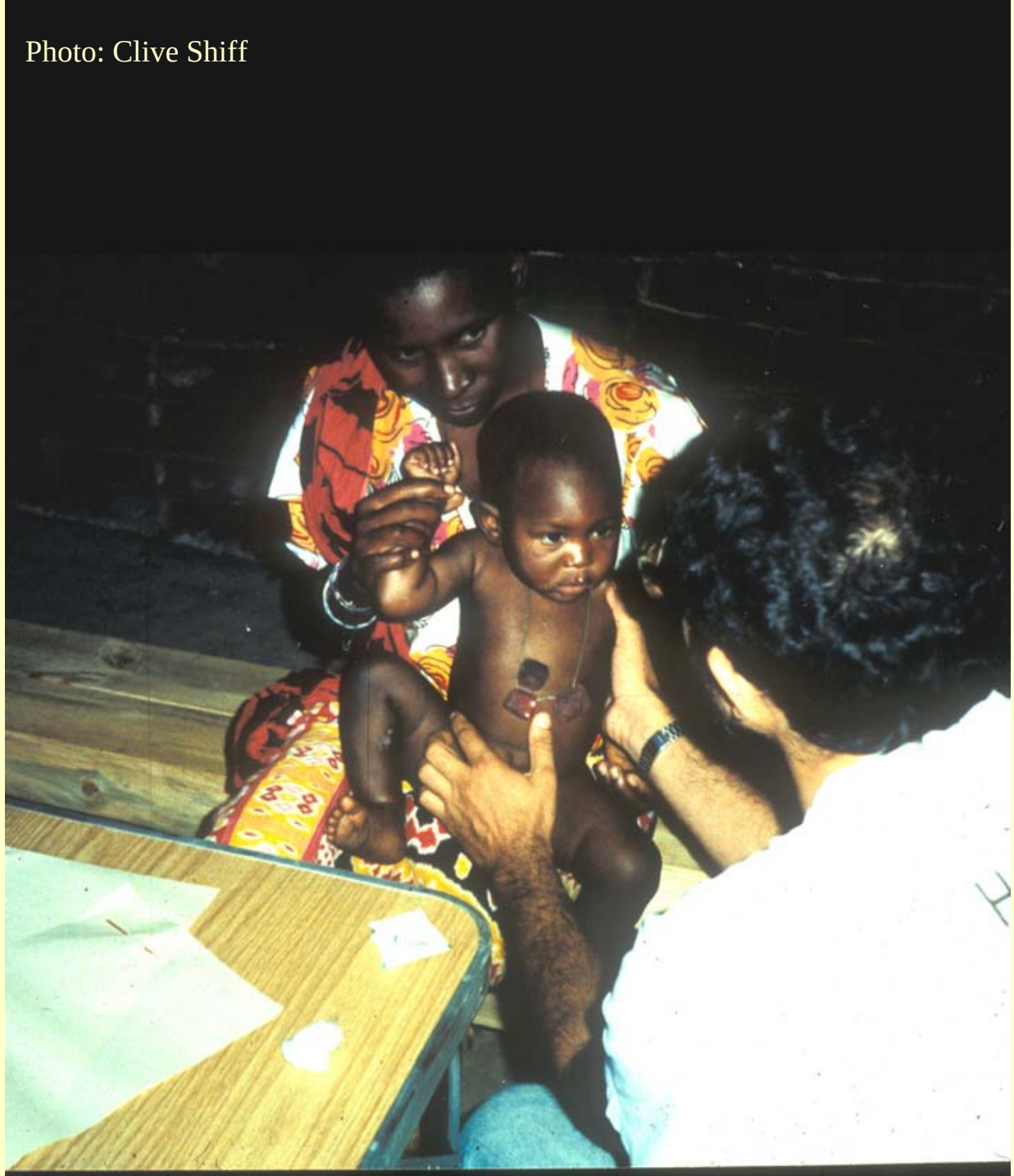



Photo: Clive Shiff

Holoendemic Malaria

- < 5 year old ***Spleen rate*** >75%
- <5 year old ***Parasitaemia*** > 60-70%
- Mortality highest in the 1st and 2nd year of life
- Anaemia most severe in early life
- Transmission conditions = STABLE MALARIA

Hyperendemic Malaria

- < 5 years old ***Spleen rate*** >50 <70
- < 5 years old ***Parasitaemia*** >50 <70
- cerebral malaria more common in older children
- transmission seasonal but intense, can still be considered stable

Mesoendemic Malaria (unstable)

- < 5years old ***Spleen rate*** >20 <50
- < 5 years old ***Parasitaemia*** < 20

- Transmission is seasonal under normal rainfall conditions In times of drought, it will decline
- Cerebral malaria common, infection tolerated well in adults
- Seasonal debilitation seen in all population groups: Condition termed **Unstable Malaria**

Hypoendemic Malaria (Unstable)

Under 5 children	***Spleen rate***	0 - <10%
Under 5 Children	***Parasitaemia***	0 - <10%

Only periodic transmission following unusual rainfall

Low transmission, vector mosquitoes difficult to find

Severe clinical outbreaks in children and adults, mortality high in all population sectors

Endemic vs Epidemic Malaria

- Stable *P. falciparum* malaria occurs in holoendemic and hyperendemic areas:
- Anaemia and high childhood mortality seen
- Deaths most common in < 2 yrs (holo) or 3-5 yrs (Hyper) ? Role of maternal infection
- Parasitaemia high in 6-15 yr olds
- Adults show some resistance, many asymptomatic

Stable Malaria

- High prevalence, frequently asymptomatic cases
- Infrequent occurrence of fever
- Anaemia high in younger ages (particularly under 2 years of age)
- Greatest mortality under 2
- Consider role of uterine exposure to *Plasmodium* antigens on the development of immunity


Photo: Clive Shiff

Why Anaemia NOT Cerebral Malaria?

- Placental infection
- Immunologically unrecognizable parasites
- Either because of poor nutrition or lowbirth weight
- Foetal haemoglobin

Unstable Malaria

- Immunity based on personal exposure to Plasmodium antigens
- Broad range of disease situations from high cerebral malaria in children 4-6 years old
- Much adult malaria
- Highly symptomatic, rapid diagnosis critical
- Effective treatment essential or else high risk of fatalities

Unstable *P. falciparum* Malaria

- Meso and hypoendemicity
- Increasing numbers of severe, complicated malaria.
- Severe morbidity and mortality in all age groups
- Severe seasonal or periodic epidemics.
- Worst case with long periods of no transmission

Eco-epidemiological Zones

- African savannah malaria: holoendemic or mesoendemic;
- Fringe malaria (Africa), desert or highland unstable, seasonal or periodic;
- Global plains and valleys: various vectors, various breeding sites
- Forest related malaria;
- Urban malaria;
- War and refugee malaria

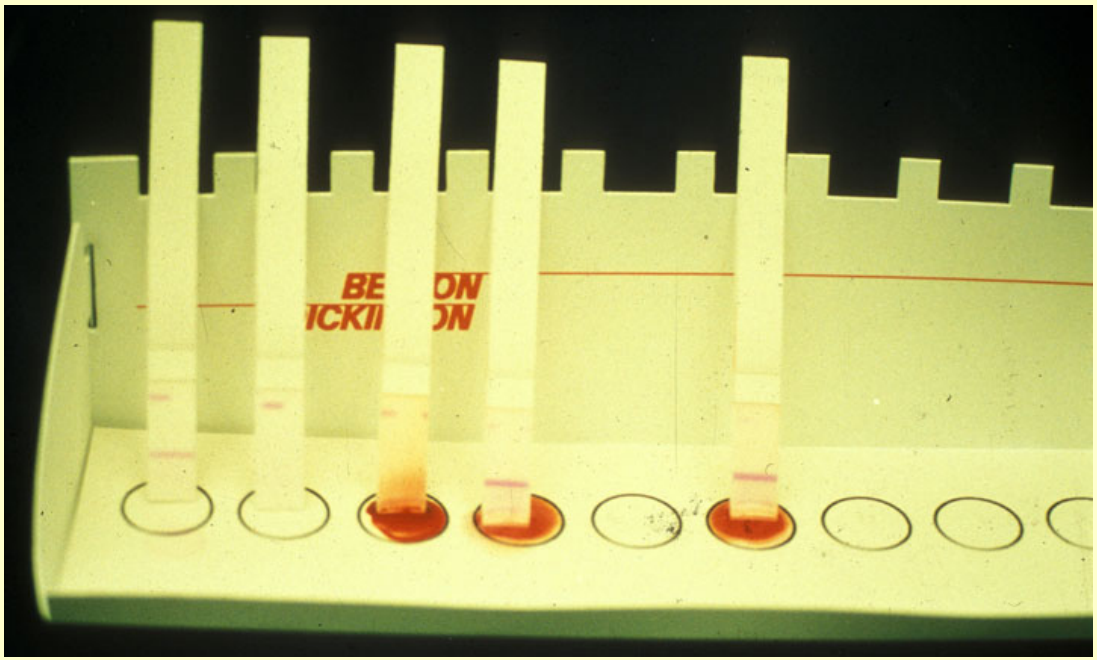
Focal Nature of Malaria

- Urban conditions: transmission associated with focal breeding sites
- Rural conditions: transmission associated with proximity of mosquito breeding sites
- Rice paddies, river systems, ponds, and stable water bodies

Inaccuracies of clinical diagnoses

- Malaria is difficult to diagnose clinically
- In studies > 70% of +ve diagnoses are non-parasitaemic.
- Beware statistics based on clinical reports

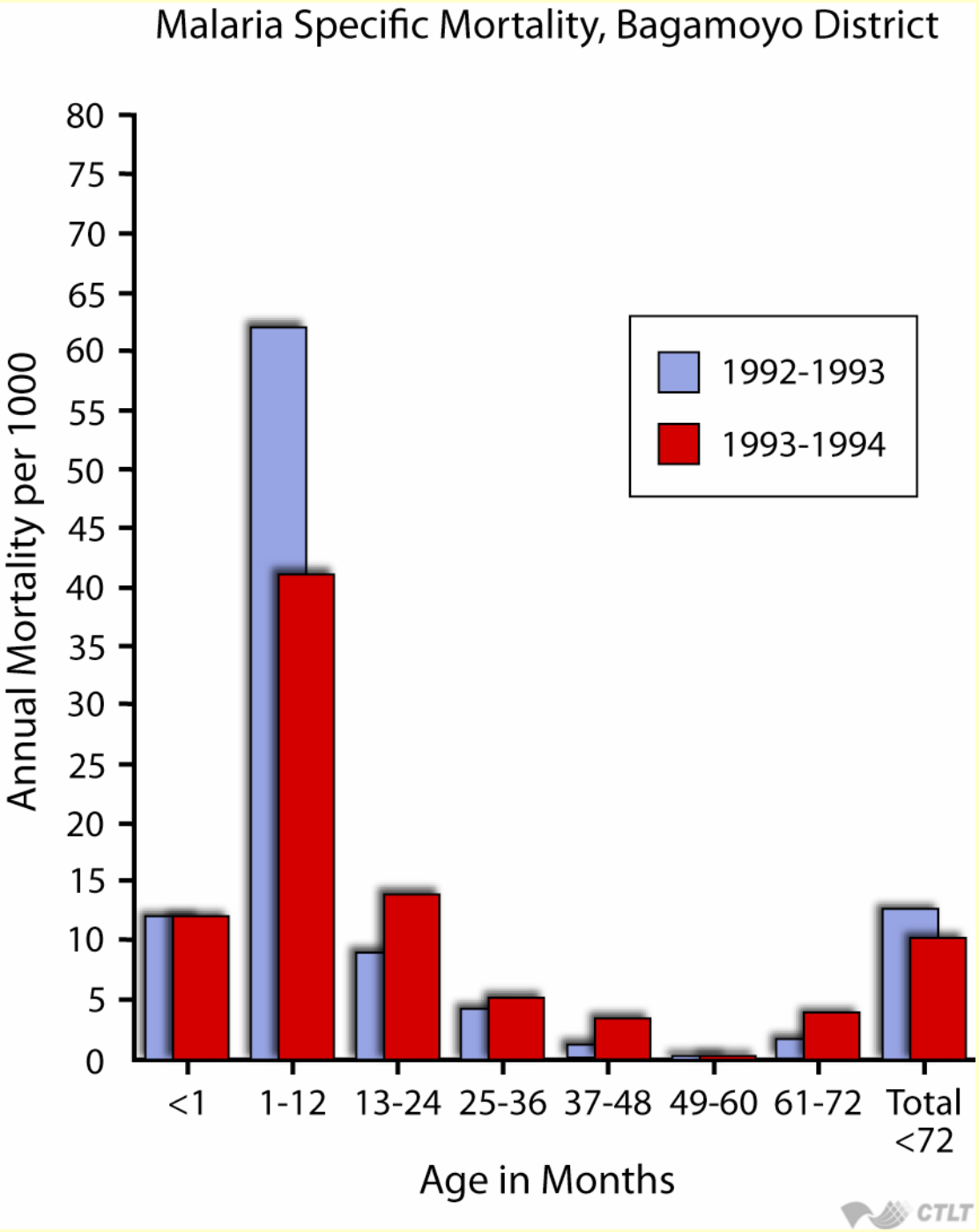
Rapid Diagnosis Immunochromatographic Test That Detects Malaria Antigens



Sensitivity 90-95%

Specificity 72-92%


Photo: Clive Shiff


Malaria Specific Mortality, Bagamoyo District
Annual Mortality per 1000
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
1992-1993
1993-1994
<1
1-12
13-24
25-36
37-48
49-60
61-72
Total <72
Age in Months

Distribution of Prevalence

Smoothed out distribution pattern of malaria prevalence in the Macha area, based on the prevalence data collected in 2004-5