MALARIA
AND
MALARIA CONTROL IN JELI
PENINSULAR MALAYSIA

By

MOHAMED RUSLI ABDULLAH

Thesis submitted in accordance with the requirements
of The University of Liverpool for
the degree of Doctor in Philosophy
by Mohamed Rusli Abdullaah

January 1998

ABSTRACT

A study of malaria was undertaken in Jeli District, Peninsular Malaysia. The aims of the study were to update the knowledge of the malaria situation and detect important variables that may help in improving malaria control strategies in the district. The variables studied were grouped into three components; environmental receptivity, community vulnerability and vigilance of the malaria control team. Epidemiological methods used for data collections included surveys, in-depth interviews, analysis of secondary data and direct observations. Study locations were selected based on pre-determined criteria and were grouped into villages near the Pergau Dam (Lawar), land scheme villages (Janggut), traditional villages (Bedil) and Orang Asli villages (Rual). Surveys conducted included social and behavioural, parasitological, serological, clinical and entomological surveys. Other investigations included testing for the susceptibility of the vectors to permethrin-impregnated bednets, review of the management of malaria patients and review of the vigilance and capability of the malaria control team. *An. maculatus*, the only vector for malaria transmission in Peninsular Malaysia, was present in all study locations but more in Bedil and Rual. The eco-systems of the study locations were favourable for the existence and breeding of *An. maculatus*. Epidemics were related to activities that involved forest clearance. Community and individual vulnerability were influenced by socio-economic and behavioural factors. Serology was useful in delineating locations with intense past and recent past transmission. ELISA results were strongly associated with malaria status. Personal protection measures with impregnated bednets were found to have protective value against malaria and there was a genuine need to expand the programme. Having water taps inside the house were protective against malaria in certain study locations. The mechanism for this was not clear but could be related to reduced humans-vector contact. The malaria control team had been vigilant and capable of controlling malaria in Jeli, but several weaknesses were observed. Recommendations for improving the vigilance and capability of the malaria control team included focused control activities in problematic areas, expanding impregnated bednet programmes, re-training of malaria workers, reducing delay in diagnosis and treatment, utilising outside resources and updating the information system.

ACKNOWLEDGEMENT

This thesis is dedicated to Julia, Zaquan, Syamim and Syauqin who have been my inspiration, and who have endured all the hardship during this study period.

My greatest appreciation goes to Dr David H Smith and Ms Sarah BJ Macfarlane for their expert and patient guidance in completing this thesis.

I am grateful to Dr Balbir Singh for guiding me through my laboratory work.

Thanks are also due to Dr Yao Sik Chi for giving me permission to utilise the facilities and manpower from the State VBDCO and Jeli MCT.

My special thanks and appreciation are extended to Dr Che Kamaludin Ahmad, for without his support, the field work would not have been completed.

I am greatly indebted to all staff members of the Jeli MCT - Nafuri, Wan Pa, Hadi, Hasanuddin, Kamarudin, Alias, Mokhtar, Salleh, Fadzli, Nik Azman, Halid and many more - for their commitment despite the extra work.

I must also thank En. Anuar and his entomology team, for without their expert help, vector studies would not have been possible.

My gratitude also goes to Hj Maliki and his staff at the malaria laboratory, VBDCO.

I would also like to thank Dr Hj Hasbullah for his co-operation in the management review of hospitalised patients.

I would also like to thank Dr Oswaldo for his willingness to spend his precious times in translating publications in Spanish and Portuguese. The same appreciation goes to Dr Ai Ping Zhou for translating publications in Chinese language.

I must acknowledge the computer support given to me by Dr Lian, Mrs Teresa Southern and Mr Paul Blackburn.

I will always appreciate the support given to me by all members of the Department of Community Medicine, Universiti Sains Malaysia. Lastly, I would like to thank the Dean and Universiti Sains Malaysia for granting me a full paid leave to pursue this degree.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

A&E	- Accident and emergency
ACD	- Active case detection
AES	- Average enlarged spleen
AMI	- Anti-malaria Inspector
BFMP	- Blood film for malaria parasite
ELISA	-Enzyme-linked immunosorbent assay
ENSO	- El-Nino Southern Oscillation
ET	- Entomology team
FC	- Field canvassers
FELCRA	- Federal Land Consolidation and Rehabilitation Authority
FELDA	- Federal Land Development Authority
Hb	- Haemoglobin
HLA	- Human lymphocyte antigen
IBN	- Insecticide-impregnated bednet
IFAT	- Immuno-fluorescent antibody test
IHAT	- Indirect haemagglutination test
KESEDAR	- South Kelantan Development Authority
LPP	- Farmers Association Board
MBS	- Mass blood survey
MCH	- Maternal and child health care
MCP	- Malaria control programme
MCT	- Malaria control team

MEP	- Malaria eradication programme
MEPP	- Malaria eradication programme
MO	- Medical officer
MOH	- Medical officer of health
NEB	- National Electricity Board
O.D	- Optical density
PBS	- Phosphate buffer sulphate
PCD	- Passive case detection
PCR	- Polymerase chain reaction
PCV	- Packed cell volume
PHC	- Primary health care
PHI	- Public health inspector
PKINK	- Kelantan State Economic Development Corporation
RBC	- Red blood cell
RISDA	- Rubber Industry Development Authority
RM	- Ringgit (Malaysian currency)
SD	- Standard deviation
SICA	- Schizont-infected cell agglutination
SPR	- Slide positivity rate
TCM	- Tissue culture media
VBDC	- Vector-borne disease control
VBDCO	- Vector-borne disease control office
VBDCP	- Vector-borne disease control programme

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Malaria is still one of the priority diseases in the Seventh Malaysian Plan, the Ministry of Health Plan of Action for the year beginning 1996 to the year 2000. The disease has receded from coastal areas following the success of control programmes and is currently confined to forest and forest fringe areas. Although Sabah and Sarawak have contributed the most to the total malaria prevalence in Malaysia, the threat of malaria in Peninsular Malaysia is still high.

Malaria epidemics and transmission in Malaysia have always been associated with the opening of new land and forest clearance (Macdonald, 1957; Sandosham and Thomas, 1983). This has mainly involved land scheme and estate developments. Dam construction also involved forest clearance but its association with malaria has never been reported in Malaysia. Evidence from other parts of the world has consistently associated epidemics or increased malaria prevalence with water resource project such as dam constructions (Kondrashin and Rashid, 1987; Bunnag *et al.* 1979).

The Malaysian government approved the construction of the Pergau Dam in order to meet intensified demands for electricity resulting from the rapid infrastructural development and industrialisation that swept Malaysia in the late 1980s. The site for the dam is in Jeli District, Kelantan, the Northeastern state bordering Thailand and one of the malarious states in Peninsular Malaysia. The whole catchment area for the

Pergau Hydroelectric Project covers 22,200 hectares (222 km^2) and is extremely rugged, with uninhabited dense rain forest. The project comprises a main earthfill dam 74m high, a 30 m high re-regulating dam, an ungated spillway, an underground power station, 24 km of aqueduct tunnels and other 'appurtenant' structures (NEB, 1989). The reservoir surface area is 4.3 square km at a full supply level of 636 m above sea level. The installed capacity is 600 MW with an estimated annual energy output of 520 million kWh.

Reaction to the project was mixed. Some non-governmental organisations opposed it fearing adverse effects for local communities and to the environment. Local communities were mainly concerned about the loss of land and income. An environmental impact assessment predicted that the overall impact on the environment would not be significant should the project be implemented (NEB, 1989). In fact, the National Electricity Board (NEB, or now called Tenaga Nasional) projected benefits to local communities in term of job opportunities, promotion of business and commerce, improvement in roads, access to the hinterland and improvement of seasonal riverflow for flood mitigation and water quality.

The construction for the dam began in 1991 near a place called Lawar which was still classified as endemic for malaria. The prevalence rate of malaria was around 1-3%. The local Malaria Control Team (MCT) in Jeli did not know what to anticipate from the development of Pergau Dam. This was the first time a hydropower dam was to be built close to a local community in Malaysia. In 1991 and 1992, there was a sudden increase in malaria cases in Lawar and the blame was placed on the Pergau Dam. No published report documented a relationship between the sudden increase in malaria cases with the Pergau Dam. The situation contradicted the pre-project health impact assessment that reported, "malaria will not be a problem because only one *Anopheles (An.) maculatus*, the only established malaria vector in Peninsular Malaysia now, was caught in the area".

The author was interested to study the impact of the Pergau Dam on malaria in areas surrounding the dam. A proposal was submitted and accepted by the State Health Authority (Kelantan). The author immediately started the study by analysing existing data in 1994 (until August) which showed not a single case of malaria had been reported from the study populations. The Pergau Dam at that time was between 30 to 50% completed. Records from health units serving the dam workers also reported no malaria parasites detected from 2000 blood films for malaria parasites (BFMP) collected from febrile workers.

State data showed that malaria cases in Kelantan halved from 3000 in 1992 to 1500 cases in 1993. At the beginning of the fieldwork that started in September 1994, total cases for the State of Kelantan until August were two thirds of the 1993 figures with no sign of escalation. One half of the cases were amongst the Orang Asli. In Jeli, malaria cases dropped from 300 - 500 cases annually to 103 in 1993. The sudden drop in 1993 was explained as expected annual variation. When cases dropped further in 1994 to the lowest recorded figure since 1980, there was joy among the people involved in the malaria control programme (MCP). Many believed that all their efforts had started to bear fruit and malaria could at last be contained. This feeling of optimism was further supported by the fact that in 1993 and 1994, data from the Orang Asli villages had been updated and validated by the State Vector-Borne Disease Control Office (VBDCO) as well as the District Health offices. Unlike in previous years, all malaria cases had been reliably reported and recorded, minimising the possibility of under reporting. The VBDCO suggested that the decline in cases was due to the effectiveness of MCP in detecting, treating and controlling the spread of infection. However there was no obvious explanation since there had been no changes in the control activities for the past 15 years. In fact, due to dramatic price increases and shortages of DDT, house spraying had been discontinued since 1993. The treatment regime had used the same regime for the last 10 years, though revised in 1993 and 1994 to include mefloquine as a standby drug for resistant cases.

The author anticipated a complex situation with no clear factors to compare and not many cases to study. However, there were two important questions. Is malaria really declining, and if so to what extent? What could be the reason for the dramatic decline in malaria? Finding answers to these questions would not be easy but could lead to better strategies for malaria control. It was necessary to update local epidemiological information. The proposal was re-directed towards studying malaria in local village communities. It was hoped that the findings would update the knowledge and understanding of malaria and the factors involved in sustaining local transmission. The MCP could then decide on an appropriate strategy to target their activities more cost-effectively.

1.2 AIMS AND OBJECTIVES

The aims of this study are:

1. to update knowledge of the malaria situation in Jeli District, Malaysia.

2. to detect important variables that may help malaria in improving control strategies in Jeli District.

The objectives are:

1. to describe the environment in which malaria exists in Jeli District.

2. to investigate the receptivity of the environment to malaria transmission by:

    a. examining factors in the eco-system that may influence malaria

    b. studying the presence, abundance, behaviour and infectivity of vectors

3. to detect variables that may explain the vulnerability of the community and level of endemicity in the study locations by:

    a. examining social and behavioural characteristics of the study populations

    b. measuring malaria sero-prevalence of the study locations

    c. investigating the risk for malaria infections in the study locations

4. to find possible explanations for the dramatic decline of malaria in Jeli District.

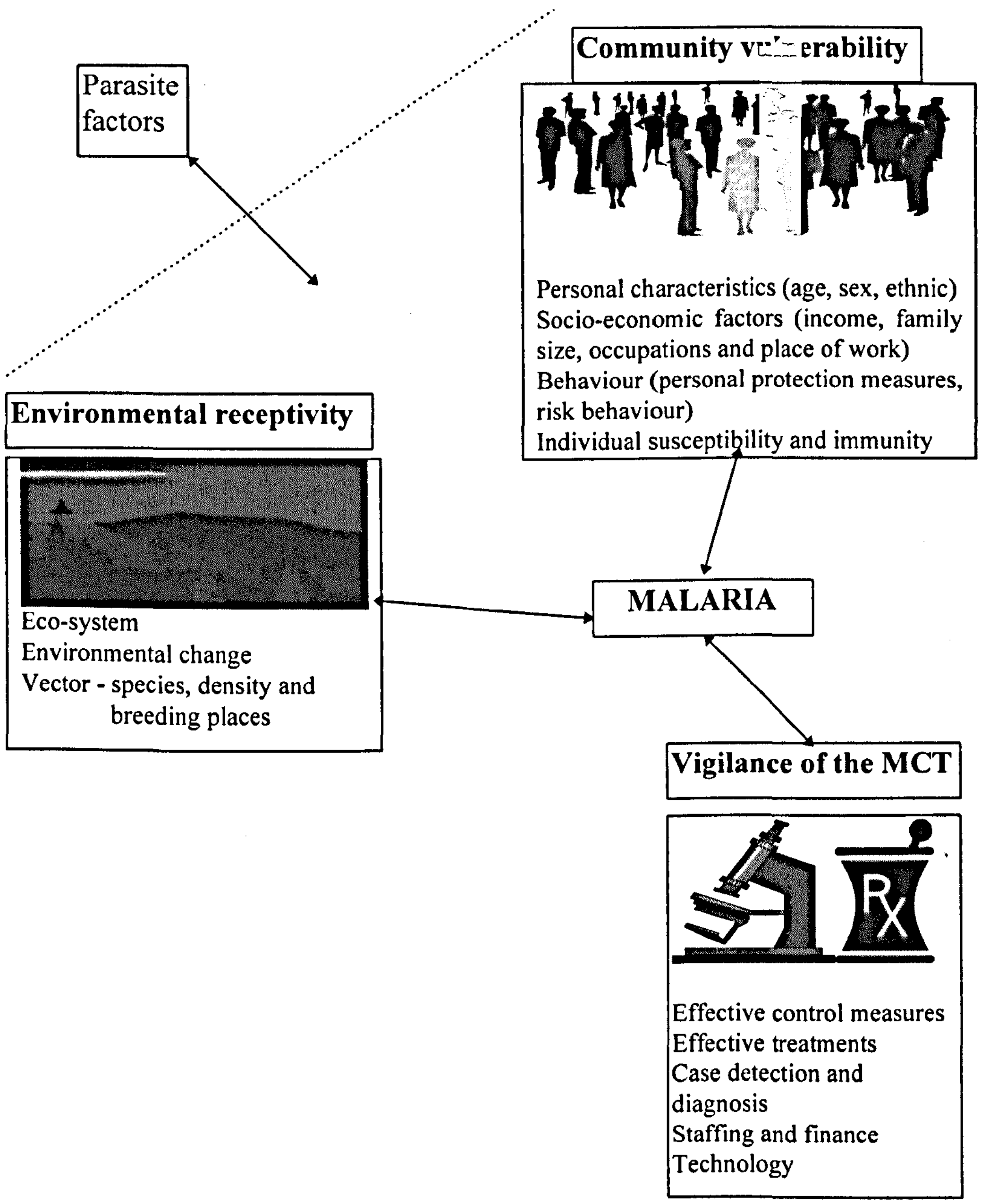
5. to recommend improved malaria control strategies where appropriate.

1.3 THE STUDY FRAMEWORK

Malaria control is normally a complex system consisting of a number of separately identifiable, though mutually interacting, component activities (Bailey, 1982) that include vector control, laboratory diagnosis, case detection and investigation and clinical assessment of malaria patients. Although many of the workers involved may have first-hand knowledge of several of these activities, few can see the whole picture in all its complexity. Perhaps even fewer, will fully understand the behaviour of the whole system as it operates within the economic, social and political constraints of a given society. Malaria control greatly benefits from the existence of a complete and up-to-date epidemiological information system. In study areas, records on mortality and morbidity have been kept since 1990 to a reasonably good standard, especially with the introduction of a computerised database. However, other information such as community responses to treatment and control programmes, and changes in population activities and vectors are not readily available. A good epidemiological information system should not only have mortality and morbidity data, but also up-to-date information on the underlying factors related to the human population, parasites, vectors and eco-systems (WHO, 1993).

This study aims to update information on the malaria situation in Jeli by adding the above information to the current knowledge. The framework for the study is shown in Fig.1.1. To achieve the objectives, variables to be studied were grouped into three components, receptivity of the environment, vulnerability of the community and vigilance of the MCT. In order to describe the eco-system and changes that had taken place , it was decided to collect data through direct observations and analysis of available information from various agencies and government departments. Information on the vectors was to be obtained by conducting a series of entomology surveys in each study location. The vulnerability of the community was to be assessed by location on the factors listed in Fig.1.1.

Fig.1.1 Summary of the study framework



In order to obtain the overall picture of the study populations, a social and behavioural survey was to be undertaken. The community and individual susceptibility to malaria infections was to be assessed based on the level of exposure to malaria infections and this information was to be collected by conducting parasitology, serology and physical examination surveys. The data were analysed to determine factors associated with malaria and factors that contribute to individual's risk for malaria. To find out if there is still a room for improvement in the malaria control strategies, a review of the MCT functions and capabilities was to be performed.

1.4 LAYOUT OF THE THESIS

Chapter 1 describes the background, objectives and famework. of the study

Chapter 2 discusses aspects of malaria relevant to the study objectives and the malaria situation in the study locations and in Malaysia.

Chapter 3 outlines the methodologies used for the various investigations conducted. The summary table at the beginning of the chapter serves as a guide to the content and arrangement of the methods. Reference values such as the cut-off points and level of ELISA O.D for serology and classification of anaemia are described in this chapter. The arrangement corresponds to the order in which the results are presented. All statistical methods are described in this section.

Chapter 4 describes the four study locations. Most of the results and arguments presented in this thesis only make sense if the eco-system of each study location is understood.

Chapter 5 presents the survey results divided into six sections, social and behavioural status survey, parasitology surveys, serology survey, physical examinations, vector study and vector susceptibility and mortality study.

Chapter 6 reviews the management of malaria patients admitted to the district hospital.

Chapter 7 is a synthesis of the findings of the study using a logistic regression model to highlight important variables associated with malaria status in the study locations. Chapter 8 provides a general discussion of the issues arising from the study and summarised the conlusions of the study and recommendations made.

CHAPTER 2: THE EPIDEMIOLOGY OF MALARIA

2.1 THE ENVIRONMENT

Malaria is endemic in an area where there has been constant measurable malaria incidence both of cases and of natural transmission over a succession of years (Pampana, 1969). The continuous transmission of malaria requires a proportion of the human population to be susceptible to infection, the existence of a sufficient gametocyte reservoir, and an adequate anthropophilic anopheline population to serve as the vector (Poolsuwan, 1995).

Environmental factors can affect the presence, continuity, sustainability and intensity of malaria transmission. These include any disturbances or modifications in the natural environment, land developments and changes in weather and temperature. Ecological changes such as those caused by dam and irrigation projects can increase malaria transmission (Bunnag *et al.* 1979; Harinasuta *et al.* 1970). Environmental changes always link closely with the climatic and temperature conditions and changes in an area. Most activities that involve environmental manipulation, such as agricultural and development projects, largely depended on weather and temperate, which in return determine the natural resources available. Disruption to the local environment may reciprocally lead to a significant change in local temperature. For example, massive deforestation can increase local temperature by 3-4°C (Matola *et al.* 1987). The expected climatic changes especially within the next few decades (IPCC, 1990 and 1992) are likely to affect malaria more than other communicable and infectious diseases. Currently 45% of the world's population lives in malarious areas (Sharp, 1996) and this percentage is expected to increase by the second half of the 21st century when the predicted increase in mean global temperatures of 3-5 °C is expected to extend transmission seasons. Whether this prediction actually materialises largely depends on community vulnerabilities and the capability of the local health services to anticipate changes in malaria transmission and deal with them effectively.

In order to assess the effect of human-induced climatic change on malaria transmission, Jetten *et al.* (1996) transformed Bradley's concept of vectorial capacity to incorporate meteorlogical climate data. They used mosquito density as a comparative index to express the epidemic potential of malaria, which is defined as the reciprocal of the critical density. Rainfall was excluded from the calculation. The results showed that the largest increase in epidemic potential will occur in those areas where mosquitoes already exist but parasite development is limited by temperature. The model predicts an increased malaria risk in areas bordering malaria endemic regions and at higher altitudes within malarious regions under a temperature increase of 2-4 °C. A change in malaria risk is related to a change in epidemic potential. Jetten *et al.* (1996) recomend caution in interpreting these results in specific situations. If the model is reliable and applicable to Malaysia, areas bordering Thailand are still under threat unless malaria on the Thailand border itself is disappearing. In this case the malaria monitoring system in Malaysia should be extended to include the situation from bordering districts in Thailand. Knowledge of changes in the malaria situation in neighbouring districts would enhance the planning process.

Temperature also plays a critical role in parasite development (Lindsay and Birley, 1996). The suitable temperature for P. vivax to develop and complete its life cycle is between 14.5-16 °C and for P. falciparum between 16-19 °C. A high temperature of more than 35 °C is lethal to the development of parasites (Garnham, 1966). The optimal feeding temperature for tropical mosquitoes is around 30 °C.

Optimum temperature is also important for the vectors as it regulates the speed of mosquito breeding (Rauyajin, 1991). Evaporation resulting from high surface temperature leads to high relative humidity and prolongs the life span of vectors (Wernsdorfer, 1980). Vectors in tropical rainforest seem well adapted to high humidities (Charlwood *et al.* 1985), hence the long life span and the potential to prolong the transmission season. Rainfall is one of the mechanisms which naturally regulates the temperature in tropical climates. It can also increase vector densities by creating breeding places and enhancing transmission. Very heavy rainfalls, however, tend to reverse the situation (Charlwood *et al.* 1985) by wiping out the anopheline larvae from existing breeding places.

Extreme weather, such as excess rainfall or drought can cause a large swing in the relative humidity. El-Nino Southern Oscillation (ENSO) is thought to have some effect on malaria transmission (Bouma *et al.* 1994a and 1994b; Nicholls, 1993) by causing drought in the affected areas. Peninsular Malaysia is said to have been affected even though ENSO does not directly come into contact with the country (Bjorge, 1995). The decrease in malaria incidence in endemic places in Peninsular Malaysia in 1992 is partly attributed to the effect of ENSO although this claim is not fully backed up with adequate observation or analyses of local data. ENSO can also cause excessive rainfall and flooding at a time when rain is not expected. This might affect malaria transmission by wiping out larvae and breeding places. Extensive studies are required to back-up the theoretical analogue, although the theory itself was very logical.

Ecological changes resulting from opening of new land, loggings and large scale agricultural expansion usually involve forest clearing and may increase malariogenic potential in those areas (Kondrashin and Rashid, 1987). In areas with forest or forest fringe malaria, outbreaks due to deforestation have been reported quite extensively. In Nepal, the increase important of *An. balabacensis* as a vector was attributed to the destruction of tropical forest (Ward, 1977). Its preference for human blood meals, feeding indoors, high level of susceptibility to falciparum malaria infection and longevity makes this species one of the most efficient vectors.

The construction of a dam often results in ecological changes that usually lead to a disturbance in the anopheline fauna in the area, even after the completion of the project. In India for example, from the dykes and surrounding dam, reservoir seepages result in perennial water flow enabling the establishment of vectors such as *An. fluviatilis* or *An. minimus* (Kondrashin and Rashid, 1987). In the township developed along the dam, *An. stephensi* adds to the problem of malaria. A high potential for malaria transmission is created by the Hirakud, Nagarjunasagar, Sikru and Srisailam dams in Andhra Pradesh, Hasdavebago Gandhisagarin in Madhya Pradesh and the Sathanoor dam in Tamil Nadu. In Indonesia, construction of ponds along the coastal areas in Java-Bali and the outer islands has given rise to an increase in breeding places and the prolongation of the breeding season of *An. sundaicus*, thereby increasing the malaria endemicity of the local population.

The direct relationship between irrigation and malaria is well established (Russel, 1938; Rao and Nasirudin, 1945). Irrigation canals created many breeding places especially during drought when there is interruption in water flow. Moreover, extensive irrigation schemes bring many changes in the micro-climatology of the terrain (Kalra, 1978) that directly or indirectly affect the mosquitoes habitat and behaviour. In Nepal, man-made marshes along the irrigation canal eventually replaced the breeding of *An. fluviatilis*, susceptible to DDT, by *An. annularis* which is highly resistant to DDT (Shreshtha, 1985). This has complicated the control programme as new methods are needed to deal with the new vectors.

2.2 HUMAN BEHAVIOUR AND SOCIO-ECONOMIC FACTORS

The occurrence of disease among human groups can ultimately be traced to their cultural practices and beliefs, socio-economic characteristics and how they interact with the environment (von Mering, 1970). This is true for almost all kinds of diseases, especially malaria. The relationship between humans and malaria is very complex and sometimes unpredictable. Every aspect of human life, social, behaviour patterns, customs and beliefs, economic activities and location of residences, can affect the interaction between malaria and man. Previous work has shown that failure to understand the importance of human factors and the complex epidemiological problems of malaria have significantly contributed to the disappointing results of malaria control programmes (Butrapon *et al.* 1986).

Theoretically, anybody is susceptible to malaria given the right combination of causal relationships. In the natural environment, malaria is a disease of the poor and thrives in poverty (Hongvivatana, 1991). Some social scientists and even malariologists view malaria as a socially produced disease rooted in the unjust social and economic order, particularly the political economy of under development (Chapin and Wasserstrom, 1983). In India for example, about 33 % of the population lives below the poverty line, and this population is at a greater risk of contracting infection (Sharma, 1996). They suffer most as they contract malaria frequently but cannot afford proper and timely treatment and often become the victims of the disease. Enhanced man mosquito contact is maintained by poor housing, settlements near the mosquito breeding sites, poor clothing, exposure during work in the jungle particularly at night in the presence of highly efficient vectors.

The concepts of risk behaviour and risk factors are still somewhat controversial and sometimes confusing. Sornmani (1992) categorised risk behaviour and risk factors into two groups. The first group relates to socio-cultural and demographic characteristics such as age, gender, education, religion, housing condition, transportation and economic status. The second group is directly related to the behaviour of particular individuals or communities such as sleeping patterns, working patterns, beliefs and traditions. In operational terms, these two categories are too broad, so Sornmani (1992) further subdivide them into four categories.

The first category concerns risk behaviour that favours the increase in occurrence and transmission of malaria. Examples are the working place, population movements, trans-migration, poor housing conditions, lack of knowledge on malaria control, nocturnal activities, not practising personal protection measures such as (using) bednets and socio-economic status. Behaviour patterns such as sleeping, washing, fetching water, defecation, clothing and urination, agricultural and economic activities, etc. may bring people into contact with infected *Anopheles* mosquitoes (Coimbra, Jr., 1988). In the Amazon, rubber tappers who leave their houses at dawn and new settlers who practise nocturnal hunting and fishing are at high risk for malaria. These activities coincide with the peak biting periods of *An. darlingi* which bites early in the evening and at dawn (Tadei *et al.* 1984). There is also a strong association between malaria incidence and house construction. Gamage-Mendis *et al.* (1991) found that poorly structured and constructed houses increase the human-vector contact by allowing significantly more vectors to enter the house dwelling compared to the well-constructed houses. The authors concluded that improving housing conditions can significantly reduce the risk of acquiring malaria in an endemic environment. The recommendation does not take into account the fact that the risk of getting infected is not only reliant on the density of the vector, but also the inoculation rate. On the other hand, the higher the vector density, the higher the chance of a person being bitten by the vector (Bradley, 1995). The location of the house may also determine the risk of getting malaria. Studies have shown that in areas with forest malaria, residents of houses located near the forest fringe have a higher risk of developing malaria than others. Contact with vectors is higher among those people because the forest edge offers optimal breeding and resting sites than the open cultivated land (Singhanetra, 1986; Butraporn *et al.* 1986).

One of the greatest problems that has hampered the effectiveness of malaria control programmes is uncontrolled population movement, either from non-endemic to endemic areas, or vice versa. The biggest effect of rapid population increase, described in many places but most prominently in India, where there is significant increase in economically backward groups, inhabiting inaccessible areas on the periphery and where malaria transmission exists (Ray, 1979). Increases in population lead to pressure on available agricultural land and to exploration and opening of uncultivated land. This land is normally in remote areas where health facilities are often deficient, as are other basic facilities such as water, road and proper housing.

Population movements accompanying development activities such as resettlement schemes, dams and irrigation works etc., are one of the principal causes of malaria resurgence in India and Sri Lanka (Andy, 1972; Hyma and Ramesh, 1980). Migrants bring new parasite strains and continue to spread malaria wherever they settle. The effects of migration on malaria transmission in other Southeast Asian countries has also been reported (Yow-Cheong *et al.* 1973). Efficient transport systems and availability of basic energy needs facilitate and encourage people to move from one place to the other in search of economic gain. However, these changes may not be all bad. Improved communication and transportation can boost a timely diagnosis and administration of treatment, that may reduce mortality and complications of malaria. If this measure is carried out to a high level of efficiency, transmission can be reduced to a very low level as the reservoir is contained and gradually eliminated, provided other aspects of malaria transmission such as vector control, are also tackled as effectively. This is where the capability of health agencies is very important and their ability to cope with the anticipated problems will determine the extent of the problems and the success of the control programme. The reality, however, is far from easy and even with rapid improvement in overall infrastructure, malaria control may not improve.

At international borders, malaria control has always been a problem due to exchange of population and illegal activities. In some areas, poor administrative control, inadequate and impractical malaria control operations and difficulties in supervision compound the problems.

The second category of risk behaviour and risk factors are those that may precipitate severe and complicated malaria such as self-medication and reliance on traditional medicine. This is of particular concern in Thailand where self-medication is widely practiced and difficult to control. The third category relates to the risk that may facilitate the development of drug resistance such as non-compliance and incomplete treatment. Although this group is well defined, evidence of its contribution to the continuation of malaria transmission is scarce and unconvincing. In order to discriminate the effect of non-compliance and incomplete treatment, it is necessary to determine and isolate other confounding factors such as self-medication and scientifically quantify the role and effect of traditional herbal treatments. No studies have addressed this issue in Malaysia. The final category relates to the risk that interfere with efficient implementation of a malaria control programme (MCP). These include active population mobility in and out of the area and customs and beliefs.

There has been many anecdotes in Malaysia incriminating a number of human behavioural patterns as important risk factors for malaria. Included amongst them are occupations in the forest or jungle, failure to comply with treatment regimes and staying out of doors to guard crops during fruit seasons (Arasu, 1992). None have been confirmed by a properly conducted study. Perhaps the most relevant study is the one conducted by Butraporn *et al.* (1986) in East Thailand. Using a matched-pair case-control study, Butraporn *et al.* (1986) found that low socio-economic status, irregular usage of bednets, periodic movement and working in the forest were amongst the important risk factors for malaria. The findings provide some indication about the groups of people at higher risk to forest fringe malaria. To use the results to plan malaria control in Malaysia is unjustified, since the vectors are different and the response of the health and malaria control teams may also be different. Local factors, such as those mentioned by Arasu (1992) should be investigated to determine their importance in promoting, enhancing or maintaining malaria transmission in Malaysia.

Much is to be gained for strengthening malaria control by going beyond the ideology of blaming the victims. A MCP can make significant strides forward when the importance of health behaviour and its determinants on the target population are recognised.

2.3 IMMUNITY TO MALARIA

Malaria, like other infectious diseases, is not homogeneously distributed in human populations. Factors that can plausibly account for clustering of malaria in individuals or households are unequal susceptibility to the disease among individuals due to innate or acquired immunity (Armstrong, 1978; Miller and Carter, 1976), unequal risk of contact with the vector mosquitoes (Dye, 1986; Burkot, 1988) and the likelihood of the parasite to recrudesce or relapse in an individual (Greenwood, 1989).

Immunity to malaria can be non-specific (which in turn can be innate or acquired) or specific (acquired). Innate resistance to malaria can occur in a person with red cell polymorphisms such as sickle cell trait (the carrier state for Haemoglobin S), β-thalassaemia, glucose-6-phosphate deficiency or conditions that affect red cell membrane such as Duffy blood group negativity. Evidence is also accumulating on the role of human leucocyte antigens (HLA) in limiting severe malaria (Marsh, 1993; Hill *et al.* 1991; Ho and Sexton, 1995). Malnutrition is one example of acquired non-specific resistance against malaria. The severe forms of malnutritions, marasmus and kwashiorkor, seem to provide protection against severe malaria.

The acquisition of malaria specific immunity is a complex process and is summarised here. Several years of exposure are usually needed for humans to develop immunity against malaria. Even then, full protection may never be achieved. In stable endemic areas, children born to immune mothers can be immune for a period, normally three to six months (Marsh, 1993; Bruce-Chwatt, 1952; Pasvol *et al.* 1976; Akanmori *et al.*

1995). Thereafter, the pattern of clinical malaria and immunity development are determined by the intensity of transmission (Ho and Sexton, 1995) as the level of passive antibody declines to almost zero before it picks up again (Marsh, 1993). Where transmission is seasonal or less intense, exposure may be insufficient to induce the development of immunity. Here, all ages are equally susceptible to clinical malaria, but may be more prominent in children ages one to four years (Greenwood *et al.* 1987). Naturally acquired immunity is also species-, strain- and stage-specific. This is important in agriculturally-oriented population movements because new settlers may have little or no immunty to the local parasite strains (Marques, 1979; PAHO, 1984) and, thus, should be monitored more closely to avoid severe complications. This whole issue of immunity and the level of community susceptibility to malaria are never straight forward. The difficulty is because there is no reliable method to measure protective immunity in the population.

Measuring antibody responses during or following malaria infections can provide means of identifying infected persons as well as valuable epidemiological evidence. In the serum of long term semi-immune residents, can be found protective antibody, malaria-specific antibody which does not correlate with protection and serological factors induced by malaria infection but reactive with non-malaria material. Within a few days of the invasion of the blood, the major serological responses to malaria are initiated. These antibody levels are maintained well beyond the crisis when the parasite numbers decrease dramatically. In fact the fall in antibody level can be so gradual that it can be detected months or years after infection. During recrudescence and relapses malaria antibody can again rise, this time more rapidly and to a higher level which are maintained for a longer time. This antibody (IgG) may be protective to the individuals against the homologous strain (Coggeshall, 1943).

Several methods are available to measure anti-malaria antibody. Direct agglutination, developed by Brown and Brown (1965), uses *P. knowlesi* for a highly sensitive, very specific schizont-infected cell agglutination (SICA) test. However, because SICA requires a synchronised infection, this has virtually restricted their application to *P. knowlesi*. Agar gel methods readily permit the analysis of multiple antigen-antibody systems, but are less suitable for quantitative work. This method relies on the precipitation in agar gel of complexes formed between diffusing soluble antigen and antibody. It was used as early as 1965 (Zuckerman and Spira, 1965) and more extensively later by McGregor *et al.* (1966). Complement Fixation test as described by Coggeshall and Eaton (1938) uses extracts of *P. knowlesi* as antigens. The difficulty of the technique and the low sensitivity of the test make it unacceptable for use in epidemiological investigations (Voller and Schindler, 1967).

The indirect haemagglutination (IHA) test (Desowitz and Stein, 1962) is based on the agglutination of malaria-sensitised carrier erythrocytes in the presence of malarial-antibody. The IHA antibody titre is the last dilution causing agglutination, and so provides a semi-quantitative indicator of the antibody content of the sample. The indirect method of the immunofluorescent test (IFAT) has been the mainstay of malaria serology since the early 1970s (Voller *et al.* 1980). Although the test is widely used, comparison of results from different laboratories is difficult and often meaningless. The outcome of the test is subjective and influenced by the type of antigen used, test conditions (that include time, temperature of incubation and washing steps), the potency of conjugate, and the observer; among the factors (Voller *et al.* 1980). Otherwise, the sensitivity and specificity of the test are acceptable and many researchers are happy to continue using IFAT in malaria research. An indirect enzyme-linked immunosorbent assay (ELISA) is analogous to the IFAT except that an enzyme is used to label the antiglobulin instead of fluorescein (Voller *et al*, 1980). The use of microplates make it more convenient and sensitive (Voller *et al.* 1975) and is becoming one of the most popular methods in malaria serology. The result of the test is reported either by visually reading colour changes of the substrate or using the photometric reading, and is proportional to the amount of antibody in the test serum.

Although a wide range of tests are available, only a few are suitable for field studies and for repeated use in operational control programmes. The majority of the sero-epidemiological studies have used either IFAT, IHAT or ELISA methods, or the combination of them. The strengths, weaknesses, advantages and disadvantages of these three methods are summarised by Gilles (1993) from the original review by Molineaux *et al.* (1988). The ELISA test that uses a 96-well microtiter plate as solid phase is more convenient to use in studies with large samples as it is faster and more objective.

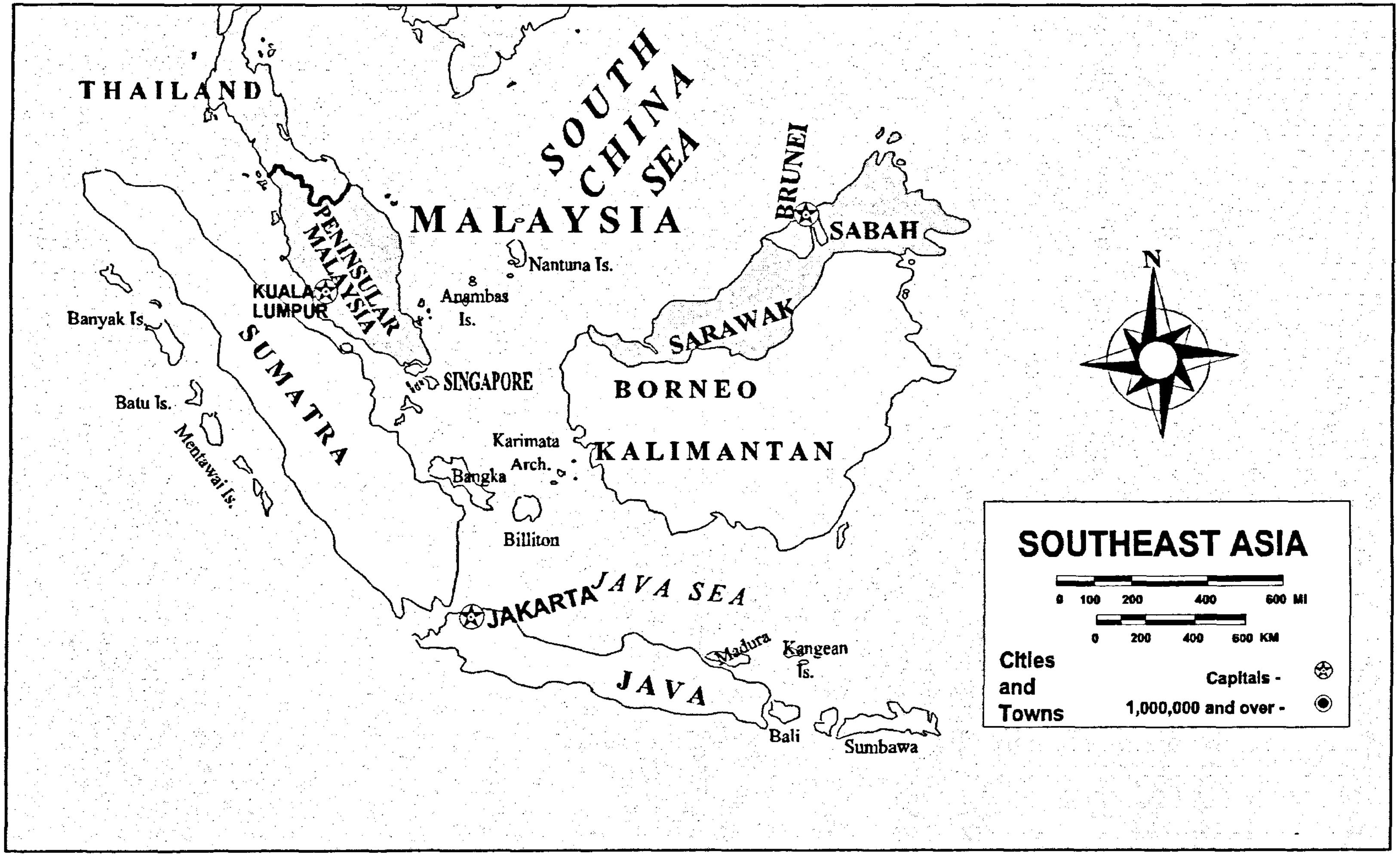
In non-endemic areas, the use of serology for antibody detection is of little value except in clinical situations where parasites detection is elusive but signs and symptoms are suggestive of malaria. In endemic areas, serology can be of great help in establishing malarial endemicity (especially age-specific indexes), assessing changes in transmission during or after anti-malaria programmes, delineating malarious areas and identifying areas or people requiring treatment, especially during control programme (WHO, 1974). The usefulness of sero-epidemiology in situations outlined above have been reported by studies as early as the 1960s (Voller and Bray, 1962; Voller and Bruce-Chwatt, 1968; Collins *et al.* 1968; Collins *et al.* 1971b). Serology also made possible the localization of endemic foci in remote areas, where blood slide examination is not feasible (Sulzer *et al.* 1978). It is also useful as a mode of monitoring progress of anti-malarial campaigns, especially when parasite rates drop to below one percent (Ambroise-Thomas *et al.* 1976).

2.4 MALARIA IN MALAYSIA

2.4.1 Malaysia in general

Malaysia is a tropical country situated in South East Asia between 1^0 to 8^0N of the equator and 99.5^0 to 119.5^0E longitudinal. It is one of the nine countries in the Western Pacific region that are affected by malaria (WHO, 1992). Malaysia is split geographically into two regions, Peninsular Malaysia and East Malaysia, separated 650 km by the South China Sea. The State of Kelantan is one of the 12 states in Peninsular Malaysia while Sabah and Sarawak form East Malaysia (Fig 2.1). Peninsular Malaysia, bordered by Thailand in the North and Singapore in the South, covers an area of 132,000 square km (km^2). All states, except Federal Territory, have flat coastal lines which gradually changing to elevated hilly areas further in the

Fig. 2.1 Map of Malaysia



mainland. Hodgkin (1956) divides Peninsular Malaysia into seven topographical regions, brackish water fringe, flat coastal plain with fresh water, broad valleys with urban areas, narrow valleys with rice fields, hills under plantation cultivation, jungle covered hills and mountains (> 150 meters). The Titiwangsa Range which runs from the north border to about two thirds of Peninsular Malaysia forms the backbone of the Peninsular dividing it into two parts, the West Coast and the East Coast. One third south from the northern border, the range cuts across the hinterland of three states, Kelantan, Perak and Pahang. These areas are covered by thick rain forest and are accessible by land vehicles only through logging tracks. Malaria is hyper-endemic, with up to 75% parasite rate but the MCP has been hampered by inaccessibility. The completion of the East-West highway in 1982, which cuts through the range from the state of Kelantan to Perak, reduced logistical difficulties but introduced non-immune people to the area. About 30% of Peninsular Malaysia is still covered by primary tropical forest, the rest being rubber or oil palm estates and other agricultural holdings such as rice plantations.

The state of Sabah covers a land surface of 76,115 km^2 and is situated on the northern part of Borneo island. Almost 70% of the malaria cases in Malaysia are from Sabah. In Sarawak, the largest state in Malaysia, malaria control is still very much limited by poor communication facilities in remote areas, compounded by difficult terrain and the existence of nomadic group populations.

Malaysia has a warm and humid climate. The sun shines throughout the year except for a period during monsoon seasons (the annual Southwest and Northeast monsoons), which are usually the wettest and coldest seasons. The mean monthly temperature is relatively constant at 27 ^{0}C (80 ^{0}F) although sometimes varying from 12 ^{0}C to 41 ^{0}C, especially on the East Coast. Annual rainfall averages 2,540mm, with considerable variations in different locations. The wettest period is usually from September to December and the driest from March to May. The difference is more marked in the East Coast States (Pahang, Terengganu and Kelantan). During the wettest season, the East Coast states usually experience flooding.

Malaysia has a population of 20.6 millions (Malaysian government statistics, 1996) plus one million foreign workers. The annual growth rate is about two percent. The male to female ratio is 1:1 and the life expectancy is 65 and 70 years respectively. The population density averages 131 inhabitants per km^2 with about 36% urbanisation. The age distribution of the Malaysian population is shown in table 1.

Table 2.1. Age distribution of the population of Malaysia (1996)

Age range(years)	Percentage
0 - 9	26.0
10 - 19	23.0
20 - 29	19.0
30 - 39	12.0
40 - 49	8.0
50 - 59	6.0
60 - 69	3.0
70 and more	3.0

Source: Malaysian government statistics96.

There are three main ethnic groups, Malay (59%), Chinese (26%) and Indians (8%). The natives (Orang Asli), still live in jungles although new settlements have been and are being built to bring the scattered groups into accessible areas. There are 6,390 Orang Asli living in Kelantan in 1996 (JHEOA, 1996).

2.4.2 Development projects that may affect or are affected by malaria

Malaria in Malaysia is forest and forest fringe, therefore, development projects that involve these two eco-systems are bound to affect or be affected by the malaria situation. The Ministry of Rural Development spent billions of Ringgits (RM) to improve the overall infra-structure in the rural and remote areas. Federal government agencies such as the South Kelantan Development Authority (KESEDAR), Federal Land Consolidation and Rehabilitation Agency (FELCRA) and Federal Land Development Authority (FELDA) were given the tasks of facilitating land development by opening new lands, distributing newly identified areas and monitoring the settlers. As a result, people have moved deeper into the jungle to develop the no-man's land. Increased demands for energy, especially electricity, have led to the building of hydroelectric power dams, seen as cheap and effective way of generating electricity. The latest, Pergau Dam, was still under construction when this study started at the end of 1994.

2.4.3 Overview of the malaria situation in Malaysia

There is no definite history on how malaria was brought into this country. Existing records suggest that it was brought in by immigrants when Penang was founded in 1786 (Sandosham, 1959). In Peninsular Malaysia, malaria cases stabilised at around 10,000 to 20,000 cases per year between 1975 and 1990. Most of the cases were from hilly jungle regions of the hinterlands of Kedah, Perak, Pahang and Kelantan as well as areas along the northern border. In 1991, cases dropped below 10,000 (9879) for the first time since 1975, making the start of the downward trend in detected malaria cases. In 1994, there were only slightly more than 5000 cases in Peninsular Malaysia (VBDCP, 1994).

Malaria in Sarawak centred around 700 cases before 1980, but over the next decade increased from 754 in 1981 to 2132 cases in 1991 (VBDCP, 1980-1991). Increased population movements to and from jungle areas were thought to be the reason for the increase. However, the role of other factors such as better detection and reporting of cases in 1991 compared to 1981, were not examined. In Sabah, which now contributes between 50 to 75% of total malaria cases for Malaysia, annual cases fluctuate from a one year low of 11,000 to over 50,000 cases. In 1991, Sabah reported 29,178, 50% of the total cases for the year. The three major elements for the uncontrolled malaria in Sabah were logistic difficulties, resistant strains and population movement (including influx of illegal immigrants from the neighbouring Philippines and Kalimantan).

Three types of malaria exist in Malaysia, *P. falciparum*, *P. vivax* and *P. malariae*. *P. falciparum* (between 55-65%) is still the predominant type among the three species, followed by *P. vivax* (between 30-40%). *P. malariae* (between 0.03-1%) is not very common. Mixed infections are usually between *P. falciparum* and *P. vivax*. The three main vectors in Malaysia are *An. maculatus* in Peninsular Malaysia, *An. balabacensis* in Sabah and *An leucosphyrus* in Sarawak.

2.4.4 The Malaria Control Programme (MCP)

Organised malaria control in Malaysia began at the beginning of the present century with the formation of a Malaria Advisory Board in 1911 (Sandosham, 1959). The use of larvicides in urban seepages and canals was among the early vector control measures employed. In 1931, these measures were augmented by mepacrine therapy, in 1946 with proguanil, and in 1949 with residual insecticide spraying of DDT, BHC, and dieldrin, and the use of 'new' anti-malaria drugs such as chloroquine and other amino-quinolones. These control measures rendered possible the economic developments especially in the highly malarious or highly receptive.remote areas.

In 1953, the Government started a pilot project for a large scale eradication programme in Sabah. In 1960, a nationwide malaria eradication pilot project (MEPP) was launched by the Ministry of Health to evaluate the feasibility of carrying out a malaria eradication programme (MEP) in Malaysia. When it ended in 1964, the results showed that MEP was feasible both from the technical as well as administrative aspects. A pre-eradication survey was then carried out from 1965 to 1966 to evaluate the actual malaria situation in Peninsular Malaysia.

A MEP began in Sabah and Sarawak in 1961, followed by Peninsular Malaysia in 1967 with the aim of eradicating malaria in Malaysia by the year 1982. The MEP was a time-limited programme to be carried out to such a degree of perfection that by 1982, all malaria transmission would have been eliminated. The successful implementation of the MEP resulted in the disappearance of malaria in large areas of Peninsular Malaysia, Sabah and Sarawak, mainly coastal regions. However, after ten years of expensive and laborious efforts, there were no signs that malaria could ever be eradicated. In 1978, the WHO suggested that the MEP be restructured, not only in Malaysia but world-wide.

At the beginning of the Fourth Malaysian Plan in 1981, all eradication programme activities and malaria control services were combined to form the Anti Malaria Programme. At the beginning of the Fifth Malaysian Plan in 1986, a new headquarters was established in Kuala Lumpur called The Vector Borne Disease Control (VBDC) Unit. The main aim of the unit was to control the six diseases recognised as potential hazards that is malaria, dengue, filariasis, typhus, Japanese encephalitis, plague and Yellow fever. The malaria division of the VBDC had two objectives, to reduce the morbidity and mortality due to malaria so that it no longer posed a public health problem, and to prevent the occurrence of malaria in malaria-free areas. Five divisions were established within the malaria division; epidemiology and laboratory, vector control, health education and training, record and documentaion and administrative units. The VBDCP at national level was responsible for formulation of policies, planning control programme, preparation of guidelines and standards, co-ordinating VBDC activities throughout the country, management and distribution of resources, monitoring and evaluating control programmes and activities, establishing inter-agency co-operation, conducting operational research and establishing training and reference centres. MCP activities are presented in Table 2.2.

Table 2.2 MCP Activities.

Main activity	Detail implementation
Case detection	Mainly active case detection (ACD) and passive case detection (PCD). Mass blood survey (MBS) is carried out in special situations, such as a sudden increase in cases in one area, during anti-malaria visits to Orang Asli interior settlements and where there is a sudden influx of foreign workers from endemic areas. In hospitals, blood donors from malarious areas are screened for malaria.
Laboratory diagnosis	
Treatment	Treatment guidelines are issued to hospitals and local malaria control teams. Prophylactic chemotherapy is given by necessity but presumptive treatments have been discontinued. Treatment regime is given in Appendix 1.
Case investigations	A must for all cases. Field canvassers have to cover at least 10 houses radius of the case.
Case follow-up	Six months for *P. falciparum* and twelve months for *P. vivax* infection.
Vector control	DDT spray used to be a routine with occasional additional special and focal spraying. Larviciding is very seldom carried out.
Entomological studies	Emphases are on vector habits and susceptibility tests.
Environmental modifications	Includes drainage, filling, stream improvement and manipulation techniques that include water management, intermittent irrigation, flushing, sluicing and clearing growth.
Reduction of contact with vectors	Screening and personal protection methods
Health education	Usually carried out during ACD, case investigations or follow-up.
Primary healt care	Employing and training primary health care (PHC) volunteers to help in control activities.
Training and research	Bednet and parasite resistance studies
Environmental impact assessment	Ideally should be carried out in all forest or forest fringe and estates related development projects, but so far has not materialised.

Some of these activities may not be actively used now and the degree of implementation of any activities may differ in different state.

2.4.5 The vector and vector control

A comprehensive listing of *Anopheles* species of Malaysia was carried out by Reid in the late 1960s (Reid, 1968). Sixty-eight species of Anopheline mosquitoes belonging to subgenera *Anopheles* and *Cellia* are known to exist in Malaysia. Since then, only one more species has been added to the Reid's list, *An. (Cellia) nemophilous* (Jaal, 1993). Nine of the sixty-nine species are confirmed malaria vectors (VBDCP, 1988). They are *An. balabacensis, An. campestris, An. dirus, An. donaldi, An. flavirostris, An. letifer, An. leucosphyrus, An. maculatus and An. sundaicus.*

In Peninsular Malaysia, the possible vectors are *An. campestris, An. dirus, An. letifer, An. sundaicus* and *An. maculatus*. In Sarawak *An. balabacensis, An. leucosphyrus* and *An. sundaicus* are the primary vectors with *An. donaldi* as the secondary vector . *An. balabacensis, An. flavirostris* and *An. sundaicus* are the vectors in Sabah. A brief description of important malaria vectors in Malaysia is given below.

An. balabacensis sensu stricto is essentially an anthropophilic and confined to the states of Sabah and Sarawak (Hii, 1982). *Balabacensis* larvae breed in shaded pools such as hoofprints, buffalo wallows, seepages, blocked drains and wheel ruts (Rajapaksa, 1971). In Sabah, 90% of the *balabacensis* species feed on human blood (Reid, 1968 and Colles, 1956).

An. campestris is currently the most important vector of malaria in the coastal plain (VBDCP, 1988). *Campestris* larvae breed in the corners of rice fields and borrow pits in coconut plantation, and sometimes in brackish water (Chow, 1970; Chooi, 1985). *An. campestris* is the most anthropophilic and endophagic of all *Anopheles* species in Malaysia. It has a preference to bite human with human:calf ratio of 3.4:1 (Reid, 1961). This species mainly bites indoor with indoor:outdoor ratio of 4.4:1 (Moorhouse and Wharton, 1965). The biting cycle of *An. campestris* is from 0100 to 0200 hours and from 0400 to 0500 hours (Reid and Hodgkin, 1950).

An. dirus is found in northern parts of Peninsular Malaysia along a narrow strip bordering Thailand. This species is not a good vector and does not pose a serious problem in Malaysia (Chow, 1970). *An. dirus* feeds readily and in large numbers on man (Scanlon and Sandinand, 1965). The species inhabits foothills, forest and forest fringes where it breeds in shaded pools such as animal footprints, seepages, wheel ruts, base of fallen tree trunks and depression in hollow logs (Peyton and Harison, 1979).

An. leucosphyrus is a vector of human malaria in Sarawak and monkey malaria in Peninsular Malaysia (Reid, 1968). It will readily enter the house to bite man but does not rest indoors during the day (Colles, 1956). *An. leucosphrus* is present in hilly areas. Larvae are commonly found in seepage pools, forest swamps and temporary pools in primary and secondary jungles alongside the foothills (Chow, 1970).

An. maculatus is the only vector responsible for transmitting malaria in hilly areas (Sandosham, 1959). The larva breeds in springs, seepages and streams exposed to sunlight or slightly shaded areas, especially in recently cleaned areas where trees have been felled and soil disturbed (Reid, 1968). Where cattle are present, the majority of adult mosquitoes feed on them. In the absence of cattle, *An. maculatus* will readily feeds on man (Davidson and Ganapathipillai, 1956). This species bites in greater numbers outdoors compared to indoors (Wharton, 1951 and 1953). However, significant numbers still enter houses at night to bite man. Adult *An. maculatus* rest outside among the vegetation (Wharton, 1950).

An. sundaicus is the primary vector in coastal areas where it breeds mainly in collection of brackish water exposed to sun, or lightly shaded by vegetation (Hodgkin, 1956). It rests both indoors and outdoors but bites in houses (Reid, 1968). *An. sundaicus* is attracted to cattle more than to man (Reid, 1961). A very successful eradication programme in the west coast, that includes spraying every house with DDT, totally wiped out this species in most areas. This species only exists in the East Coast now.

In Peninsular Malaysia, the most important vector for malaria is *An. maculatus* (Hodgkin, 1956; Wharton *et al.* 1963; Gordon *et al.* 1991; Kittayapong *et al.* 1993). *An. maculatus Theobald sensu lato* is a species complex consisting of eight siblings. Most of the studies on *An. maculatus* in Peninsular Malaysia were done in the 1950s and 1960s. Since Hodgkin (1956) and Reid (1968), the work by Kittayapong *et al.* (1993) in incriminating *An. maculatus* form E as the primary vector for malaria transmission in Peninsular Malaysia was perhaps, the most confirmative of all. In the study, Kittayapong and colleagues carried out a gas chromatographic analysis and principal component analysis by cuticular lipid differences to identify and separate the two species of *An. maculatus* thought to exist in Peninsular Malaysia, the widely distributed sensu strictu (B form) and E form. They found that both forms, B and E exist with the E form predominate except in the south.. *An. maculatus* samples from Kelantan revealed only form E. The difference in the distribution of the two forms of *maculatus* could be due to the presence of vast palm oil plantations in the south of Peninsular Malaysia, which was thought not suitable for form E. An argument could also be placed on the basis of the lack of primary forest or thick secondary forest in the south, an ecology prefered by the form E.

All members of *An. maculatus* tend to exhibit a zoophilic and exophagic, biting behaviour (Upatham *et al.* 1988). They feed at all hours of the night, with a peak between 2100 hours and 2400 hours for the Malayan species (Sandosham & Thomas, 1983) and around 1900 hours for the species in central Thailand (Upatham *et al.* 1988). Species from the equatorial tropical forest zone of Malaysia are very efficient malarial vectors, with natural infection rates of 10 to 15% (Sandosham & Thomas, 1983). Negative sporozoite infections, however, have been consistently reported for this species elsewhere in the mainland of Southeastern Asia (*Gould et al.* 1966; Eyles *et al.* 1964; Ismail *et al.* 1974; Upatham *et al.* 1988).

A more recent study on the behaviour of the *An. maculatus* was reported by Chiang *et al.* (1991). The study was conducted in an isolated hyper-endemic Orang Asli resettlement village of Pos Betau, in Pahang, Peninsular Malaysia to investigate the possible existence of indoor and outdoor genetic varieties of *An. maculatus sensu stricto* and to obtain information concerning their dispersal and flight range using the capture-mark-release-recapture technique. The authors collected the mosquitoes using the landing catch method on human bait inside and outside village houses between 1900 and 0400 hours for two consecutive nights. After marking them, the mosquitos were released just before sunrise between 0500 and 0600 hours. The recapture rates were between 10.7-12.0% and most of the mosquitoes were recaptured near the place they were released. The maximum flight range recorded was 1.6 km. They did not find any discreet indoor and outdoor biting populations of *An. maculatus* in that area but the recaptured mosquitoes showed a 3:1 outdoor biting preferences. The oviposition cycle was 2.35 ± 0.45 days and the survival rate was 0.699-0.705. The findings were close to the ones reported by Loong *et al.* (1990) of 2.30 ± 0.47 days and 0.710-0.761 respectively. The findings by Loong *et al.* (1990) and Chiang *et al.* (1991) were significant to the MCP. The flight range demonstrated by the mosquitoes means that any control measure related to the vector must consider at least a two km radius of areas.

Studies on other *Anopheles* populations in Malaysia have also been reported but are of lesser interest since they are not vectors of malaria. Jaal and McDonald (1993a &b) surveyed the ecology and fauna of anopheline species in coastal areas of the north-west Peninsular Malaysia. They found seven predominant species, but did not find any *maculatus* species. They also confirmed the non-existence of the once very efficient vector, *An. sundaicus*, in the coastal plain of the West Coast of Peninsular Malaysia.

Other possible vectors have also been investigated to determine their status. Rahman *et al.* (1992) reported the presence of malaria oocyst from *An. kochi*, *An. aconitus* and *An. philipinensis* in an endemic village located in an area where the jungle had been extensively cleared in the early 1980s for the construction of the East West Highway. In another study (Rahman *et al.* 1995), they found that *An. vagus* and *An. kochi* peak after dusk and declined steadily towards midnight in contrast to *An. aconitus* and *An. maculatus* which bite through the night. Nevertheless, they confirmed that the only vector for malaria transmission is *An. maculatus*.

Effective vector control is crucial if the MCP is to be successful and sustainable. The forest and forest fringe vectors are the most difficult to control because of the ecological constraints and variable habitats. This problem is of particular importance to the MCT in the study areas. The lack of publications describing the nature and behaviour of *An. maculatus* are compounded by the absence of information on the vector locally. It is assumed that since *An. maculatus* is the only vector and there is only one species exists (Kittayapong *et al.* 1993), the behaviour of the vector will be the same throughout endemic areas. Initial strategies for vector control include spraying the house with DDT and environmental management. Despite being very effective in the early years of active vector control activities, the use of DDT for house spraying suffered a few setbacks that eventually brought its discontinuation. First, the development of resistance by the malaria vectors to it, and then the refusal of recipients to let their house spayed with DDT because of its unpleasant effects (Sharma and Mehotra, 1986). DDT is also blamed to be hazardous to the environment. There is no active protest against the use of DDT for house spraying in

Malaysia. However, DDT was eventually discontinued from routine malaria control activities because of supply shortages. Environmental management to control *Anopheles* breeding has been quite successful but this method is not as universal as it was thought to be when it was first adopted. In India, the environmental management method is only successful in the drier areas (Sharma, 1991). In places with high rainfall such as Assam, this method is not effective (Jana-karu *et al.* 1995). In Malaysia, environmental management is very successful in controlling coastal and urban malaria (Sandosham and Thomas, 1983). Using this method, coupled with the use of DDT, case detection and case management, malaria has been eradicated from coastal and urban areas and *An. sundaicus*, the vector responsible for the transmission of malaria in coastal areas of the West Coast of Peninsular Malaysia has also been wiped out. As happened in India, this method is useless against the forest and forest fringe vectors.

The most coveted method of vector control now is the use of insecticide-impregnated bednets (Curtis, 1992a and b; Webber, 1996). Bednets have long been used by people for protection against mosquitoes (Port and Boreham, 1982; Bradley *et al.* 1986; Lindsay and Gibson, 1988). However, ordinary bednets have serious shortfalls if not used properly. Torn or not properly tucked-in bednets can permit access for mosquitoes to bite people sleeping underneath. Mosquitoes can also probe through if any parts of the body is connected with the bednet. Insecticide-impregnated bednets (IBN) have been shown to overcome these problems (Rozendaal and Curtis, 1989; Curtis 1989 and 1990). Numerous trials have been reported from malarious countries on the effectiveness of insecticide-impregnated bednets in malaria control (Curtis, 1993). Jana-karu *et al.* (1995) conducted a case control study in the state of Assam, India to find out if deltamethrin-impregnated bednets are effective in reducing malaria. They reported a reduction in malaria of between 66 to 80 % compared to the control villages. However their wide confidence interval (25-88%) means further analysis of their results is needed to determine which parameter that they adopted is useful as a measure of effectiveness. Studies by Charlwood and Graves (1987), Lindsay *et al.* (1991), Magesa *et al.* (1991) and Samarawickrema *et al* (1992) have shown that permethrin-impregnated bednets caused marked reductions in the number of *Anopheles* vectors with up to 70% reduction in morbidity and mortality (Alonso *et al.* 1990).

Vythilingam *et al.* (1995) carried out a similar study in an Orang Asli village, in Pahang, Peninsular Malaysia. DDT spraying had been suspended one year prior to the study. They found that after two years of trials, the sporozoite rate in the study village was significantly lower (0.02%) than in control villages (0.6%). Parous *An. maculatus* were also reduced from 62% before to 44.1% after the trials. Biting cycles showed two peaks, at 2230 to 2330 and 0230 hours. After the trial, the peaks were suppressed and biting times were evenly distributed. The vector even shifted to biting early after the introduction of bednets. Bioassays showed only 80% mortality after one month and <60% after six months. After retreatment of the bednets, bioassays showed 90 % mortality even after eight months. The authors suggested that it was sufficient to re-impregnate bednets every six months. Another trial on impregnated bednets was conducted in Sabah (Hii *et al.* 1995). In the study , impregnation of bednets with insecticides was carried out by the villagers themselves. Eleven villages were selected as trial villages with another eleven villages put on DDT spray. The impact of the intervention was determined separately for each village. Using Wilcoxon and Mann-Whitney U test for the analysis of their skewed data, they showed all incidence of malaria decreased in the first year, with higher median in the bednets village, 211 as to 108 in the DDT villages. In the second year of the study, results from the DDT village varied with some decreased and the rest increased. In the trial villages, the incidence of malaria was either maintained as in the previous year or decreased further.

In Thailand, Somboon *et al.* (1995) did a village case control study to determine the effect of bednets on the mass mortality of mosquitoes. The results showed no significant difference in the number of mosquitoes caught before and after bednets were used. This absence of detectable mass killing effect did not agree with the result of Jana-karu *et al.* (1995) in Assam, India. This could be due to the behaviour differences of the vectors. Perhaps the effect of the presence of large numbers of cattle was not explained, but could be the reason for the lack of apparent effect on *An. maculatus* because they are more zoophilic and exophagic.

In summary, current malaria control activities in Malaysia are centred around case detection and case management. With the discontinuation of DDT, there is no more uniform vector control activity. Although the use of bednets is continuously being promoted and encouraged, the use of insecticide-impregnated bednets is still patchy and has not become a nationwide control strategy. Malaysia can claim the honour of being the first country in the world to have successfully applied environme management as a method to control malaria, but it is not suitable for forest and forest fringe vectors. Current control activities may be adequate provided there are proper surveillance and monitoring measures. The control authorities in Malaysia must remember the lesson learned from the now abandoned MEP: malaria cannot be dealt with as a single and uniform world-wide problem (Spielman *et al.* 1993).

CHAPTER 3: MATERIALS AND METHODS

3.1 SUMMARY OF METHODS ADOPTED IN THE STUDY

Methods used to achieve the study objectives include surveys, analyses of existing data and direct observations. Quantitative data are supplemented by qualitative information from interviews with key informants. The investigations that were conducted are summarised in Table 3.1.

Table 3.1 Summary of investigations conducted in the study.

Research component	Methods
Component 1. Description of study locations. Area descriptions, eco-system classifications and grading of environmental variables.	Direct observations and synthesis of records from the Health Office, Aborigines Department, District Office and Land Scheme Agencies.
Component 2. Social and behavioural survey	Structured questionnaire interview of the head of households and in-depth interviews with key informants
Component 3. Parasitology survey	Two cross-sectional surveys, one in the rainy and one in the dry seasons plus routine monthly slide surveys by field canvassers
Component 4. Serology survey*	Two cross-sectional surveys on consenting respondents, one in the rainy and one in the dry season using the ELISA method
Component 5. Physical examination*	Physical examinations performed to detect spleen and liver enlargement and anaemia on the same respondents as in Investigation 4.
Component 6. Vector study	Indoor and outdoor whole night catches fortnightly using the bare-leg method.
Component 7. Permethrin-impregnated bednets and vector mortality study	Case control study on the effect of impregnated bednets and ordinary bednets on vector mortality
Component 8. Review on management of malaria patients	All patients admitted to the District Hospital between January 1995 and June 1996
Component 9. Capabilities of the Control Team	Participant observations, in-depth interview, review of current control activities and team capacity.

Note: * Indicate surveys carried out on the same respondents (same sample size)

3.2 THE STUDY AREA

The study took place in the District of Jeli, in the State of Kelantan, the northern most state bordering Thailand. Jeli covers an area of 128,020 hectares with 39,000 population (Census, 1994). The Jeli District Health Office was granted administrative power only in 1995 with an appointment of a Medical Officer of Health. Until the late 1950s, Jeli was highly inaccessible. The tarred road reached only up to Tanah Merah Town, which is 30 km east of the present Jeli Town. From here, a journey to Jeli takes about one week on foot through areas surrounded by the evergreen primary tropical forest. After World War Two, communist uprising was the greatest problem for Malaysia and the geographical location of Jeli made it a perfect hiding place for the guerrillas. To overcome the problems posed to the army, the government upgraded the infra-structure and road to this area. Jeli town was created both to promote development and to facilitate the movement of army and security forces. However, proximity to the Thailand's border remained a problem. The hilly land covered with tropical rain forest extended beyond the Thailand border and was inhabited by wild animals. Even now, villagers still come across elephants, bears, wild boars and tigers during their jungle trips, with some occasionally entering villages in search of food.

Jeli is also part of 'The Hinterland Triangle', an area covered by thick primary forest bordering 3 states, Kelantan, Perak and Pahang. This area was one of the most underdeveloped areas until the early 1970s. The construction of the East-West Highway, which began in the late 1970s and completed in 1982, cut across Jeli and the Titiwangsa Range, and through part of the triangle. The highway facilitated army mobilisation and restricted the communist activities. The strictly enforced security measures encouraged people to use the highway and developed Jeli. After the surrender of Communist National Party in the mid 1980s, Jeli was open to public.

Initially, the main economic activities were agriculture and logging. Before the 1960s, agricultural activities were family based. The size of the land worked by the family depended on their capability. When the State government enforced the Land Act, the family could only work on the land entitled to them, depending on the success of their claim. In the early 1960s, Federal and State agencies distributed land to successful applicants in a more organised procedure. Applicants were designated specific areas to build houses and other areas for cultivation. The agencies not only advised on the type of crops, but also supervised and advised on technical issues, and gave settlers advance wages if needed. Certain agencies even marketed the products on behalf of the settlers to make sure they obtained the right price.

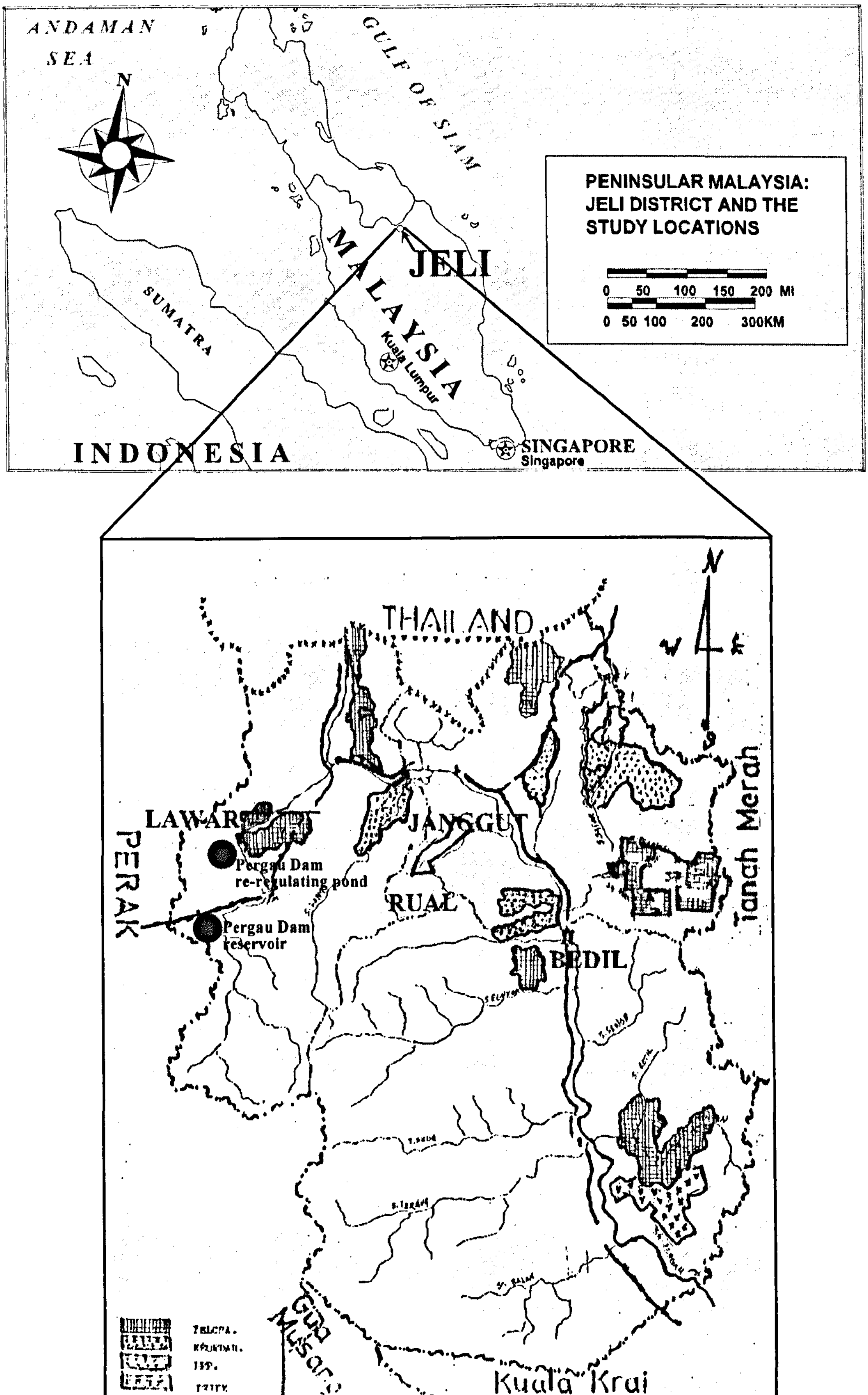
There are five agencies operating in Jeli District; the Federal Land Consolidation and Rehabilitation Authority (FELCRA), The South Kelantan Development Authority (KESEDAR), Rubber Industry Development Authority (RISDA), Farmers Association Board (LPP) and Kelantan State Economic Development Corporation (PKINK). The agencies have different objectives and different procedures. The PKINK is the privatised wing of the State government and aims at making profit. The LPP supervises farmers in areas under its jurisdiction. FELCRA identifies problematic areas that have been developed either by groups of individuals or relevant agencies and rehabilitates them to become economically viable again. They have full authority over settlers and sometimes take part of the responsibility from settlers in maintaining cultivation. One example is in the cleaning of plantations for which FELCRA hires labourers and deducts the charges from the settlers' accounts when they sell their products to FELCRA. RISDA provides technical assistance and supervision to rubber plantation owners. One activity in which RISDA is fully involved is the replanting of rubber trees. RISDA helps farmers to cut old trees, prepare land for replanting, provide new young crops and supervise maintenance during growth. Farmers are given advance wages while waiting until the new trees are ready for tapping. KESEDAR is one of the largest land development agencies in Kelantan. Ironically, KESEDAR does not directly interfere with daily activities of the settlers under its jurisdiction. Successful applicants are directed to the selected Land Scheme village where they are advised about the rules and regulations of their land entitlement, the type of crops and their economic potential, but are free to programme their own activities. KESEDAR will try to help solve any problems faced by settlers and provide links to other agencies that can offer technical support such as RISDA, the Veterinary Department and other relevant state departments.

Basic health services are provided by three health centres and 14 community clinics. The District Health Office is headed by a Medical Officer of Health supported by three medical officers, one for each health centre. There are also three medical assistants to assist each medical officer in running the outpatient and emergency clinic in the health centres. Other services include Maternal and Child Health (MCH), Dengue Control, Water Supply , Food Quality Control and Malaria Units.

Jeli is one of the four Districts in Kelantan that are endemic for malaria. The other three, namely Gua Musang, Kuala Krai and Tanah Merah, all border with Jeli. Malaria prevalence in Jeli was consistently more than 25 per 10,000 population until 1994 when the prevalence dropped to 19.5 per 10,000 population. The national definition for an endemic area is 10 cases per 10,000 population (VBDCP, 1992). The population of Jeli is classified as at risk for malaria. Army personnel, land scheme settlers, Malay-Thai migrants and Orang Asli are classified as the most vulnerable groups. The malaria morbidity pattern has never been established for this district. The main activities of the MCT are ACD, case investigations and treatment of parasitaemic patients. Unless patients are very ill or harbour highly dense gametocytes, they are treated at home. Most patients refuse admission because of the distance of the hospital and the economic burden of hospitalisation. Mortality due to malaria has always been very low in Jeli with none reported since 1991.

The study locations were selected from more than 100 traditional and land scheme villages, and an Orang Asli settlement. Differences between traditional and land scheme villages are described in Chapter 4. For this study, the villages are grouped into 4 types, the traditional village, land scheme village, Orang Asli settlement and villages near the Pergau Dam. All villages within the 30 km radius of the dam were listed under the respective category. Because of the varied sizes of the villages, two villages next to each other, and which have similar characteristics were tagged together. Each one of this tagged villages was assigned a name they will be called in the study and kept in boxes according to the village category. One tagged village was drawn from each box and chosen village formed the study locations. The method and

Fig. 3.1 Maps of the study locations



number of villages selected in the study were chosen after considering financial, manpower and time limitations. The selected villages were Lawar for the location near the Pergau Dam, Janggut for the land scheme village, Bedil for the traditional villages and Rual for the Orang Asli village (Fig.3.1).

3.3 COMPONENT 1: DESCRIPTION OF STUDY LOCATIONS

Information regarding the location was gathered and recorded through the author's observations, interviews with key informants and analysis of local data. All the information was recorded on a pre-prepared form which included geographical descriptions, population and socioeconomic activities, basic infrastructure, health services and malaria situation. Some of the information was provided by land scheme agencies and the District Office.

Geographical descriptions were made of ecological characteristics such as proximity to jungle or forest fringes, foothills, highway or main road and proximity to streams or rivers. Current and past environmental manipulation, especially large scale forest clearance, agricultural projects, replanting of rubber trees and logging were recorded. Part of this information was obtained by filling in the questionnaire in the social and behavioural survey and by direct observations of the study locations during field visits. Additional information was collected qualitatively by interviewing the appropriate person in the relevant authority.

Accessibility to study locations was assessed several times during the field work in various weather conditions. Past experiences of the MCT staff, respondents and staff from land scheme agencies were also recorded. The level of accessibility was ranked as low if accessible only during dry season, moderate if not accessible only during the height of the flood season, high if accessible but with difficulty that may slow down routine works and emergency aids and easy if highly accessible all year round. The results for this component can be found in Chapter 4.

3.4 COMPONENT 2: SOCIAL AND BEHAVIOURAL SURVEY

The survey was carried out using a structured-questionnaire to obtain information regarding the characteristics of households important for malaria control. This included risk factors such as age, sex and ethnic groups, location of the house and other basic amenities, ecological changes such as deforestation, risk behaviours such as occupation, sleeping habits and other behaviour that promoted contact with the vectors such as going into the forest, and the practice of personal protection method against mosquito bites (Appendix I).

Four field canvassers were trained to administer the questionnaire. Mock sessions were conducted in the malaria office to ensure the field canvassers understood the questions and were familiar with the terminology and adopted the same approach when administering the questionnaire. The questionnaire was designed and administered in Malay. The wording of the questionnaire was carefully chosen to have similar meaning in local dialects. Several meetings were held with members of the MCT to discuss the content, wording and terminology used in the questionnaire. All possible answers to each question were listed and discussed. The mode of reporting additional information offered by interviewee but not included in the questionnaire was clarified and verified.

The questionnaire was piloted in two nearby villages, one a traditional and the other a land scheme village. The purpose was to ensure clarity and validity of the responses from the villagers. Unanswered questions were clarified with the interviewer, and where possible the interviewee. The final questionnaire was based on the results the pilot survey. The pilot study also revealed that reliable information could be obtained from 12 years old children and above. This age limit was used in the actual survey.

The respondents for this questionnaire survey were heads of household or a representative. The heavy workload of the Jeli MCT meant only two trained staff were available at any one time to administer the questionnaire, together with the author. A house-to-house visit was made with one hundred percent population coverage intended. Empty houses were revisited at the weekend (Friday). Financial and time constraints restricted the visits to a maximum of two per house. Households with no member above 12 years old during visists were regarded non-responders. The results for this component can be found in Chapter 5.1.

3.5 COMPONENT 3: PARASITOLOGY SURVEY

Two cross-sectional surveys, one in the rainy and another in the dry season, were carried out in all four study locations to determine the true prevalence of malaria among the study population. A one hundred percent sample was also intended here. The reason for this seemingly uneconomic approach was because of the sudden drop in the reported incidence of malaria in this area to less than 0.2% immediately preceding the commencement of the field work. Thick and thin blood films were prepared, stained with 10% Giemsa and examined under microscopes x100 oil immersion. A minimum of 100 fields were examined before the slide was labelled negative. All positive and negative blood films were re-examined by the malaria technicians at the Vector Borne Disease Control Office (VBDCO) for quality control. Positive slides were reported using the plus system; for example V+ for vivax malaria with + infection, F+g+ for falciparum malaria with + infection and + gametocytes, etc., for standardization with the VBDCO reporting system.

Routine monthly slide collections by field canvassers were maintained in all study locations throughout the field work. The target was to take slides from 5% of the population randomly selected from each village. In addition, all fever cases also had their slides taken. Detection of fever was either by personal communication or notified by other villagers. Positive cases were promptly treated using the guidelines issued by the Ministry of Health (VBDCP, 1994). Treated patients were followed-up monthly for six months in the case of falciparum malaria and 12 months for vivax. Full investigations were performed for each case to determine the source of infection. The results for this component can be found in Chapter 5 (Section 5.2).

3.6 COMPONENT 4: SEROLOGICAL STUDY USING ENZYME-LINKED IMMUNOSORBENT ASSAY (ELISA)

3.6.1 Collection of sera for ELISA

Blood samples for the enzyme-linked immunosorbent assay (ELISA) were taken together with the BFMP. A hundred per cent sample was intended because the sero-prevalence was not known. Unoccupied houses were revisited as explained for the parasitology survey. Consent was sought and obtained from all individuals because serology was not part of the routine investigations of the MCT. Non-inclusion was a result of either non-consenting or non-availability during the time when the survey was being conducted.

One ml of blood collected either by venepuncture or heel prick in case of infants was put in a sterile vacutainer containing gel separator. The gel separator helped in maximising serum extraction from the tube, especially when a small volume of blood is involved. During collection, blood samples were kept cool in an ice box. They were left in the vacutainer for at least four hours to allow red cells to settle. All samples were spun at 1000 rpm for five minutes. Sera were extracted, transferred into a 1.5 ml centrifuge tube and transported back to the testing laboratory as soon as possible where they were kept in -20°C until used. There was no freezer at the field station. If the samples could not be transported to the laboratory on the same day, they were kept at 4°C. Sera from each respondent were kept in two or more centrifuge tubes, depending on the amount available, to avoid repeated freeze-thawfreeze process should repeat tests be needed. Haemolysed blood samples were excluded as they were expected to produce higher optical density (O.D).

3.6.2 Antigen preparation

3.6.2.1 Malaria culture

Antigens for the ELISA were prepared from cultured *P.falciparum* strain 3D and clone. The frozen parasites were retrieved using the David Walliker Protocol (Appendix II). The retrieved parasites were transfered to a culture flask where a pre-prepared tissue culture media (TCM) was added. The flask was put in a dessicator, with appropriate oxygen and carbon dioxide concentration and kept at 4°C. The method and material for TCM preparation are in Appendix III.

The TCM were changed every day by the following procedure. The culture flask was carefully removed from a refrigerator and put in an incubator at 37°C for half an hour.It was then transfered to a hood and left for one hour to allow cells to settle. Spent TCM were drawn out with a Pasteur pipette while tilting the flask to avoid disturbing the cells. Fresh TCM were added, maintaining the 10% cell suspension level. In this case, 10ml of TCM were maintained against one ml of packed cell volume (PCV). Slides were prepared from each flask after every replacement of TCM to monitor parasite growth and level of parasitemia. The procedures were carried out under sterile technique to avoid contamination. Flasks were then put back into the dessicator and kept in a refrigerator at 4°C.

Cells were diluted with fresh red blood cells (RBC) when parasitemia reached 5%, unless a Percoll Gradient Schizont extraction was to be carried out. The dilution was normally made to return the parasitemia level to between 0.5% to 1.0%.

3.6.2.2 Percoll gradient technique

A Percoll gradient technique was performed for the purification of *P. falciparum* late trophozoites and schizonts using density gradient centrifugation. The procedure needed stock isotonic Percoll, 72% Percoll and 40% Percoll. The isotonic Percoll was prepared by mixing nine volumes of Percoll (Pharmacia) with one volume of sterile x10 phosphate buffer sulphate (PBS) and stored at 4°C. To produce 100ml of 72% Percoll, 72 ml of isotonic Percoll was added to 28ml RPMI-bic. The two solutions were mixed under aseptic technique. To produce 100ml of 40% Percoll, 40ml of isotonic Percoll was added to 60ml RPMI-bic and mixed under aseptic technique.

Six ml of 72% Percoll was pippeted into a sterile 15ml centrifuge tube clamped upright. Two ml of 40% Percoll was layered as a second cushion on top of the 72% Percoll, carefully maintaining the interface between the two solutions. This was accomplished by running the 40% Percoll slowly down the side of the tube at a constant rate. The contents from the culture flasks were centrifuged and the supernatant was removed to leave a ratio of 50% haematocrite. This was layered on the Percoll as described for the 40% Percoll. The tube containing the contents from the culture flask and Percoll was then centrifuged at 400g for 20 minutes at room temperature.

Five layers were formed after the spin. The top layer consisted of debris and broken cells, followeed by a layer of 40% Percoll. The parasitized cells of late trophozoites and schizonts sat at the interface (third layer) of the 40% and 72% Percoll (fourth layer). The layer was distinguished by its brown colour. The pellet at the base of the tube consisted of uninfected RBCs or RBS with early trophozoites (fifth layer). The brown layer containing schizonts was carefully aspirated and placed in a sterile 15 ml centrifuge tube. Normally about two ml of red cells suspended in Percoll were obtained. RPMI-bic was added to make up 12 ml and centrifuged at 400g for five minutes. The supernatant was removed and the washing procedure was repeated twice. After the third wash, the suspension was removed to a three ml sterile vial. PBS was added in a 1:1 ratio. The content was sonicated using Labsonic 2000 sonicator twice for 15 seconds, with a short interval in between the two sonication.

3.6.3 The ELISA technique

The ELISA required an ELISA plate (Linbro 96 wells falt bottom), antigens, coating buffers, washing buffer, conjugate [the one used was enzyme-labelled species specific antiglobulin: Anti-human IgG (γ-chain specific) labelled with alkaline phosphatase (Product No. A-3150)], substrate [(p-nitrophenyl phosphate): Sigma Fast pNPP Substrate Tablet Set (Product No. N-1891)], serum incubation buffer (SIB), PBS tablets and a plate reader (Dynatech MR5000).

The antigen was diluted in coating buffer at 1:100 and absorbed to the solid phase (ELISA plate) overnight at 4°C. The antigen was discarded and the plate washed three times with washing buffer to remove excess antigen. The plate was emptied against absorbance papers to ensure complete removals of excess antigen from the wells. Test sera were diluted to 1:100 and added to duplicate wells and left for one hour at room temperature. The plate was then washed three times as above, to remove unbound sera. The conjugate was added at 1:1000 dilution and left at room temperature for one hour. The plate was again washed as above to remove excess antiglobulin. Lastly the substrate was added to the wells and observed for colour changes at regular intervals (in this test every 15 minutes). The plate was read with Dynatech MR5000 spectrophotometer at 410 nm every 15 minute until the pre-set standard was reached. If the reading did not fulfil the pre-set standard, the test was repeated after the fault was identified.

3.6.4 Standards and criteria for result definitions

Following checkerboard titrations, test serum and antigen dilution was fixed at 1:100. The results of checkerboard titrations were most consistent at this dilution. Fifteen negative controls, taken from individuals who had never been exposed to malaria infection, and ten strongly positive controls with known antibody titres were used in the checkerboards. The negative controls O.D consistently gave O.D around 0.100 and positive controls >0.500. The same controls and antigens were used in the tests.

Two negative and two positive controls in duplicate wells were used in each test to ensure the validity and reliability of the readings. In all tests, negative controls' O.D were aimed at around 0.100 ± 2SD and the positive controls 0.500 or more. Colour changes were noted, especially for the controls to ensure the consistency between O.D and colour change. Antigens were prepared in batches and pooled before use to avoid variability that mmight have affected the readings. Cutoff points were determined separately for each survey by calculating the mean of the negative control O.D + 2SD. For the rainy season survey, the cutoff point was 0.135, which was the mean of negative control sera plus 2 SD. For the dry season survey, the cutoff point was 0.136. The test was accepted if the negative controls O.D were not more than 0.135 for the rainy season or 0.136 for the dry season survey and the positive controls were more than 0.500 for both surveys.

Naked eye observation revealed four distinct colour changes from the test sera. The negative samples were clear and the positive ranged from light yellow, yellow and dark yellow. These colours correspond to the O.D as shown in Table 3.2.

Table 3.2 Colour changes and the corresponding O.D during the ELISA test

Colour	O.D	Level of ELISA
Clear	0.136 or less	Negative
Light yellow	0.137 - 0.199	Low positve
Yellow	0.200 - 0.499	Medium positive
Dark yellow	0.500 and above	High positive

The above classification is used to describe the strength or level of seropositivity in the sus.

3.7 COMPONENT 5: PHYSICAL EXAMINATION

3.7.1 Clinical Examination

Physical examinations were performed by the author on consenting villagers at their own house. These were the same respondents for the serological survey. Since this was the first time physical examination had been done on an apparently healthy people outside health facilities, the procedure was explained in detail to the villagers and consent was asked. For the women, consent was also asked from the husband, or parent in the case of single women. The physical examination was performed to obtain baseline information on the spleen rate and other obvious malaria related findings that included fever, pallor and liver enlargement. Temperatures were taken orally for adults and axially for children and recorded in Celsius. Fever was present if the recorded temperature was >37.5 °C.

Abdominal palpations for liver and spleen were done with respondents lying flat on their back and both knees bent (Hunter, 1968) as photographed in Appendix 5. Liver and spleen enlargements were recorded for their size in centimetre (cm) using a measuring tape. This method of recording was chosen in favour of other methods to avoid subjective variations. In the case of spleens, the outcome of the examinations were also recorded according to Hackett's classification to enable for the calculation of the average enlarged spleen (AES). Pallor was clinically determined by examining the conjunctiva of both eyes. The results were compared with the estimation of haemoglobins by Cymetnate (Drabkin) method. Assessment was made as to whether the clinical judgement corresponded with the laboratory estimation of the haemoglobin using the Kappa method.

3.7.2 Haemoglobin estimation

Haemoglobin was measured using the Cymetnate method which required Drabkin's solution, 10 μl capillary tubes and a calorimeter. The calorimeter was calibrated to the same starting value before each batch of samples was processed. Blood collected in heparinised tubes was brought back to the laboratory on the same day. Haemolysed bloods were discarded and collected again. Drabkin solution was prepared fresh for each batch of blood samples. The level of haemoglobin was expressed in Hb (g/dl). The definition and levels of anaemia used in this study followed the one by the Malaysian Ministry of Health as shown in Table 3.3.

Table 3.3 The definition and levels of anaemia based on the level of haemoglobin estimated using the Cymetnate (Drabkin) method.

Hb (g/dl)	Classification of anaemia
≥ 12.0	Not anaemic
10.0 - 11.9	Mild anaemia
8.0 - 9.9	Moderate anaemia
< 8.0	Severe anaemia

3.8 COMPONENT 6: VECTOR STUDY

3.8.1 Adult mosquito surveys

Entomological surveys were conducted in all study villages with expert assistance of the ET from the VBDCO, Kota Bharu. Even though the original plan was to carry out the survey for one year which would have covered 96 nights of mosquito collections, financial constraints limited the work to only 152 nights. In each survey, one house was chosen at random from each village in which a whole night collection was undertaken. If the owner of the house refused or was not at home, another house was chosen in the same manner. The team returned to the location after a fortnight when another house was selected.

Two pairs of catchers carried out the catch using a bare-leg method indoor and outdoor (Service, 1993). Catchers were asked to take prophylaxis according to the guidelines. All mosquitoes that landed on the catchers' leg were caught, placed in plastic vials covered with cotton wool and identified. Confirmation of species and dissection findings were made by an entomologist from the State VBDCO. All *Anopheles* species caught were dissected under a dissecting microscope the following afternoon to look for the presence of sporozoite in salivary glands, and the parity of the mosquitoes. Findings were recorded on official forms.

3.8.2 Larvae Surveys

The same team conducted larval surveys in the same village the following morning. Starting from the house where mosquito catching was done, the team circled the area within 10 houses radius looking for places where larvae were expected to be present. Again, manpower and time constraints prevented the team from surveying the whole village. In addtion, surveys were carried out on the banks of streams, rivers and pools. Using a dipper, three dips were made at specified intervals in any one perceived breeding places. Larvae collected were again identified by an entomologist before findings were recorded.

3.9 COMPONENT 7. PERMETHRIN-IMPREGNATED BEDNETS AND VECTOR MORTALITY STUDY

Additional catches were made to determine the effectiveness of the permethrin-impregnated bednets (IBN). Thirty *An. maculatus* caught from study locations were released into IBN and the times they were 'knocked down' and died were noted. The same quantity of *An. maculatus* were also tested by similar procedures against ordinary bednets and washed IBN as controls.

Eight tests were carried out using eight IBN selected from the same villages. The number of IBN between five to six months duration after the last impregnation or those that were due for reimpregnation in one month were listed. The IBN must not be washed in between the last impregnation and the time of the test and had been used regularly. Eight bednets were used for control, four were ordinary bednets and four IBN that had been washed once after the last impregnation.

After exposure to the bednet, the 'knock down' time (the time the mosquito fell and died) of the mosquitoes were recorded every 10 minutes. In this study, the time of knock down was extended to 120 minutes instead of the standard 60 minutes test procedure recommended by the VBDCO because one *An. maculatus* was knocked down only after 110 minutes.

3.10 COMPONENT 8. REVIEW ON THE MANAGEMENT OF MALARIA IN-PATIENTS

This study was conducted in Gua Musang Hospital. All cases diagnosed and discharged as malaria between January 1995 and June 1996 were included. These included cases of clinical malaria (a diagnosis of malaria was based only on clinical judgement even though blood films were negative) and cases referred from health centres with positive blood film, but were negative whilst in the ward. Details of the cases were recorded in a pre-prepared format (Appendix 6). Treatment review were carried out for all malaria with special emphasis on falciparum malaria.

3.11 DATA MANAGEMENT AND STATISTICAL METHODS

3.11.1 Data processing

The questionnaire for the structured interview used for the social and behaviour survey (Component 2) was created using Epi-info version 6.03. Databases were created using Epi-info for study components 2 to 10. Data were entered using double entry and the check programme was used to detect typing and classification errors.

Preliminary analyses of the collected data were performed using Epi-info. Some of the databases were exported to SPSS for Windows version 6.1 and combined for further analysis. Most of the analytical procedures and all graphics were done with SPSS.

3.11.2 Statistical procedures

The level of significance used throughout the thesis was the five percent. Means of continuous variables were compared between groups using analysis of variance. For comparison of means between two groups, this reduced to a pooled t-test (Armitage and Berry, 1987). Relationships between two continuous variables were explored using linear regression. The distribution of optical densities was skewed and it was necessary to take a logarithmic transformation (to the base 10) of the value before performing the regression analysis (Altman, 1990).

Relationships between two categorical variables were explored using the chi-squared test with the appropriate degrees of freedom (Armitage and Berry, 1987). Malaria status was defined as a binary variable. The relationship of malaria status with a number of independent variables was explored using logistic regression (Norussis / SPSS Inc., 1994). The results were expressed in the form of logistic regression equations which provided estimates of the odds for individuals of having the defined malaria status (Schlesselman, 1980). The equation was expressed as:

$\ln \text{odds} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots\dots\dots + \beta_p x_p$, where ln = logarithm (to the base e) and $\beta_0, \beta_1, \beta_2 \dots\dots\dots \beta_p$ are parameter estimates for the variables constant, $x_1, x_2, \dots x_p$.

Models were selected using a forward stepwise procedure with selection variables based on the probability of the likelihood-ratio statistics (Norussis / SPSS Inc., 1994). The goodness of fit of the final model was assessed by examining the classification table and model chi-square. The classification table compared the model predictions with the observed outcomes and gave the percentage of the respondents correctly classified by the model. The model chi-squared value was the difference in the log likelihood value between the model with no variable (i.e the null model) and the fitted model, with degrees of freedom equal to the number of variables introduced in the model.

CHAPTER 4: THE STUDY LOCATIONS

This chapter has two components. The first part (Section 4.1 to 4.5) describes in detail each study location in terms of its development, geographical eco-system, population and socio-economic activities, health services and malaria situation. Differences that exist between each location are important in the analysis of data as some of the explanations for the analysed variables lie in these differences. The second part of this chapter (Section 4.6 onwards) reviews the current MCP in Jeli and actual activities carried out by the Jeli MCT. The aim of this review is to assess the vigilance of the local MCT.

4.1 LAWAR

4.1.1 Geographical descriptions

The location Lawar is made up of two villages; Kampung Lawar and Kampung Bukit Ipoh. The original site of Kampung Lawar is situated along the bank of Pergau River and just a few metres from the site of re-regulating pond of the Pergau Dam. Heavy floods in 1990 wiped out most of the houses in the old village and forced the villagers to move up to the present site. Kampung Lawar and Kampung Bukit Ipoh lie next to each other with no clear border demarcation and are similar in every aspect. Situated about 50 meters above the Pergau river (Fig.4.1.1) and the construction sites of the dam, Lawar is only 1 km down the river from the re-regulating pond, electric generation turbines and power house of the Pergau Dam,

Fig.4.1.1 The Pergau river.
This river runs behind the village.

Fig. 4.1.2 At the edge of Lawar
The road leading to the main construction site for the Pergau Dam (white arrow) which was clearly visible from the village.

separated by bushes and secondary forest (Fig.4.1.2). The main reservoir (the Kuala Yong Dam) is situated 3 km from the village.

Ten km north of Lawar is the international border with Thailand. This area between Lawar and the border is covered by a mix of primary and secondary forest, fruit farms and rubber plantations. The rubber plantations are under the authority of the Federal Land Consolidation and Rehabilitation Authority (FELCRA). Logging activities are observed about 10 km from the village near the Kelantan-Perak Border. However, the loggers use different routes and have no direct contact with the village. Most of them are private companies, under the supervision of the Forestry Department and the Kelantan State Economic Development Corporation (PKINK). Extensive deforestation occurred at the present construction sites for the Pergau Dam in 1991 and 1992. Forest clearing had stopped for a year when the field work began. Previous forest clearings existed only on small scale for rubber planting and fruit farms.

Lawar is a traditional village. No written documents are available on the early years of Lawar. Personal communication with the villagers revealed that some of them came to the area more than 50 years ago with their parents to explore new land. Most of them are very poor and migrated to this area hoping to realise their dreams of owning land. However, the Kelantan Sultanate history revealed that this area has been part of a very important historical civilisation. Gunong Reng, 1.5 km from Lawar, used to be the centre of Queen Che Siti Wan Kembang administration, a famous female ruler in the 17th century.

Fig. 4.1.3 The road to Lawar.
The road signs (yellow diamond with black and white pole) mark the boundary of the village.

Fig. 4.1.4 The houses and surroundings in Lawar.
Rubber plantations, fruit orchards and secondary forest form the background.

4.1.2 Population and socio-economic activities

Lawar has a population of 741, all of Malay ethnicity and most have stayed for more than 10 years. The villagers practise a wide range of economic activities from agriculture to small business and being government employees. Some of the villagers own fruit farms. The most popular fruit trees are 'Durian' and 'Duku'. Fruit farm owners can generate between RM5,000 to RM10,000 per year from each type of fruit. Since both fruits are usually planted on the same farm, most of the fruit farmers profit from both Durian and Duku.

From 1991, many of Lawar villagers took advantage of the work opportunities created by the construction of the Pergau Dam. The dam has arguably increased the income of the villagers irrespective of whether they work for the dam companies or carry out contracted jobs.

4.1.3 Basic infrastructure

Tenaga Nasional replaced the old narrow tar road with a better and wider one, which passes through Lawar connecting the Pergau Dam construction head office to the main road (Fig.4.1.3). Electricity is 24 hours and television (TV) reception is fairly good except for certain channels because of interference from the Thailand's transmission tower near the border. Water supply is by gravity feed and available to every house. Public transport is available through routine bus services and private taxis. The majority of the houses are typical wooden Malay house (Fig.4.1.4).

4.1.4 Health services

There is one community clinic in Lawar situated in Kampung Bukit Ipoh. The clinic is run by one community nurse and a midwife. It provides services for maternal and child health (MCH) care which cover routine bookings and examinations of pregnant mothers, immunisation and child care. A doctor from Jeli Health Centre visits the clinic once a month for ante-natal and child check-up. Laboratory examinations are carried out by a technician who travels with the team. This is normally limited to estimations of haemoglobin or blood film for malaria parasites (BFMP) for febrile patients. The community nurse and midwife conduct deliveries at home for normal pregnancies and mothers with gravida two to five. High risk mothers that include primigravida, multigravida more than five, hypertensive, etc., are referred to hospital. Some of the high risk mothers are also delivered at home due to lack of ambulance and the nurses being called late. The nurses are only allowed to dispense paracetamol, anti-helminthics, multivitamins and cough mixture. Other treatments need a doctor's or medical assistant's prescription. There is no private clinic or general practitioner in this location. The nearest private practitioner is in Jeli town, 15 km from Lawar.

4.1.5 Malaria situation

Lawar is an unstable endemic area with annual case fluctuation ranging from 1.6 to 65 per 1000 (years 1980 till 1993) population. Only *P.falciparum* and *P.vivax* have been reported. Vector control is limited to house spraying with DDT every 6 month which has been stopped since 1993 after 51 cycles. ACD is carried out routinely by field canvassers (FC) in which slides are taken from 5% of the population (VBDCP, 1993). Anti-malaria treatments are provided only by the MCT or government clinics. No other sources of treatment have been identified.

4.2 JANGGUT

4.2.1 Geographical description

Janggut is a land scheme village opened to settlers in 1964, under the authority of the South Kelantan Development Authority (KESEDAR). Prospective settlers are selected by KESEDAR, and when successful are given areas to build houses and other land for cultivation. Janggut can be accessed by crossing a 50 m bridge, or tracking a red-soil hilly road from the other end (Fig.4.2.1). Kampung Sungai Rual Melayu which made up two third of the total area of Janggut, is split into two parts by a stream flowing across the village (Fig.4.2.2). To the West of this village is Kampung Lata Janggut, separated from Kampung Sungai Rual Melayu by rubber trees, fruit farms and hilly jungle. Kg Lata Janggut is at a remote end in a line of land scheme villages, thus in proximity with rubber plantations, fruit farms and forest. No recent forest clearing has occurred in this location and the plantations and settlers are settled.

4.2.2 Population and socio-economic activities

There are 241 people living in Janggut. Officially, only Malays are entitled to apply as settlers in land scheme villages. Malay-Thais are brought in by settlers to tap

Fig. 4.2.1 Walking through Janggut.
The muddy soil road began at the river bank to end at the bank of another river. Houses scattered on either side of the road.

Fig. 4.2.2 The second river.
This tributary of Renyuk river runs across Janggut splitting the village into two parts. Water level varies from less than 0.5 m deep in the dry season to around 2 m in the rainy season. Numerous rock pools were observed along the bank of this river, providing ideal breeding places for An. maculatus.

rubber trees. They are preferred to local Malays because of their cheap labour rate and work commitment. In rainy season when tapping rubber is not possible, they work on fruit farms. Employers normally build huts for them to live near or in the rubber plantations. Some settlers allow their Malay-Thai workers to occupy their houses and work their farms and plantations, while they build their own houses somewhere else. The Malay-Thai families go back to Thailand once the work is completed and return the following year. The exact number of Malay-Thais working in Janggut are not known because some of the plantation owners refused to reveal their huts.

4.2.3 Basic infrastructure

Motorcycles are the main mode of transport with very few people owning a car. In the dry season, crossing the river is easy via a bridge that is built just a few feet above the water level. At the height of the rainy season, this could be very difficult and dangerous. The river bank is normally flooded up to a few meters above the bridge with a strong current (Fig.4.2.3). The red-soil road ends at the bank of another river, which will be flooded as well. Electricity is available 24 hours a day. Water supply is by gravity-feed method. Television reception is generally poor except for one or two channels. Houses are almost identical in architecture (Fig.4.2.4).

4.2.4 Health services

Health care is available in Jeli Health Centre which is 5 km from the village. The nearest community clinic is about 2 km from the village. The community clinic is staffed by a community nurse and mid-wife as in Lawar who provide the same level of services. Although access to treatment is available most of the months in a year, floods can hamper immediate access to treatment because of the poor accessibility. Villagers can also go to a private general practitioner in Jeli Town as an alternative to Jeli government clinic.

4.2.5 Malaria situation

Until the early 1990s, malaria was highly endemic. As in Lawar, Janggut also presented with the feature of unstable endemic malaria with wide annual fluctuations. Malaria data between 1980 and 1993 revealed annual cases between 16 to 19 per 1,000 population. Land scheme settlers are classified as a high risk group for malaria. However, as in other places, malaria is declining fast in Janggut. So far only *P. falciparum* and *P. vivax* have been reported. No vector study has been conducted in this area. Vector control in the form of DDT house spraying has also reached 51 cycles before it was discontinued in 1993. In 1990, the villagers were given insecticide-impregnated bednets (IBN) as a trial. This was more towards political than malaria control strategy, therefore, there was no proper monitoring and evaluation procedures. Other malaria control activities such as ACD, PCD and case investigations are not interrupted. Treatments for BFMP positive patients are administered as in Lawar. Self- treatments are not known amongst Malays, but this is less certain for the Malay-Thais because anti-malaria drugs are easily available in Thailand, and these workers travel to and from Thailand quite frequently.

Fig. 4.2.3 Transportation to Janggut.
This river had been flooded for 2 weeks and the bridge was still 1m under the water. The bamboo raft was the only mode of transport to cross the river that separated Janggut from the main road.

Fig. 4.2.4 Typical type of house in Janggut.
As in other locations, all occupied houses were visisted during surveys.

4.3 BEDIL

4.3.1 Geographical description

Kampung Renyuk and Kampung Chegar Bedil form the Bedil location are examples of a typical traditional village in Jeli. The villages were built gradually by the villagers who came from nearby villages or other districts. Kampung Renyuk and Chegar Bedil lay side by side along the main road, separated by the Renyuk river (Fig.4.3.1). The land is flat and suitable for crops such as sweet corn, sweet potatoes and other popular fruits, 'durian' and 'duku'. Small tributaries of the Renyuk River span behind Kampung Renyuk and Kampung Chegar Bedil and form the natural border. Behind are jungle and rubber plantations that come under the supervision of two land scheme authorities, KESEDAR and FELCRA. Being a traditional village, some of the agricultural fields are situated just at the edge of the village. There is no restriction on the usage of land as the village is not governed by any of the land scheme authorities.

4.3.2 Population and socio-economic activities

The population of Bedil is 420 of which 80% are Malays and the rest Malay-Thais. Duration of residency varies as villagers move in and out of the area to pursue greener pastures. Fifty per cent of the Malay-Thais in Bedil own their houses, which also means that they are now permanent residents compared to a few years back when the majority would travel to from their homes in Thailand. The other 50% are temporary workers. The Malays have a wide range of occupations from farming

Fig. 4.3.1 The Renyuk River running beside Bedil.

Fig. 4.3.2 Bedil
Houses scattered on each side of this main road. The bridge is above the Renyuk river.

being government employees. The Malay-Thais are normally rubber tappers, odd job workers or work on fruit farms clearing land.

4.3.3 Basic infrastructure

All houses are within 150 m of the main road (Fig.4.3.2). Early houses were very similar in structure and quality, but some have undergone renovations as the owners prosper (Fig.4.3.3). Most of the temporay workers live in houses with poorer condition compared to the rest (Fig.4.3.4). Electricity is 24 hours a day, television reception is generally good and public telephones are available by the roadside. Public transport passes through Bedil from Jeli to Jelawang, a tourist attraction area near the Kuala Krai District. Bedil is easily accessible throughout the year.

4.3.4 Health services

The nearest health centre is in Jeli Town which is about 10 km from Bedil. MCH care is provided by two community clinics situated two km down the road, in either direction. The community clinics provide the same level of health care as in Lawar. A private general practitioner in Jeli is an alternative treatment provider to the government clinics.

4.3.5 Malaria situation

Malaria is one of the important health problems in Bedil, but never to the extent experienced by Janggut or Lawar until recently. In early 1995, some of the villagers are given IBN. The selection of the recipients is based on socio-economic status.

Fig. 4.3.3 Type of house in Bedil
This house belongs to one of the patients with falciparum malaria. It represents the average quality of housing conditions in this location.

Fig. 4.3.4 One of the houses of Malay-Thai families.

4.4 RUAL

4.4.1 Geographical description

Rual is the only Orang Asli settlement in Jeli. Before 1990, Orang Asli live in small villages of 10-20 temporary huts, scattered in jungle and forest. They seldom stayed in one area for more than two years. The settlement was built by the Orang Asli Department with helps from the Ministry of Rural Development, Department of Social Welfare, Religious Department, Education Department and the State government, with the aim of improving the welfare of Orang Asli. The settlement has tremendously improved accessibility and facilitated the integration of Orang Asli into local communities. The Rual settlement (quite often called Rual Orang Asli to differentiate from Kampung Sungai Rual Melayu) is built along the Rual river (Fig.4.4.1), about 40 km from the town of Jeli. It is embedded to the foothill and forest fringe, but in the clearings surrounded by primary and secondary forest and rubber plantations (Fig.4.4.2). The nearest village, Janggut, is five km from Rual.

4.4.2 Population and soci-economic activities

The Orang Asli in Rual are from the Jahai sub-ethnic and parts of the 6390 Orang Asli residing in Kelantan. The population differs from one census to another as the community is still practicing a semi-nomadic lifestyle, though less frequent than previously. Their movements now are economically oriented rather than because of customs and belief as previously. There are between 47 to 60 families with 150 to 200 people living in Rual. Economic activities include tapping rubber, clearing land for land scheme agencies and private land owners and collecting forest products

Fig. 4.4.1 The continuation of the stream pictured in Fig. 4.4.4
This runs behind the village into the forest. Note the proximity of the house to the river.

Fig. 4.4.2 Houses in Rual.
Rubber and fruit trees form the background.

(rattan) for local market. They still practise shifting cultivation, but will come back to the settlement after the crops are harvested. Most of their products are sold to local people and traders in return for daily needs. They also form part of the skilled work force for logging companies. The integration of this community into the local population is a gradual but continuous process.

4.4.3 Basic infrastructure

Until 1992, access to Rual was very difficult especially in the rainy season. The hilly and steep slopes are dangerous even for skilful drivers. Journeys from Jeli town to Rual normally take a few hours. After floods destroyed some of the original villages in 1990, every family was given a one bedroom wooden house altough some still prefer to live in their traditional huts (Fig.4.4.3). Access improved with the construction of a tarred road that started at the edge of Janggut to the edge of the village, and the flattening of slippery slopes and dangerous track. The original three streams in between the tarred road and the village were diverted and reconstructed to become one. It is a clear and slow flowing stream with rocky beds and banks. There are many rock pools especially in the dry season when water level is shallow (Fig.4.4.4). The road across the village is made of cement blocks. Water supply is by gravity feed with a single water tap outside the house. Latrines, however, are still the traditional bush toilets, or rather "stream-toilets" except in the clinic or mosque. Children attend school staffed by three teachers in a one classroom building. Nearby are a small mosque and a clinic.

Fig.4.4.3 The Orang Asli traditional hut.
Seen for comparison in front of the one bedroom wooden house provided by the government.

Fig. 4.4.4 The road to Rual.
For a few hundred metres this stream forms part of the road. The Landrover has just left the soil track. This picture was taken in the dry season. The rest of the stream runs to the left from the point the Landrover entered the stream. Thousands of pools (see arrow) exist along the stream which contain clean water and are exposed to sunlight, providing ideal breeding sites for An. maculatus.

4.4.4 Health services

The Orang Asli Department posted one medical assistant to run the clinic in the village who works on a six-week or three-month rotation basis. The clinic does not seem to function very well. The facilities are very basic, not much better than community clinics. The lack of electricity and transportation aggravated the situation and hampered efforts to increase or improve the capacity of the clinic. The rotation of staff made it difficult for the on-duty medical assistant to monitor the needs of the population and plan future action. So far there is no plan from any department or ministry to review the function of this clinic. Most of the basic medical services are provided by the Jeli health centre. A medical officer from Jeli visits the village once a month with her MCH unit to provide services to children, pregnant women and out-patient treatment of general medical conditions. The MCT travels with this team and conduct the control activities at the same time.

4.4. 5 Malaria situation

Rual has always been a hyper-endemic area. Before the settlement existed, control programme has been hampered by inaccessibility and the nomadic lifestyle of the communities. There is no reliable register and the Orang Asli kept changing their names and ages, making it difficult to follow-up and monitor the progress of treatments. Until 1993, many patients are lost to follow-up and many are not properly treated as they went missing before treatment could be administered. A register of the Rual population is completed in 1993 in which cases from Rual are fully integrated into the state malaria database. In 1994, Rual contributed 50% of the total cases recorded from the district. However, their semi-nomadic lifestyle is still responsible for the lost to follow-up cases. Three types of malaria parasites have been reported from Rual, *P. falciparum*, *P. vivax* and *P. malariae*. Treatments, case investigations and follow-up are the responsibility of the MCT from Jeli. The medical assistant from the Orang Asli Department who run the village's clinic does not take part in either of these activities and does not seem to have any role in the MCP.

4.5 SUMMARY OF THE LOCATIONS

The four study locations have many similarities as well as differences. Some of these differences are important in understanding certain variables in the study and the malaria situation in Jeli. A summary of each location's characteristics is given in Table 4.1.

Table 4.1 Summary of important variables in relation to the four study locations

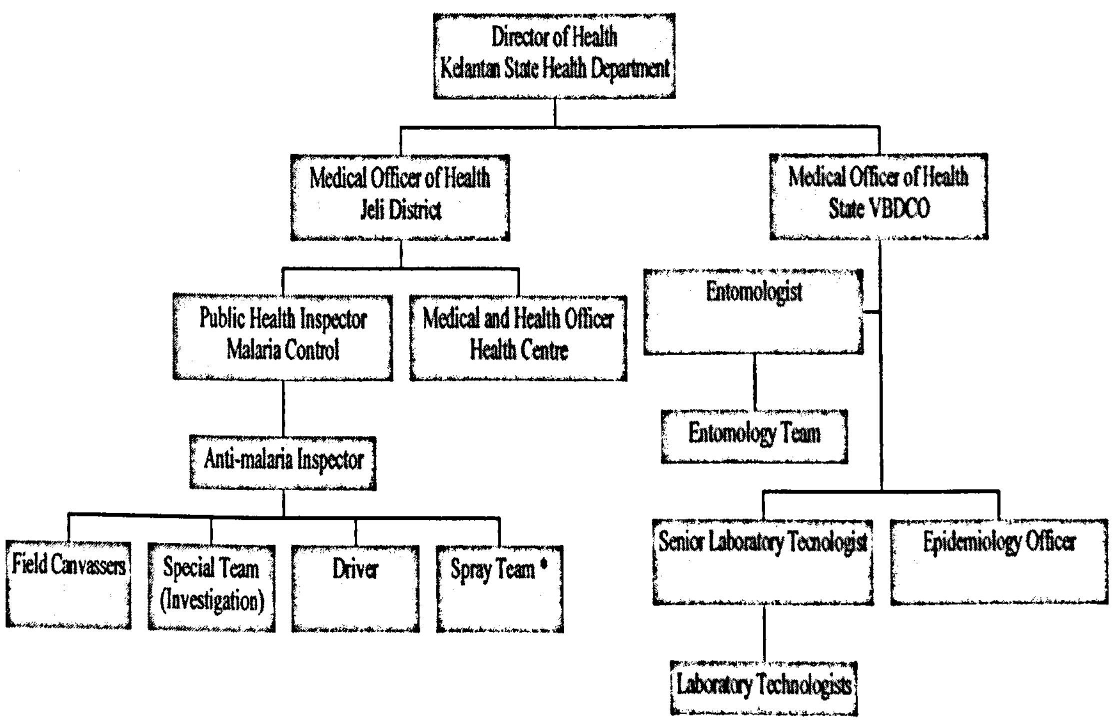
Characteristic	Lawar	Janggut	Bedil	Rual
1. Type of location	Traditional village (near Pergau Dam)	Land scheme village	Traditional village	Orang Asli settlement
2. Forest clearing	Previous	Previous	Previous	No
3. Forest fringe	Yes	Yes	No	Yes
4. River/streams	Yes	Yes	Yes	Yes
5. Dam	Yes	No	No	No
6. Accessibility	Easy	Moderate	Easy	High
7. Access to treatment	Yes	Yes	Yes	Limited
8. Endemic	Yes	Yes	Yes	Yes
9. Transportation	Private and public	Mainly Private	Private and public	No
10. Documented risk groups	Rubber tappers Fruit farm owner	All settlers (rubber tappers)	Rubber tappers Fruit farm owner Malay-Thai ethn.	All

4.6 THE LOCAL MALARIA CONTROL TEAM (MCT)

4.6.1 Organisation and administrative hierarchy

The organisation chart of the malaria control team (MCT) is shown in Fig.4.5. This is the latest organisational hierarchy and was established in mid 1995. Before 1995, Jeli MCT was answerable to two MOH. They have to follow directives from the VBDC MOH on malaria control activities and implementation of the control programme. However, resource allocations, transportation and fuels, equipment and claims were controlled by the MOH for Tanah Merah District. Quite often, this has resulted in conflicting decisions. The problem has been resolved with the MCT came fully under the MOH of Jeli District. The VBDCO act as technical advisors and programme co-ordinators.

Fig.4.5 Organization chart of Jeli MCT



* The spray team was disbanded in 1996.

4.6.2 Staffing

The MCT has 10 regular members, headed by the Public Health Inspectors (PHI) for malaria control. He is assisted by the Anti-malaria Inspector (AMI) who supervised the field work, seven field canvassers (FC), in which one is normally in the special team, and a driver. The spray team travels with the dengue control team and are called when needed.

4.6.3 Activities

4.6.3.1 Case detection and case investigations

ACD is carried out by FC who are assigned specific operational areas to cover. The target is to take monthly thin and thick BFMP from five percent of the population in their operational areas. PCD is performed by medical officers, medical assisstants, community nurses and midwifes for febrile patients. MBS is now carried out only for army personnel who just returned from jungle operations.

Case investigations are carried out for all positive cases. The objectives are to determine the source of infection, to find other infected person and to limit the spread of the infection. This is normally carried out by a special team and the field canvasser responsible for the area. The activitiy usually covers ten house radius from the malaria case.

4.6.3.2 Treatments and follow-up for confirmed malaria cases

The special team and field canvasser responsible for the area visit every house of the newly diagnosed cases and administer treatment supervised by either the AMI or

PHI. The field canvasser has to follow-up the patients every month in which BFMP were taken. The follow-ups were 6 months for P. falciparum and 12 months for P. vivax. Complicated cases are referred to the MOH for further action.

4.6.3.3 Laboratory diagnosis

Slides collected by PCD are examined by laboratory technologists in health centres. The technologists are required to send all positive slides and 10% (normally less) of the negative slides to the VBDC laboratory for quality control. Slides taken by ACD, case investigations and follow-up are sent direct to the VBDC laboratory for diagnosis. Results are posted back to the district, but positive slides are normally informed by telephone. All laboratories used 10% Giemsa for staining.

4.6.3.4 Vector control

After DDT house spraying was discontinued in 1993, there is no vector control activity conducted in Jeli. IBN have been distributed to certain locations but in a very limited quantity as it has yet to become a nation-wide control strategy. The local MCT has no entomological component. The only entomology team (ET) in the State is based at the State VBDCO, Kota Bharu and they are not just for malaria control. There is no record of any entomological study conducted in Jeli before this study. The ET is supervised by an entomologist and has six members, including one driver. Their scope of work includes surveys on the abundance and habits of the vectors, larva survey, dissections of the mosquitoes to determine the presence of sporozoite and parity and sensitivity test to IBN. Because of their involvement in other entomological activities, the team's involvement in malaria control programme is sporadic and depend on needs.

4.6.3.5 Multi-sectorial link

At the moment, there is no organised involvement of other agencies operating in the district in malaria control. Co-operation from agencies such as FELCRA and KESEDAR are always on ad-hoc basis.

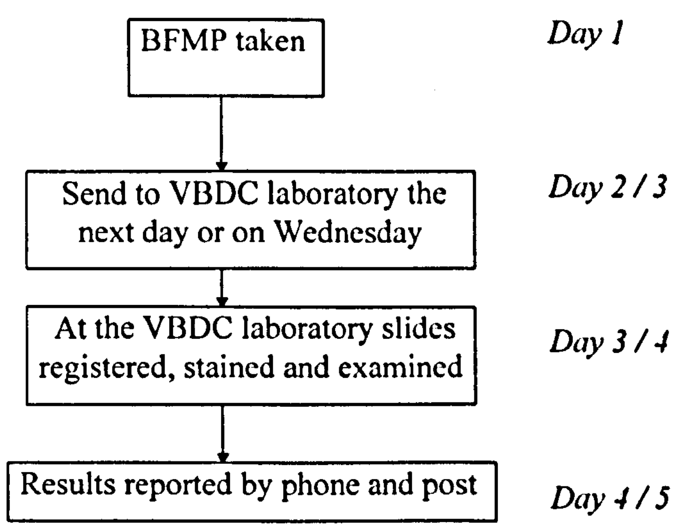
4.6.3.6 Health education

Health education is given during case investigations, follow-up and visit to villages. The scope of information relayed to the public include the cause and how malaria occurred, the importance of personal protection measures against mosquitoes, the critical aspects of complete and proper treatment and the sign and symptoms of malaria. The impact of this activity on malaria control for the study population is not known as there has been no study conducted.

4.6.4 Capabilities of the MCT

The MCT is coping very well with current malaria situations in the District. Given adequate resources, they have the capability to perform more than what they are currently directed to do. From the author's direct observations, this team possessed the right spirits and enthusiasms and are willing to listen to suggestions and adapting to new approach in control activities. However, limited resources can be the main setback in improving the capabilities of the team. The location of the laboratory delayed the administration of treatment for patients detected by ACD or case investigations (Fig.4.2). Slides taken by PCD were normally stained and examined on the same day. Treatments are quite straight forward. Until now patients responded to the treatment regime very well and showed no signs of resistance. Drugs are easily available. Compliance is enhanced by dispensing drugs in three different plastic envelopes marked with the day they should be taken and children can choose syrups if they prefer. Data return and register are still done manually. The MCT has been given one unit of computer recently, but it may take sometime for the staff to learn how to use it. With the introduction of IBN, the team also carry out re-impregnation of the bednets. Users are charged RM5.00 for re-impregnation and they have to replace the torn or damaged bednets. Current control strategies have been followed since the early 1980s but appear to be still very effective in controlling malaria in the district, even if the strategies might not be the cause for the dramatic decline of malaria in Jeli and other malarious areas.

Fig.4.6 Flow chart showing the diagnostic process of malaria for ACD



CHAPTER 5. SURVEY RESULTS

This chapter presents the results of the surveys and studies conducted. It is divided into six sections based on the study components.

Section 5.1 presents the results of the social and behavioural survey. This survey was conducted by interviewing the head or representative of the household to obtain data on socio-economic and behavioural status of the population. Although the characteristics of the respondents were pertinent to the interviewee, other data reflected the whole household.

Section 5.2 presents results of two cross-sectional surveys and monthly active case detection (ACD). The cross-sectional surveys were intended to cover the whole study population whereas the monthly ACD was the continuation of the routine slide collection under the malaria control activities carried out by the field canvassers.

Section 5.3 presents the results of the rainy and dry cross-sectional serological surveys. The methods and definition of important values are described in Chapter 3.6. ELISA positive in this chapter is defined as O.D > 0.135 for the rainy season survey and > 0.136 for the dry season survey. The values are the mean + 2SD of the negative controls. The survey looked at the prevalence of sero-positivity in study locations, changes in O.D between the two surveys and the antibody levels.

Section 5.4 presents the results of the physical examination performed on 510 consenting respondents, the same respondents as described in Section 5.3. The examination took place during the serological survey in the dry season. The objective of this survey is to record the presence of hepatosplenomegaly and anaemia.

Section 5.5 presents the results of surveys on the vectors carried out every fortnight in all study locations. The survey involved indoor and outdoor catches using the bare leg method. Detail on the methods are described in Chapter 3.8.

Section 5.6 presents the results of the susceptibility of *An. maculatus* to permethrin-impregnated bednets (IBN). The study was carried out just before the date of re-impregnation of bednets, that is six months after the IBN were distributed. The mosquitoes used were wild caught *An. maculatus* which were tested against the IBN owned and used by villagers.

SECTION 5.1 SOCIAL AND BEHAVIOURAL SURVEY

5.1.1 Socio-economic characteristics

5.1.1.1 Personal and social characteristics

Two hundred and seventy (64%) heads or representatives of households were interviewed (Table 5.1.1). The proportion of female respondents was higher in all study locations except Rual where more than 80% of the respondents were male. This is despite the fact that the main target group, the head of the household, was male. The questionnaire was designed to obtain information regarding the household rather than the head of the household and so the reliability and validity of the information collected is unlikely to have been significantly affected.

Table 5.1.1 Sex of the respondents by location

Location	Female (%)	Male (%)	% of location's total occupied houses
Lawar	62 (60.2)	41 (39.8)	59.5
Janggut	22 (57.9)	16 (42.1)	57.6
Bedil	57 (58.8)	40 (41.2)	78.9
Rual	6 (18.8)	26 (81.3)	53.3
Total	147 (54.4)	123 (45.6)	64.1

The age distribution of the respondents ranged from 12 to 90 years old with a mean (SD) age of 39.2 (15.48) years. The mean (SD) age for female respondents was 37.0 (13.84) years and for male 41.6 (16.99) years. Respondents from Rual were younger compared to those from Lawar, Janggut and Bedil in which 50% were less than 25 years (Fig. 5.1.1).

Fig.5.1.1 Cumulative percentage of the age of respondents by location.

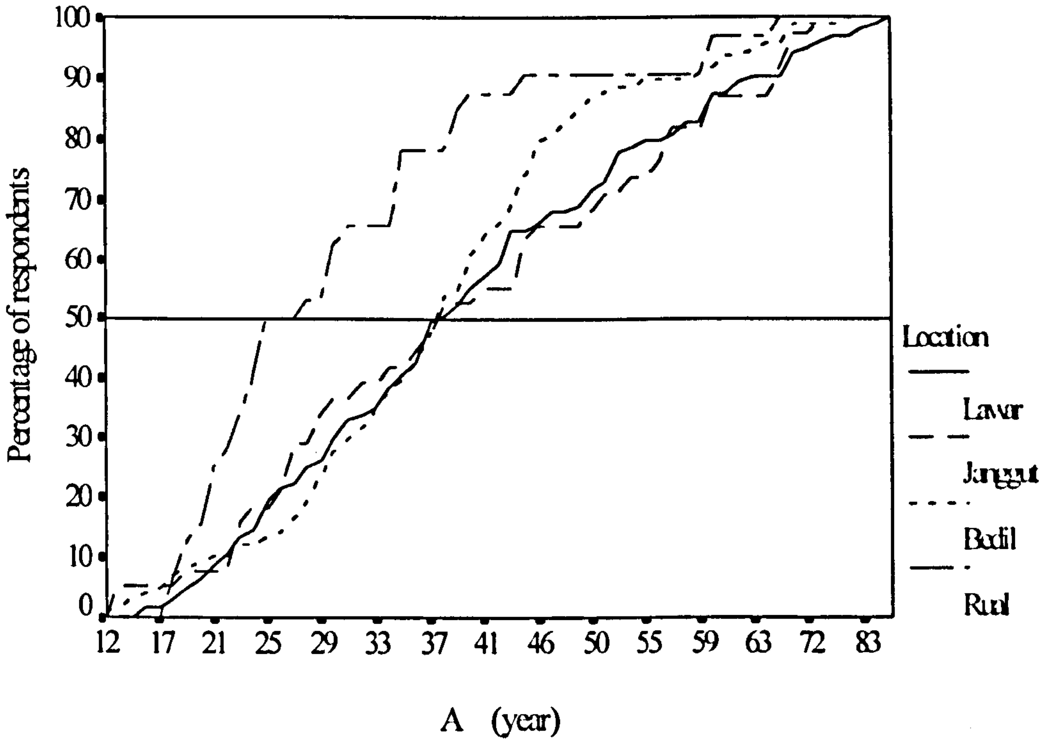


Table 5.1.2 Ethnic distribution of the respondents by study location

Location	Malays (%)	Malay-Thai (%)	Orang Asli (%)	Total
Lawar	103 (100)	0 (0)	0 (0)	103
Janggut	36 (94.7)	2 (5.3)	0 (0)	38
Bedil	85 (87.6)	12 (12.4)	0 (0)	97
Rual	1 (3.1)	0 (0)	31 (96.9)	32
Total	225	14	31	270

All respondents from Lawar were Malays. In Janggut, 94.7% were Malays and 5.3% Malay-Thais. A higher percentage of Malay-Thais (12.4%) was interviewed in Bedil. Rual was wholly Orang Asli. The one Malay respondent found in this village was a staff member from the Ministry of Welfare and Community Development.

Income was based on regular sources per calendar month. Since most of the respondents did not regularly receive monthly payment for their work, the amount recorded was an average, taking into account all financially rewarded activities in a year. A one-off paid job that was not likely to be a regular source of income was excluded. The monthly income ranged from RM50.00, which is equivalent (≡) to £6.50) to RM1500.00 (≡ £200.00). In Jeli, an income RM700.00 or more is considered high, and a person earning more than RM1000.00 could lead a luxury life. The mean (SD) income of the respondents was RM562.72 (360.89) and was much higher for Lawar [RM750.00 (377.10)] compared with Janggut [RM453.26 (254.393)], Bedil [RM400.26 (197.050)] and Rual [RM212.82 (74.027)] ($F=77.9$; 3, 507 df; $p < 0.001$).

Duration of stay at the current location was not pertinent to the interviewee but rather to the household. Fifty-eight per cent of the respondents from Bedil had lived in the area less than 10 years, of which 29 % were five years or less. More than 70% of Janggut and Rual and 67% of Lawar had lived in the respective locations more than 10 years (Fig.5.1.2). Seventy-one percent of the respondents from Lawar were either early settlers (residents of 50 years or more) or from nearby villages. In Janggut, 15.8% respondents were from nearby villages, 78.9% came from other districts and

5.3% from Thailand. In Bedil, 53.6% were local or from nearby villages. The rest were from other non-endemic areas in addition to a notable 12.4% from Thailand. Ninety per cent of the respondents in Rual were classified as local. However, before they lived in the settlement, they have never stayed in one area for more than 2 years.

Fig.5.1.2 The cumulative percentage of respondents in relation to their duration of stay by location

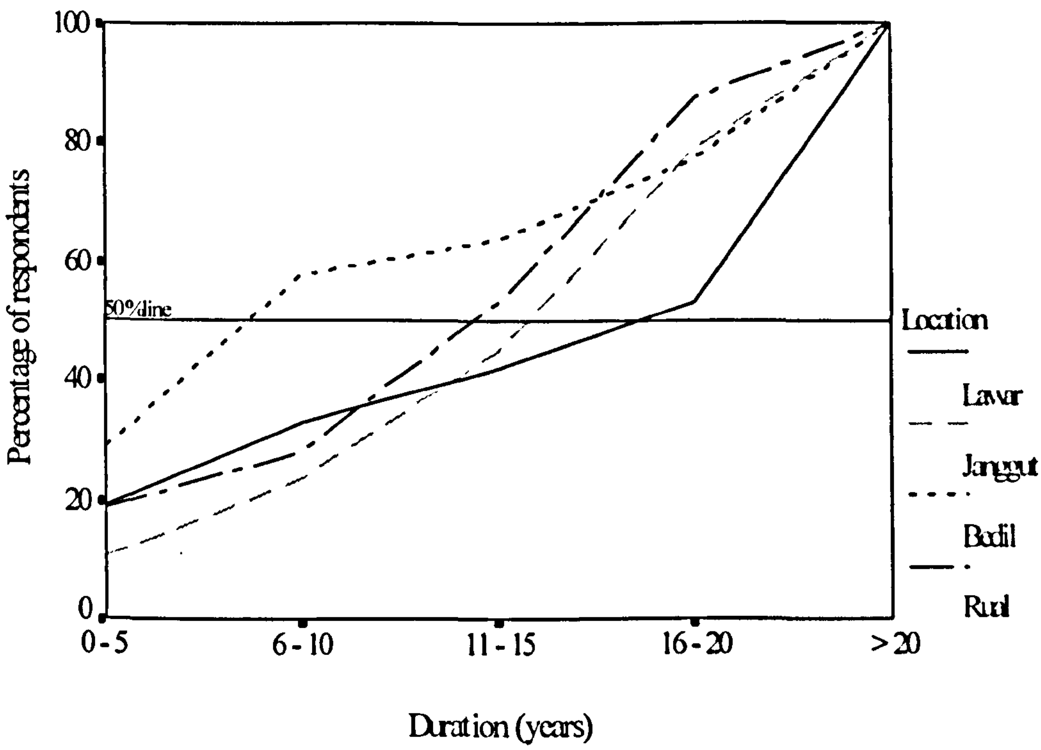


Table 5.1.3 The the number of rooms in houses and the mean family size by location.

Location	No. of rooms per house						Mean family
	0 (%)	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	size
Lawar	0 (0)	37 (35.9)	36 (35.0)	21 (20.4)	8 (7.8)	1 (1.0)	5.7
Janggut	0 (0)	22 (57.9)	15 (39.5)	1 (2.6)	0 (0)	0 (0)	4.9
Bedil	0 (0)	36 (37.1)	35 (36.1)	21 (21.6)	2 (2.1)	3 (3.1)	6.3
Rual	3 (9.4)	29 (90.6)	0 (0)	0 (0)	0 (0)	0 (0)	4.3
Total	3 (1.1)	124(45.9)	86(31.9)	43(15.9)	10 (3.7)	4 (1.5)	

Note: % = percentage respondents by location.

All houses in Rual had only one room whereas traditional huts had no room at all. Fifty-eight per cent of houses in Janggut had one room and the rest two rooms. Lawar and Bedil had houses with up to five rooms. Table 5.1.3 shows the percentages of rooms per house and the relative size of the family of the respondents.

5.1.1.2 Housing condition and basic amenities

The majority were typical Malay village houses with wooden floor and walls. In some houses, there were gaps between the wall and the roof to allow air circulation and to cool the house. Although there were differences in size, quality of wood used and condition of the house, architecture or structural design were quite similar. Brick houses were normally shop houses in which the owner lived at the back. In Rual, every family was given a one bedroom wooden house but some, six (19.4%) in this survey, still preferred to live in their traditional huts. Whereas 60.7% of the houses had a water tap inside the house, the reverse was true for latrines. In Rual, all latrines and water taps, except one, were outside the house.

Table 5.1.4 The location of toilet and water tap for domestic uses in relation to the respondents' house (outside the house or inside)

Location	**Water tap**		**Latrine**		**Total**
	Inside	**Outside**	**Inside**	**Outside**	
Lawar	79 (76.7)	24 (23.3)	61 (59.2)	42 (40.8)	103
Janggut	21 (55.3)	17 (44.7)	9 (23.7)	29 (76.3)	38
Bedil	63 (64.9)	34 (35.1)	44 (45.4)	53 (54.6)	97
Rual	1 (3.1)	31 (96.9)	0 (0)	32 (100)	32
Total	164 (60.7)	106 (39.3)	114 (42.2)	156 (57.8)	270

5.1.1.3 Occupation and place of work

The type of occupations reported by the respondents are summarised in Table 5.1.3. Housewives were classified as not working even though many actually assisted their husbands either on the fruit farms or tapping rubber. Rubber tapper was the main occupation in Janggut and one of the main for Bedil (29.6% of all repsondents). Certain occupations were almost exclusive to one location such as working in the dam site (Lawar) and rattan collector (Rual). Respondents from Bedil were involved in a wide range of occupations. The majority of Malay-Thais were rubber tappers.

Table 5.1.5 Occupations of the respondents by location and ethnic groups

Occupation	Location				Ethnic		
	Lawar	Janggut	Bedil	Rual	Malays	M-Thai	O.Asli
R. Tapper	13(12.6)	24(63.2)	34(35.1)	9(28.1)	60(26.7)	11(78.6)	9(29.0)
Fruit Farm	6(5.8)	0(0)	4(4.1)	3(9.4)	10(4.4)	0(0)	3(9.7)
Clear Land	4(3.9)	0(0)	2(2.1)	9(28.1)	6(2.7)	0(0)	9(29.0)
Dam	15(14.6)	0(0)	3(3.1)	0(0)	18(8.0)	0(0)	0(0)
Odd jobs	10(9.7)	0(0)	16(16.5)	1(3.1)	26(11.6)	0(0)	1(3.2)
Col. rattan	0(0)	0(0)	0(0)	8(25.0)	0(0)	0(0)	8(25.8)
Logger	0(0)	0(0)	3(3.1)	0(0)	3(1.3)	0(0)	0(0)
Highway	3(2.9)	0(0)	0(0)	0(0)	3(1.3)	0(0)	0(0)
Business	7(6.8)	1(2.6)	6(6.2)	0(0)	13(5.8)	1(7.1)	0(0)
G'ment	2(1.9)	0(0)	3(3.1)	2(6.3)	6(2.7)	0(0)	1(3.2)
N. working	43(41.7)	13(34.2)	26(26.8)	0(0)	80(35.6)	2(14.3)	0(0)
Total	103	38	97	32	225	14	31

Seventy-eight (28.9%) respondents worked in forest fringe areas, 41 (15.2%) in deep jungle, 18 (6.7%) in the dam construction sites, 4 (1.9%) in town and the rest (47.4%) in their village or nearby villages. The last group included housewives and students. Deep jungle workers were mainly rattan collectors, loggers, a few rubber tappers, odd job workers and those paid to clear newly opened land. For the Orang Asli, the place of work could not be classified properly because the settlement itself could be considered as forest fringe. The Orang Asli quite frequently travel into the jungle which made the classification of place of work inaccurate.

5.1.2 Behavioural factors

5.1.2.1 Personal protection measures

Out of 270 respondents, 211 (78.1%) used bednets for self protection against mosquito bites. The proportion of bednet users varied from one location to the other with Lawar 83.5%, Janggut 78.9%, Bedil 69.1% and Rual 87.5% (Table 5.1.5). The respondents in Lawar used only ordinary bednets, whereas in Janggut and Rual, users only used permethrin-impregnated bednets (IBN). In Bedil, there was an equal proportion of IBN, ordinary bednets and non-bednet users. Two thirds of the respondents used more than one bednet per house (Table 5.1.6).

Table 5.1.6 Number of respondents that used bednets and the type of bed nets used.

Location	**Used Bednets**		**Did not use bednets**	**Total**
	Ordinary(%)	IBN(%)		
Lawar	85 (83.5)	0 (0)	17 (16.5)	103
Janggut	0 (0)	30 (78.9)	8 (21.1)	38
Bedil	33 (34.0)	34 (35.1)	30 (30.9)	97
Rual	0 (0)	28 (87.5)	4 (12.5)	32
Total	119 (44.1)	92 (34.0)	59 (21.9)	270

Out of 211 bednet users, 88.2% used them every night while the rest (11.8%) used bednets irregularly, about two to three nights per week. Although some of the respondents had been using bednets for several years, IBN were introduced quite recently except for the respondents in Janggut who have been using IBN since 1991. The majority of other respondents (72.8%) started using IBN only six to twelve months before this survey which began in early 1995.

Table 5.1.7 Number of bednets used per house by bednet users

Location	**No. of bednets used**					
	1(%)	**2(%)**	**3(%)**	**4(%)**	**5(%)**	**6(%)**
Lawar	31 (36.0)	27 (31.4)	18 (20.9)	9 (10.5)	1 (1.2)	0 (0)
Janggut	9 (30.0)	12 (40.0)	6 (20.0)	3 (10.0)	0 (0)	0 (0)
Bedil	17 (25.4)	24 (35.8)	18 (26.9)	3 (10.0)	4 (6.0)	1 (1.5)
Rual	14 (50.0)	8 (28.6)	5 (17.9)	1 (3.6)	0 (0)	0 (0)
Total	71 (33.6)	71 (33.6)	47 (22.3)	16 (7.6)	5 (2.4)	1 (0.5)

Note: In parentheses are the percentages of respondents in the particular location owning the respective number of bednets.

Thirty-six (39.1%) respondents who used IBN washed their bednets. The frequency of the washing varied greatly from once a month (5.7% of the users) to once a year (5.7%), but the majority (71.4%) washed their bednets at six-monthly intervals. In Janggut, 46.7% respondents washed their bednets, mostly at six-monthly intervals. The same proportion in Rual (46.4%) washed their bednets but at a more frequent interval (61.5% at six-monthly intervals and the rest less than six months). Eight (23.5%) respondents from Bedil washed their bednets of which 62.5% did so at six monthly intervals, 25% at two monthly and 25% at a yearly interval.

Re-impregnation of bednets was carried out in the village itself between six to 12 months after the launch of impregnated-bednets programme. Users who had used bednets for more than six months were asked to bring their bednets to a specified centre for re-impregnation. Ordinary bednet users were also asked to re-impregnate their bednets for a fee of RM5.00 (≡ £0.85) to cover the cost of the chemicals. For the recipients of subsidised or donated impregnated bednets, the money would have been collected at the time the bednets were distributed. The RM5.00 fee was charged per household and users could impregnate as many bednets as they owned. The same procedure applied to the non-recipients of such a programme.

5.1.2.2 Personal protection measures other than bednets

Less than half (45.6%) of the respondents used additional protection measures when sleeping. For those who did, 114 (92.7%) used mosquito coils or insecticide spray. Only 93 (34.4%) respondents used these additional measures before going to bed, of which 81 (87.1 %) used mosquito coils. The use of additional protection measures was limited exclusively to bednet users.

5.1.2.3 Bed and rising time

Seventy-five per cent of the respondents went to bed after 2200 hours. In the morning, 55.6% got up before 0600 hours.

5.1.2.4 Other risk behaviour

Forty-two (15.6%) respondents made regular jungle trips. Thirty-two (80%) were job related of which twenty-six (68.4%) were rattan collectors (Orang Asli) and six

(15.8%) loggers (Table 5.1.8). The rest were either jungle guides or fruit farm owners guarding young fruit trees from wild animals. The respondents who regularly spent nights in the jungle were from Lawar (5.8%), Bedil (14.4%) and Rual (68.8).

Out of the 42, only 11 (26.2%) used any protection measures. All of them used mosquito repellents when in the jungle but none took proper prophylaxis. A few respondents reported taking anti-malaria drugs left by the FC before going in or after coming back from the jungle, especially when they thought they had fever or symptoms of malaria such as chills or rigor.

Table 5.1.8 Reasons given by the respondents for spending nights in jungle

Reasons	**No. of respondents (%)**
Logging	6 (14.29)
Collect rattan	26 (61.91)
Leisure (fishing, work as a guide)	3 (7.14)
Working in the dam	3 (7.14)
Working in fruit farm	4 (9.52)
Total	42

5.1.3 Environmental factors

Important variables in the eco-system included rivers or streams, dam and main roads or highways. Rivers or streams existed in all study locations running beside, at the back or across villages. Among the four study locations, Lawar was the only one that came into direct contact with jungle clearing activities for the construction of the Pergau Dam which had stopped two years before the study began. Minor jungle clearing took place near Janggut and Bedil during the early phase of the construction work when new roads were laid to access the place for the construction of the underground tunnels. However, major jungle clearing activities were 25 and 15 km away from these villages respectively. Rual was not involved geographically with the dam being more than 30 km away. Forest clearing in this area was due to logging activities, which were still active at the time the survey was carried out, within the 10 km radius of the village. Patches of bald hill, the after-effects of logging, were clearly visible from Rual. Bedil is situated along the main road with Lawar three km, Janggut 11 km and Rual 12 km away.

Table 5.1.9: Distance of river and streams from houses in the village summarised for each location by range and means of distance (meters)

Location	Range (metre)	Mean distance (SD) in meters
Lawar	5 to 990	254 (253)
Janggut	10 to 500	153 (148)
Bedil	10 to 900	219 (231)
Rual	10 to 200	27 (36)

5.1.4 Malaria cases

Only three respondents had a current malaria infection at the time of the survey, two from Rual and one from Bedil. All three were treated at home by the MCT. Forty (14.8%) respondents reported malaria infection in the past. Details of past malaria infection by location and ethnic are given in Table 5.1.10.

Table 5.1.10 History of past malaria infection by location

		Past malaria history presence	Total
Location	Lawar	9 (8.7)	103
	Janggut	4 (10.5)	38
	Bedil	16 (16.5)	97
	Rual	11 (34.4)	32
Ethnic	Malay	25 (11.1)	225
	Malay-Thai	4 (28.6)	14
	Orang Asli	11 (35.5)	31

SECTION 5.2 PARASITOLOGY SURVEY

5.2.1 Cross-sectional surveys

Two cross-sectional surveys were conducted in all study locations, one in the rainy season (from December 1994 to February 1995) and the other in the dry season (July and August 1995). Although 100% coverage was intended, the rainy season survey covered 65.3% while the dry season survey 50.1% of the total study populations. Malaria positive cases were treated using standard guidelines produced by the Malaysian Ministry of Health. Age coverage for the rainy and dry season surveys is shown in Table 5.2.1.

Table 5.2.1 Age distribution of the respondents for the two cross-sectional surveys

	Rainy Season	**Dry Season**
Age group (year)	No. of respondents(%)	No. of respondents(%)
< 5	195 (19.2)	128 (16.4)
5 - 14	330 (32.5)	293 (37.6)
15 - 24	172 (16.9)	155 (19.9)
25 - 34	122 (12.0)	94 (12.1)
35 - 44	69 (6.8)	70 (9.0)
≥ 45	127 (12.5)	39 (5.0)
Total	1015	779

The proportions in the ethnic groups were consistent with the results of the social and behavioural survey, both in the rainy and dry season surveys (Table 5.2.2).

Table 5.2.2 Respondents by location and ethnic groups (rainy season/dry season)

Location	Malay(%)		Malay-Thai(%)		Orang Asli(%)		Total	
	Rainy(%)	Dry(%)	Rainy(%)	Dry(%)	Rainy(%)	Dry(%)	Rainy(%)	Dry(%)
Lawar	556(100))	295(100)	0(0)	0(0)	0(0)	0(0)	556	295
Janggut	65(90.3)	158(93.5)	7(9.7)	11(6.5)	0(0)	0(0)	72	169
Bedil	233(85.4)	173(79.4)	40(14.7)	45(20.6)	0(0)	0(0)	273	218
Rual	0(0)	0(0)	0(0)	0(0)	114(100)	97(100)	114	97
Total	854	626	47	56	114	97	1015	779

5.2.1.1 The first survey: The rainy season

Out of 1015 slides examined, only three were positive for malaria parasites (Table 5.2.3). Two were from Bedil, a three year old girl and seven years old boy (both falciparum malaria), and a 2 year old girl from Rual (malariae malaria). All three cases were indigenous cases.

Table 5.2.3 Distribution of slides collected in the rainy season survey

Location	slides(% of total slide)	%(location's population)	Slide positive (SPR)	Malaria Species	
				P. falciparum(%)	*P. malariae(%)*
Lawar	556 (54.8)	75.0	0 (0)	0 (0)	0 (0)
Janggut	72 (7.1)	29.9	0 (0)	0 (0)	0 (0)
Bedil	273 (26.9)	65.0	2 (0.7)	2 (100)	0 (0)
Rual	114 (11.2)	75.0	1 (0.9)	0 (0)	1 (100)
Total	1015	65.3	3 (0.3)	2 (66.7)	1 (33.3)

5.2.1.2 The second survey: The dry season

Out of 779 slides taken in the dry season survey, 12 were positive for malaria parasites. As in the rainy season, the 12 cases were detected from Bedil (seven cases) and Rual (five cases). The slide positivity rate was 3.2% and 5.2% respectively. The overall SPR was 1.5%.

Table 5.2.4 Slides collected during the dry season survey

Location	Slides(%)	%(Location's population)	Slide Positive (SPR)	Malaria Species	
				P. falciparum(%)	*P. vivax*(%)
Lawar	295 (37.8)	39.8	0 (0)	0 (0)	0 (0)
Janggut	169 (21.7)	70.1	0 (0)	0 (0)	0 (0)
Bedil	218 (28.0)	51.9	7 (3.2)	6 (85.7)	1 (14.3)
Rual	97 (12.5)	63.8	5 (5.2)	2 (40.0)	3 (60.0)
Total	779	50.1	12 (1.5)	8 (66.7)	4 (33.3)

Out of seven cases from Bedil, four were Malay-Thais (SPR = 8.9%) and three Malays (SPR = 1.7%). The *falciparum: vivax* ratio was 2:1 (Table 5.2.5)

Table 5.2.5 Malaria species detected in study locations (Rainy Season/Dry Season)

Ethnic	***P. falciparum*(%)**		***P. vivax*(%)**		***P. malariae*(%)**	
	Rainy	**Dry**	**Rainy**	**Dry**	**Rainy**	**Dry**
Malay	2 (0.2)	2 (0.3)	0 (0)	1 (0.2)	0 (0)	0(0)
Malay-Thai	0 (0)	4 (7.1)	0 (0)	0 (0)	0 (0)	0(0)
Orang Asli	0 (0)	2 (2.1)	0 (0)	3 (3.1)	1 (0.9)	0(0)
Total	2 (0.2)	8 (1.0)	0 (0)	4 (0.5)	1 (0.1)	0

5.2.2 Monthly ACD

Twenty-nine cases were detected by the monthly ACD for the period of 18 months between January 1995 and June 1996. Twelve cases (41.38%) were falciparum, thirteen (44.83%) were vivax and four (13.79%) malariae malaria (Table 5.2.6). Fifteen cases were from Bedil, eleven from Rual, two from Janggut and one from Lawar. There were no recurrent or relapse cases. Cases from Lawar and Janggut were all vivax malaria. Eight cases were detected in the first six months of 1996, four were vivax and four malariae malaria. *P. malariae* was only found in Rual.

Table 5.2.6 Cases detected by monthly slides examinations and the malaria species

Month	All location		Lawar		Janggut		Bedil		Rual		*P. falciparum*	*P. vivax*	*P. malariae*
	n (%)	D	n (%)	D	n (%)	D	n (%)	D	n (%)	D	n (%)	n (%)	n (%)
January 95	1(3.5)	573	0(0)	278	0(0)	41	1(100)	181	0(0)	73	1(100)	0(0)	0(0)
February 95	-	-	-	-	-	-	-	-	-	-	-	-	-
March 95	7(24.1)	139	0(0)	59	1(14.3)	26	5(71.4)	34	1(14.3)	20	3(42.9)	4(57.1)	0(0)
April 95	1(3.5)	122	0(0)	45	1(100)	31	0(0)	25	0(0)	21	0(0)	1(100)	0(0)
May 95	-	-	-	-	-	-	-	-	-	-	-	-	-
June 95	-	-	-	-	-	-	-	-	-	-	-	-	-
July 95	6(20.7)	387	0(0)	140	0(0)	80	4(66.7)	120	2(33.3)	47	3(50.0)	3(50.0)	0(0)
August 95	6(20.7)	392	0(0)	155	0(0)	89	3(50.0)	98	3(50.0)	50	5(83.3)	1(16.7)	0(0)
September 95	-	-	-	-	-	-	-	-	-	-	-	-	-
October 95	-	-	-	-	-	-	-	-	-	-	-	-	-
November 95	-	-	-	-	-	-	-	-	-	-	-	-	-
December 95	-	-	-	-	-	-	-	-	-	-	-	-	-
January 96	4(13.8)	125	0(0)	66	0(0)	8	0(0)	28	4(100)	23	0(0)	0(0)	4(100)
February 96	2(6.9)	121	0(0)	59	0(0)	13	2(100)	25	0(0)	24	0(0)	2(100)	0(0)
March 96	-	-	-	-	-	-	-	-	-	-	-	-	-
April 96	1(3.5)	116	1(100)	56	0(0)	11	0(0)	29	0(0)	20	0(0)	1(100)	0(0)
May 96	-	-	-	-	-	-	-	-	-	-	-	-	-
June 96	1(3.5)	103	0(0)	54	0(0)	11	0(0)	23	1(100)	15	0(0)	1(100)	0(0)
Total	29	2078	1(3.45)	912	2(6.9)	310	15(51.7)	563	11(37.9)	293	12(41.4)	13(44.8)	4(13.8)

Note: [-] Indicate no survey conducted during the month.
D is the denominator (number of slides examined per survey per location).

SECTION 5.3 DETECTION OF ANTI-MALARIA ANTIBODY (IgG) IN THE STUDY POPULATION BY ENZYME-LINKED IMMUNOSORBENT ASSAY

5.3.1 Characteristics of the respondents

Paired sera collected from 510 villagers in the 4 study locations during the dry and rainy seasons were tested for the presence of anti-malaria antibodies (IgG) using the Enzyme-linked immunosorbent assay (ELISA). These samples which constituted 32.8% of the total study population were low compared to the one hundred per cent intended. The main reason for the low coverage was the difficulty in persuading villagers to give consent. Written consent was required because serological investigation was not one of the routine examinations carried out by the MCT. Some children ran away on seeing the health personnel. Others were not at home; either at work, out of the village or attending political campaigns and gatherings. Some of the Malay-Thais, especially rubber tappers, went home to Thailand because the rainy season prevented them from work. The missing Orang Asli were on their jungle trip, which normally take between six weeks to three months, involving the whole family.

As in other surveys, the populations in Lawar and Rual were homogenous; Malays in Lawar and Orang Asli in Rual (Table 5.3.1). Bedil and Janggut had a mixture of Malay and Malay-Thai residents. However, the numbers of Malay-Thai respondents in these two locations were small and were grouped together with the Malays for data analysis. Female respondents were higher than male by 5.9% (Table 5.3.2). This near equal proportion was maintained in three locations with the exception of Lawar where female (63.8%) respondents almost doubled the male (36.2%).

Table 5.3.1 Distribution of the respondents by location and ethnic group

Location	Orang Asli (% in location)	Malay (% in location)	Malay-Thai (% in location)	Total (% in location)
Lawar	0 (0)	94 (23.7)	0 (0)	94 (12.7)
Janggut	0 (0)	129 (32.5)	9 (34.6)	138 (57.3)
Bedil	0 (0)	174 (43.8)	17(65.4)	191 (45.5)
Rual	87 (100.0)	0 (0)	0 (0)	87 (57.2)
No. of respondents (% of ethnic population)	87 (57.2)	397 (31.5)	26 (18.6)	510 (32.8)
Total ethnic population	152	1262	140	1554

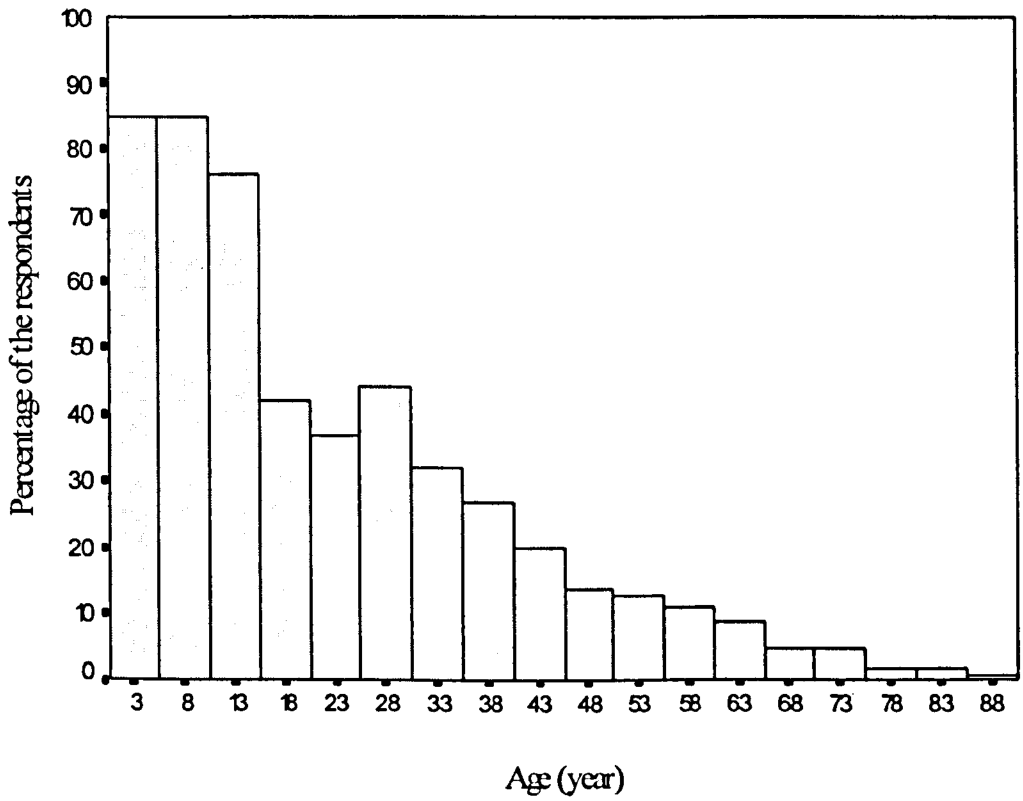
Table 5.3.2 Sex and age of the respondents by location

Location	Female (%)	Male (%)	Age range (year)	Mean age (SD)
Lawar	60 (63.8)	34 (36.2)	1 - 75	25.2 (18.02)
Janggut	67 (48.5)	71 (51.5)	1 - 88	24.9 (20.73)
Bedil	102 (53.7)	89 (46.3)	1 - 80	20.1 (16.9)
Rual	41 (46.6)	46 (53.4)	1 - 50	12.9 (12.13)
Total	270 (52.9)	240 (47.1)	1 - 88	21.1 (18.04)

Differences in male and female proportion by location; $\chi^2 = 6.74$, 3 d.f; $p=0.08$

The age distribution ranged from 1 to 88 years (Fig.5.3.1 and Table 5.3.2) with a mean (SD) of 21.1 (18.04) years. The female mean (SD) age was 22.0 (16.19) years and the male was 20.0 (19.42) years. The difference in mean age between the four study locations was significantly different ($F=10.38$; 3, 506 df; $p<0.001$). This was due to the effect of the mean age of the respondents from Rual which was significantly lower than the other three locations.

Fig.5.3.1 Age distribution of the respondents for the ELISA surveys



5.3.2 Sero-prevalence

Three-hundred and eight (60.4%) respondents in the rainy season and 325 (63.7%) in the dry season survey were positive for the ELISA test (Table 5.3.3). The increase of 18 (3.3%) sero-positives in the dry season (McNemar test =5.78; p=0.016) resulted from the 6.7% respondents who converted from sero-negative in the rainy season to sero-positive in the dry season, double the number of respondents who converted from seropositive to sero-negative (3.1%). This increase was marginal in Lawar (2.1%) and Janggut (2.2%) compared to Bedil (4.8%) and Rual (4.6%) (Fig.5.3.2). The differences in the increases were statistically significant both for the rainy (χ^2=25.34; df=3; p=0.000) and dry season surveys (χ^2=27.53; df=3; p=0.000). Rual had the highest percentage of positive respondents in both dry (83.9%) and rainy (79.3%) seasons, followed by Lawar, Bedil and Janggut in declining order (Table 5.3.3).

Fig.5.3.2 The proportion of sero-positive respondents in the rainy and dry season surveys by location

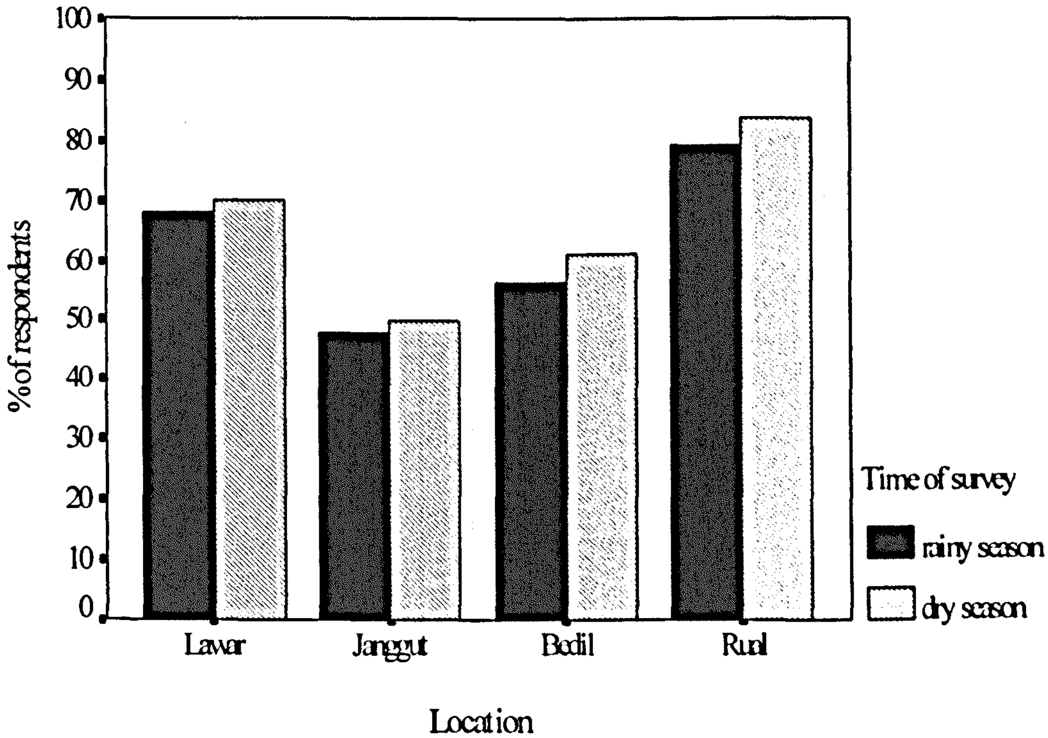


Table 5.3.3. Level of seropositivity by location for the rainy and dry season surveys

Location	n	Rainy Season Negative (%)	Rainy Season Low positive (%)	Rainy Season Medium positive (%)	Rainy Season High positive (%)	Rainy Season Total positive (%)	Dry Season Negative (%)	Dry Season Low positive (%)	Dry Season Medium positive (%)	Dry Season High positive (%)	Dry Season Total positive (%)
Lawar	94	30(31.9)	15(16.0)	34(36.2)	15(16.0)	64(68.1)	28(29.8)	17(18.1)	37(39.4)	12 (12.8)	66(70.2)
Janggut	138	72(52.2)	25(18.1)	30(21.1)	11(8.0)	66(47.8)	69(50.0)	23(16.7)	36(26.1)	10(7.2)	69(50.0)
Bedil	191	83(43.5)	26(13.6)	55(28.8)	27(14.1)	108(56.5)	74(38.7)	26(13.6)	59(30.9)	32(16.8)	117(61.3)
Rual	87	17(19.5)	7(8.1)	25(28.7)	38(43.7)	69(79.3)	14(16.1)	7(8.0)	18(20.7)	48(55.2)	73(83.9)
Total	510	202(39.6)	73 (14.3)	144 (28.2)	91 (17.8)	308(60.4)	185(36.3)	73 (14.3)	150 (29.4)	102 (20.0)	325(63.7)

Note: 1. Sample size was the same for the rainy and dry season surveys.

2. Cut-off point for positive O.D = 0.136 for the rainy season and 0.135 for the dry season.

3. Level of positivity: Low positive = O. D between 0.137 to 0.199.

Medium positive = O. D between 0.200 to 0.499 and

High positive = O. D of 0.500 or more.

5.3.2.1 Sero-positivity by age

Regression of O.D on age showed no correlation either in rainy or dry season (Fig.5.3.3). Further exploration was made of the relationship between sero-positivity and age by looking at the proportion of sero-positives in different age groups. This analysis was carried out only on the dry survey O.D because there was not much variation in the results of the two surveys. Only Bedil and Janggut showed differences in the proportion of sero-positivity between different age groups (Table 5.3.4).

Fig.5.3.3. Correlation between O.D and age in the rainy and dry season surveys

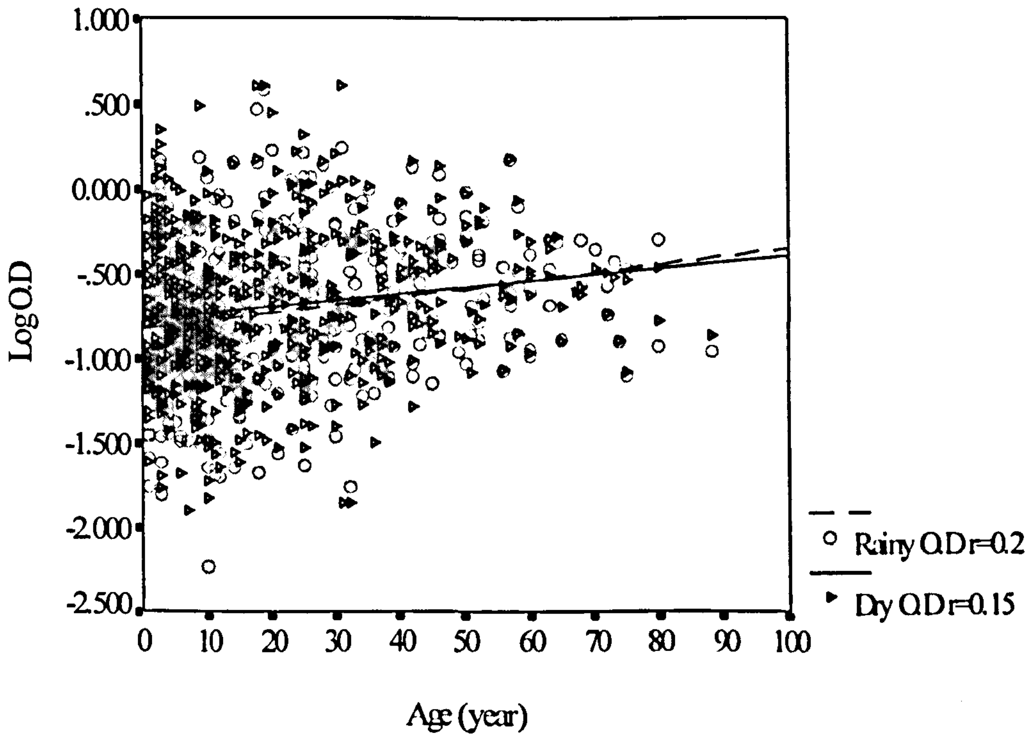


Table 5.3.4. The proportion (%) of sero-positives by age group and location

Age group (year)	Lawar	Janggut	Bedil	Rual	All locations
1 - 5	62.5	42.1	47.4	84.2	61.2
6 - 10	55.6	28.1	65.7	83.3	53.6
11 - 15	61.5	25.0	56.5	50.0	48.2
16 - 25	88.2	52.9	52.8	90.5	68.1
26 - 35	50.0	62.5	64.3	100.0	66.1
> 35	80.0	76.3	83.8	60.0	78.8
χ^2	9.51	22.18	15.04	7.54	21.61
p-value (5df)	$p > 0.05$	$p < 0.001$	$p < 0.01$	$p > 0.05$	$p < 0.001$

5.3.2.2 Level of sero-positivity

ELISA positive cases were further divided into 3 categories, low positive, medium positive and high positive. Definitions for each category are given in the note section for Table 5.3.3 and methods (Chapter 3.6). The cut-off point for the ELISA positive was 0.136 which was the mean + 2SD of the negative controls for the rainy season and 0.135 for the dry season. The value for each category was chosen after checkerboard titrations, and was based on the strength of colour changes and O.D of positive controls used in the test. Details of the steps taken were described under the methods (Chapter 3.6).

The proportion of respondents in each category level of positivity followed a similar pattern in Lawar, Janggut and Bedil (Fig.5.3.4 and Fig. 5.3.5). In Rual, the majority of respondents were in the high positive group. There was no different in the level of positivity between the male and female respondents (Table 5.3.5).

Fig5.3.4 The proportion of respondents in ELISA category for the rainy season survey by location

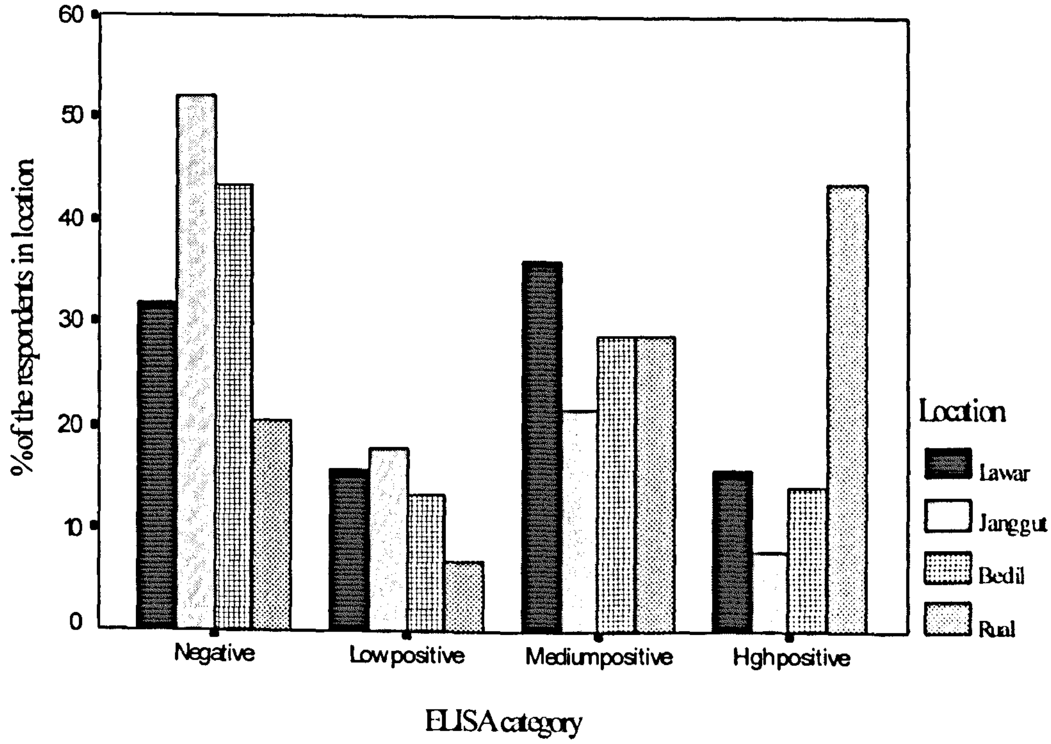


Fig.5.3.5 The proportion of respondents in ELISA category for the dry season survey by location

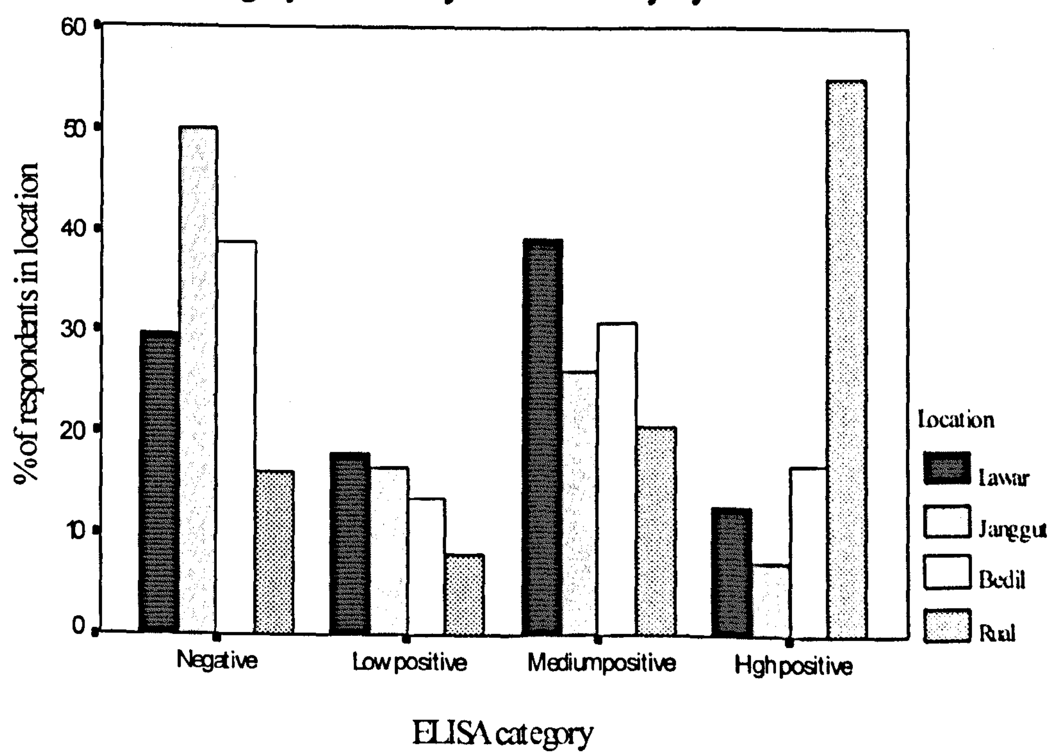


Table 5.3.5. Level of positivity by sex

Sex	Rainy Season Survey Negative (%)	Low positive (%)	Medium positive (%)	High positive (%)	Total positive (%)	Dry Season Survey Negative (%)	Low positive (%)	Medium positive (%)	High positive (%)	Total positive (%)
Male	92(38.3)	38(15.8)	68(28.3)	42 (17.5)	148 (61.7)	80 (33.3)	38 (15.8)	73 (30.4)	49 (20.4)	160 (66.7)
Female	110(40.7)	35(13.0)	76(28.1)	49 (18.1)	160 (59.3)	108 (40.0)	30 (11.1)	79 (29.3)	53 (19.6)	162 (60.0)
Total	202 (39.6)	73 (14.3)	144 (28.2)	91(17.8)	308 (60.4)	185 (36.3)	73 (14.3)	150 (29.4)	102 (20.0)	325 (63.7)

Table 5.3.6. Relationship between the level of ELISA positive and malaria status

ELISA results	Rainy Season No malaria (%)	Past malaria (%)	Current malaria (%)	No. of respondents (%)	Dry Season No malaria (%)	Past malaria (%)	Current malaria (%)	No. of respondents (%)
Negative	184 (53.8)	18 (5.4)	0(0)	202(39.6)	175 (53.2)	10 (7.2)	0 (0)	185 (36.3)
Low positive	64 (18.7)	9 (5.5)	0(0)	73(14.3)	60 (17.5)	11 (7.9)	2 (6.9)	73 (14.3)
Medium positive	94 (27.5)	50 (30.3)	0(0)	144(28.2)	107 (31.3)	36 (25.9)	7 (24.1)	150 (29.4)
High positive	0 (0)	88 (53.3)	3 (100)	91(17.8)	0 (0)	82 (59.0)	20 (69.0)	102 (20.0)
Total (row %)	342(67.1)	165(32.4)	3(0.6)	510	342 (67.1)	139 (27.3)	29 (5.7)	510

Note: % is a column percentage unless indicated otherwise.

5.3.2.3 Sero-positivity and malaria status.

Malaria status was categorised as current infection, past infection or negative. Current infection was defined as any respondent with positive slides for malaria parasites within the last 2 months of the survey date, irrespective of whether it was a new case or relapse. Past infection was defined as previous malaria infection at current residency, without limits to the number or time of infections.

The level of seropositivity was highly correlated with the malaria status of the respondents (χ^2=199.25, 3 df, $p<0.001$ for the rainy season and χ^2=216.69, 3 df, $p<0.001$ for the dry season). The results as shown in Table 5.3.6 indicated that all current malaria were seropositives. On the other aspect, no respondents who had never had malaria, had high positive ELISA.

5.3.3 Changes in the second survey O.D compared with the first survey

Regression analysis of log O.D in the 2 surveys showed highly positive correlation in all locations (Fig. 5.3.6 - 5.3.10). Changes in antibody levels were measured using O.D as proxy, and were defined as a change of ≥ 0.100 in the O.D of dry from rainy season survey. This value was 2 times the mean (0.044) O.D differences of sera with known anti-malaria antibody levels, that have been tested repeatedly to determine reading variability and reproducibility. Using this value, changes could be attributed to changes in the antibody level, and not because of testing variability or plate variations. The change was calculated by subtracting the rainy season O.D from the dry season O.D. If the answer of the substraction was positive and more than 0.044, there was an increase (called Up in Table 5.3.7) in the O.D. If the answer from the substract was negative and less than -0.044, the change was a decrease (called Down in Table 5.3.7). Differences between -0.044 and 0.044 were considered as no change (called No change in Table 5.3.7). Twenty-two per cent of the respondents in Bedil and more than one third in Rual had increased O.D, compared to only five and two percent with lower O.D, respectively. In Lawar and Janggut, the changes, either positive or negative, were small.

Table 5.3.7: Changes in O.D in the dry compared to the rainy season survey.

Location	Up (%) n = 83 (16.3)	Down (%) n = 31 (6.1)	No change(%) n = 396 (77.6)	Total N=510
Lawar	3 (3.2)	10 (10.6)	81 (86.2)	94
Janggut	6 (4.3)	8 (5.8)	124 (89.9)	138
Bedil	43 (22.5)	11 (5.8)	137 (71.7)	191
Rual	31 (35.6)	2 (2.3)	54 (62.1)	87
Female	44 (16.3)	15 (5.6)	211 (78.1)	270
Male	39 (16.3)	16 (6.7)	185 (77.1)	240

Fig.5.3.6 Correlation between the dry and rainy season for Lawar

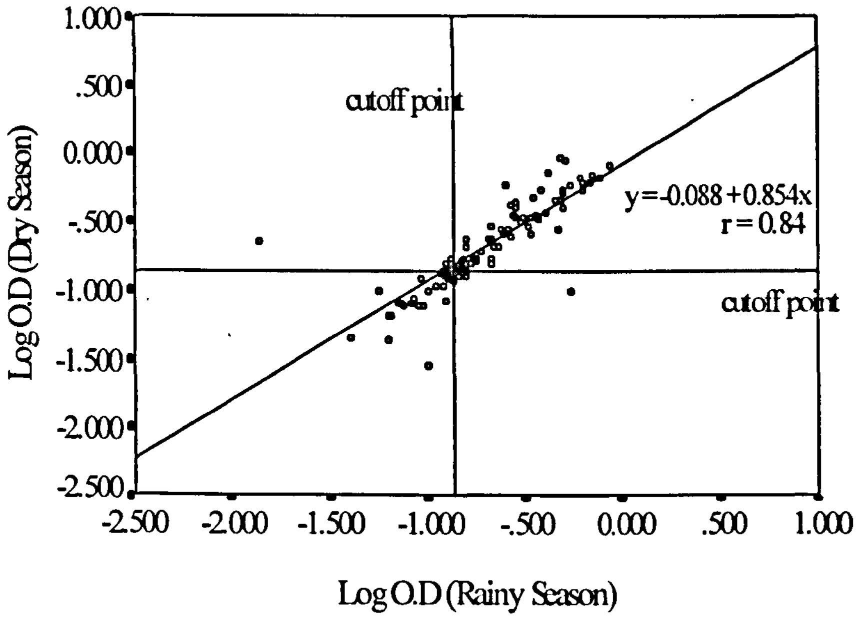


Fig.5.3.7 Correlation between the dry and rainy season O.D for Janggut

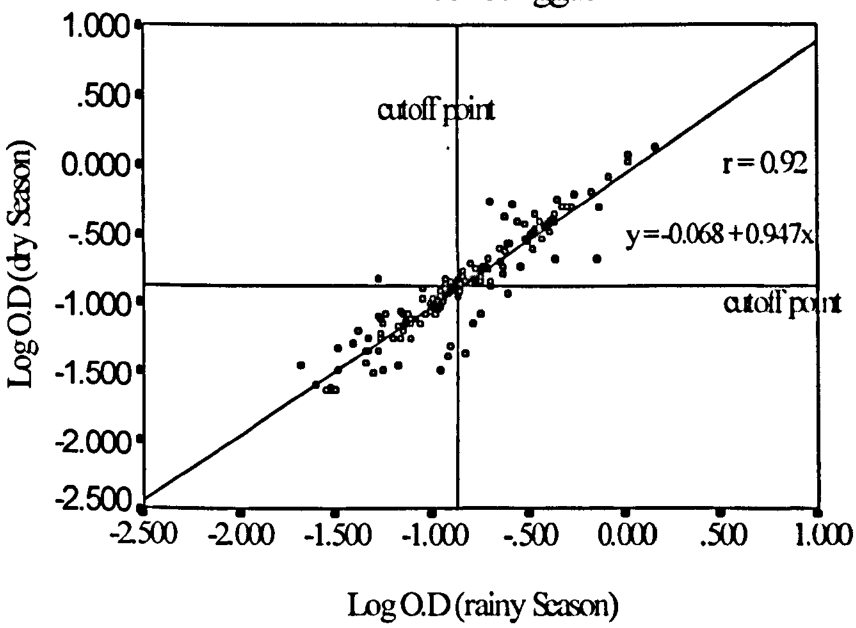


Fig.5.3.8 Correlation between the dry and rainy season O.D for Bedil

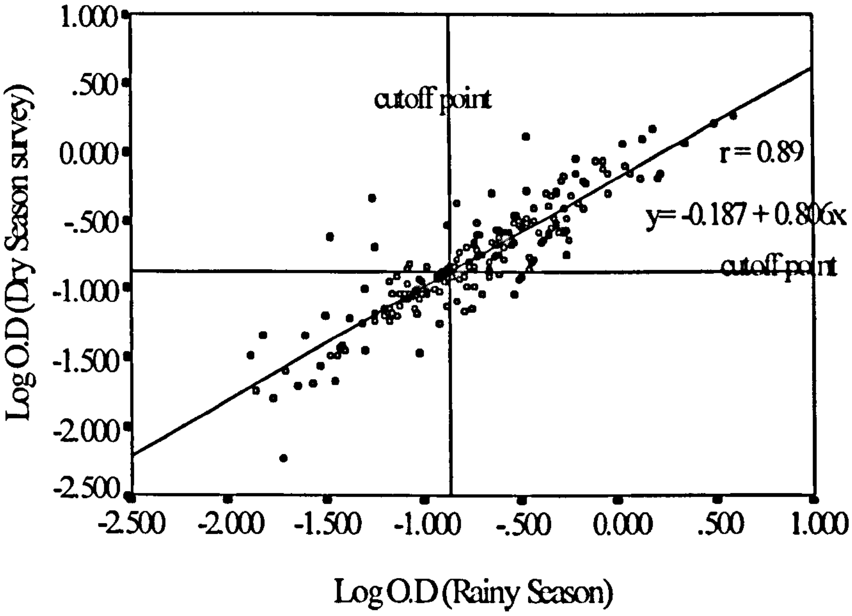


Fig.5.3.9 Correlation between the dry and rainy season O.D for Rual

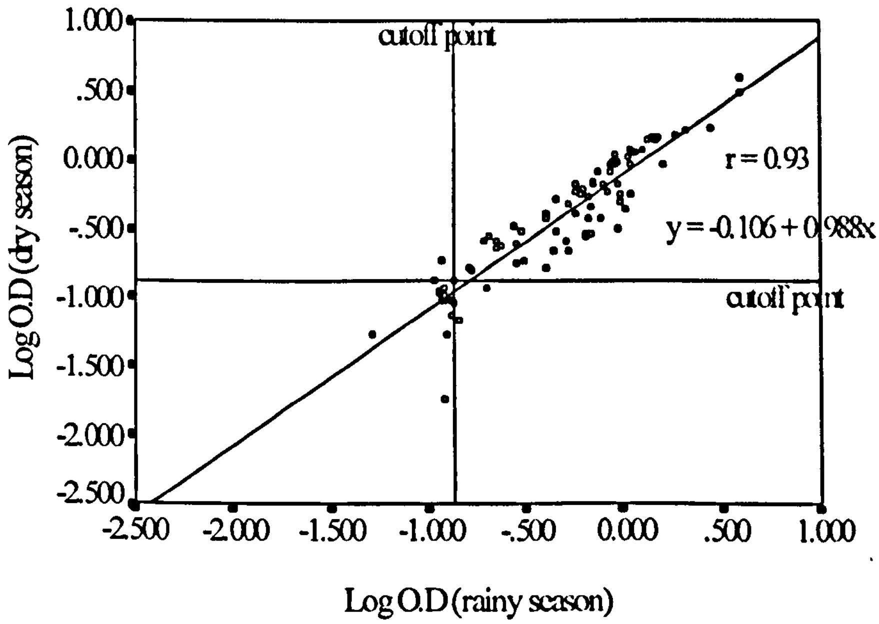


Fig.5.3.10 Correlation between the dry and rainy season O.D for all respondents

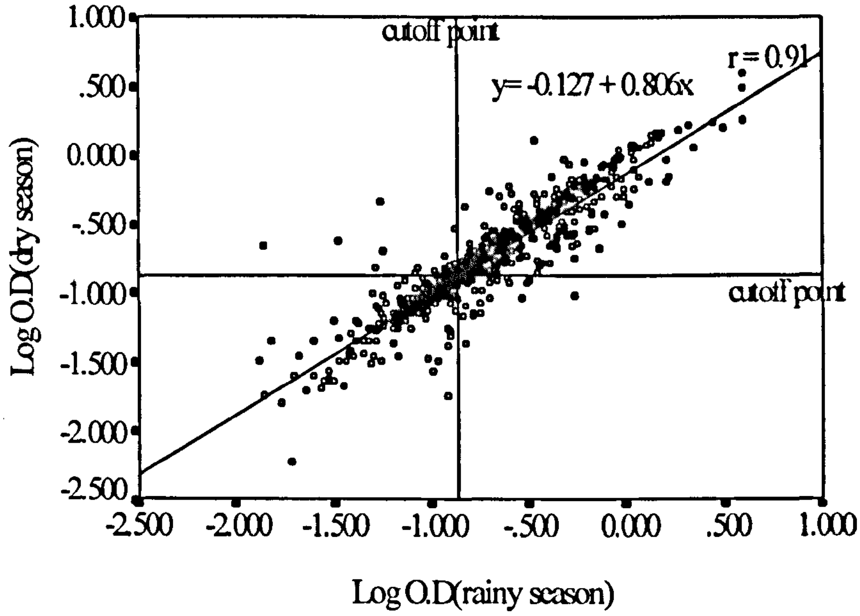
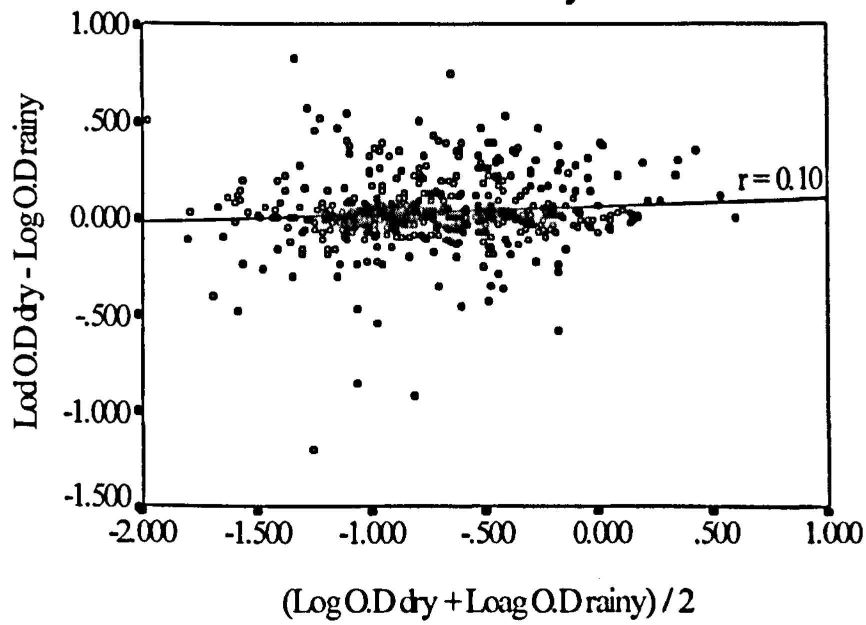


Fig.5.3.11 Differences in O.D between the dry and rainy season survey



SECTION 5.4 PHYSICAL EXAMINATION

5.4.1 Hepatosplenomegaly

Twelve percent of the respondents had enlarged spleen (Table 5.4.1). Spleen sizes ranged from 1 cm to 10 cm with a mean (SD) of 3.5 cm (1.98). All the spleen palpated were firm and non-tender.

Table 5.4.1 The presence of hepatosplenomegaly in the repsondents by location

Location	n	Splenomegaly [spleen rate(%)]	Hepatomegaly (%)
Lawar	94	1 (1.1)	5 (5.3)
Janggut	138	3 (2.2)	8 (5.1)
Bedil	191	14 (7.3)	12 (6.3)
Rual	87	42 (49.4)	15 (17.2)
Total		60(12.0)	40 (7.6)

1. Differences in the number of enlarged spleen by location: $\chi^2=143.0$; 3 df; $p < 0.001$
2. Differences in the number of enlarged liver by location: $\chi^2=13.9$; 3 df; $p < 0.005$

The spleen rate was significantly higher in Rual than the rest of the locations combined ($\chi^2=135.6$; 1 df; $p < 0.001$). The mean spleen size was also higher for Rual than other locations (F = 48.9; 3, 506 df; $p < 0.001$). Splenomegaly was strongly associated with malaria status, especially current malaria ($\chi^2=70.5$; 2 df; $p < 0.001$). There was no significant difference in the mean size of spleen between the group with and without a history of positive malaria. The spleen rate was also higher in the sero-positives than sero-negatives ($\chi^2= 10.4$; 1 df; $p < 0.001$).

Hepatomegaly was detected in 40 (7.6%) respondents and the liver sizes ranged between one to five cm and a mean (SD) of 1.9 (0.90) cm. Ten (34.5%) out of 29 respondents with positive blood films had hepatomegaly compared to 7.2% in respondents with negative blood films but with past history of malaria infection and 5.8% in respondents with negative blood films and no history of malaria infection. The prevalence of hepatomegaly was significantly higher in children (82.5%) compared to adults. However, there was no significant different in the prevalence between the under 5 years (14.6%) and older children (13.3%). The prevalence of hepatomegaly was higher in Rual than in other locations although the mean size, as for spleen, was not significantly different between the study locations. The presence of hepatomegaly was not associated with past history of malaria ($\chi^2=0.7$; 1 df; $p > 0.05$) or sero-positivity.

Hepatosplenomegaly was present in only 4.7% of the respondents and strongly associated with positive history of malaria (Fisher's exact 2-tailed $p < 0.001$). A strong association was also observed between hepatosplenomegaly and seropositivity ($\chi^2=9.7$; 1 df; $p < 0.01$), especially in the highly positive group ($\chi^2=50.0$; 3 df; $p < 0.001$).

The average enlarged spleen (AES) was measured in two overlapping age groups, 2 - 9 years and 0 - 88 years (Table 5.4.2). Although the spleen rate in the 0 - 88 year was much lower, than the 2 to 9 year, the AES was almost the same. This indicated the group in the high classification (Hackett's classification 3 and above) in the 0 - 88 years was bigger than in the age group 2 to 9 years. The big difference in the spleen rate but not the AES in the two overlapping age groups also indicated that the reduction in spleen size was a very slow process.

Table 5.4.2 Spleen enlargement based on Hackett's classification and the AES for the 2 - 9 years and 0 - 88 years in all study locations

Hackett's	**2 - 9 years**		**0 - 88 years**	
Classification	**Frequency**	**Total in Class**	**Frequency**	**Total in Class**
0	116	-	450	-
1	0	0	2	2
2	7	14	14	28
3	15	45	25	75
4	10	40	16	64
5	2	10	6	30
Total	147	109	510	199
Spleen Rate	21.1 %		11.8%	
AES		3.52		3.32

5.4.2 The presence of anaemia

The results of the conjunctiva examination for pallor detection were recorded as no pallor, mild pallor, moderate pallor and severe pallor. This grading was equivalent to haemoglobin levels of ≥12.0 g/dl, 10.0 - 11.9 g/dl and 8.0 - 9.9 g/dl and less than 8 g/dl respectively (see definition of anaemia in 3.6.2). Severe anaemia was defined as haemoglobin level of less than 8.0 g/dl, equivalent to grade 3 pallor. No respondent was recorded as having grade 3 pallor.

Table 5.4.3 The presence of anemia and a comparison of detection methods using clinical grading of pallor and the value haemoglobin estimated with Drabkin method

	Anaemia Grading				
Methods	**No anaemia (% respondents)**	**Mild anaemia (% respondents)**	**Moderate anaemia (% respondents)**	**Severe anaemia (% respondents)**	**Total**
Pallor	427 (83.7)	76 (14.9)	7 (1.4)	0 (0)	510
Hb g/dl (Drabkin)	264 (51.7)	188 (36.9)	51 (10.0)	7 (1.4)	510
Mean Hb (SD)	13.6 (1.37)	10.8 (0.68)	9.1 (0.56)	7.4 (0.58)	12.1 (2.08)

The mean haemoglobin in the male and female respondents was almost the same, 12.1 and 12.0 g/dl respectively. There was no correlation between age and haemoglobin (r=0.22). The mean haemoglobin for Lawar (12.9 g/dl) was higher than for Bedil (11.4 g/dl), Janggut (11.9 g/dl and Rual (11.9 g/dl) ($F=6.8$; 3, 506 df; $p < 0.001$). The differences between the ethnic groups, however, were not significant.

The Kappa coefficient between the two methods of anaemia detection was 0.08 following the above grading. However, when the haemoglobin value was re-categorised to include the value as < 10.0 g/dl as anaemia, the Kappa coefficient increased dramatically to 0.78. The mean (SD) haemoglobin was lower in respondents with current malaria infection than without, 11.0 g/dl (2.10) and 12.1 g/dl(2.01) respectively ($t=2.8$; 508 df; $p < 0.01$). Lower mean (SD) haemoglobin was observed in respondents falciparum malaria [10.6 g/dl (4.97)] and vivax [10.9 g/dl (3.58)] compared to malariae [12.2 g/dl (1.62)] and respondents with no malaria [12.1 g/dl (4.27)] [$F = 3.7$; 3, 506 df; $p < 0.01$).

Table 5.4.4. The presence of anemia in relation to investigation parameters

Parameters		Anaemia Yes (%)	No (%)	χ^2	p value
Age groups	Children	147 (59.8)	99 (40.2)	25.26	0.000
	Adult	99 (37.5)	165 (62.5)		
Sex	Male	119 (49.6)	121 (50.4)	0.33	0.566
	Female	127 (47.0)	143 (53.0)		
ELISA	Seropositive	152 (46.8)	173 (65.5)	0.77	0.380
	Seronegative	94 (50.8)	91 (49.2)		
Blood films	No infection	155 (45.2)	188 (54.8)	10.31	0.006
	Past infection	69 (50.0)	69 (50.0)		
	Current infection	22 (75.9)	7 (24.1)		
Spleen	Enlarged	40 (66.7)	20 (33.3)	9.25	0.002
	Not enlarged	206 (45.8)	244 (54.2)		
Liver	Enlarged	29 (72.5)	11 (27.5)	10.24	0.001
	Not enlarged	217 (46.2)	253 (53.8)		
Location	Lawar	25 (26.6)	69 (73.4)	22.86	0.000
	Janggut	69 (50.0)	69 (50.0)		
	Bedil	107 (56.0)	84 (44.0)		
	Rual	45 (51.7)	42 (48.3)		

SECTION 5.5 ENTOMOLOGY SURVEY

5.5.1 Introduction

The vector survey was conducted in all study areas every fortnight. The objectives of the survey were:

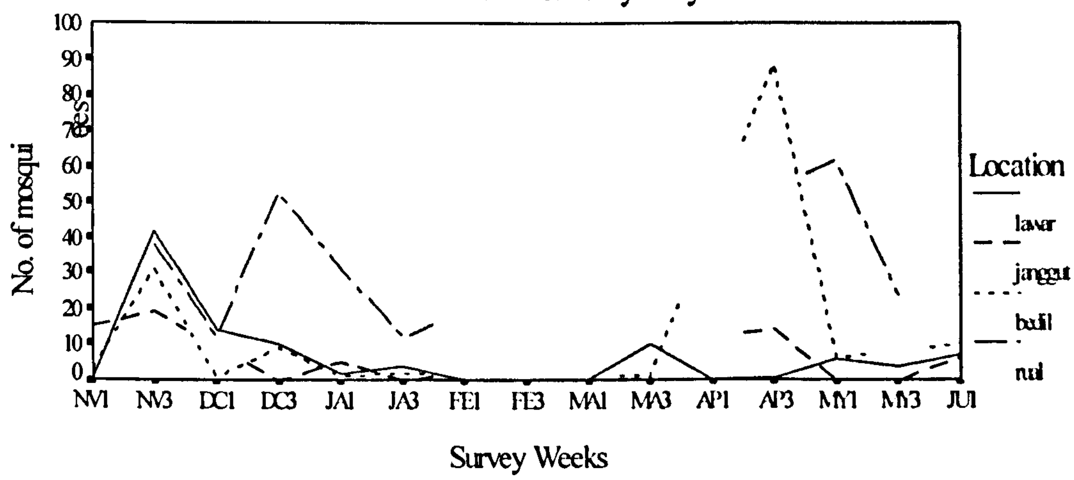
1. to investigate the abundance of vectors (*An. maculatus*) in study locations
2. to obtain information on the behaviour of the vectors with respect to biting habits
3. to investigate the type of breeding places preferred by the vector and
4. to document the presence of other species of anophelines in study locations.

The information gathered from this survey was vital in the planning of the malaria control strategy. There was no previously documented information on *An. maculatus* from the study locations.

5.5.2 *An. maculatus* vectors

Thirty-eight surveys were conducted involving all study location beginning the first week of November 1994 and ending June 1995. There were breaks in February and March due to the Ramadhan month and Eid Festival, two of the most sacred months in Islamic calendar. The number of surveys varied in each location due to unavoidable circumstances. Twelve surveys were conducted in Lawar, eight in Janggut, 10 in Bedil and seven in Rual. These surveys were equivalent to 152 man-nights or 1520 man-hour catch. A total of 545 *An. maculatus* were caught in 33 of the 38 surveys. *An. maculatus* were present in all four study locations. The mosquitoes were caught in every survey in Bedil and Rual. No *An. maculatus* caught in one out 10 surveys in Lawar and in four out of eight surveys in Janggut. The highest mean *An. maculatus* per survey was caught in Rual, followed by Bedil, Lawar and Janggut. The highest number of *An. maculatus* (89 mosquitoes) in one survey-night was collected in Bedil in the third week of April 1995 (Fig.5.5.1).

Fig 5.5.1 An. maculatus caught per survey week from November 1994 till June 1995 by study location



No survey was conducted in FE1, FE3 and MA1

NV1, NV2........JU1 represents the week of the month-survey.

Note:

NV1 = First week of November 1994, NV3 = Third week of November 1994
DC1 = First week of December 1994, DC3 = Third week of November 1994
JA1 = First week of January 1995, JA3 = Third week of January 1995
FE1 = First week of February 1995, FE3 = Third week of February 1995
MA1 = First week of March 1995, MA3 = Third week of March 1995
AP1 = First week of April 1995, AP3 = Third week of April 1995
MY1 = First week of May 1995, MY3 = Third week of May 1995
JU1 = First week of June 1995

The four study locations showed different trends in density patterns (Fig. 5.5.1). The catch from Lawar increased dramatically in the second survey, which was the fourth week of the rainy season, but then persistently produced low numbers of catch throughout the survey after that. A similar trend was observed in Janggut. Bedil followed the same trend as Lawar and Janggut until it suddenly produced a very high catch in the 9th survey, the 3rd week of April. April is normally one of the driest months. Rual did not show any distinct trend, but compared to other locations, the number of *An. maculatus* caught in Rual was higher at most survey points.

An. maculatus was predominantly exophagic (outdoor biting) in which 448 (82.2%) of them were caught biting outdoors. The proportion of outdoor biting was higher than indoor biting in every survey conducted in all locations. The mean indoor biting in Rual was 9.9 mosquitoes, and higher than the other locations. The indoor biting-rate for Rual was 0.74/man-hour-survey compared to between 0.03 to 0.08/man-hour-survey in other locations.

The proportion of multiparous *An. maculatus* varied from 0-50% in Lawar and Janggut, 0-100% in Bedil and 33-90% in Rual. Salivary gland dissections for sporozoite was performed on all caught mosquitoes but none revealed positive for sporozoite.

5.5.3 Larva survey

Possible breeding places were searched for the presence of *Anopheles*, especially *maculatus* larvae. In the four locations, larvae were found in three eco-systems; clear water ponds, both slow and fast flowing streams and river banks. Puddles, pools and marshlands were also surveyed but none revealed any *Anopheles* larvae. The highest number was found in Bedil in which 50 larvae were caught. Thirty-seven (74%) were found in clear water ponds, six (12%) in streams and the rest in the river. Seventeen larvae were caught in Rual, seven in Janggut and three in Lawar; all from streams.

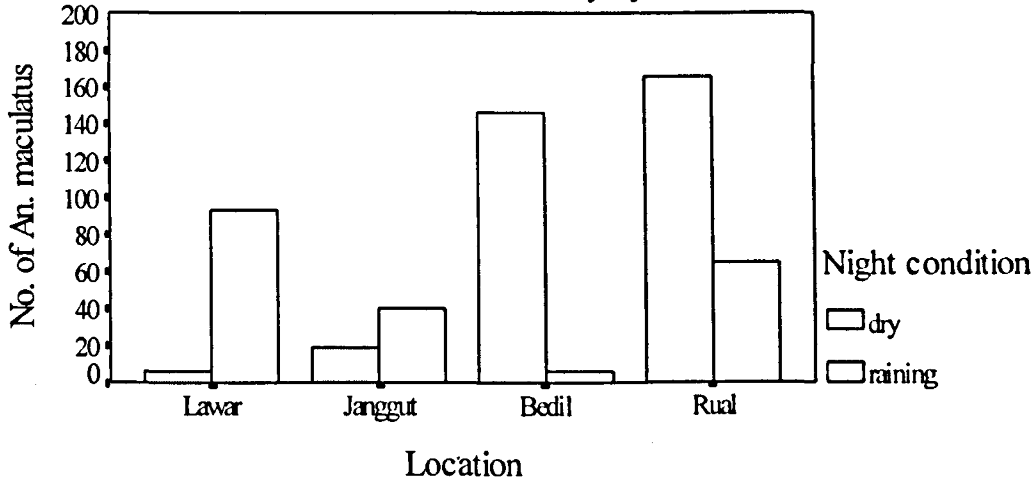
5.5.4 Other mosquitoes

Besides *An. maculatus*, other mosquitoes caught in the surveys included other anophelines, a few *Aedes*, both *aegypti* and *albopictus* and culex species such as *Culex mansonia* in Rual. Other *Anopheles* caught included 67 *An. aconitus*, two *An. philipinensis*, eight *An. barbirostris*, one *An. vagus* and two *An. kawari*. Larvae of *An. hyrcanus* and *An. vagus* were also found in the same breeding places.

5.5.5 Weather conditions during surveys

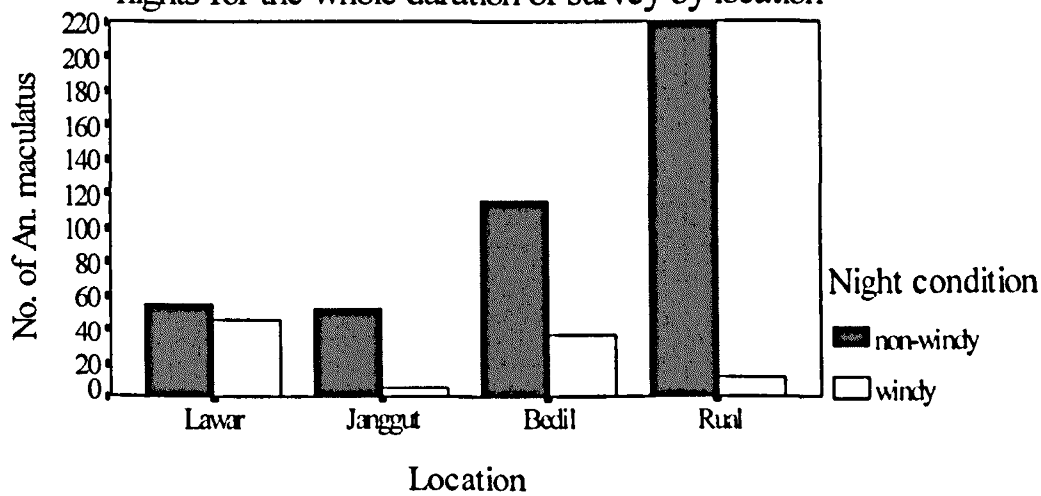
Weather conditions noted at the time of surveys included moonlight, rain and the strength of wind. All were based on subjective but experienced observations of the entomology team (ET) staff members and local villagers. With one exception, the nights were dark with 17 rainy nights. The number of *An. maculatus* caught in Lawar and Janggut was higher during the rainy nights, but the reverse was found in Bedil and Rual (Fig. 5.5.2).

Fig.5.5.2. An maculatus caught during rainy and dry nights for the whole duration of survey by location



In all locations, a greater number of *An. maculatus* were caught on non-windy than windy nights(Fig.5.5.3).

Fig.5.5.3 An. of maculatus caught in windy and non-windy nights for the whole duration of survey by location



SECTION 5.6 PERMETHRIN-IMPREGNATED BEDNETS (IBN) AND VECTOR MORTALITY STUDY

5.6.1 Introduction

IBN are being used by villagers in malarious areas as one of the protection measures against malaria vectors. In the study locations, the use of IBN is not uniform and does not cover the whole population even within a village locality. Since the first test in the Kinabatangan District of the State of Sabah (Hii *et al.* 1987), the distribution of IBN to the high risk population has mainly been political rather than being part of a well-planned malaria control strategy. In Jeli District, the same situation followed. IBN was first introduced in the district in 1991 which included Janggut (Jeli, 1991). In 1994 and 1995, IBN were distributed to the population of Rual and part of Bedil under the development project for the poor.

Since the introduction of IBN in 1991, no formal evaluation has been conducted. The first retrospective evaluation was done using the incidence and prevalence of malaria as indicators, one year before and after the usage of IBN. The results showed a marked reduction in malaria incidence in villages that used IBN compared to control villages (Abdullah *et al.* 1996).

This study was aimed to determine the effectiveness of the IBN just before the scheduled re-impregnation, or between five to six months after the last impregnation. The results would indirectly indicate whether or not the vectors have developed resistance to the chemical used for the impregnation of bednets.

5.6.2 The mortality rate of *An. maculatus*

The 'knock down' of the *An. maculatus* after being exposed to the IBN, washed IBN and control bednets was recorded every 10 minutes. In this study the time was extended to 120 minutes because in one of the studies, one *An. maculatus* was knocked down at the 110th minute. The same number of vectors, 30 wild caught *An. maculatus*, was used in all tests and controls.

The mortality rate for *An. maculatus* exposed to the IBN was 100%. The result is shown in a series of survival function graphs Fig.5.6.1. to Fig.5.6.5. The rates were based on the proportion of *An. maculatus* survived at the specified time. The proportion of the vectors affected at each knock down time varied from one test to another. In all the tests, 50% of the vectors were knocked down between 30 to 40 minutes, and all with an exception of one, were knocked down at the 60th minute. In the control group using ordinary bednets and washed IBNs, the mortality was less than 20% at any knock down time from 10 minutes onward.

Fig.5.6.1 Knock down rate of An. maculatus in Test 1, Test 2, Control 1(ordinary) and Control 1(washed IBN)

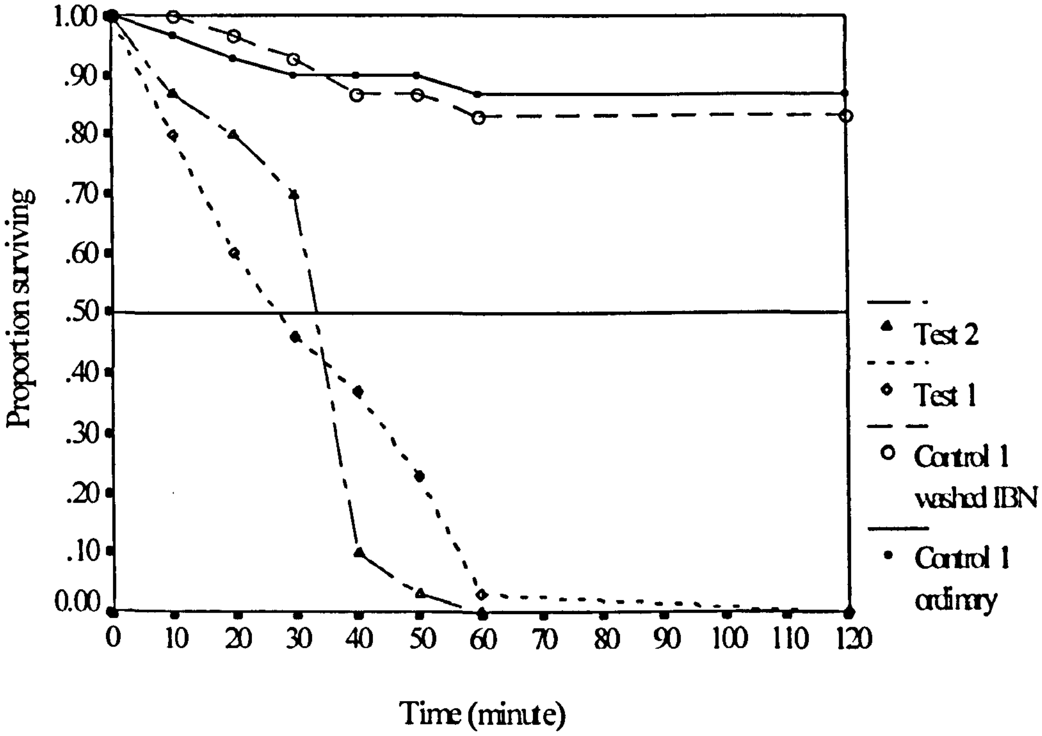


Fig.5.6.2 Knock down rate of An. maculatus in Test 3, Test 4, Control 2(ordinary) and Control 2(washed IBN)

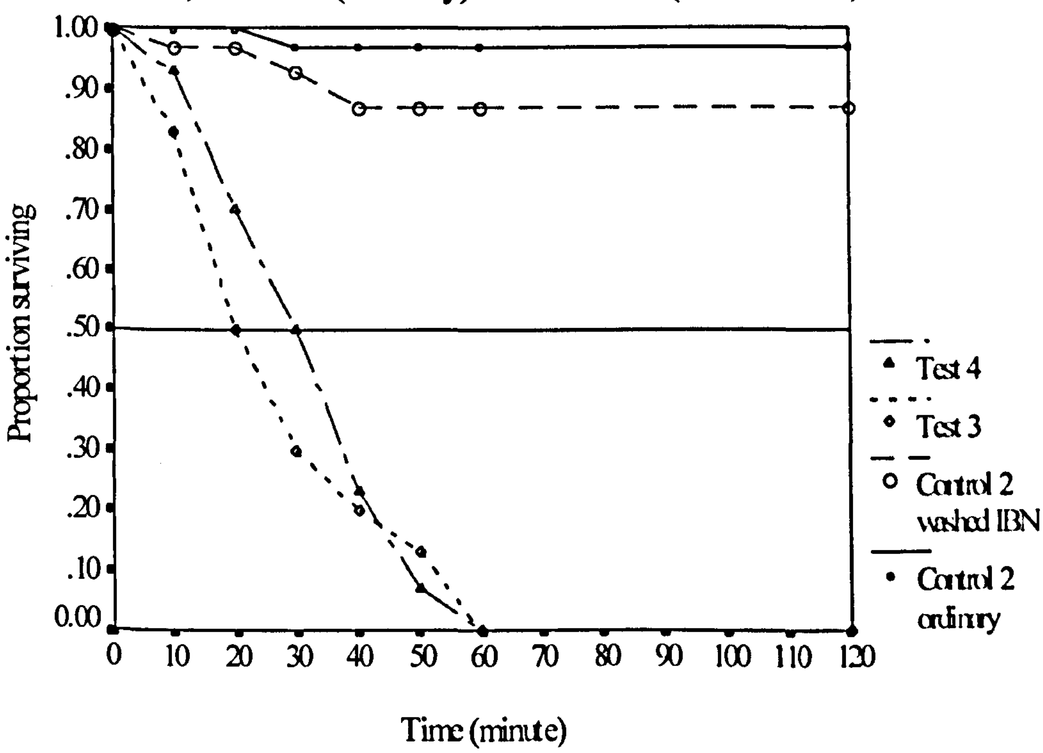


Fig.5.6.3 Knock down rate of An. maculatus in Test 5, Test 6, Control 3(ordinary) and Control 3(washed IBN)

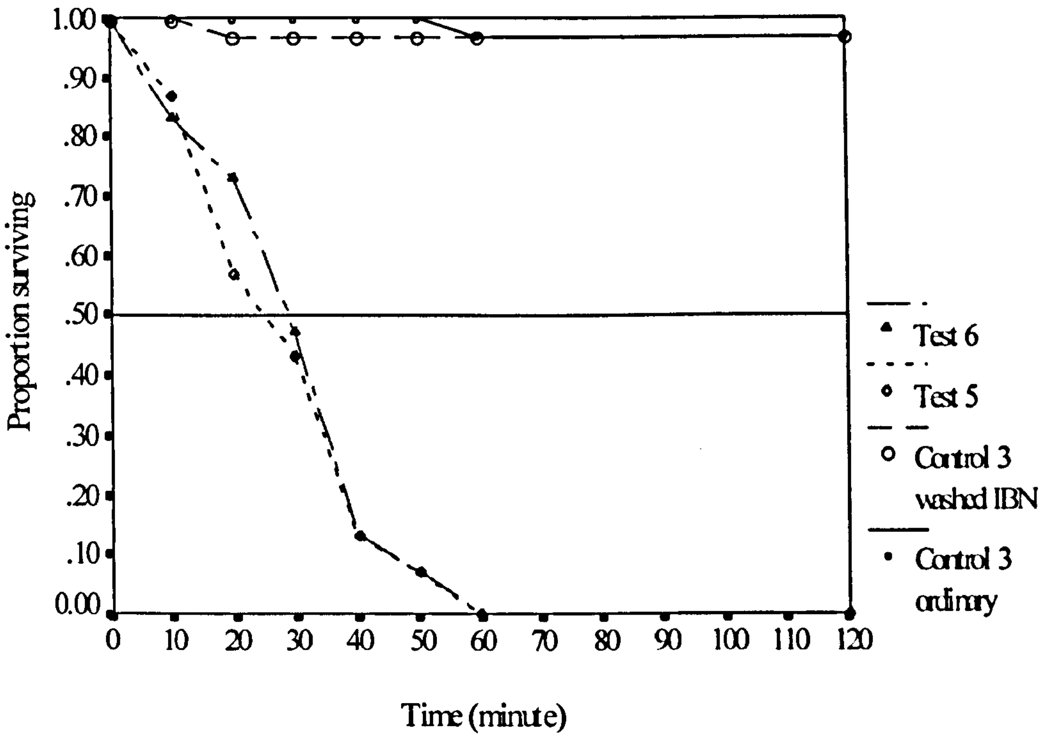


Fig.5.6.4 Knock down rate of An. maculatus in Test 7, Test 8, Control 4(ordinary) and Control 4(washed IBN)

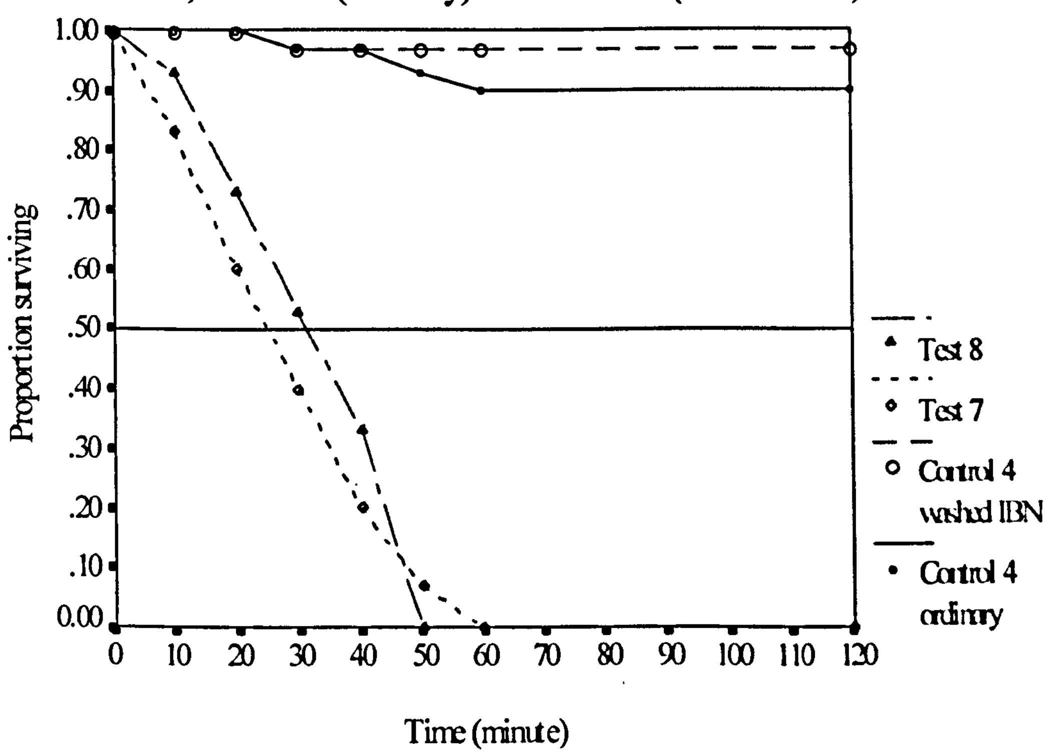
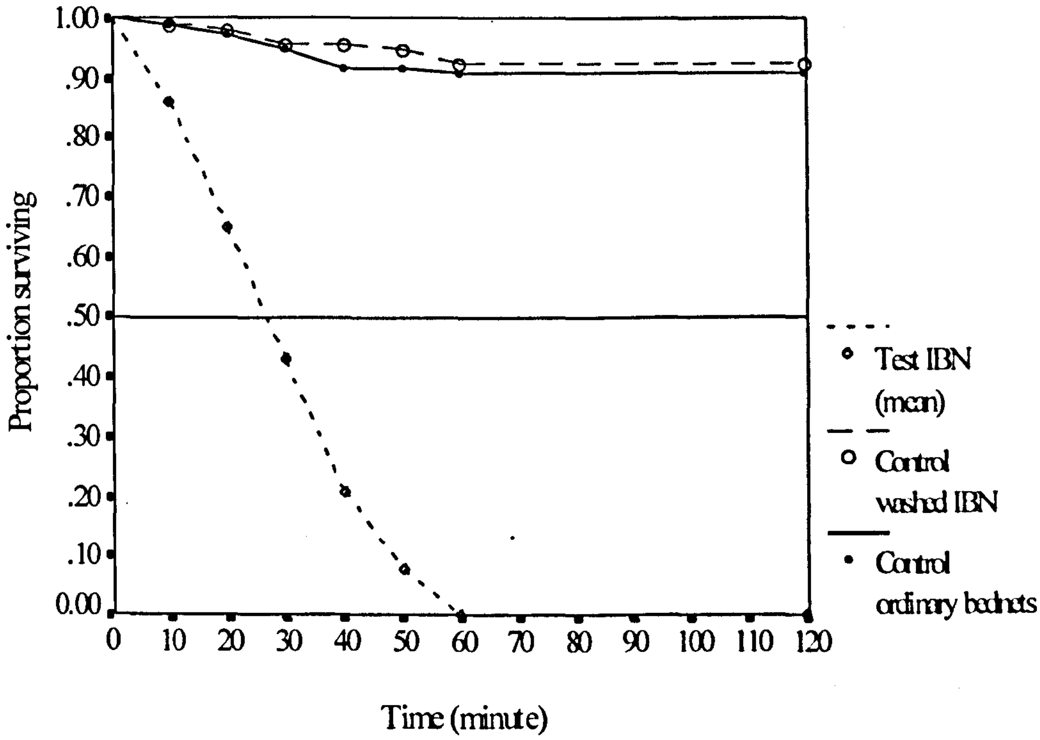


Fig.5.6.5 The mean Knock down rate of An. maculatus in Test IBN, Control with Ordinary Bednets and Control with Washed IBN



CHAPTER 6. A REVIEW ON THE MANAGEMENT OF MALARIA IN-PATIENTS

6.1 INTRODUCTION

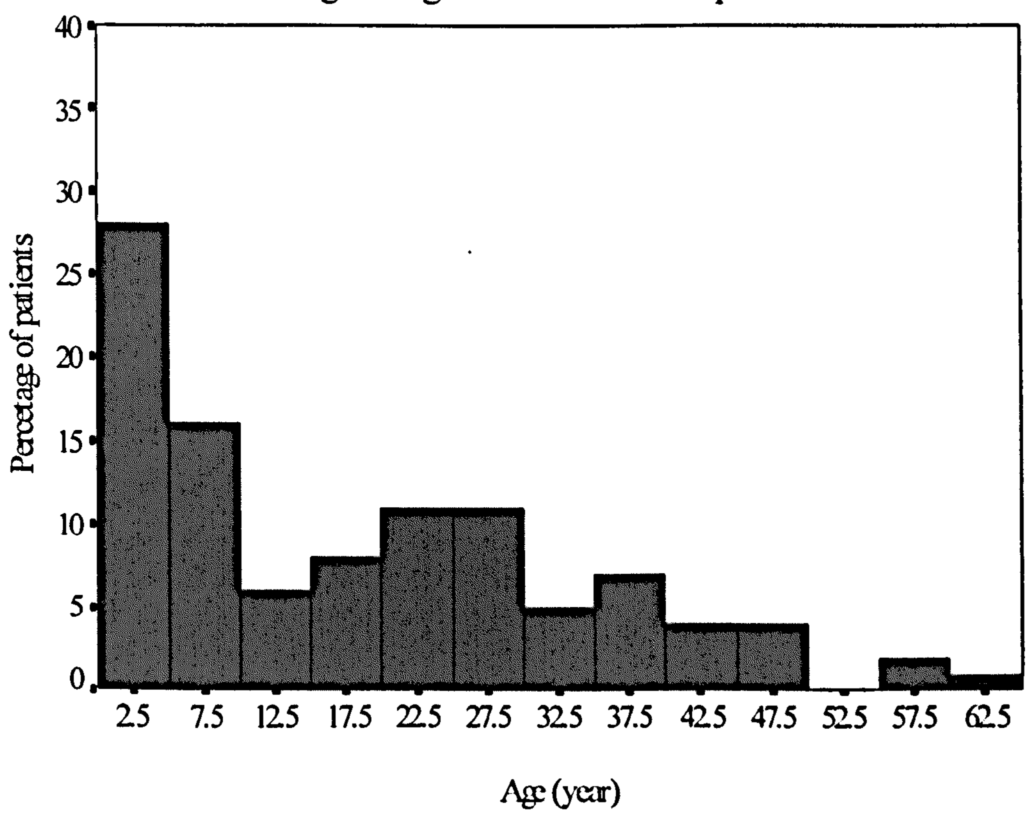
This chapter presents the results of the review of the management of hospitalised in-patients. The methods have been described in Chapter 3.9. The first part of this chapter describes all malaria admissions, and the second mainly discuss treatments for patients with falciparum malaria.

Hospitals form part of the vigilance and capabilities of the malaria control team (MCT). The notion is that hospitalised patients are better treated and well managed compared to patients treated at home. This review aims to study the characteristics of the patients admitted, their clinical features and the treatment they received. The study was conducted at Gua Musang Hospital, a 34 bedded hospital situated 50 km from the study locations. The hospital provides accident and emergencies (A&E), obstetrics, general paediatrics, general medical and basic laboratory services. There is no intensive care unit and all critically ill patients are referred to either the general or university hospital. The hospital is managed by one medical officer (MO) who is answerable to the Medical Officer of Health (MOH), who is also the director of the hospital. The A&E and outpatient units are mainly run by medical assistants with the supervision of the MO.

6.2 SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENTS

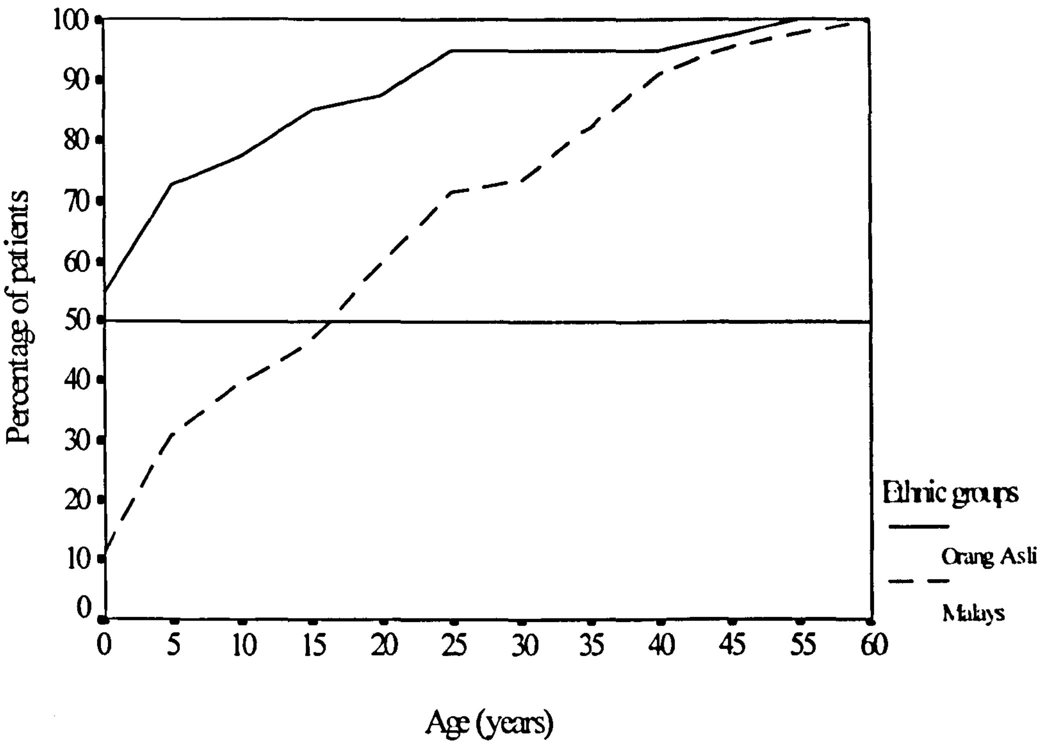
Altogether, 103 patients were admitted and treated for malaria in Gua Musang Hospital between January 1995 and June 1996. Two thirds of the patients (64.1%) were male and one third (35.9%) was female. Patients' ages varied from infancy to 60 years old (Fig.6.1). Female patients were predominantly younger than the male, of which 50% were below 9 years old compared to 20 years for the male. Children below 5 years constituted more than a quarter (27.0%) of the patients.

Fig.6.1 Age distribution of the patients



The patients were mainly from the Malay (43.7%) and Orang Asli (38.8%) ethnic groups. The rest were Chinese, Indian, Malay-Thai ethnic and foreign workers from Indonesia (8.7%) and Bangladesh (2.9%). Malay patients had an almost equal proportion of children (<15 years old) and adult but the Orang Asli patients comprised 80.0% children (Fig.6.2).

Fig.6.2 Cumulative percentage of age of the Malays and Orang Asli patients



Only 41 (39.8%) of the 103 patients were employed, the rest were housewives (7.8%) and children (52.4%). Among those who worked, 4.9% were government employees, 17.1% farmers, 17.1% loggers and 61.0% odd job workers.

Monthly admissions varied from month to month with no distinctive trend . Fifty-nine (57.3%) patients were admitted through the hospital's outpatient clinics or A&E unit after the patients presented themselves for treatment. The rest were referred by health centres (37.9%), the MCT (1.9%), private general practitioners (1.9%) and the Orang Asli Department (1.0%).

6.3 CLINICAL PRESENTATIONS

Most of the patients had other concurrent ailments, of which the most common was respiratory infections. Other symptoms are as shown in Table 6.2.

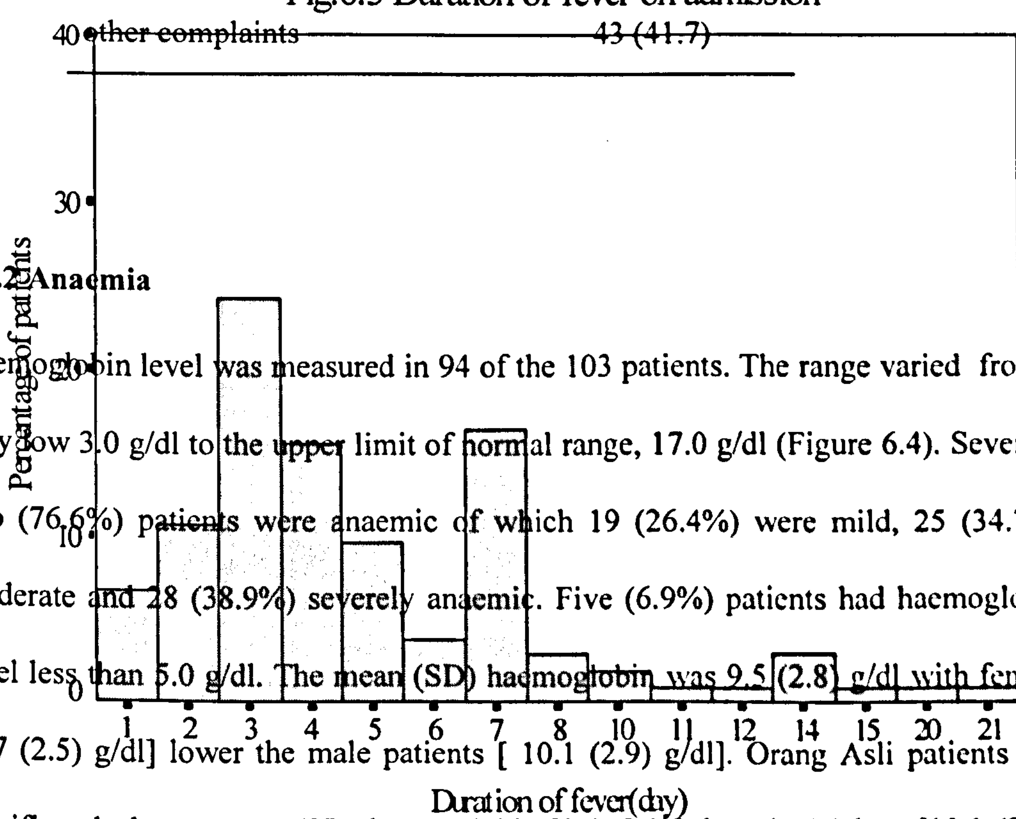
6.3.1 Presenting signs and symptoms on admission

Table 6.2 Presenting signs and symptoms on admission

Symptoms	present (%)
Cough	75 (72.8)
Rigor	58 (56.3)
Headache	28 (27.2)
Vomiting	31 (30.1)
Nausea	4 (3.9)
Diarrhoea	12 (11.7)
Abdominal pain	8 (7.8)
Loss of appetite	31 (30.1)
profuse sweating	5 (4.9)
other complaints	43 (41.7)

All patients complained of fever ranging from 1 to 21 days on admission (Fig. 6.3). The mean (SD) fever days at the time of admission was 5.1 (3.7) days. The one patient who presented after 21 days of fever was critically ill on admission and died several days later of cerebral malaria, although he was immediately referred to the University Hospital. Ninety-nine (96.1%) patients complained of continuous fever and 4 (3.9%) had alternate day fever. The four patients with alternate day fever had vivax malaria.

Fig.6.3 Duration of fever on admission

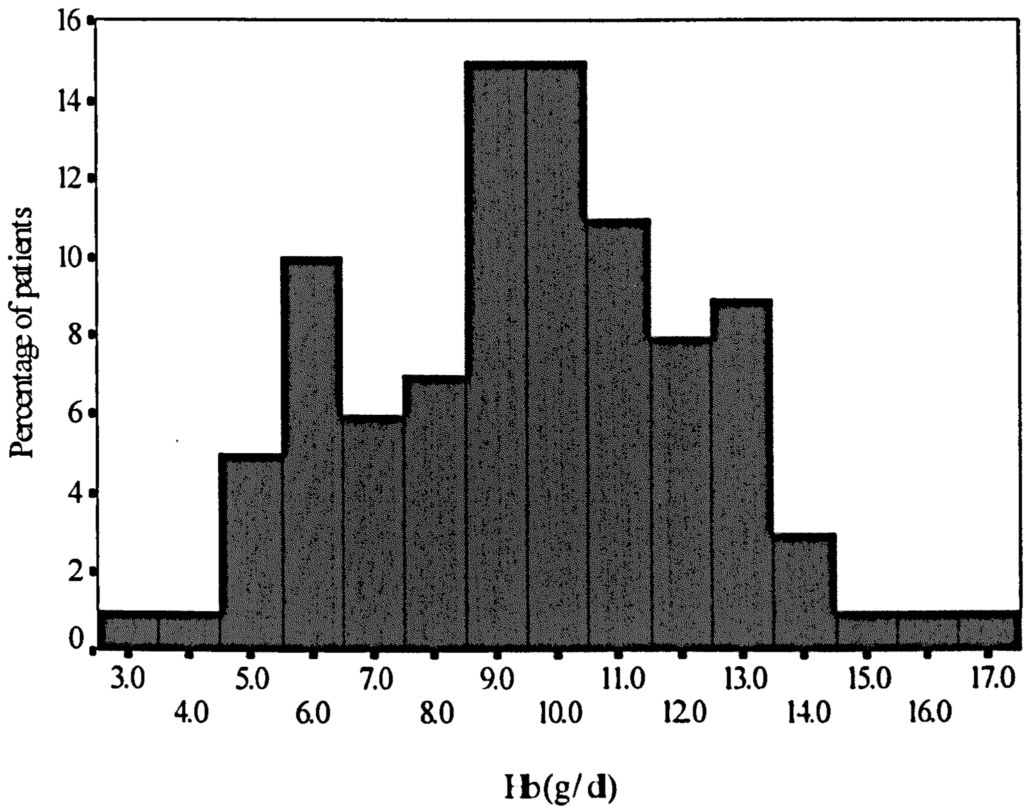


6.3.2 Anaemia

Haemoglobin level was measured in 94 of the 103 patients. The range varied from a very low 3.0 g/dl to the upper limit of normal range, 17.0 g/dl (Figure 6.4). Seventy-two (76.6%) patients were anaemic of which 19 (26.4%) were mild, 25 (34.7%) moderate and 28 (38.9%) severely anaemic. Five (6.9%) patients had haemoglobin level less than 5.0 g/dl. The mean (SD) haemoglobin was 9.5 (2.8) g/dl with female [8.7 (2.5) g/dl] lower the male patients [10.1 (2.9) g/dl]. Orang Asli patients had significantly lower mean (SD) haemoglobin [8.4 (2.9)] than the Malays [10.1 (2.3)] ($t=-2.69$; 78 df; $p < 0.01$).

Patients with severe anaemia included one Bangladeshi and one Chinese. These patients were investigated to exclude other causes of anaemia such as blood dyscrasias, worm infestation, malnutrition, etc. Differences in the mean of haemoglobin in patients infected by different species of malaria and different level of parasite densities were not significant.

Fig.6.4 Distributions of Hb level of the patients



6.3.3 Hepatosplenomegaly

Liver and spleen rate were higher in children than in adults (Table 6.3). Of the 16 patients with palpable liver, eight (50.0%) were Orang Asli, five (31.3%) Malays, one Indonesian and one Indian. There was no significant difference in the liver rate between the Orang Asli and Malay patients.

Table 6.3 Liver and/ or spleen rate of the patients

	Yes (%)	**Rate (%) in children (<15 years old)**	**Rate (%) in adult (≥ 15 years old)**
Hepatomegaly	16 (15.5)	22.0	9.4
Splenomegaly	20 (19.4)	30.0	7.5
Hepatosplenomegaly	8 (7.8)	100	0

Sixty-five per cent of the patients with enlarged spleen were Orang Asli, and the rest Malays. Hepatosplenomegaly was detected only in children < 10 years with 62.5% from the children aged 0-5 years.

6.3.4 Length of stay in hospital and criteria for discharge

Hospitalisation varied from one to 23 days (mean stay = 4.7 (2.7) days). The mean (SD) hospital stay for the Malays was 4.6 (1.8) days and for the Orang Asli 4.7 (3.5) days. Patients who had falciparum malaria stayed longer in the ward on average compared to vivax (5.5 days and 3.6 days respectively). The length of stay was not associated with age or other medical problems.

Forty-six (44.7%) patients were discharged after three consecutive negative slides. The rest were discharged after one or two negative blood films. Eleven (10.7%) patients were discharged while still febrile. A follow-up date was fixed only for patients with complications such as severe anaemia. Otherwise, patients' monthly follow-up would be done by the MCT staff.

6.4 TYPE OF INFECTION

P. falciparum (50.5%) and *P. vivax* (33.0%) were the two infections detected with *P. falciparum:vivax* ratio 1.5:1.0. All mixed infections were between *P. falciparum* and *P. vivax*. Eight (7.8%) patients presented with signs and symptoms of malaria but blood film examinations were negative. They responded well to anti-malaria chemotherapy.

Parasite density from blood film examination was reported using the plus system where 1+ means the presence of ≤10 parasites in 100 field, 2+ means the presence of between 10 - 100 parasites in 100 field, 3+ means the presence of ≤10 parasites in one field and 4+ (severe malaria) the presence of >10 parasites in one field. In this study there were eight (7.8%) patients with 4+ parasites in their blood of which seven were *P. falciparum* (Table 6.4). Gametocytes were present in five patients.

Table 6.4 Parasite density (plus system) according to the species of infection

Parasite density	*P. falciparum* (%)	*P. vivax* (%)	Mixed infection (%)	Blood film negative (%)	Total
0	-	-	-	8 (100)	8 (7.8)
1	17 (32.7)	17 (50.0)	4 (44.4)	-	38 (36.9)
2	19 (36.5)	10 (29.4)	2 (22.2)	-	31(30.1
3	9 (17.3)	6 (17.6)	3 (33.3)	-	18 (17.5)
4	7 (13.5)	1 (2.9)	-	-	8 (7.8)
Total	52 (50.5)	34 (33.0)	9 (8.7)	8 (7.8)	103

6.5 CHEMOTHERAPY

6.5.1 All infections

Four drugs were used in the treatments, depending on the species of the parasite (Table 7.7). Syrup quinine was used for infant patients. In some patients, a bolus (slow i.v.) dose of quinine was used on top of the other regimes. Seventy-five (72.8%) patients were given chloroquine in combination with other drugs. Twenty-seven(26.2%) were given quinine either alone or in combination with other drugs.

Chloroquine was given to 31 (59.6%) patients with falciparum malaria, three (37.5%) out of eight patients with negative blood films, all patients with vivax malaria and seven (77.8%) of nine patients with mixed infection. Quinine was used in 22 (42.3%) patients with falciparum malaria, one patient with negative blood films and four patients with mixed infection. Two patients with falciparum malaria and 2 patients with mixed infection had both quinine and chloroquine. There was also one case of falciparum malaria that was treated with primaquine alone and discharged after three consecutive negative blood films.

Table 6.5 Drugs used in patients' treatment

Type of drugs	No. of patients treated (%)
Chloroquine	75 (72.8)
Quinine	27 (26.2)
Fansidar	41 (39.8)
Primaquine	93 (90.3)

6.6.2 *P. falciparum* malaria patients

Treatment for infant patients was within the guidelines given by the MOH, except for the prolonged use of primaquine; 14 days in two patients and five days in one patient. In patients age 1- 4 years, one (14.3%) patient received half of the recommended dose of chloroquine. Another four patients in this age group were given 14 days of primaquine therapy.

One (14.3%) patient in the age group 5 - 9 years old received half of the recommended dose for chloroquine while three (42.9%) patients were given lower doses of primaquine. As in the previous age group, four patients were prescribed 14 days of primaquine.

The 10-14 year old group received a variety of inappropriate treatments that included one (20.0%) overdosage and one underdosage of chloroquine, one overdosage and two (40.0%) underdosage of primaquine and another three with 14 days primaquine treatment.

There were 28 adults out of 52 falciparum malaria patients. Out of this, six (21.4%) received lower doses of chloroquine, two received higher doses of chloroquine and 19 (67.9%) patients were prescribed lower doses of fansidar. Fourteen days primaquine treatment was given to 19 patients in this age group. One patient was given only primaquine for 14 days.

CHAPTER 7. FACTORS ASSOCIATED WITH MALARIA

7.1 INTRODUCTION

Factors described in the study framework have been studied in order to understand the malaria situation in the study locations. However, conclusions also need to be drawn about the risks of malaria for individuals. Information on socio-economic, behavioural and environmental factors were available for 510 consenting respondents as for the serological and physical examination surveys. This chapter describes analyses conducted on these respondents in order to assess the association of the variables with malaria status. The aim was to use the results to inform decisions about malaria control strategies.

Malaria status was defined in two ways: 'current malaria' and 'current and past malaria'. 'Current malaria' was defined as respondents who were slide positive at the time of the survey. 'Current and past malaria' was defined as respondents with current malaria, previous malaria or a combination of current and previous malaria. Previous malaria was defined as respondents who had had proven malaria infections for the time they were living at the current address. The full definition for previous malaria is given in Chapter 3.

The number of respondents with 'current malaria' and 'current and past malaria' in each location is shown in Table 7.1. The analysis of these variables for the odds for 'current malaria' was carried out only for Bedil and Rual since current cases were only detected from these two locations. For 'current and past malaria', the analysis was performed for all four locations .

Table 7.1 Number of respondents by malaria status according to location

Location	Current malaria(%)	Current and past malaria(%)	n
Lawar	0 (0)	23 (24.5)	94
Janggut	0 (0)	23 (16.7)	138
Bedil	17 (8.9)	57 (29.8)	191
Rual	12 (13.8)	65 (74.7)	87
Total	29	168	510

Separate analyses were carried out for each study location for three reasons. Firstly, separate analysis could highlight the relative importance of a range of factors pertinent to each location, and as such might explain the differences in the level of malaria in the study locations. Secondly, the clear cut differences between the four locations which have been described in Chapter 4 and 5 could have confused the interpretations of the model, should all the locations be grouped and treated as a whole. Lastly, selection of the study villages did not produce a balance of population which was representative of the district.

Explanatory variables were grouped into four categories; socio-economic, behavioural, environmental and physical and laboratory results.

7.2 UNIVARIATE ANALYSIS

Univariate analysis was performed on selected variables to estimate the odds for 'current malaria' and for 'current and past malaria'. The results are shown in Table 7.2a, 7.2b. 7.3a and 7.3b.

7.2.1 Socio-economic factors

Several socio-economic variables were associated with malaria status. Age showed a protective effect, the higher the age, the less the odds for 'current malaria' in both Bedil and Rual. The Malay-Thai ethnic group was found to have 5.6 times higher odds of having current malaria infection than the Malays. Ethnicity was not an important variable in the analysis of 'past and current malaria'. Income, number of rooms, and the location of latrine and domestic water tap were part of economic indicators. These factors showed a protective effect, and were consistent against each other and against the malaria status. There were differences in the risk groups for 'current malaria' and 'current and past malaria' in terms of occupation. For 'current malaria', being a student in Bedil and not working in Rual had significantly higher odds. The odds for place of work did not significantly differ from each other. For 'current and past malaria', rubber tappers in Janggut had high risks, reflecting the risk of settlers in land scheme villages because they were originally all rubber tappers, and the majority still are.

7.2.2 Behaviour factors

In the behaviour factors category, only the use of personal protection during sleep was significant. It was found to provide protective effects in Bedil both for 'current malaria' and 'current and past malaria'. The odds increased by four times in 'current and past malaria' analysis for using bednets and might be due to the increased usage after being infected rather than negative effect of bednets. There might also be a complex interaction between bednet users and users of other personal protection method as the second was mutually exclusive to the first as discussed in Chapter 5.1.

7.2.3 Environmental factors

The odds for 'current malaria' and 'current and past malaria' decreased as the distance of houses and rivers or streams increased. The effect was consistent for both, Bedil and Rual. For 'current and past malaria', the same effect was detected with the dam and highway.

7.2.4 Physical and laboratory investigations

Liver and spleen enlargement were significantly associated with 'current malaria' in Bedil but not in Rual. For 'current and past malaria', only spleen enlargement produced higher odds, to a lesser extent than it had for 'current malaria'. Anaemia was associated with both 'current malaria' and 'current and past malaria'. The odds for the person being currently infected and or having had past malaria infection reduced as the level of haemoglobin increased. The result was reversed for Rual for 'current and past malaria' where the odds increased as the haemoglobin level increased. Positive ELISA (defined as medium positive or high positive) produced odds of being currently infected up to 21 times high in Bedil but was not significant in Rual. However, for 'current and past malaria', the odds were between 8-16 times higher than for people with ELISA negative (in this analysis defined as low positive or negative).

Table 7.2a Univariate analysis of 'current malaria' against the variables identified from the study locations: socio-economic variables

Var. No.	Variable name	Bedil (n=191) % Category[1] mean(SD)[2]	Bedil (n=191) Odds ratio	Rual (n=87) % Category mean(SD)	Rual (n=87) Odds ratio
	Socio-economic factors				
	Personal and social variables				
1	Age	20.1(16.90)	0.89 ***	12.9(12.13)	0.79***
2	Sex: Male	46.6	3.02	52.9	5.42*
	Ethnicity				
3a	Malay	91.1	1.00	0	N/A
3b	Malay-Thai	8.9	5.63**	0	N/A
3c	Orang Asli	-	N/A	100.0	1.00
4	Income	400 (197)	1.00***	212 (74)	0.99***
5	Duration of stay ≤ 5 years	10.0	6.76 **	10.3	0
6	Family size	6.9(1.7)	0.69***	4.4(1.6)	0.66***
7	No. of rooms in house	1.8(0.77)	0.22***	0.9(0.23)	0.17***
8	Latrine inside the house	47.6	0.13***	0	N/A
9	Water tap inside the house	53.4	0.10***	0	N/A
	Occupation[3]				
10a	Not working	31.4	0	48.3	6.72 *
10b	Student	25.9	3.77 *	13.8	1.30
10c	Rubber tapper	28.8	1.39	10.3	0
10d	Other	39.9	0	27.6	0
	Place of work				
11a	Village	66.5	0.92	66.7	N/A
11b	Deep jungle	2.6	0	33.3	N/A
11c	Forest fringe	30.9	1.25	100.0	N/A

1. The percentage category is for categorical variables.

2. The mean (SD) is for continuous variables.

3. Each type of occupation was analysed independently against all the others without a reference category because of the presence of zero cases.

NB: For binomial variables, the odds ratio is given for the category shown against the other category.

* indicates levels of statistical significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7.2b. Univariate analysis of 'current malaria' against the variables identified from the study locations: behavioural, environmental and physical and laboratory investigation.

Var No.	Variable name	Bedil (n=191) % category[1] mean (SD)[2]	Bedil (n=191) Odds ratio	Rual (n=87) % category mean(SD)	Rual (n=87) Odds ratio
	Behavioural factors				
12	Other anti-mosquito measure while sleeping	49.7	0.12**	6.9	0.00
13	Anti-mosquito measure before sleep	10.5	1.16	5.7	0.00
14	Sleep before 2200 hours	28.3	0.76	56.3	0.50
15	Rising before 0600 hours	59.2	0.76	1.1	0.00
16	Uses bednets				
16a	Does not use bednet	28.8	0	25.3	1.00
16a	Used Ordinary bednet	49.2	0.11	0	N/A
16b	Used impregnated bednet	22.0	1.54	74.7	1.02
	Environmental factors				
17	Distance of house from river	163.7(173.08)	0.99***	38.1(50.46)	0.92 ***
18	Distance of house from dam	N/A	N/A	N/A	N/A
19	Distance of house from highway	N/A	N/A	N/A	N/A
	Physical and laboratory investigations				
20	Enlarged liver	6.3	15.27 ***	17.2	2.91
21	Enlarged spleen	7.3	16.70 ***	48.3	1.60
22	Haemoglobin	11.8(2.20)	0.81***	11.9(1.95)	0.85***
23	ELISA positive (medium and high positive)	47.6	21.12 ***	75.9	4.00

1. The percentage category is for categorical variables.

2. The mean (SD) is for continuous variables.

NB: For binomial variables, the odds ratio is given for the category shown against the other category.

* indicates levels of statistical significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Tables 7.3a Univariate analysis of 'current and past malaria' against the variables identified from the study locations: socio-economic variables

Var. No	Variable name	Lawar (n = 94)		Janggut (n = 138)		Bedil (n = 191)		Rual (n = 87)		Combine (n = 423)	
		% Category mean (SD)	Odds ratio	% Category mean (SD)	Odds ratio	% Category mean (SD)	Odds ratio	% Category mean (SD)	Odds ratio	%Category mean(SD)	Odds ratio
	Socio-economic factors										
	Personal and social factors										
1	Age	-	-	-	-	-	-	-	-	-	-
2	Sex: Male	36.2	0.19 *	51.4	1.58	46.6	2.62 **	52.9	1.04	45.9	1.35
3a	Ethnic: Malay	100.0	N/A	93.5	1.00	91.1	1.00	0	N/A	93.9	1.00
3b	Malay-Thai	0	N/A	6.5	0.00	8.9	5.10 **	0	N/A	6.1	2.43 *
3c	Orang Asli	0	N/A	0	N/A	0	N/A	100.0	N/A	0	N/A
4	Income	750.0(377.1)	1.00 ***	453.3(254.4)	0.997***	400.3(197.1)	1.00***	212.8(74.0)	1.00***	495.3(298.24)	1.00***
5	Duration of stay ≤5 years	3.2	0.00	16.7	1.50	10.0	2.96 *	10.3	3.50	10.6	1.65
6	Family size	5.5(2.42)	0.86***	5.0(2.09)	0.80***	6.9(1.70)	0.87***	4.4(1.61)	1.21***	6.0(2.18)	0.84***
7	No. of rooms in house	2.4(0.97)	0.71***	1.3(0.58)	0.35 ***	1.8(0.77)	0.60***	0.9(0.23)	3.10 ***	1.8(0.87)	0.59***
8	Latrine inside the house	28.4	2.28	21.0	1.41	47.6	0.53	-	N/A	44.2	1.02
9	Water tap inside the house	28.6	0.40 ***	57.2	1.49	53.4	0.47 *	-	N/A	61.0	0.86
	Occupation										
10a	Not working	29.8	1.04	23.2	0.44	31.4	0.62	48.3	2.76	28.4	0.71
10b	Student	30.9	2.11	29.0	0.32	25.9	1.05	13.8	0.29	27.9	0.95
10c	Rubber tapper	14.9	0.82	37.0	0.22 ***	28.8	1.72	10.3	0.40	28.4	1.90 **
10d	Other	24.4	0.39	11.8	0.33	2.1	0.80	23.0	1.11	15. 4	0.59
	Place of work										
11a	Village	74.5	1.86	60.9	0.22 **	66.5	0.65	66.7	1.82	66.4	0.63
11b	Deep jungle	6.4	0.60	0.7	0.00	2.6	0.58	33.3	0.55	2.8	0.61
11c	Forest fringe	19.1	0.56	38.4	4.82 **	30.9	1.65	-	N/A	30.7	1.72 *

For definitions, classifications and interpretations of the variables, see footnotes for Table 7.2.

Tables 7.3b Univariate analysis of 'current and past malaria' against the variables identified from the study locations: behavioural, environmental and physical and laboratory investigation variables.

Var. No	Variable name	Lawar (n = 94)		Janggut (n = 138)		Bedil (n = 191)		Rual (n = 87)		Combine (n = 423)	
		% Category / mean (SD)	OR	% Category / mean (SD)	OR	% Category / mean (SD)	OR	% Category /mean (SD)	OR	%Category /mean(SD)	OR
	Behavioural factors										
12	Other anti-mosquito measure while sleeping	63.8	2.49	22.5	1.66	49.7	0.27 ***	6.9	0.33	44.0	0.80
13	Anti-mosquito measure before sleep	29.8	1.76	20.3	1.49	10.5	0.38	5.7	0.52	18.0	0.96
14	Sleep before 2200 hours	23.4	0.00	31.9	0.54	28.3	0.58	56.3	0.99	28.4	0.42 **
15	Rising before 0600 hours	71.3	0.90	76.1	0.87	59.2	1.76	1.1	all case	67.4	1.17
16	Uses Bednets										
16a	Does not use bednets	29.8	1.00	18.8	1.00	28.8	1.00	25.3	1.00	25.8	1.00
16b	Use ordinary bednets	70.2	0.57	81.2	0.80	71.2	3.99 **	74.7	0.36	74.2	1.48
16c	Use impregnated bednets	-	N/A	-	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Environmental factors										
17	Distance of house from river	272.6 (250.73	1.00***	128.5 (121.36)	0.99 ***	163.3 (173.08)	1.00 **	38.1 (50.46)	1.02 **	176.4 (189.10)	1.00***
18	Distance of house from dam	1.68 (0.57)	0.62***	25.6 (0.36)	0.94***	-	N/A	-	N/A	20.5 (9.97)	0.95***
19	Distance of house from highway	3.0 (0.31)	0.69***	6.1 (4.03)	0.74***	-	N/A	-	N/A	2.7(3.54)	0.72***
	Physical and laboratory investigations										
20	Enlarged liver	5.3	0.76	5.8	0.00	6.3	5.31 *	17.2	0.99	5.9	1.82
21	Enlarged spleen	1.1	0.00	2.2	2.57	7.3	6.91 **	48.3	2.13	4.3	5.35 ***
22	Hb	12.9 (1.95)	0.92 ***	11.9 (2.20)	0.88 ***	11.8 (2.20)	0.93***	11.9 (1.95)	1.08***	12.1 (2.11)	0.91***
23	ELISA positive	52.1	16.13 ***	33.3	8.40 ***	47.6	16.20 ***	75.9	9.10 ***	44.0	13.29 ***

For definitions, classifications and interpretations of the variables, see footnotes for Table 7.2.

7.3 MULTIVARIATE ANALYSIS

7.3.1 Multiple logistic regression analysis

In the univariate analysis, the selected factors were analysed independently of each other for the odds of having the defined malaria status ('current malaria' and 'current and past malaria'). Several variables were found to have significant association with malaria status. Because the aim of the analysis was to look for factors that could explain the malaria situation in study locations, the association of those factors with malaria status for individuals needs to be investigated, taking into account the possibility of the effect of other factors. Multivariate analyses were performed with the same factors in all four study locations using the multiple logistic regression technique. The technique was chosen because of the binomial nature of the dependent variables.

Multivariate analysis of the dependent variable 'current malaria' was performed only for Bedil and Rual as for the univariate analysis. Results are shown in Table 7.4. For 'current and past malaria', the analysis was performed for all four study locations and the results are shown in Table 7.5.

Two models were explored for each study location, and for each dependent variable. The explorations were based on the level of information included in the analysis. Model 1 used information collected only from questionnaire surveys and interviews with the respondents. For Model 2, results of physical and laboratory investigations were added to the variables in Model 1. The parameter estimates for the models are given in Table 7.4 and 7.5. The interpretation of Model 1 for 'current malaria' in Bedil, for example, is as follows:

The probability of a person having 'current malaria' is related to the person possessing the characteristics selected, and is calculated as:

ln odds of having 'current malaria' = 0.9406 + 4.4182 (if student)

+ 3.5700 (if rubber tapper)

+ 1.9872 (if duration of stay $\leq$ 5 years)

+ 0.0064 (x income in RM)

- 1.0591 (x family size)

- 2.5736 (water tap is inside the house)

where ln = logarithm (base e).

For example, if a person is a rubber tapper, stayed less than 5 years, has an income of RM500.00, lives with 5 other family members and the water tap is outside the house, his odds of having current malaria will be:

ln odds = 0.9406 + 3.5700 + 1.9872 + (0.0064 x 500) - (1.0591 x 6) - (2.5736 x 0)

= 3.3432

The odds for that person of having 'current malaria' = antilog (3.3432) = 28.3

Table 7.4 Multiple logistic regression models for the odds of having 'current malaria' against the variables identified from the study locations

Var. No.	Variable name	Bedil (n=191) Model 1	Bedil (n=191) Model 2	Rual (n=87) Model 1	Rual (n=87) Model 2
0	Constant	0.9406	-7.3768	-0.6732	-0.6732
1	Age			-0.1503	-0.1503
2	Sex: Male		1.4543		
4	Income	0.0064			
7	Duration of stay ≤ 5 years	1.9872	3.6693		
8	Family size	-1.0591			
14	No. of rooms in house				
16	Water tap inside house	-2.5736	-4.1768		
10a	Not working				
10b	Student	4.4182	3.8639		
10c	Rubber tapper	3.5700			
11c	Work place: forest fringe		2.7532		
9	Anti-mosquito measure while sleep		-3.5637		
10	Anti-mosquito measure before sleep				
11	Sleep before 2200 hours				
13	Use bednets				
18	Distance of house from river				
19	Distance of house from dam				
20	Distance of house from highway				
24	Enlarged spleen		3.6089		
24	ELISA		3.9041		
	Initial -2 LL	114.69	114.69	69.81	69.81
	Model -2 LL	46.07	40.84	59.08	59.08
	Model χ^2 (d.f)	68.62 (6)	73.85(7)	10.73 (1)	10.73(1)
	Correct classification (%)	94.24	95.29	86.21	86.21

Table 7.5 Multiple logistic regression of the odds for 'current and past malaria' against the variables identified from the study location

Var. No	Variable Name	Lawar (n=94) Model 1	Lawar (n=94) Model 2	Janggut (n=138) Model 1	Janggut (n=138) Model 2	Bedil (n=191) Model 1	Bedil (n=191) Model 2	Rual (n=87) Model 1	Rual (n=87) Model 2	Combine (n=423) Model 1	Combine (n=423) Model 2
0	Constant	0.4015	-2.8600	-5.1016	-3.1580	-4.1563	-3.5187	0.5947	-1.6068	-0.8323	-2.8627
1	Age										
2b	Male	-1.6835	-1.4297			1.5987	1.4543				
3b	Ethnic Malay-Thai										1.1771
4	Income			0.0025		0.0047	0.0042				
5	Duration of stay ≤ 5 years					1.3597					
6	Family size										
7	Rooms in house			0.7604							
8	Water tap inside the house										
10a	Not working							1.0146	1.7727		
10b	Student		1.4624								
10c	Rubber tapper			2.3190	1.2634					0.6005	
12	Other anti-mosquito measure while sleeping					-2.4331	-3.0922			-0.5135	
13	Anti-mosquito measure before sleep										
15	Sleep before 2200 hours	-0.9799				-2.1811	-1.7885			-1.1290	
16	Bednet					1.6158					
17	Distance of house from river	-0.0024									
21	Enlarged spleen										1.2282
23	ELISA positive		2.8245		1.8534		3.4792		2.7804		2.6143
	Initial -2 LL	104.61	104.61	124.35	124.35	232.84	232.84	100.50	100.50	469.60	469.60
	Model -2 LL	76.05	64.20	103.20	98.99	154.32	123.79	96.42	60.00	447.65	358.11
	Model χ^2 (d.f)	28.56(3)	40.41(3)	21.15(3)	25.36(2)	78.61(6)	109.05(5)	4.08(1)	8.13(2)	21.95(3)	111.48(3)
	Correct classification (%)	77.66	91.49	81.88	90.58	80.10	91.10	73.56	83.91	76.83	87.94

Note:Combine=Lawar+Bedil+Janggut

7.3.2 Interpretation of the models

The models were acceptable biologically and physically. The final outcome between Model 1 and Model 2 in the same location were consistent but for details in the equation parameters. Because the models were not meant to give precise information on the odds for the outcome variable, that is the 'current malaria' or 'current and past malaria' status, the differences in the equation parameters are not important. Except for bednets, other factors followed the expected increased or decreased risk for malaria status. As expected, there were variations in the relative importance of the factors analysed in different locations. Taking Model 1 and 2 for 'current malaria', the difference is striking. In Model 1 for Bedil, the predictor variables included six socio-economic variables, whereas in Rual, the outcome solely depended on age. Even with the addition of physical and laboratory investigation data, only age prevailed in the model equation for Rual. This result shows the uniformity of the population malaria risk and the high level of endemicity in Rual. This was consistent with previous results. For Bedil, the addition of physical and laboratory data slightly changed the predictor factors. ELISA emerged as a strong predictor, and appeared to play a role in the selection of factors in the model.

For 'current and past malaria' models, the predictor variables differed in each location. These differences may have been related to the level of malaria transmission and the location's characteristics. In Rual, where malaria has been hyperendemic for a long time, the outcome of the model was determined by being in the unemployed group. This consisted mainly of children less than seven years old, and the higher risk in this group was consistent with the features of an endemic area. In the other three locations, all factors pointed towards the occurrence of transmission mainly in the village itself rather than the work place. For example, sleeping before 2200 hours and living further from the river in the Model 1 for Lawar were protective, and this was in line with the findings in the vector studies. In Janggut, rubber tapper, income and number of rooms in house were the important variables associated with the odds for 'current and past malaria'.

The relatively less stable population of Bedil again demonstrated a higher odds for people who were residents for five years or less. The number of factors highlighted by the models were considerably more than in other locations in the analyses for 'current malaria' and 'current and past malaria', for both Model 1 and 2. This indicates the varied susceptibility of the population to malaria and may also indicate wide range of behaviour differences in Bedil.

The two models explored, 'current malaria' and 'current and past malaria' would have highlighted the differences in risk factors or the relative importance of certain risk factors over time. However, there were limitations in interpreting the model for 'current and past malaria' within the context of time related changes. In locations where many of the respondents had had previous malaria and survived, the prevalence would be higher than in locations in which most of the villagers infected had died, or moved from the location. This will not reflect the true risk for malaria in the village as those who had died might have different risk factors. The rate of changes in the environment and community in each location was not measured but were assumed to occur at the same speed. There was a chance that a model for 'current malaria' produced repeatedly over time, say every two or five years, might have given different results than the model for 'current and past malaria' explored in this study.

7.3.3 Validating the models

The acceptance of a model for further action depends on whether it is valid or not. This requires that certain conditions are observed and the model is tested to ensure that it will behave in the same manner for different data set from similar populations. The process of validating the model is outlined below.

The first step is the clarification of thought and concepts. The models were developed with malaria control strategy in mind at the simplest level possible using the available information. The emphasis was on the practicality and relevance of the models and not on accurate determination of the odds of having 'current malaria' or 'current and past malaria' for individuals with given characteristics. In other words, translation of the model's equation into real strategic control activities must be simple, meaningful, reliable and consistent. The models were based on certain assumptions and it is imperative to understand them (Jeffers, 1982) as well as the environment under which these models were developed. The assumptions made were as follows:

1. A respondent with certain characteristics behaved on average in the same manner as other respondents with the same characteristics.

2. For each vector-related variable, for example distance of house from the river(a breeding place for the vector), the vector was assumed to select its victim at random and only the variable acted as the determinant.

Although the environment under which the models were developed was crude and the assumptions that accompanied the process were simplistic, the model outcomes fulfilled the objectives the model was set out to achieve. Most of the outcomes were consistent with the relevant individual survey and provided better insights into the process of change of the many interactive components of malaria in the studied communities.

The second step is to make sure that the models conformed with the in-depth logical analysis. The outcome of the models both 'current malaria' and 'current and past malaria' conformed to the biological, physical and current knowledge in malaria control. Variables that deviated from the expected outcome were explicable. Although, no single model could fully explain the whole situation in study locations, this was expected as the variables and malaria status were not stratified under specific time periods.

The third step in the validation of models is to examine the statistical fitting of the models to data. This is best carried out with empirical data to see how the models behave in real environment (Altman, 1990). There was no opportunity for these models to be tested using further empirical data from the population. To use the data that were used to define the models would not have been appropriate because those data formed part of the environment in which the models were created.

In summary, all the models discussed in this chapter were consistent in outcome. The models highlighted important factors associated with malaria status and could be helpful in planning control activities.

CHAPTER 8. DISCUSSION

8.1 INTRODUCTION

Although many parts of the world are experiencing resurgence of malaria, Peninsular Malaysia has recently enjoyed a reduction in cases. However, malaria control remains one of the most expensive health programmes in Malaysia and is fast becoming less than cost-effective. The only vector responsible for malaria transmission now is *An. maculatus* which exists in the forest and forest fringe. The issue now is the choice of the most appropriate malaria control strategy if the prevalence is to remain constant or continue to decline.

Factors responsible for malaria transmission in each area have to be understood so that the MCT can modify control strategies to suit the local situation. This study set out to update the epidemiology of malaria in Jeli district, one of the malarious areas in Peninsular Malaysia which has experienced massive infrastructure and socio-economic developments, the latest of which is the Pergau hydro-electric power project.

The study confirmed that the decline in malaria cases observed in the study locations was genuine rather than reflecting poor reporting mechanisms. Reasons for the reduction were not obvious and could be due to several factors. The vigilance and effectiveness of the MCT in treating and preventing the spread of infection by delivering prompt treatment, and conducting adequate case investigations could have eliminated local reservoirs of infection and therefore, minimised transmission

(Sandosham, 1959). It could also be that reductions in the number of "effective" vectors either by natural causes or by planned control activities, have reduced the transmission potential below the critical level (Macdonald, 1952). Changes in human behaviour could have affected transmission either by increasing or reducing contact with malaria vectors. Changes in the environment, rainfall, temperature and eco-systems could also be responsible and must always be kept in mind. Parasite factors and host immunity could influence the course of the disease and sustain transmission.

8.2 THE VECTORS

Successful malaria transmission largely depends on the availability of effective vectors and susceptible communities, enhanced by favourable environmental or ecological conditions.. Over the years, many models have been developed to enable malariologists and responsible authorities to calculate the intensity of transmission. By doing this, it is hoped that a proper strategy can be developed to effectively arrest malaria transmission. Findings from previous studies, such as The Garki Project (Molyneux and Gramiccia, 1980) have been very helpful in focusing strategies. However, simple mathematical calculation does not always work. Even the most labour intensive and costly investigations such as the determination of inoculation rates in open communities, can only serve as relative indicators, and not the actual index of the true transmission. What the indicators tell us is the relative intensity of the transmission rate against other study variables such as time points and seasons.

Nevertheless, such comparisons are very helpful in deciding what strategy to use to control malaria, and when.

There was no record of studies of malaria vectors in Jeli District. This study was designed to document the abundance and behaviour of vectors in study locations and to relate, if possible, the behaviour of the vectors and the people living in the affected communities. *An. maculatus Theobald* is documented as the only vector responsible for the transmission of malaria in Peninsular Malaysia (Sulaiman, 1992). As *An. maculatus* was present in all study locations, it is clear that the threat of indigenous malaria still exists, given the availability of reservoirs or sources of infection. The species have been documented to exhibit definite seasonal abundance (Sandosham & Thomas, 1983). The primary peak is at the end of March and beginning of April and the secondary peak is in September. January-February and June-July are the least abundant periods for *An maculatus.* Although the current survey did not cover the whole year, the findings from November till June 1995 are consistent with those of Sandosham and Thomas (1983), with Rual as the only exception.

Transmission potential is normally determined by malaria sporozoite rates and inoculation rates. The malaria sporozoite rate is defined as the proportion of female *Anopheles* showing *Plasmodium* sporozoites in their salivary gland (Bruce-Chwatt, 1980). The sporozoite rate and the man-biting rate taken together provide an estimate of the potentially infective bites a person can expect to receive at the place and time the mosquitoes are collected (MacDonald, 1952; MacDonald, 1957). In this study, not a single positive gland was dissected from the *An. maculatus* collected. The result is consistent with previous experiences which have shown that the sporozoite rate is very low in an area where malaria prevalence is low. In some African countries where malaria is hyper-endemic, the sporozoite rate is around 5%. Such studies are rare in Malaysia. Sporozoite rates of *An. maculatus* collected in Pos Betau, the Orang Asli settlement in the neighbouring state of Pahang, from June 1986 to December 1987 were between 0.38% to 5.08% (Loong *et al.*, 1988). The ELISA test performed on 75 *An. maculatus* collected from Kg Jerek and Meranto in Gua Musang, revealed a 5.3% sporozoite positivity rate (Sulaiman, 1992). At a glance, these two studies seem to contrast with the result of the current study. However, the studies by Loong *et al.* (1988) and Sulaiman (1992) were on *An. maculatus* collected from high malaria prevalence areas. In the Orang Asli communities from the hinterland, as in the Post Betau, and in Kg Jerek and Meranto, malaria prevalence is consistently between 50-75%. Therefore, it is not surprising that the sporozoite rate was as high as 5%. These localities, until now, do not represent the true picture of malarious areas in Peninsular Malaysia. In other areas, especially in the current study locations, malaria prevalence is between 0.1 to 2.0%.

The exophagic nature of the *An maculatus* in the current study areas is consistent with previous findings (Wharton, 1951). Even though *An. maculatus* was found to be zoophilic (Loong *et al.* 1990; Wharton, 1953), this does not affect the number of human bites in this study as there were very few cattle and other domestic animals present when the collections were made. An interesting finding regarding the zoophilic-anthropophilic nature of *An. maculatus* was reported by Sulaiman (1992) when he noted that the preference of *An. maculatus* towards animal hosts are seasonal, mainly in April and May and December and January. In March, June and

August, the preference shifts to human hosts, with equal animal-humans preferences in September and October.

In this current study, *An. maculatus* larvae were found in three types of breeding places; clear water ponds, streams and river. The highest numbers of larvae were caught in Bedil and Rual. The existence of clear water ponds in Bedil and slow flowing streams, with numerous rock pools exposed to sunlight in Rual could be the reason for the high larvae caught. These places are the favourite breeding places for *An. maculatus* (Vythilingam *et al.* 1992). Larva control strategies are very difficult with these eco-systems.

8.3 SERO-PREVALENCE

The ELISA technique was chosen because it provided automation in the test process and afforded economical use of antigen preparation (Molineaux *et al.* 1988; Bruce-Chwatt, 1985; WHO, 1988), hence a more convenient method compared to IFAT and IHAT (Voller, 1988, Akenji *et al.* 1993). Sensitivity and reliability of the ELISA technique are comparable to the other two methods (Molineaux *et al.* 1988).

This study was one of few sero-epidemiological studies conducted in open communities in Malaysia. Previous work has mainly been conducted in Orang Asli settlements, which were hyperendemic with perennial transmission (Thomas *et al.* 1981, Mak *et al.* 1987). There was, therefore, no baseline information for reference or relative comparison of results. This study aimed to define the prevalence of sero-positivity and to examine the potential of using serology as an indicator of the level of malarial endemicity in areas with low or declining endemicity.

The antigen used in the test was crude schizont *P. falciparum* antigen from the 3D and clone cultured in the laboratory. Although, the test could have benefited from using species-specific antigen, efforts to culture or obtain *P. vivax* and *P. malariae* antigen were unsuccessful. Other researcher have also faced difficulties in maintaining *P. vivax* under laboratory culture (Ray *et al.* 1994). However, *P. falciparum* could also be used as sources for antigens for the test against *P. vivax* with satisfactory results (Ray *et al.* 1983; Mahajan *et al.* 1984).

8.3.1 Sero-prevalence by study location

One of the main uses of sero-epidemiology is to determine the level of malarial endemicity by looking at the prevalence of sero-positives. Since ELISA measures anti-malaria IgG antibodies, a person who was sero-positive may have had a current malaria infection or may have had previous exposure to malaria parasites (Kagan, 1972; Spencer *et al.* 1979). In all locations, the proportion of sero-positives was just slightly higher in the dry season, which included more than 80% of the respondents in Rual, 70% in Lawar, 61% in Bedil and 50% in Janggut. The results were expected in Rual and Janggut, but it was expected that the proportion of sero-positives would be higher in Bedil than in Lawar. This is because Lawar had not reported any malaria cases for almost two years before the test, in contrast to Bedil which was one of the problematic areas.

Antibodies can persist in the body for up to six months (Marsh, 1993), but the period could easily be shorter or longer. The development and sustainability of antibodies depends on the intensity, frequency and rate of infections within a specific period of time, and the treatment received by the individual. Prompt and adequate treatment may prevent the infected person from developing a high level of antibodies, thus can be found negative within a shorter period of time than a person who received late treatment. This might be the reason for the results that were observed from individuals in Lawar and Bedil.

Records showed that before 1993, Lawar was hyper-endemic with annual cases five times more than Bedil (VBDC, 1980-1992). Vigorous activities were carried out by the MCT in Lawar during the epidemics of 1991 and 1992, and included mass blood survey, rigorous case investigation and case follow-up and focal spraying of all houses with DDT. No sero-epidemiological survey was conducted, thus no record of the level of antibodies and prevalence of seropositivity are available. The high prevalence of sero-positive individuals could be due to the existence of some individuals with a high degree of immunity to malaria that render them asymptomatic with low parasitaemias. The very low density of parasites may not be detectable using conventional microscopy. Using more sensitive diagnostic methods such as the nested PCR assay, Roper *et al.* (1996) have found that a substantial group of asymptomatic, submicroscopically patent *P. falciparum* exist within the population of a Sudanese village with unstable malaria. This group was PCR positive almost throughout the year although clinical episodes in the village were confined to the malaria transmission season, which lasted for three wet months of the year.

Therefore, despite the lack of cases in Lawar and Janggut in 1993 and 1994, it is possible that there may be certain individuals present who may have harboured low levels of parasites undetected by microscopy without showing any signs of clinical malaria.

The almost equal proportion of sero-positivity amongst males and females suggested equal exposure in both genders to malaria. Since the majority of women were unemployed, it is fair to assume that the risk for malaria in residential villages is comparable to other places of work, if not higher. The evidence of intra-village transmission is supported by the fact that almost two thirds of current malaria cases in Bedil were unemployed.

Although it is well accepted that the O.D of ELISA does not linearly correlate with the actual level of antibodies, it does indicate its relative amounts. A person with an O.D of 3.000 has higher antibody level than a person with an O.D of 1.500, but may not be two times higher as shown by the O.D. Based on this assumption, it is possible to assess the intensity of transmission in each location by looking at the proportion in each category level of the ELISA, in addition to the proportion of total sero-positivity. The results of this study showed that 55.2% of the respondents in Rual were in the high positive category, followed by Bedil with 16.8%. Lawar and Janggut had less than 13% of the respondents in this category. Perhaps the proportion of high positive group is a better indication of the intensity of recent malaria transmission when making a comparison among the four study locations, rather than just using the total sero-prevalence. The same conclusion was reported by Tonggol-Rivera *et al.*

(1993) when they concluded that people living near the forest were the foci of infections because they have higher antibody titres than the populations from other locations on both dry and rainy season surveys.

8.3.2 Sero-prevalence and age

Age-related sero-positivity depends on the level of endemicity. In hyper-endemic areas, the young, especially infants, are the most susceptible group to develop severe and clinical malaria because they have not developed immunity to local parasite strains. The survival of this group largely depends on the level of antibodies passively transferred from the exposed mother to the foetus during pregnancy. After birth, this passively transferred antibody will wane off until it becomes almost zero, before the infant starts to develop its own antibodies following repeated exposure to parasites (Marsh, 1993).

The locations in this study are in transition from previously hyper-endemic, to unstable malarious area. The prevalence and trend of anti-malaria antibodies may not follow those of hyper-endemic or unstable areas. Although there was no correlation between age and O.D for the overall respondents, differences in the proportion of sero-positivity by age group were significant in Janggut and Bedil. The sero-prevalence decreased in the age groups 6 - 10 and 11 - 14 year olds compared with the age group 1 - 5 years, before it increased in the subsequent age groups. None of the four study locations exhibited the trend observed in hyperendemic areas where the proportion of sero-positives increases with age to reach a plateau somewh early adulthood (Genton *et al.* 1995; Cattani *et al.* 1986b; Cox *et al.* 1994; de Arruda *et al.* 1996), indicating the development of acquired immunity as an effect of exposure (Wilson and Garnham, 1950; Williamson and Gilles, 1978; Molineaux and Gramiccia, 1980; Rosenberg and Makeswary, 1982). Variations in sero-prevalence between age groups are still not fully explainable. However, small-area variation in the epidemiology of malaria is well known (Cattani *et al.* 1986a; McGregor *et al.* 1966; Greenwood, 1989; Bjorkman *et al.* 1985),

8.3.3 Serology and malaria status

The relationship between current malaria infection and serology was best studied from the dry season survey only as there were only three cases in the rainy season survey. Amongst the 29 blood film positive respondents, 69% were high positive, 24% medium positive and 7% low positive ELISA. All of them had had previous malaria infections. Current infection introduces a new challenge that theoretically will result in higher antibody level, thus higher O.D. The O.D of malaria positive individuals were expected to be higher in the dry season compared with their reading in the rainy season. Where none of them showed a reduction in the O.D, only 41% have increased O.D after current infections. This non-responsiveness especially in the medium positive category is not clearly understood. One postulation relates to the stage of the immune globulin reaction to new challenges. The IgM which responded to current infection normally will be released first followed by IgG. Since the test only measures IgG, the circulating IgM was not measured. Although it is well acknowledged that protective immunity is species and stage specific against the geographic variants of the same species (Ferreira, 1990), it is not clear how residents in the study population reacted to the infection because of lack of baseline information on this subject. Another possibility, although less convincing, is that the infection was at an early stage and the host antibody reaction has not yet been initiated at the time of measurement. It has been demonstrated that immune globulin has its main effect at the time of schizont rupture (Cohen *et al.* 1961; McGregor *et al.* 1963), the stage of antigens used in the test. The time the sera were drawn may be crucial in determining whether the antibody reaction and development to the new infection have taken place. This lack of clear cut measures of antibody responses was also observed by Mathews and Dondero (1982b) in an endemic area in the West Coast of Malaysia. They found that antibody titre increased either simultaneously or as late as four weeks after the diagnosis of parasitemia by blood slide examination. The authors also reported fluctuations in antibody levels with episodes of parasitemia, both increases (56%) and decreases (18%) (Mathews and Dondero, 1982a).

8.3.4 Sero-prevalence and level of transmission

This study also looks at the possibility of the ELISA to differentiate the intensity of transmission between the rainy and dry season. The evidence has not been impressive. In Malaysia, proliferation of breeding places at the beginning and after the rainy season are said to produce higher transmission than the rest of the year and malaria cases are expected to be high in June, July and August. Serology should be able to pick-up this increase transmission activities if it exist as demonstrated by

Tonggol-Riviera *et al.* (1993) when they detected a small peak of rising antibody titre from their dry season survey data after recent past epidemics in the rainy season. In this study, the dry season survey detected 3.3% more sero-positives than the rainy season survey, a result of 6.7% respondents who converted from sero-negative to sero-positive compared with 3.1% vice versa. Since the development of antibodies is related to the periods of parasitic latency in the peripheral bloods (McGregor, 1983) and disappears when there is no repeated exposure to the infection (Ferreira, 1990), the converted sero-positives may have been exposed to the parasites in between the two surveys, and the converted sero-negatives may have not. However, the increase was too small to be used as evidence for increased transmission because of the uncertainty in the time and magnitude of antibody developments (Mathews and Dondero, 1982a), and the time it takes to disappear from the circulation (Marsh, 1993).

8.4 RISK AND OTHER FACTORS ASSOCIATED WITH MALARIA

8.4.1 Socio-economic factors

Malaria has always been associated with social and economic activities of the local population (Chapin, 1983). A long list of risk factors has been documented, although with different emphases in different places (Rossenfield, 1981; Andy, 1972; Arasu 1992). Some of these factors are strongly associated with malaria status in the study locations.

The Malay-Thais were found to be at higher risk than the Malays, both in Janggut and Bedil. The majority of them worked in rubber plantations, fruit farms or clearing new land. The coverage of this ethnic group in the study was small, because the illegal temporary workers evaded the study team. Although there was no evidence that they were more high risk than the permanent residents, previous records showed that malaria positive cases detected from illegal Malay-Thai workers were normally lost to follow-up (Jeli MCT, 1990 - 1995) because of fear of apprehension by the authorities. The Orang Asli are synonymous with Rual. Therefore all the factors that increase risk for malaria in Rual are directly related to the Orang Asli. The risk for malaria in this group were collective and uniform. This is highlighted by the multiple logistic regression models for Rual for which the odds for having 'current malaria' or 'current and past malaria' were determined only by age.

There were notable differences in the average monthly income between the four study locations. Income is well documented to have an effect on the risk for malaria, as the poor are said to be more susceptible (Hongvivatana, 1991). Respondents from Rual, perhaps by nature of their location and lifestyle, had lower income than the rest of the respondents. In the hinterland, money is probably the least important issue to the Orang Asli, but having been lured from their remote villages to the fringe of outside civilisation, money has become increasingly important. Economic-oriented jobs for the Orang Asli are still forest related. Even when they are doing similar jobs to the Malays, tapping rubber, for example, their plantations are close to jungle or forest fringes. This might be the reason why they were more susceptible to malaria infection.

Duration of stay is a good indicator of population movement and stability. Lawar had the most stable population compared to other locations although this village is a traditional village. Even the construction of the Pergau Dam did not introduce new people to the village. This factor was one of the variables highlighted in the model for 'current malaria and 'current and past malaria' for Bedil. The higher odds for individuals who stayed less than five years could be related to the lack of anti-malaria antibodies for the local parasite strain compared with people who have resided more than five years.

The location of basic amenities and risk for malaria have not been described before. Surprisingly, this factor was one of the significant factors related to the odds of having 'current malaria' for Bedil. The protective effect of having a water tap for domestic uses inside the house could be related to the behaviour of the households and vectors. Just before sunrise and sunset are the busiest times in the daily routine of the villagers in Kelantan when they normally bathe or wash to prepare for the "Subuh"(dawn) and "Maghrib"(dusk) prayer. If the source of water is outside, family members will have to queue outside waiting for their turn. In theory this could expose them to the vector that begins to disperse after being disturbed by the change in light and temperature.

Rubber tapper is the only occupation with higher risk for malaria. The importance of this type of occupation could be related to the nature and time of work, which exposed them to vector bites more than other occupations (Coimbra, Jr., 1988; Tadei *et al.* (1984). For Janggut, being a land scheme village, all the original settlers were rubber tappers. Although many of the settlers are now involved in other agricultural activities, the majority of them are still rubber tappers. The high prevalence rate in students in Bedil could be related to individual susceptibility due to inadequate immunity development because of unstable exposure in the recent past. In Rual, although cases were grouped in the unemployed category, all of them were children age 1 - 14 years. This trend indicate the high level of endemicity in Rual.

8.4.2 Behavioural factors

Although risk behaviour and risk avoidance behaviour for malaria were both examined in this study, only the second group was significantly associated with malaria status. This included the use of personal protection measures and behaviour that might reduce contact with vectors.

Personal protection is perhaps the easiest way of limiting contact with the malaria vector. Bednets have been used as a method of preventing mosquito bites for a very long time in Malaysia and many parts of the world (Port and Boreham, 1982; Bradley et al. 1986; Lindsay and Gibson, 1988). The coverage of bednets in the study locations was quite high, between 69 to 87%. Although the respondents in Lawar only used ordinary bednets, it might be enough to protect them from vector bites while they were asleep. In Thailand, Butraporn *et al.*(1986) did a case-control study on malaria cases and found that regular use of bednets (ordinary) was more common amongst the controls than amongst malaria cases. The introduction of insecticide-impregnated bednets (IBN) in certain villages in Jeli district could provide extra protection. The high percentages of IBN users in Janggut and Rual were because these two locations had been included in a special programme where IBN were distributed free to the villagers. Because of the non-existence in the monitoring procedure, the protective value of the IBN compared with ordinary bednets could not be determined. However, a crude comparative study between villages which used IBN and those which did not, showed a reduction of cases in the IBN villages of more than 100% one year after (Abdullah *et al.* 1996). In control villages, variations in cases were between 20 to 30%. Elsewhere, the effectiveness and usefulness of IBN have been shown in numerous studies (WHO, 1989; Hii *et al.* 1995) with up to 90% protection against mosquito bites (Snow *et al.* 1988) and is currently acknowledged as an appropriate technology in vector control (Curtis, 1989). However, users need to understand the principle behind this method. The washing of IBNs by a substantial proportion of the respondents in the study locations defied the purpose of impregnating bednets with insecticides (Miller *et al.* 1991; Pleass *et al.* 1993) although the vector is very susceptible to the insecticide used (Section 5.6). It seems more difficult for the respondents to appreciate the benefit of the insecticide than the nets, judging from the proportion of the respondents who used bednets.

Voluntary re-impregnation of bednets was non-existent, perhaps due to the weakness in the MCP rather than the users. Routine re-impregnation has not reached one hundred per cent coverage. Although logistical problems were cited as the reason for the poor re-impregnation rate (in-depth interview - malaria control staff and key personnel in study locations), users' perception of the importance of re-impregnation, and political and social divisions within the community need to be ascertained. These factors had been found to be the reasons for the poor re-impregnation rate in Tanzania (Winch *et. al.* 1997). The introduction of IBN could be one of the reasons for declining malaria in the study locations. Other than physical barriers, studies have shown that IBN reduced the size of the sporozoite inoculum (Snow *et al.* 1988; Greenwood *et al.* 1991; Bermeejo and Veeken, 1992) that limit the severity and density of parasites in the infected individuals. Studies on vectors in Malaysia (Vythilingam *et al.* 1995) and Africa (Lindsay *et al.* 1989) showed reduced biting rate when IBN were used. However, uses of IBN were not widespread in the study locations, and there was a need to improve the coverage.

Another method used for personal protection against mosquitoes was mosquito coils. The limited use of this method exclusively by bednet users could not be explained by this study, but it could reflect the understanding and awareness on personal protection methods against malaria by the users compared with non-users. The majority of bednet users, especially IBN, had been exposed to malaria infections in the past (Jeli, 1990-1995). This was also the reason why bednet users had higher odds of having 'current and past malaria' in the model of factors associated with malaria (Chapter 7). The effectiveness of mosquito coils as repellents is probably quite good judging by its popularity amongst the people in Kelantan. However, its value in malaria prevention has not been established in Malaysia. Studies from Africa and Papua New Guinea have reported relative effectiveness of pyrethtroid-contained mosquito coils that varied according to active ingredients, species of mosquitoes, environmental condition, housing structure and behaviour of the inhabitants (Chadwick, 1970; Charlwood and Jolley, 1984; Hudson and Esozed, 1971; Lubega *et* *al.* 1977). Birley *et al.* (1987) showed reduced biting rate by *An. gambiae* and *Aedes aegypti* when mosquito coils were used, but they could not determine the effect of this method on the vector survival. However, if mosquito coils could reduce biting rates against *An. maculatus* in the study locations, they could be an effective measure given the very low level of transmission. The only obstacle to using mosquito coils could be the repeated cost.

Forest movement is recognised as one of the major risk factors for malaria in Malaysia, especially when the movement promotes contact with Orang Asli. The number of respondents involved in these activities in Lawar, Bedil and Janggut were too small for further exploratory analysis with malaria status. For Rual, forest movement is part of the lifestyle of Orang Asli, but because it is practised by the whole community, it is not possible to quantify the odds for individuals. In a study from Thailand, which exhibited similar forest fringe and forest malaria, albeit different vectors, frequent movement into the forest produced 14.3 fold increase risk of getting malaria (Butraporn *et al.* 1986).

8.5 ENVIRONMENTAL FACTORS

This district has had three major developments that involve large scale forest clearance, the land scheme project in the 1960s and 1970s, the construction of East-West highway in the early 1980s and the latest, the Pergau Dam in 1991. These events are important for malaria control because malaria epidemics in Malaysia have always been associated with activities that involve forest clearance (de Las Llagas,

1985) which encourages the breeding of *An. maculatus* (O'Holohan, 1982). The Pergau Dam was not anticipated to cause epidemics by the MCT, judging by the lack of attention given to the area until the epidemics in 1991 and 1992. By referring to the behaviour of the vectors, those epidemics could be due to sudden increases in vector densities resulting from proliferation of breeding places after the initial forest clearance. Vector density is one of the key variables for malaria transmission and its relationship with the transmission potential is said to be linear (Bradley, 1995). Because of the proximity of the place with Lawar, the construction could have also displaced the vectors towards Lawar. The cases ceased after forest clearing stopped and the area has stabilised. Similar observations have also been made during estates and land scheme development in other parts of Peninsular Malaysia. The large scale of multiplication of breeding places turned the previously unstable, into stable malarious area, but reverted back to being unstable after the estate and population settled (Macdonald, 1957). Although such experience with dam construction has not been studied in Malaysia, experience from Thailand showed increase malaria prevalence (Bunnag *et al.* 1979) and vector densities (Harinasuta *et al.* 1970) following dam development.

8.6 VIGILANCE OF THE MCT

8.6.1Control activities

The MCT has the capability to respond swiftly to malaria epidemics. ACD, case investigations, follow-up and treatment for positive malaria cases are routinely carried out to some degree of efficiency. Resources such as manpower, transportation, materials and drugs, are adequate to deal with the current malaria situation but are becoming constrained. The team is not encouraged to work overtime and daily paid members of the spray team are no longer employed.

Health centres, community clinics and hospitals form part of the vigilance of malaria control. These centres took slides for PCD and prescribed treatment for malaria positive cases. General practitioners do not normally treat malaria patients. There was a growing concern by the MCT with regards to the effect of self treatment by the temporary illegal workers from Thailand. There was no opportunity to explore this issue during the study, but there was a genuine need to look into the matter in future research.

Several weaknesses in the control programme were also observed. A review of the methods and strategies for malaria control in Jeli was undertaken by Abdullah *et.al.* (1996). This showed that less than one third of the FC achieved the target set by the VBDC head office in ACD, and only 7.3% of confirmed cases in 1994 had complete follow-up. They also reported a significantly higher detection rate by FC who achieved their target compared to those who did not. This finding rendered necessary the investigation of whether the FC need to be vigilantly monitored in order to increase case detection rate and further reduce malaria cases.

The lack of local laboratory services caused delays in diagnosis and treatment as shown by Fig.4.2. Taking the laboratory to Jeli is the ideal solution, but it is easier said than done. The extra cost to the district for laboratory expansion, equipment, manpower and consumable need to be defined. Persuading staff who have been working in the State VBDC laboratory in the city to move to a remote district like Jeli can be a daunting task. Forced postings can be far from motivational and cannot guarantee commitment. Furthermore, the government may refuse to allocate more money for this purpose given the declining prevalence of malaria. However, although the lessons from the failed malaria eradication programme are still keenly remembered, there is a possibility here that malaria in Jeli can be reduced to a very low level if the vigilance is stepped up.

8.6.2 Treatment review with special reference to hospitalised patients

Treatments for malaria cases detected from the surveys were carried out according to the guidelines issued by the Ministry of Health. During the field work, there was no evidence of improper administration of treatment by the FC to patients treated at home. This by no means conclusive as the FC might have been extra careful during the period of observation. Compliance was enhanced by dispensing the tablets in three plastic bags marked the day they should be taken. Syrup preparations enhanced compliance from children. There was no sign of resistance to the drugs used.

The review in Chapter 6 provided information on how patients were managed in the ward. The most difficult problem with using hospital data is the unrepresentativeness of the patients (Muller and van Ginneken, 1991). Nevertheless, hospital data warrant more attention due to the vast amount of information available (Petit, 1995).

The patients presented here definitely do not represent malaria patients in the district. These patients were either referred by health centres for high parasitemia, gametocytaemia or because of their young age. It is the government policy that wherever possible, infants and patients who harbour gametocytes in their blood must be admitted (VBDC, 1992). Fifty-seven percent of these patients voluntarily presented themselves to the hospital. Whatever the reasons that made them come to hospital, be it the severity of the disease, the awareness of the importance of early treatment or the distance from the hospital, they were different from the rest of the parasite-positive people in the population, at least with regard to the treatment seeking behaviour.

Anaemia is one of the main problems that accompanies malaria infection in patients from endemic areas. The chronic nature of the infections that interfere with the red blood cell mechanisms in various ways tends to precipitate or aggravate anaemia in malaria patients (Mashaal, 1986). In this study haemoglobin levels were not linearly related to the age of patients. However the high percentage of anaemia in children, especially infants, is quite alarming. All eight infant patients were anaemic of which six (75%) were severe, and one had a haemoglobin just 3.0 g/dl. Although all patients were discharged well, there has to be a special procedure, which is currently not available, to monitor these infants. Without a proper long term management, they are more likely to succumb to chronic anaemia and its vicious cycle, which may result in growth retardation or other serious complications if they are continuously expose to malaria infection.

8.6.3 Chemotherapy for falciparum malaria

Errors in the management and treatment of malaria cases might be acutely fatal whilst other consequences may emerge later. Mashaal (1993) listed 20 common errors made by treatment providers and three of them were documented in this study i.e errors in dosage, too early cessation without justification and unnecessary extended chemotherapy.

Errors in dosage included both under and over dosages and occurred in all age groups except infants. Over dosages have no added benefit. Increasing the dose of chloroquine does not raise the parasitological cure rate (Na-Bangchang and Karbwang, 1993a), but may produce or exacerbate side effects which may affect compliance. No side effect was documented from the patients.

Primaquine, an 8-aminoquinoline, is the only compound for the treatment of hypnozoite form of *P. vivax* and is given as a standard 14 day-regime (VBDC, 1993). For *P. falciparum*, primaquine is used as a gametocydal drug and is normally given in a single dose. In Malaysia, primaquine is to be given at 0.25 mg base per kg body weight for three consecutive days (VBDC, 1994). And yet, almost 60% of patients with falciparum malaria were given primaquine for 14 days. If this unnecessary extension of treatment was unintentional, it can only be assumed that confusions had occurred with the treatment for *P. vivax*. The use of primaquine in infants is controversial. Some said that this drug is contraindicated in infancy, pregnancy and acutely ill patients (Na-Bangchang and Karbwang, 1993b). In Malaysia, primaquine is used on the first, second and third day of treatments to achieve the gametol effect, including infants. Whether a three days' administration is more beneficial than a single dose is difficult to tell because there has been no recent study. Primaquine has a narrow therapeutic index and must be used appropriately. It can also cause methaemoglobinaemia in susceptible patients beside other side effects such as nausea, vomiting and abdominal cramps. Another justification for the study is to document recent evidence to support the continuing use of this drug in infants, especially in areas with high prevalence of G6PD deficiency. Mashaal's (1993) regime in the treatment of falciparum malaria in infant does not include primaquine below the age of one year, thus in line with Na-Bangchang and Karbwang (1993).

Prescribing below therapeutic dosages of chloroquine can promote drug resistance. There is no justification for this unless patients complain of severe side-effects, which did not occur in the patients studied. There may be some exception for vivax malaria where the efficacy is still very high, no resistance is being reported, and studies have shown that a low single dose still results in rapid clearance of parasites and fever with no recrudescence (Na-Bangchang and Karbwang, 1993a). Therefore, it is assumed that the under dosage treatments were given out of ignorance or without consulting the guidelines. This practice can spell disaster because there is no mechanism to give feedback on treatment failure after patients are discharged. The issue is relevant since not all patients were discharged after the standard three times negative blood films as required. In fact, Gilles (1987) suggested that in areas where P. falciparum is sensitive to choloroquine, patient is to be given a loading dose of choloroquine (base) 600 mg, followed by 300 mg on each of the following three days.

8.7 IMPROVING THE CONTROL STRATEGIES

The prevention and control of malaria involve measures to prevent mosquitoes feeding on humans, measures to prevent or reduce breeding of vectors by eliminating breeding places, measures to destroy the larvae of the vectors, measures to kill adult mosquitoes and measures to eliminate the malaria parasites in the human host (Russel, 1952; Oaks *et al.* 1991; Onori *et al.* 1993). In discussing how to improve malaria control strategies in the study locations, the grouping of malaria control principles by Onori *et al.* (1993) is easier to follow. The measures are grouped under the vector control, personal protection measures and antiplasmodia measures. Vector control directed at the reduction of breeding habitats, has very little room for improvement. In the study locations, larvae were mainly collected from the streams, river banks, swamps and small pools. Mitigation measures against these breeding places are difficult. Environmental management techniques such as stream reconstruction and river edge improvements are very costly and not viable because of the annual flooding which affects the study locations. DDT has been found to be very effective but has been discontinued because of shortages in supplies and high prices. As the vectors enter houses in search of blood meals, IBN can kill the exposed mosquitoes as well as preventing the sleepers from being bitten. Other methods such as biocontrol agents that include entomophagus bacteria such as *Bacillus thuriengiensis var. israelensis* and *Bacillus sphaerias*, fungi, microsporidians, predators and parasites against malaria vectors have been tested and found useful (Das and Amalraj, 1997). None of those have been tested with forest malaria vectors, therefore, their usefulness in vector control in Malaysia is unknown.

The value of personal protection measures for malaria control has not been fully utilised. One of the weaknesses identified is the lack of promotion on IBN. Because IBN is normally distributed by the MCT or other agencies, it is assumed that the same procedure must always apply. An expansion of current strategy of re-impregnating bednets every six month to include other villages with no IBN programmes can substantially increase IBN coverage. Villages like Lawar which has 83% of the population using bednets may greatly benefit. Bednets impregnation has to be included in the yearly activity planners. Another important strategy is to provide individual based re-impregnation where villagers can collect the insecticide and perform the procedure themselves. This alternative, of course requires training, which may not be difficult. This way, the coverage of IBN can be increased with reasonable cost compared to the previous strategy of giving out pre-impregnated bednets.

Antiplasmodia measures aimed at elimination of malaria parasites and prevention of transmission require prompt treatment of cases, preferably within 24 hours of the onset of symptoms for children. This study demonstrated that the malaria situation differs considerably from one location to another to a great extent. Although previous experience indicates that malaria eradication has not been possible in Peninsular Malaysia, there is an opportunity now to bring malaria to the lowest ever possible cases. This can be done by re-orientating control strategy to target problematic areas. Improving case detection coverage in problematic areas such as Bedil and Rual can reduce reservoirs of infection by early diagnosis and treatment. In Rual, ACD is the only method for malaria detection because of the relative lack of accessibility to health centres. However, the MCT conducted ACD only once a month. Although they look for febrile cases, most of the time slides are taken at 'random' from available villagers to cover between 5 - 10% of the population. Because of this strategy, villagers who return from their jungle trips the day after ACD is conducted will be missed until at least the next month. The high immunity (as shown by the serology and the occurrence of malaria cases only in children) in this group may cause individuals to have low level of parasites and become reservoirs without showing signs of clinical malaria. The medical assistant from the Orang Asli Department so far has not been involved in malaria control, and yet, he can play a vital role in the programme. The Orang Asli enter the forest in groups either to search for rattan, to hunt or to help other groups to harvest crops. The contact with the other groups of Orang Asli, especially those from the hinterland, exposes them to infection. The medical assistant can take BFMP from these groups as soon as they return from the forest and send them to the MCT office for staining and examination. This way, villagers who are infected while on the trip, can be quickly detected and treated, minimising the spread of infection in the village.

ACD as a routine procedure should be discontinued based on the very low case detection rate shown in this study. Malaria workers should be re-trained as primary health workers, with particular emphasis on the early diagnosis and treatment of malaria.

The MCT should improve links with other agencies in the district, especially those involved in hiring foreign workers. This will enable accurate assessment on malaria status. Arrangements should also be made with private employers to allow access to migrant workers so that they can be included in the routine ACD, or special surveys if necessary.

An EIS should be set-up locally to analyse and appraise the local situation. This is currently non-existence, and directives normally come from the State VBDCO. The epidemiological information system should include information regarding the malaria situation from bordering districts including the Thailand border.

Serology is a helpful tool in delineating areas with intense transmission in the recent past. The technique, if available, should be used to assess the malaria situation for the whole district. Serological investigations can also help in making decisions about whether more sensitive diagnostic tools such as PCR are needed. This is of particular importance when efforts are concentrated at the elimination of reservoirs of infection at a very low level of parasitaemia, especially when being suppressed by high levels of immunity and not be detectable by the conventional microscopy.

8.8 LIMITATIONS OF THE STUDY

The author intended to conduct a comprehensive vector surveys for a year that would require expert assistance of the entomological team from the state VBDCO. The author also intended to conduct a longitudinal study of malaria patients that would involve serial measurements of antibodies after malaria infection. The sponsoring agency initially agreed to provide the fund but changed the decision after the study had begun. The reason cited was that a Ph.D. candidate should not be given any field assistance for his Ph.D. work. The field work was funded by part of the bench fees.

The approach and design of the study had to be modified at the beginning of the field work because of the local malaria situation and this disturbed the schedule of the study. National and international controversies surrounding the Pergau Dam also delayed progress. Much of the information needed about the dam were not available during the planning phase.

The study also suffered from administrative bureaucracy at the beginning of the field work because the MCT was answerable to two MOH, before it came fully under the authority of Jeli MOH in 1995. The entomology team, however, remained under the State VBDCO. The changing of MOH for the State VBDCO in the middle of the study was a problem as the available facilities were reduced by the new MOH, citing lack of financial resources as the reason. This resulted in increased cost. It took the author a few months before a relationship was again established with the new MOH.

The survey coincided with the build-up for the national election and Jeli was one of the priority areas. The intensity of the election process not only affected the villagers but also the MCT. Many of the scheduled activities had to be re-scheduled to accommodate the political campaigns and rallies. There were times when during the fieldwork, very few villagers were available as the rest attended political programmes.

8.9 CONCLUSIONS

The study revealed a genuine lack of malaria cases in study locations especially in Lawar and Janggut. This was consistent with the fast declining prevalence of this disease in Peninsular Malaysia. The decline might be related to the epidemiological features of malaria and the nature of malaria transmission in Peninsular Malaysia. Changes in the receptivity of the environment, vulnerability of the community and vigilance of the MCT could all be responsible. The development of Pergau Dam has caused epidemics, but resolved as the construction work was confined to specific areas and the forest clearance stopped. The same could be said about Janggut, which as a land scheme village, had been subjected to large scale forest clearance in the beginning but has now settled. This phenomenon has been the nature of malaria epidemics in Malaysia caused by *An. maculatus,* were present in all study locations. The natural environment favours the existence and breeding of the vector *An maculatus*. The parity of the mosquitoes caught and the results of larva surveys indicated that breeding places took place in the villages. Community and individual vulnerability to malaria infections were different among the four study locations. The differences were related to socio-economic factors, behaviour, population stability, acquired immunity and exposure to control measures. These factors were highlighted in the logistic regression models. The use of bednets as a means of personal protection against mosquito bites has been enhanced by the introduction of IBN. There was a genuine need to expand the programme to other villages. Other methods like mosquito coils were being used but their value in malaria control need to be ascertained. Serology has proved valuable in delineating locations which had had intense transmission in the past or recent past. Serological results greatly influenced the outcome of the individual assessment of risks of having or having had malaria. Recent and past evidence suggested that the MCT in Jeli was capable of dealing with epidemics and limiting the spread of infection. Current control activities were adequate to deal with the present malaria situation in the District. However, weaknesses were also observed in the control activities. Other available resources which could increase the effectiveness of the control programme were not fully utilised. Improvement in these two factors might increase the efficiency of the control programme and could bring down the prevalence of malaria to near zero. Recommendations for improving the vigilance and capabilities of the MCT are summarised as follows.

1. Re-focus control activities to target problematic areas, such as Rual and Bedil.
2. Discontinue ACD as a routine procedure.
3. Re-train malaria workers as primary health workers with particular emphasis on the early diagnosis and treatment.
4. Reduce delay in diagnosis by setting up laboratory diagnosis in the District.
5. Identify and use other resources outside the MCT and VBDCO.
6. Expand the use of IBN in all endemic locations and actively encourage communities who are already widely using ordinary bednets to impregnate them.
7. Consider replacing permethrin with a more wash-resistant insecticide such as deltamethrin.
8. Up-date the epidemiological information system to include information on vectors, environment, socio-economic and behavioural factors. Analysis of these factors as performed in this study may provide the necessary information needed to target control strategies more effectively.

REFERENCES

Abdullah, M.R., Ahmad, C.K., Abdullah, W.P.W. and Nafuri, H. (1996). A review of the malaria control strategy in Jeli District, Kelantan, Malaysia. Health System Research. Kelantan State Health Office. HSR/MAL/KEL.JELI96.

Abdullah, N.R., Furuta, T., Taib, R., Kita, K. Kojima, S. and Wah, M.J. (1996). Short report: Development of a new diagnostic method for Plasmodium falciparum infection using a reverse transcriptase-polymerase chain reaction. *American Journal of Tropical Medicine and Hygiene*, **54**(2): 162 - 3.

ADB. (1992). Guidelines for the health impact assessment of development projects. ADB Environment Paper No. 11. Office of the environment, Asian Development Bank, November.

Akanmori, B.D., Afari, E.A., Sakatoku, H. and Nkrumah, F.K. (1995). A longitudinal study of malaria infections morbidity and antibody titres in infant of a rural community in Ghana. *Transaction of the Royal Society of Tropical Medicine and Hygiene*, **89**; 560-561.

Akenji, T.N., Deas, J.E. and Leke, G.R. (1993). Correlation between serum levels of antibodies to the 96 KD antigen of Plasmodium falciparum and protective immunity in Cameroon: A longitudinal study. *American Journal of Tropical Medicine and Hygiene*, **49**: 566 - 73.

Alonso, P.L., Lindsay, S.W. and Armstrong, J.R.M. (1990) The effect of insecticide treated bednets on mortality of Gambian children. *Lancet*, **337**: 1499 - 502.

Altman, D.G. (1992). Practical statistics for medical research. Chapman and Hall (London).

Ambroise-Thomas, P., Wernsdorfer, W., Grab, B., Bertagna, P. and Cullen, J. (1976). Longitudinal sero-epidemiological studies on malaria in Tunisia. *Bulletin of the World Health Organization*, **54**: 335-367.

Anderson, U., Bird, A.G., Britton, S. and Palacios, R. (1981). Humoral and cellular immunity in humans studied at the cell level from birth to 2 years of age. *Immunological Reviews*, **57**: 5 - 38.

Andy, J.R.. (1972). Aspects of human behaviour interfering with vector control. In: PAHO. Vector control and recrudescence of vector-borne diseases. Proceedings of a symposium held during the 10th meeting of the PAHO Advisory committee on medical research, 15 June 1971, Washington DC. Scientific Publication NO. 238, PAHO/WHO, 67-82.

Arasu, G.D. (1992). Risk behaviour in malaria in Malaysia. *The Southeast Asian Journal of Tropical Medicine and Public Health*, **23**: Supplement 1 - 51 - 6.

Armitage, P. and Berry, G. (1987). Statistical methods in medical research. 2nd edition. Blackwell Scientific (Oxford).

Armstrong, J.C. (1978). Susceptibility to vivax malaria in Ethiopia. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **72**: 342 - 344.

Bailey, N.T.J. (1982). The biomathematics of malaria. Charles Griffin and Company Ltd. (London).

Bermeejo, A. and Veeneken, H. (1992). Insecticide-impregnated bednets for malaria control: a review of the field trials. *Bulletin of the World Health Organization*, **70**: 293 - 6.

Birley, M.H. (1989). Guidelines for forecasting the vector-borne disease implications of water resources development. WHO/FAO/UNEP Panel of experts on environmental management for vector control. VBC/89.6.

Birley, M.H., Mutero, C.M., Turner, I.F. and Chadwick, P.R. (1987). The effectiveness of mosquito coils containing esbiothin under laboratory and field conditions. *Annals of Tropical Medicine and Parasitology*, **81**(2): 163 - 71.

Bjorge, S.S. (1995). A study of determinants of malaria in Kelantan, Malaysia. Ph.D Thesis, University of Hawai'i.

Bjorkman, A., Hedman, P., Brohult, J., Wilcox, M., Diamant, I., Pehrson, P.O., Rombo, L. and Bengston, E. (1985). Different malarial control activities in an area in Liberia -effects on malarimetric parameters. *Annals of Tropical Medicicne and Parasitology*, **79**: 239-246.

Bouma, M.J., Sondorp, H.E. and van der Kay, H.J. (1994a). Health and climate change. Lancet, i: 302.

Bouma, M.J., Sondorp, H.E. and van der Kay, H.J. (1994b). Climate change and periodic epidemic malaria. *Lancet*, **i**: 1440.

Brabin, BJ. (1991). The risk and severity of malaria in pregnant women. In Applied Field Researchin Malaria Reports No. 1. UNDP/World Bank/ WHO Special Programme for Research and Training in Tropical Diseases (TDR), WHO, Geneva, (Switzerland).

Bradley, A.K., Greenwood, B.M., Greenwood, A.M., Marsh, K., Byass, P. Tulloch, S. and Hayes, R. (1986). Bednets (mosquito nets) and morbidity for malaria. *Lancet*, 2(8500): 204 - 7.

Bradley, D.J. (1995). The epidemiology of malaria in clinical infectious disease. In Bailliere's clinical infectious diseases: International practice and research - malaria. (Pasvol G., ed.). Bailliere Tindall (London), 2(2): 211 - 16.

Brown, K.N. and Brown, I.N. (1965). Antigenic variation in chronic infection of *Plasmodium knowlesi. Nature*, **208**: 1286-1288.

Bruce-Chwatt, L.J. (1952). Malaria in African infants and children in Southern Nigeria. *Annals of Tropical Medicine and Parasitology*, **46**: 73.

Bruce-Chwatt, L.J. (1980). Essential malariology. William Heinemann, London.

Bruce-Chwatt, L.J. (1985). Essential malariology, 2nd edition. William Heinemann Medical Books (London).

Bunnag, T., Sornmani, S., Pinithpongse, S. and Harinasuta, C. (1979). Surveilance of water-borne parasite infection and the studies on the impact of ecological changes on the vector mosquito on malaria after dam construction. *The Southeast Asian Journal of Tropical Medicine and Public Health*, **10**: 656 - 60.

Burkot, T.R. (1985). Non-random host selection by *Anopheles* mosquitoes. *Parasitology Today*, 4: 156 - 162.

Butraporn, P., Sornmani, S. and Hungsapruek, T. (1986). Social, behavioural, housing factors and their interactive effects associated with malaria occurrence in East Thailand. *The Southeast Asian Journal of Tropical Medicine and Public Health*, **17** (3): 386 - 392.

Cattani, J.A., Moir, J.S., Gibson, F.D., Ginny, M., Paino, J., Davidson, W. and Alpers, M.P. (1986a). Small area variations in the epidemilogy of malaria in Madang Province. *Papua New Guinea Medical Journal*, **29**: 11-17.

Cattani, J.A., Tulloch, S., Vrbova, H., Jolley, D., Gibson, F.D., Moir, J.S., Haywood, P.F., Alpers, M.P., Stevenson, A. and Clancy, R. (1986b). The epidemiology of malaria in a population surrounding Madang , Papua New Guinea. *Amercan Journal of Tropical Medicine and Hygiene*, **35**: 1 - 15.

Census. (1994). Population census 1994. Statistics, Malaysian Government.

Chadwick, P.R. (1970). The action of DC-allthenolone-D-trans-chrysanthenate and other pyrethroids in mosquito coils. *Mosquito News*, **30**: 162 - 70.

Chapin, C. and Wasserstrom, R. (1983). Pesticide use and malaria resurgence in Central America and India. *Social Science and Medicine*, **17**: 273 - 90.

Charlwood, J.D. and Graves, P.M. (1987). The effect of permethrin-impregnated bednets on a population of Anopheles farauti in coastal Papua New Guinea. *Medical and Veterinary Entomology*, **1**(3): 319 - 27.

Charlwood, J.D. and Jolley, D. (1984). The coil works (against mosquitoes in Papua New Guinea). *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **78**: 678.

Charlwood, J.D., Birley, M.H., Dagoro, H., Paru, R. and Holmes, P.R. (1985). Assessing survival rates of *An. farauti* (Diptera: Cullicidae) for Papua New Guinea. *Journal of Animal Biology*, **54**: 1003 - 16.

Chiang, G.L., Loong, K.P., Chan, S.T., Eng, K.L and Yap, H.H. (1991). Capture re-capture studies with An. maculatus Theobald (Diptera: Cullicidae) the vector of malaria in Peninsular Malaysia. *Southeast Asian Journal of Tropical Medicine and Public Health*, **22** (4): 643 - 7.

Chooi, C.K. (1985). Status of malaria vectors in Malaysia. *The Southeast Asian Journal of Tropical Medicine and Public Health*, **16**: 133 - 138.

Chow, C.Y. (1970). Bionomics of malaria vectors in the Western Pacific Region. *The Southeast Asian Journal of Tropical Medicine and Public Health*, **1**: 40 - 57.

Coggeshall, L.T. (1943). Immunity in malaria. *Medicine (Baltimore)*, **22**: 87-98.

Coggeshall, L.T. and Eaton, M.D. (1938). The complement fixation reaction in monkey malaria. *Journal of Experimental Medicine*, **67**: 871 - 83.

Cohen, S., McGregor, I.A. and Carrington, S.P. (1961). Gamma-globulin and acquired immunity to human malaria. *Nature (London).* **192**: 733-737.

Coimbra, Jr., C.E.A. (1988). Human Factors in the epidemiology of malaria in the Brazillian Amazon. *Human Organization*, **47** (3): 255 - 260.

Colles, D.H. (1956). Observatins on anopheline mosquitoes of the Akah River, 4th Division of Sarawak. *Bulletin of Entomological Research*, **47**: 115 - 123.

Collins, R.T., Jung, R.K., Anoez, H., Sutrisno, K.H. and Putut, B. (1979). A study of the coastal malaria vectors, *Anopheles subpictus* (Rodenwaldt) and *Anopheles subpictus Grassi*, in South Sulawesi, Sulawesi, Indonesia. WHO/VBC/79.740 (unpublished document).

Collins, W.E., Warren, McW. and Skinner, J.C. (1971) Serological survey of Ethiopian highlands. *American Journal of Tropical Medicine and Hygiene*, **20**: 199-205.

Collins, W.E., Warren, McW., Skinner, J.C. and Fredericks, H.J. (1968). Studies on the relationship between fluorescent antibody response and ecology of malaria in Malaysia. *Bulletin of the World Health Organization*, **39**: 451-463.

Cox, M.J., Kum, D.E., Tawil, L., Narara, A.. Raiko, A., Baisor, M., Alpers, M.P. Medley, G.F. and Day, K.P. (1994). Dynamics of malaria parasitaemia associated with febrile illness in children from a rural area of Madang, Papua New Guinea. *American Journal of Tropical Medicine and Hygiene*, **35**: 3 - 15.

Curtis, C.F. (1989). Malaria control through anti mosquito measures. *Journal of the Royal Society of Medicine*, **81**: 18 - 22.

Curtis, C.F. (1992a). Personal protection methods against Vectors of Disease. *Review of the Medical Veterinary Entomology*, **80** (10): 543 - 553.

Curtis, C.F. (1992b). Spraying bednets with deltamethrin in Sichuan China. *Tropical Disease Bulletin*, **89** (8): R1- R6.

Curtis, C.F. (1993). Workshop in impregnated bednets at the International Congress of tropical medicine. *Japanese Journal of Sanitary Zoology*, **44**: 65 - 68.

Curtis, C.F., Lines, J.D. and Carnevale, P. (1990). Impregnated bednets and curtains against malaria mosquitos. In. Appropriate methods of vector control (Curtis C.F., ed.). Boca Raton: CRC Press (Florida): 5 - 46.

Das, P.K. and Amalraj, D.D. (1997). Biological control of malaria vectors. *Indian Journal of Medical Research*, **106**: 174 - 97.

Davidson, G. and Ganapathipillai, A. (1956). Observations on the bionomics of the adults of some Malayan anopheline mosquitoes. *Annals of Tropical Medicine and Parasitology*, **50**: 137 - 146.

de Arruda, M.E., Aragaki, C., Gagliardi, F. and Haile, R.W. (1996). A sero-prevalence and descriptive epidemiological study of malaria among Indian tribes of the Amazon basin of Brazil. *Annals of Tropical Medicine and Parasitology*, **90** (2): 135-143.

de Las Llagas, L.A. (1985). Impact of ecological changes on Anopheles vectors of malaria in some countries of SEA. *Southeast Asian Journal of Tropical Medicine and Public Health*, **16**(1): 146-8.

Desowitz, R.S and Stein, B. (1962). A tanned red cell haemagglutination test using *P. berghei* and homogenous anti-sera. *Transactions of the Royal Scoiety of Tropical Medicine and Hygiene*, **56**: 257 - 262.

Dutta, H.M and Dutt, A.K. (1975). Malaria ecology: A global perspective. *Social Science and Medicine*, **12**: 69 - 84.

Dye, C. (1986). Vectorial capacity: must we measure all its component? *Parasitology Today*, **2**: 2 - 8.

Eyles, D.E., Wharton, R.H., Cheong, W.H. and Warren, McW. (1964). Studies on malaria and *An. balabacensis* in Cambodia. *Bulletin of the World Health Organization*, **30**: 7 - 21.

Gabaldon, A. (1972). Recrudescence of malaria. In Pan American Health Organization: Vector control and the recrudescence of vector-borne disease. Proceeding of a symposium held during the 10th meeting of the PAHO Advisory Committee on Medical Research, 15 June 1971(Washington D.C.).PAHO/WHO/Scientific publication No. 238: 23 - 4.

Gamage-Mendis, A.C., Rajakaruna, J., Carter, R. and Mendis, K.N. (1991). Infectious reservoir of *Plasmodium vivax* and *Plasmosium falciparum* malaria in an endemic region of Sri Lanka. *American Journal of Tropical Medicine and Hygiene*, **45**(4): 479 - 487.

Gamage-Mendis, C.A., Carter, R., Arjuna, C.M., de Zoysa, P.K., Herath, P.R.J. and Mendis, K. (1991). Clustering of malaria infections within an endemic population: Risk of malaria associated with the type of housing construction. *American Journal of Tropica Medicine and Hygiene*, **45** (1): 77 - 85.

Garnham, P.C.C. (1966). Malaria parasites and other haemosporidia. Blackwell Scientific Publication (Oxford).

Gebreel, A.O., Gilles, H.M. and Prescott, J.e. (1985). Studies on the sero-epidemiology of endemic diseases in Libya.IV: Malaria. *Annals of Tropical Medicine and Parasitology*, **79**(4): 341 - 7.

Genton, B., Al-Yaman, A., Beck, H.P., Hii, J., Melor, S., Narara, A., Gibson, N., Smith, T. and Alpers, M.P. (1995). The epidemiology of malaria in the Wosera area, East Sepik Province, Papua New Guinea, in preparation for vaccine trials I. Malariometric indices and immunity. *Annals of Tropical Medicine and Parasitology*, **89** (4): 359-376.

Genton, B., Al-Yaman, F., Beck, H.P., Hii, J., Mellor, S., Rare, L., Ginny, M., Smith, T. and Alpers, M.P. (1995). The epidemiology of malaria in the Wosera area, East Sepik Province, Papua New Guinea, in preparation of vaccine trials. II. Mortality and morbidity. *Annals of Tropical Medicine and Parasitology*, **89** (4): 377 - 390.

Gilles, H.M. (1993). Chapter 8 Epidemiology of malaria. In Bruce-Chwatt's essential malariology, 3rd edition. (Gilles H.M and Warrel D.A., eds.). Edward Arnold (London): 124 - 163.

Gilles, H.M. (1987). The treatment and prophylaxis of malaria. *Annals of Tropical Medicine and Parasitology*, **81**(5): 607 - 617.

Gordon, D.M., Davis, D.R., Lee, M., Lambross, C., Harrison, B.A., Samuel, R., Campbell, G.H., Jegathesan, M., Selearajan, K. and Lewis, Jr., G.E. (1991). Significance of circumsporozoite-specific antibody in the natural transmission of *Plasmodium falciparum, Plasmodium vivax* and *Plasmodium malariae* in an aboriginal village (Orang Asli) population of central Peninsular Malaysia. *American Journal of Tropical Medicine and Hygiene*, **45**: 49 - 56.

Gould, D.J., Acanlon, J.E., Major, M.S.C. and Ward, R.A. (1966). *Anopheles* vectors of malaria in *Southeast Asia. Army Science Conference Proceedings*, **1**: 361 - 73.

Greenwood, B., Marsh, K. and Snow, R. (1991). Why do African children develop severe malaria. *Parasitology Today*, **7**: 277 - 81.

Greenwood, B.M. (1989). The micro-epidemiology of malaria and its importance to malaria control. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **83**: Supplement - 25-29.

Greenwood, B.M., Bradley, A.K., Greenwood, A.M., Byass, P., Jamneh, K., Marsh, K., Tulloch, S., Oldfield, F.S.J. and Hayes, R. (1987). Mortality and morbidity from malaria among children in a rural area of The Gambia, West Africa. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **81**: 478 - 486.

Greenwood, B.M., Marsh, K. and Snow, R. (1991). Why do some African children develop severe malaria? *Parasitology Today*, **7**: 277 - 81.

Harinasuta, C., Jetanesen, S., Impand, P. and Maegraith, B.G. (1970). Health problems and socioeconomic development : Investiagations on the health patterns of endemicity of diseases occurring following the construction of dams in Northeast Thailand. *The Southeast Asian Journal of Tropical Medicine and Public Health*, **1**: 530 - 52.

Haynes, B.F., Martin, M.E., Kay, H.H. and Kurtzberg, J. (1988). Early events in human T cell ontogeny. Phenotypic characterisation and immunohistologic localization of T cell precursors in early human foetal tissues. *Journal of Experimental Medicine*, **168**: 1061-1080.

Hii, H., Alexander, N., Chuan, C.K., Rahman, H.A., Safri, A. and Chan, M.K.C. (1995). Lambdacyhalothrin impregnated bednets control malaria in Sabah, Malaysia. *The Southeast Asian Journal of Tropical Medicine and Public Health*, **26** (2): 371 - 74.

Hii, J.L., Vun, Y.S., Chin, K.F., Chua, R., Tambakah, S., Binisol, E.S., Fernandez, E., Singh, N. and Chan, M.K. (1987). The influence of permethrin-impregnated bednets and mass drug administration on the influence of

Plasmodium falciparum in children in Sabah, Malaysia. *Medical and Veterinary Entomology*, **1**(4): 397 - 407.

Hii, J.L.K. (1982). Laboratory studies of three member species of the *Anopheles balabcensis balabacensis* complex(Diptera: Culicidae). PhD thesis. University of London.

Hill, A.V.S., Allsopp, H.K. and Kwitkowski, D. (1991). Common West African HLA antigens are associated with protection from severe malaria. *Nature*, **352**: 595 -600.

Ho, M. and Sexton, M.M. (1995). Clinical immunology of malaria. In Baillire's International practice and diseases: Clinical Infectious Diseases - Malaria (Pasvol G., ed.). Baillire Tindall (London): 227 - 247.

Hodgkin, E.P. (1956). The transmission of malaria in Malaya. Studies from the Institute of medical Research Federation of Malaya, 27: 98.

Hongvivatana, T. (1991). Human behaviour and malaria. In Social and economic aspects of malaria control (Sornmani S. and Fungladda W., eds.). MRC-TROPMED. Faculty of Tropical Medicine, Mahidol University (Bangkok).

Huailu, C., Wen, Y., Wuanmin, K. and Chongyi, L. (1994). Large scale spraying of bednets to control mosquito vectors and malaria in Sichuan, China. *Bulletin of the World Health Organization*, **73** (3): 321 - 8.

Hudson, J.E. and Esozed, S. (1971). The effects of smoke from mosquito coils on *An. gambiae gilles* and *Mansonia uniformis (Theobald)* in verandah-trap huts at Magugu, Ytanzania. *Bulletin of Entomological Research*, **61**: 247 - 65.

Hutter, N.H. (1987). The mechanisms and consequences of malaria in pregnancy : a critical discussion of current beliefs. Msc CHDC Thesis, University of London, (London).

Hyma, B. and Ramesh, A. (1980). The reappearance of malaria in Sathanur reservoir and environs, Tamil Nadu, India. *Journal of Social Sciences and Medicine*, **14**: 337.

IPCC. (1990). Intergovernmental Panel on Climate change: Climate change, the IPCC scientific assessment. Cambridge University Press (Cambridge).

IPCC. (1992). Intergovernmental Panel on Climate change: Climate change, the Supplementary report to the IPCC scientific assessment. Cambridge University Press (Cambridge).

Ismail, I.A.H., Notananda, V. and Schepens, J. (1974). Studies on malaria and responses of *Anopheles balabacencis balabacencis* and *Anopheles minimus*

DDT spraying in Thailand. Part 1. Pre-spraying observations. *Acta Tropica*, **31**: 129 - 64.

Jaal, Z. and Macdonald, W.W. (1993a). The ecology of anopheline mosquitos in northwest coastal Malaysia: host preferences and biting-cycles. *Southeast Asian Journal of Tropical Medicine and Public Health*, **24**(3): 530 - 5.

Jaal, Z. and Macdonald, W.W. (1993b). The ecology of anopheline mosquitos in northwest coastal Malaysia: larval habitats and adult seasonal abundance. *Southeast Asian Journal of Tropical Medicine and Public Health*, **24**(3): 522 -9.

Jaal, Z. (1993). Studies on the ecology of the coastal anopheline mosquito of northwestern Peninsular Malaysia. Ph.D. Thesis, University of Liverpool.

Jana-kara, B.R., Fihullah, W.A., Shahi, B., Dev, V., Curtis, C.F. and Sharma, V.P. (1995). *The Journal of Tropical Medicine and Hygiene*, **98**(2): 73 - 83.

Jeffers, J.N.R. (1982). Outline studies in ecology: Modelling. Chapman and Hall (London).

Jeli. (1990 - 1995). *Laporan tahunan kejadian kes malaria dan siasatan kes*. A report by the malaria control team, Jeli Health Office.

Jetten, T.H., and Martens, W.J.M. and Takken, W. (1996). Model simulations to estimate malaria risk under climate change. *Journal of Medical Entomology*, **33** (3): 361-71.

JHEOA. (1996). Reports on the Orang Asli in Kelantan. The Orang Asli Social and Welfare Department. The State of Kelantan.

Kagan, I.G. (1972a). Evaluation of indirect haemagglutination test as an epidemiologic technique for malaria. *American Journal of Tropical Medicine and Hygiene*, **21**: 683 - 9.

Kagan, I.G. (1972b). Malaria sero-epidemiology and serologic diagnosis. *Experimental Parasitology*, **31**: 126 - 35.

Kalra, N.L. (1978). National malaria eradication programme, India: Its problems, management and research needs. *Journal of Communicable Disease*, **10**(1): 1 - 20.

Kittayapong, P., Clark, J.M., Edmar, J.D., Larine, B.K., Marion, J.R. and Brooks, M. (1993). Survey of the *An. maculatus* complex (Diptera: Culicidae) in Peninsular Malaysia by analysis of cuticular lipids. *Journal of Medical Entomology*, **30**(6): 969 - 74.

Kondrashin, A.V. and Rashid, K.M. (1987). Epidemiological consideration for planning malaria control in SEAR. WHO Regional Office for South East Asia (New Delhi).

Lindsay, S.W. and Birley, M.H. (1996). Climate change and malaria transmission. *Annals of Tropical Medicine and Parasitology*, **90** (6): 573-588.

Lindsay, S.W. and Gibson, M.E. (1988). Bednets re-visited: Old idea, new angle. *Parasitology Today*, **4**(10): 270 - 272.

Lindsay, S.W., Adiamah, J.H., Miller, J.E. and Armstrong, J.R.M. (1991). Pyrethroid-treated bednets on mosquitos of the *Anopheles gambiae* complex in the Gambia. *Medical and Veterinary Entomology*, **5**: 477- 83.

Lindsay, S.W., Snow, R.M., Broomfield , G.L., Semega, M.J., Wirtz, R.A. and Greenwood, B.M. (1989). Impact of permethrin treated bednets on malaria transmission by the *An. gambiae* complex in The Gambia. *Medical and Veterinary Entomology*, **3**(3): 266 - 71.

Loevinsohn, B.P., Sutter, R.W. and Costales, M.O. (1997). Using cost-effectiveness analysis to evaluate targetting strategies: The case of vitamin A supplement. *Health Policy and Planning*, **12**(1): 29 - 37.

Loong, K.P., Chiang, G.L. and Yap H.H (1988). Field studies of the bionomics of *Anopheles maculatus* and its role in malaria transmission in Malaysia. *The Southeast Asian Journal of Tropical Medicine and Public Health*, **19**: 724.

Loong, K.P., Chiang, G.L., Eng, K.L., Chan, S.T. and Yap, H.H. (1990). Survival and feeding behaviour of Malaysian strain of *Anopheles maculatus Theobald* (Diptera: Cullicidae) and their role in malaria transmission. *Tropical Biomedicine*, **7**: 71 - 6.

Lubega, R., Obudho, W.O and Myanba, J.B. (1977). Verandah-trap hut assessments of mosquito coils perfumed with aggarbati. *East African Journal of Medical Research*, **4**: 31 - 37.

MacDonald, G. (1952). The analysis of the sporozoite rate. *Tropical Disease Bulletin*, **49**: 569-585.

Macdonald, G. (1957). The epidemiology and control of malaria. Oxford University Press (London).

Mackey, L.J., McGregor, I.A., Padunova, N. and Lambert, P.H. (1982). Diagnosis of *P. falciparum* infection in man: Detection of parasites antigen by ELISA. *Bulletin of the World Health Organization*, **60**: 69 - 75.

Magesa, S.M., Wilkes, T.J. and Mnzwa, A.E.P. (1991). Trial of pyrethroid impregnated bednets in an area of Tanzanian holoendemic for malaria Part 2: Effects on the malaria vector population. *Acta Tropica*, **49**: 97 - 108.

Mahajan, M.C. and Ganguly, N.K. (1984). Role of etiology of malaria under Indian condition. In Proceedings of the Indo-UK workshop on malaria. (Sharma V.P., ed.). Malaria Research Centre (Delhi): 233 - 37.

Mak, J.W., Lim, P.K.C., Tan, M.A.J.A., Lam, P.L.W., Noorain, A., Selvadurai, G.D. and Harjeet, K. (1987). Parasitological and serological surveys for malaria among inhabitants of an aborigine village and adjacent Malay village. *Acta Tropica*, **44**(1): 83 - 9.

Marques, A.C. (1979). Migracoes internas e as grandens endemicias. *Revista Brasiliera de malarilogia e. Doencais Tropica*, **31**: 137 - 158.

Marsh, K. (1993). Immunology of human malaria. In Bruce-Chwatt's essential malariology, 3rd edition (Gilles H.M. and Warrel D.A., eds). Edward Arnold (London).

Mashaal, H.A.H. (1993). Physician's guide to effective management of cases of malaria. South East Asian Medical Information Center, International Medical Foundation of Japan.

Mashaal, H. (1986). Clinical malariology. SEAMIC, International Medical Foundation of Japan.

Matola, Y.G., White, G.B. and Magayuka, S.A. (1987). The changed pattern of malaria endemicity and transmission at Amani in the eastern Usambara mountains, north-eatern Tanzania. *Journal of Tropical Medicine and Hygiene*, **90**(3): 127 - 34.

Mathews, H.M. and Dondero, Jr., T.J. (1982a). A longitudinal study of malaria antibodies in a Malaysian population I. Group responses. *American Journal of Tropical Medicine and Hygiene*, **31** (1): 14-18.

Mathews, H.M. and Dondero, Jr., T.J. (1982b). A longitudinal study of malaria antibodies in a Malaysian population II. Follow-up of individuals. *American Journal of Tropical Medicine and Hygiene*, **31** (1): 19-23.

McGregor, I.A. (1983). Current concept concerning man's resistance to infection with malaria. *Bulletin of the World Health Organization*, **76**: 443 - 445.

McGregor, I.A., Carrington, S.P. and Cohen, S. (1963). Treatment of East African *Plasmodium falciparum* malaria with West African human gamma-globulin. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **57**: 170-175.

McGregor, I.A., Hall, P.J., Williams, K., Hardy, C.L.S. and Truner, M.W. (1966). Demonstration of circulating antibodies to *Plasmodium falciparum* by gel-diffusion techniques. *Nature*, **210**: 1384 - 1386.

McGregor, I.A., Williams, K., Billewicz, W.Z. and Thomson, A.M. (1966). Haemoglobin concentration and anaemia in young West African (Gambian) children. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **60**: 650-657.

Miller, J.E., Lindsay, S.W., Armstrong-Schellenberg, J.R.M. (1993). Village trials with bednets impregnated with wash-resisitant permethrin treated compared with other pyrethroid formulations. *Medical and Veterinary Entomology*, **9**(1): 43 - 9

Miller, L.H. and Carter, R. (1976). A review: innate resistance in malaria. *Experimental Parasitology*, **40**: 132 - 146.

Molineaux, L. (1988). The epidemiology of human malaria as an explanation of its distribution, including some implications for its control. In Malaria: Principles and practice of malariology (Wernsdorfer W.H. and Mcgregor I., eds.), volume 2. Churchill Livingston (London): 913 - 918.

Molineaux, L., Muir, D.A., Spencer, H.C. and Wernsdorfer, W.H. (1988). The epidemiology of malaria and its measurement. In Malaria: Principles and practice of malariology. (Wernsdorfer W.H. and McGregor I., eds.), volume 2. Churchill Livingston (London): 999 - 1090.

Molineaux, L. and Gramiccia, G. (1980). The Garki Project. Research on epidemiology and control of malaria in the Sudan Savannah of West Africa. Geneva: World Health Organization.

Moorhouse, D.E. and Wharton, R.H. (1965). Studies on Malayan vectors of malaria: methods of trapping, and observations on biting cycles. *Journal of Medical Entomology*, **1**: 359 - 370.

Muller, A.S. and van Ginneken, J.K. (1991). Morbidity and mortality in Machakos, Kenya, 1974-1981. In diseases and mortality in sub Saharan Africa (Feachem R.G.A. and Jamison D.T., eds.) Oxford University Press (Oxford): 262-285.

Na-Bangchang, K. and Karbwang, J. (1993a) Chapter 5 Chloroquine. Clinical pharmacology of chloroquine. In Clinical pharmacology of antimalarials (Karbwang J. and Wernsdorfer W., eds.). Faculty of Tropical Medicine Mahidol University (Bangkok): 85-125.

Na-Bangchang, K. and Karbwang, J. (1993b). Chapter 6 Quinine. In Clinical pharmacology of antimalarials (Karbwang J. and Wernsdorfer W., eds.). Faculty of Tropical Medicine Mahidol University (Bangkok): 127-165.

Na-Bangchang, K. and Karbwang, J (1993c). Chapter 10 Primaquine. In Clinical pharmacology of antimalarials (Karbwang J. and Wernsdorfer W., eds.). Faculty of Tropical Medicine Mahidol University (Bangkok): 305-336.

NEB. (1989). Pergau hydrelectric project: The project and its environment. National Electricity Board.

Nicholls, N. (1993). El-ninoSouthern Oscillation and vector-borne disease. *Lancet*, **342**: 1284 - 1285.

Norussis, M.J./SPSS Inc. (1994). SPSS: Advanced statistics. SPSS Inc. (USA).

O'Holohan, D.R. (1982). Malaria with special reference to rubber and palm tree oil estates. *Family Practitioner*, **5**:13.

Oaks, S.C., Mitchell, V.S., Pearson, G.W. and Carpenter, C.C.J. (1991). Malaria: Obstacles and Opportunities. A report of the Committee fro the study on Malaria Prevention and Control: Status review and alternative strategie, Division of International Health, Institute of Medicine. National Academy Press (Washington, D.C).

Onori, E., Beales, P.F. and Gilles, H.M. (1993). Rationale and technique of malaria control. In Bruce-Chwatt's essential malariology, 3rd edition (Gilles H.M and Warrel D.A., eds). Edward Arnold (London).

PAHO. (1984). Epidemiology and control of falciparum malaria in the Americans. Pan American Health Organisation, Scientific publication No. 471 (Washington D.C).

Pampana E. (1969). A textbook of malaria eradication. Oxford University Press (London).

Pasvol, G., Weatherall, D.J., Wilson, R.J.M., Smith, D.H. and Gilles, H.M. (1976). Fetal haemoglobin and malaria. *Lancet*, **1**: 1269 - 1272.

Petit, P.L.C and van Ginneken, J.K. (1995). Analysis of hospital records in four African countries, 1975-1990, with emphasis on infectious diseases. *Journal of Tropical Medicine and Hygiene*, **98**: 217-227.

Peyton, E.L. and Harrison, B.A. (1979). *Anopheles (Cellia) dirus*, a new species of the *leucosphyrus* group from Thailand (Diptera: Cullicidae). *Mosquito Systematics*, **11**: 40 - 53.

Pleass, K.J., Armstrong, J.R.M., Curtis, C.F., Jawara, M. and Lindsay, S.W. (1993). Comparison of permethrin treatment for bednets in The Gambia. *Bulletin of Entomological Research*, **83**(1): 133 - 140.

Poolsuwan, S. (1995). Malaria in prehistoric Southeastern Asia. *The Southeast Asian Journal of Tropical Medicine and Public Health*, 26 (1): 3 - 22.

Port, G.R. and Boreham, P.F.L. (1982). The effect of bednets on feeding by *Anopheles gambiae gilles* (Diptera: Cullicidae). *Bulletin of the World Health Organization*, 72: 483 - 8.

Rahman, W.A., Abu-Hassan, A., Adanan, C.R and Mohd-Razha, R. (1995). A report of *Anopheles* (Diptera: Culicidae) attracted to cow bait in a malaria endemic village in Peninsular Malaysia near the Thailand Border. *The Southeast Asian Journal of Tropical Medicine and Public Health*, 26 (2): 359 - 363.

Rahman, W.A., Abu-Hassan, A., Adanan, C.R., Mohd-Razha, R., Rashid, A. and Khalid, A.K. (1992). Malaria transmission in a remote village located in northen Peninsular Malaysia near the Malaysia-Thailand border. *Tropical Biomedicine*, 9: 83 - 9.

Rajapaksa, N. (1971). Field and laboratory observations in Sabah, East Malaysia, on the proportion of *Anopheles balabcensis balabacensis* eggs hatching after holding in humid atmosphere. *Bulletin of the World Health Organization*, 45: 263 - 265

Ralisoa, O., Rasamindrakotroka, A., Ravelojana, B., Rafarasoa, L., Randrianarisoa, Rakotoson, R., Bosman, A. and Coluzzi, M. (1991). *Plasmodium falciparum* malaria transmission indices in a highland village of the Ikopa River Valley near Mananarivo, Madagascar. *Parasitologgia*, 55: 219-225.

Rao, B.A. and Nasiruddin, M. (1945). Malaria in the Irwin canal area, Mysore State, Part I. *Journal of malariology of the Institute of India*: 109 - 128.

Rauyajin, O. (1991). Factors affecting malaria related behaviour: a literature review of behavioural theories and relevant research. In Social and economic aspects of malaria control.(Sommani S. and Fungladda W., eds). MRC-TROPMED. Faculty of tropical medicine, Mahidol University (Bangkok): 36 - 69.

Ray, A.P. (1979). Some aspect of *P. falciparum* containment programme. *Indian Journal of Medical Research*, 70: Supplement - 1 - 13.

Ray, K., Chowdhuri, A.N.R., Sharma, R.S., Rai, A., Choudhury, D.S. and Lobel, H.O. (1981). Indirect haemagglutinating malaria antibodies in fever cases from a rural community in Alwar District, Rajasthan. *Indian Journal of Medical Research*, 73: 78 - 81.

Ray, P., Ansari, M.A. and Sharma, Y.D. (1994). *P. vivax*: immune responses in a cross-section of the people in the Delhi area of India. *American Journal of Tropical Medicine and Hygiene*, 51(4): 436 - 43.

Reid, J.A. (1961). The attraction of mosquitoes by human or animal baits in relation to the transmission of disease. *Bulletin of Entomological Research*, **52**: 43 - 62.

Reid, J.A. (1968). Anopheline mosquitoes of Malaya and North Borneo. Studies from the Institute of Medical Research Malaysia, 31: 520.

Reid, J.A. and Hodgkin, E.P. (1950). The *Anopheles umbrosus* group (Diptera : Culicidae). Part I: systematics with description of two new species. Part II: biology and transmission of malaria. *Transactions Of the Royal Entomological Society of London*, **101**: 281 - 334.

Roper, C., El-Hasan, I.M., Huiid, L., Giha, H., Richardson, W., Babiker, H., Satti, G.M.H.J., Theander, T.G. and Arnot, D.E. (1996). Detection of very low level of Plasmodium falciparum infection using the nested polymerase chain reaction and a re-assessment of epidemiology of unstable malaria in Sudan. *American Journal of Tropical Medicine and Hygiene*, **54**(4): 325 - 31.

Rosenberg, R. and Makeswary, N.P. (1982). Forest malaria in Bangladesh. I. Parasitology. *American Journal of Tropical Medicine and Hygiene*, **31**: 175-182.

Rossenfield, P.L., Widstrand, C.G. and Ruderman, A.P. (1981). Social and economic research in the UNDP/World Bank/WHO. Special programme for research and training in tropical diseases. *Social Science and Medicine*, **15A**: 529 - 38.

Rozendaal, J.A. and Curtis, C.Y. (1989). Recent research on impregnated mosquito nets. *Journal of the American Mosquito Control Association*, **5**: 500 - 7.

Russel, P.F. (1938). Malaria due to defective and untidy irrigation. A preliminary discussion. *Journal of the Malaria Institute of India*, **1**(4): 334 - 349.

Russel, P.F. (1952). Malaria: Basic principle briefly stated. Blackwell Scientific Publications (Oxford).

Samarawikrema, W.A., Parkinson, A.D., Kere, N. and Galo, O. (1992). Seasonal abundance and biting behaviour of *Anopheles punctulatus* and *An. Koliensis* in Malaita Province, Solomon Islands and a trial of permethrin impregnated bednets against malaria transmission. *Medical and Veterinary Entomology*, **6**: 371- 8.

Sandosham, A.A. (1959). Malariology with special reference to Malaya. Singapore University of Malaya Press.

Sandosham, A.A. and Thomas, V. (1983). Malariology with special reference to Malaya. Singapore University Press.

Sanjeevi, C.B., Vivekanandan, S. and Narayanan, P.R. (1991). Fetal response to maternal ascariasis as evidenced by anti *Ascaris lumbricoides* IgM antibodies in the cord blood. *Acta Paediatrica Scandinavica*, **80**: 1134 - 1138.

Scanlon, J.E. and Sandinand, U. (1965). The distribution and biology of *Anopheles balabacensis* in Thailand (Diptera:Culicidae). *Journal of Medical Entomology*, **2**: 61 - 69.

Schlesselman, J.J. (1980). Case control studies: Design, conduct and analysis. Oxford University Press (Oxford).

Service, M.W. (1993). Mosquito ecology: Field sampling methods, 2nd edition. Elsevier (London).

Sharma, V.P. (1991). Environmental management in malaria control in India In Malaria: waiting for the vaccine (Targett G.A.T., ed.). John Wiley (Chichester): 49 - 63.

Sharma, V.P. (1996). Re-emergence of malaria in India. *Indian Journal of Medical Research*, **103**: 26-45.

Sharma, V.P. and Mehrotra, K.N. (1986). Malaria resurgence in India: a critical study. *Social Science and Medicine*, **22** (8): 835 - 845.

Sharp, D. (1996). Malaria range set to spread in a warmer world (news). *Lancet*, **347** (9015): 1612.

Shreshtha, S.L. (1985). Dynamics of malaria transmission with reference to development projects in Nepal. *Journal of Communicable Disease*, **17**(4): 287 - 92.

Singahanetra, R.A. (1986). Population movement, socio-economic behaviour and the transmission of malaria in northern Thailand. *Southeast Asian Journal of Tropical Medicine and Public Health*, **17**(3): 396 - 405.

Snow, R.W., Rowan, K.M., Lindsay, S.W. and Greenwood, B.M. (1988). A trial of bednets(mosquito nets) as a malaria control strategy in a rural area of the Gambia, West Africa. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **82**: 212 - 215.

Somboon, P., Lines, J., Aramrattana, A., Chitprarop, U., Prajakwong, S. and Khamboonruang, C. (1995). Entomological evaluation of community-wide use of lambdacyhalothrin-impregnated bednets against malaria in border of northwest Thailand. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **5** (89): 248 - 254.

Sornmani, S. (1992). Current knowledge of risk behaviour and risk factors in malaria in Southeast Asia. *The Southeast Asian Journal of Tropical Medicine and Public Health*, **23**: Supplement 1 - 6-8.

Spencer, H.C., Collins, W.E., Chin, W. and Skinner, J.C. (1979). The ELISA II. Comparison with the malaria IFAT. *American Journal of Tropical Medicine and Hygiene*, **28**: 933 - 936.

Spielman, A., Kitron, U. and Pollack, R.J. (1993). Time limitation and the role of research in the worldwide attempt to eradicate malaria. *Journal of Medical Entomology*, **30**(1): 6 - 19.

Sulaiman, W.M.I. (1992). Bionomics and control of malaria vectors with special reference to Kelantan. Vector Control Seminar, The States of Kelantan. Perdana Beach Resort (unpublished).

Sulzer, A.J., Sulzer, K.R., Cantella, R.A., Colichon, H., Latore, C.R. and Welch, M. (1978). Study of coinciding foci of malaria and leptospirosis in the Peruvian Amazon area. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **72**: 76-83.

Svetsereni, T. (1982). Anthropological study of malaria prone behaviour: A case study of Nong Rhea Canton, Kanchanburi. Mimeographed.

Tadei, W.P., Mascarenhas, B.M. and Podesta, M.G. (1984). Biologia dos Anofelinos Amazonicas VIII. Conhecimento sobre a distribuicao de especies de *Anopheles* na regias de Tucumi-Maraba (Para). *Acta Amazonica*, **13**: 103 - 140.

Thomas, V., Hock, S.K. and Leng, Y.P. (1981). Sero-epidemiology of malaria: Age-specific pattern of *Plasmodium falciparum* antibody, parasite and spleen rates among children in an endemic area in Peninsular Malaysia. *Tropical Doctor*, **11**: 149 - 54.

Tonggol-Rivera, P., Kano, S., Miguel, E., Tonggol, P. and Suzuki, M. (1993). Application of seroepidemiology in identification of local foci in a malarious community in Palawan, *The Philippines. American Journal of Tropical Medicine and Hygiene*, **49** (5): 608 - 612.

Upatham, E.S., Prasittisuk, C., Ratanatham, S., Rathatham, S., Green, C.A., Rojanasunan, W., Setakana, P., Theerasilp, N., Tremongkol A. and Vijayanant, V. (1988). Bionomics of *Anopheles maculatus* complex and their role in malaria transmission in Thailand. *The Southeast Asian Journal of Tropical Medicine and Public Health*, **19**: 259 - 69.

VBDC. (1980 - 1992). *Laporan tahunan kejadian kes malaria, Malaysia*. Vector-Borne Disease Control Office, Ministry of Health (Kuala Lumpur).

VBDC. (1992). Guidelines for the treatment of malaria. Vector-Borne Disease Control Office, Ministry of Health (Kuala Lumpur).

VBDCP. (1993). Malaria Control Programme. Vector-Borne Disease Control Programme, The State VBDCO (Kelantan).

VBDC. (1994). Guidelines for the treatment of malaria: Revised. Vector-Borne Disease Control Office, Ministry of Health (Kuala Lumpur).

VBDCP. (1988). Report on malaria situation in Malaysia for Brunei-Indonesia-Malaysia-Singapore Border meeting on Malaria in Bali, Indonesia, 24-25 Oct. 1988. Mimeographed.

Voller, A. (1988). The immunodiagnosis of malaria. In Principles and practice of malariology (Wernsdorfer W.H. and McGregor, S.I., eds.), volume 1. Churchill Livingston (London): 815 - 826.

Voller, A. and Bray, S. (1962) Fluorescent antibody staining as a measure of malaria antibody. *Procedure Society of Experimental Biology and Medicine*, **110**: 907 - 10.

Voller, A. and Bruce-Chwatt, L.J. (1968). Serological malaria surveys in Nigeria. *Bulletin of the Worl Health Organization*, **39**: 883-897.

Voller, A. and Schindler, R. (1967). An evaluation of CFT and IFA with a simian malarial antigen in a study of malaria antibody levels in a malaria endemic area. *Bulletin of the Worl Health Organization*, **37**: 675-678.

Voller, A., Huldt, G., Thors, C. and Engvall, E. (1975). A new serological test for malaria. *British Medical Journal*, **1**: 659-661.

Voller, A., Meuwissen, J.H.E. and Verhave, J.P. (1980). Methods for measuring the immunological response to *plasmodia*. In Malaria. Vol 3: Immunology and immunization (Kreier J.P., ed.). Academic Press: 67 - 101.

von Mering, O. (1970). Medicine and psychiatry. In Anthropology and the behaviour and health sciences. (von Merring O. and Kasdan L., eds). University of Pittsburgh Press, Wagley and Charles.

Vythilingam, I., Chiang, G.L., Lee, H.L. and Inder-Singh, K.. (1992). Bionomics of important mosquito vectors in Malaysia. Special report from TROPMED/Malaysia, 23 (4): December.

Vythilingam, I., Foo, L.C., Chiang, G.L., Chan, S.T., Eng, K.L., Mahadevan, S., Mark, J.W. and Inder-Singh, K. (1995). The impact of permethrin impregnated bednets on the malariia vector *Anopheles maculatus* (Diptera: Culicidae) in Aboriginal villages of Pos Betau Pahang Malaysia. *The*

Southeast Asian Journal of Tropical Medicine and Public Health, **26** (2): 354 - 358.

Ward, R.A. (1977). Recent changes in the epidemiology of malaria relating to human ecology. In Proceeding of the 15th International Congress of Entomology (Washington): 523 - 529.

Webber, R. (1996). Communicable disease epidemiology and control. CAB International, University Press (Cambridge).

Wernsdorfer, W.H. (1980). The importance of malaria in the world. In Malaria volume 1: Epidemiology, chemotherapy, morphology and metabolism. (Kreier J.P., ed). Academic Press (New York).

Wharton, R.H. (1950). Daytime resting places of *Anopheles maculatus* and other anophelines in Malaya, with results of precipithin tests. *Medical Journal of Malaya*, **4**: 260 - 71.

Wharton, R.H. (1951). The habits of adult mosquito in Malaya. I: Observation on anophelines in Window-trap huts and at cattle sheds. *Annals of Tropical Medicine and Parasitiology*, **45**: 141 - 154.

Wharton, R.H. (1953). The habits of adult mosquitoes in Malaya. III: Feeding preferences of anophelines. *Annals of Tropical Medicine and Parasitiology*, **47**: 272 - 284.

Wharton, R.H., Laing, A.B.G. and Cheong, W.H. (1963). Studies on the distribution of malaria and filariasis among aborigines in Malaya. *Annals of Tropical Medicine and Parasitology*, **57**: 235 - 254.

WHO. (1993). A global strategy for malaria control. Geneva: World Health Organization.

WHO. (1992). Malaria in the Western Pacific Region. World Health Organization.

WHO. (1974). Serological testing in malaria. *Bulletin of the World Health Organization*, **50**: 527.

WHO. (1988). Malaria diagnosis: Memorandum from a WHO meeting. Bulletin of the World Health Organization, 66: 575.

WHO. (1989). The use of impregnated-bednets and other materials for vector-borne disease control. World Health Organization/VBC/89.981.

Wickeromasinghe, F.A. (1969). An epidemiological analysis of the malaria epidemic in Ceylon. WHO/SEA/Epid/M/SEM 2/WP/20.

Williams, E.H., Hayes, R.J. and Smith, P.G. (1986). Admissions to a rural hospital in the West Nile District of Uganda over a 27 year period. *Journal of Tropical Medicine and Hygiene*, **89**: 193-211.

Williamson, W.A and Gilles, H.M. (1978). Malumfashi Endemic Diseases Research Project II. Malariometry in Malumfashi, Northern Nigeria. *Annals of Tropical Medicine and Parasitology*, **72**: 323-328.

Wilson, D.B. and Garnham, P.C.C. (1950). A review of hyperendemic malaria. *Tropical Disease Bulletin*, **47**: 677-698.

Winch, P.J., Makemba, A.M., Makame, V.K., Mgaume, M.S., Lynch, M.C., Premj, Z., Mingas, J.N. and Schiff, C.J. (1997). Social and cultural factors affecting rates of regular retreatment of mosquito nets with insecticide in Bagamoyo District, Tanzania. *Tropical Medicine and International Health*, **2**(8): 760 - 70.

Yow-Cheong, C., Kai-Lok, C. and Beng-Chuan, H. (1973). Vector control in SEA. Proceedings of the first SEAMEO workshop, 17 - 18 August 1972. University of Singapore (Singapore).

Zuckerman, A. and Spira, D. (1965). Immuno-electrophoretic comparison of *plasmodial* antigens. Mal. doc. World Health Organization, 449: 65 - 70.

APPENDIX

Appendix I
Questionnaire for social and behavioural survey (English version).
MALARIA SURVEY IN JELI DISTRICT, KELANTAN.
A social and behavioural survey in Jeli District, Kelantan, Malaysia, with special reference to the Pergau Hydroelectric Power Project.

CODE: [_ _ _ _ _/_ _ _]   Date: [__/__/__]   Interviewer: ____________

1. Name: ________________________________ Income ______________

2. Sex: L [ ] P [ ]   3. Age (year/month if <2 year old) [_ _ _]

4. Ethnic (M=Malay; T=Thai; MT=Malay-Thai; L=others) [____]

5. Address: ____

6. Duration of stay here.

1. 0 - 5	years	[ ]
2. 6 - 10	years	[ ]
3. 11 - 15	years	[ ]
4. 16 - 20	years	[ ]
5. > 20	years	[ ]

7. History of movement or travelling before residing here.

____

____

8. Area Location

1. Near Pergau Dam	[ ]
2. Land scheme village	[ ]
3. Malay traditional village	[ ]
4. Orang Asli settlement	[ ]
5. Other	[ ]
please state ______________________	

9. Occupation

1. Rubber tapper	[ ]
2. Work in fruit farms	[ ]
3. Clearing land	[ ]
4. Housewife	[ ]
5. Other	[ ]
please state ______________________	

10. Place of work: 1. village 2. forest fringe 3. deep jungle 4. others [ ]
If others, please state ____
11. How many people live in this house]

12. Household details

Name	Age	Sex	Status	Relationship	Place of work/school

{Status: S=schooling, B=working, TB=neither working nor schooling}
{Relationship:realtionship with head of the family or the person interviewed}

13. No. of bedrooms in this house. [__] rooms

14. Do you use bednets Yes [ ] No [ ]

If yes, answer the following questions. If no, answer question 25.

15. How long have you been using bednet? [ ] years

16. How many bednet is in used? [__]

17. How often do you bednet?
1. Every night [ ]
2. Occasionally [ ]
3. Other [ ]
please state________________

18. Type of bednet used. Impregnated bed net[ ] Ordinary [ ]

If you use impregnated bednet, answer the following questions. If not, go to question 25.

19. How long have you been using impregnated bed net?
1. < 6 months [ ]
2. 6 - 12 months [ ]
3. 13 - 18 months [ ]
4. 19 - 24 months [ ]
5. > 2 4 months [ ]

20. Have you ever wash your bednet? Yes [ ] No [ ]

21. If yes, how many times have you washed you bednet? [___]times

22. How frequent did you wash your bednet? every [___]months

23. How many times have you re impregnate your bednet? [___]times

24. How frequent did you re impregnate your bednets? every[___]months

LIFE STYLE

25. What time do you normally go to bed?
1. 9.00 pm [ ]
2. 9.30 pm [ ]
3. 10.00 pm [ ]
4. 10.30 pm [ ]
5. > 10.30 pm [ ]

26. Do you use any other method (other than bednet) to prevent mosquito bites when you sleep? Yes [ ] No [ ]

27. If yes, what method do you use?.
1. Mosquito coil [ ]
2. Insecticide spray [ ]
3. Other [ ]
please state______________

28. Do you any method/s to prevent mosquito bite before you go to bed?
Yes [ ] No [ ]

29. If yes, what method do you use?
1. Mosquito coil [ ]
2. Insecticide Spray [ ]
3. Other [ ]
please state__________________

30. What time did you wake up from sleep?
1. 5.00 am [ ]
2. 5.30 am [ ]
3. 6.00 am [ ]
4. 6.30 am [ ]
5. Other [ ]
please state________________

31. Domestic water suply.
1. Inside the house [ ]
2. Outside the house [ ]

32. Toilet
1. Inside the house [ ]
2. Outside the house [ ]

33. Type of house
1. Tradisional wooden house [ ]
2. Brick house [ ]
3. Other [ ]
please state___________________

34. Have you ever stayed overnight in the jungle? Yes [ ] No [ ]
If yes, answer the following questions. If no, answer question 38.

35. How frequent did you stay overnight in the jungle?
1. > 1 times/week [ ]
2. a few times/month [ ]
3. < 1 times/month [ ]

36. Why did you stay overnight in the jungle?______________________________

7. Did you take any protection measures/prophylaxis against malaria before/whilst you overnight in the jungle? Yes [ ] No [ ]
38. Distance of river/stream from the house? [____]meter

39. Any jungle/land clearing activities near the house? Yes [ ] No [ ]
If yes, answer the following questions. If no, answer question 44.

40. If yes, how far is it from the house? [___] km

41. Is it still going on? Yes [ ] No [ ]

42. If no, how long has it stop? [____]months
43. How long was the activity poersisted? [____]months

44. Distance of dam/reservoir from the house? [____] km

45. Distance of the highway/main road from the house? [____] km

MEDICAL HISTORY
46. Do you have malaria now? (< 2 month) Yes [ ] No [ ]
47. If yes, please fill in the table below.
Date infected____________________
Clinical signs and symptoms____________________
Treatment____________________
Place/source of treatment____________________
Lenght of treatment____________________

48. Have you had malaria before (while residing at present address)? Yes [ ] No [ ]

49. How do you know you had malaria?
1. Self diagnosis [ ]
2. Told by a doctor [ ]
3. Told by malaria staff [ ]
4. Told by a GP [ ]
5. Other [ ]
please state____________________
50. How many times have you had malaria? [ ]times

51. Please give details of your previous malaria infection.

Date	Place/source of Rx	Lenght of Rx	Notes

Thank you for your co-operation.

(To be completed by the researcher)
Health record
56. Source____________________

57. Symptoms

____

____

58. Signs

____

____

59. Treatment

____

____

60. If admitted to hospital, please state:
Date of admission...
Length of stay..
Place of admission..
61.Investigations...
....

62. Parasitological investigations.
Parasite species...
Stage of infection...
63. Other relevant problems...
....
64. Physical examinations

Appendix II

Retrieving parasites for culture

The David Walliker Protocol was used in retrieving frozen malaria parasites for culture. The materials used for retrieving parasites were Solution A (12% NaCl in distilled water), Solution B (1.6% NaCl), Solution C (0.2% Dextrose/0.9% NaCl in distilled water.RPMI), fresh type O red blood cells, tissue culture media (TCM), 10ml and 5ml pipettes, 12ml and 25ml culture flasks, sterile disposable pipettes, 0.5ml centrifuge tubes and glass slides, microscope and oil immersion, a filter, Giemsa stain.

Solutions A, B and C were prepared and sterilised by filtration. The ampoule containing deep-frozen Plasmodium falciparum CD7A was removed from a liquid nitrogen container and placed in a water bath at 37 °C until it fully thawed. The content of the ampoule was then transferred to a sterile 15ml round bottom centrifuge tube and the packed cell volume (PCV) was measured. Solution A was added drop by drop while stirring constantly. For every one ml of original blood thawed, 0.2 ml of solution A was used.

The tube was left for three minutes before adding Solution B in the same manner as Solution A. Ten ml of Solution B were used per each original one ml of blood thawed. The whole content was centrifuged at 1500 rpm for five minutes at 20°C. The supernatant was removed and Solution C was added as for Solution A and B at 10ml per one ml of original blood. The whole content was again centrifuged at 1500 rpm for five minutes at the same temperature. The supernatant was removed and the remaining PCV resuspended in a complete RPMI medium. The PCV was re-measured and depending on the haematocrite level, fresh red cells were added. The retrieved parasites were transferred to a culture flask where pre-prepared TCM was added to begin the culture. A drop of the blood was centrifuged and a thin blood film prepared. The slide was stained with 10% Giemsa after methanol fixation and examined under oil immersion. Culture flasks were put in a dessicator, with appropriate O2 and CO2 concentration kept at 4 °C.

Appendix III

Tissue culture media (TCM).

Materials needed for preparing TCM were RPMI-bic, 1M HEPES Buffer, Gentamycin sulphate and a filter (Nalgene 0.45μm). RPMI-bic was prepared by mixing RPMI 1640-GIBCO in 1x 1L pack of lyophilized form with 1L deionised distilled water (dH2O) and 2g NaHCO3. The mixture was stirred for 15 to 30 minutes. Solution's pH was adjusted with 1M HCl to be around 7.2 to 7.3. The mixture was filter-sterilised with Sterivex GS bell filter (0.22μm), sealed with parafilm and stored at 4°C.

For every 100ml of RPMI-bic was added 2ml HEPES buffer (final concentration to be 25mM), 300μl Gentamycin sulphate (50mg/ml) and 11ml human serum (final concentration to be 10%). The mixture was filtered using 115 ml Millipore Nalgene filter unit.

Appendix IV

In-depth interview with key informants: Open ended questionnaire.

1. Have you noticed any changes in the village with regard to:

   the environment and eco-system?

   people's habits and behaviour?

   main economic activities?

2. What is your opininon on the malaria situation in this village?

3. Do you think the changes you mentioned in 1 have any influence or effect on the malaria situation here?

4. What is your opinion on personal protection measures?

5. Which one is effective, or more effective?

6. What about other people? Do you think they share your opinion?

7. Following up from the social and behavioural survey, why do you think people wash their IBN?

8. Any other matters that you would like to talk about?